

The Occurrence of Cold-Water Calanoid Copepods in the Coastal Waters of the San'in District, Japan Sea

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Abstract

The occurrence of five cold-water calanoids, *Calanus cristatus*, *Calanus plumchrus*, *Pseudocalanus elongatus*, *Scolecithricella minor* and *Metridia lucens*, was observed from the plankton samples collected in the upper 50m stratum off San'in District in the Japan Sea from April 1968 to September 1969. The occurrence of cold-water calanoids was common at stations with temperature lower than 12°C at 50m depth in those cold months, January through May. It was observed that certain species among above cold-water forms occurred not only in cold areas in cold seasons but also in the area warmer than 13°C in summer months. This suggests the mixing process of cold and warm watermasses and/or the invading ability into the warmer area of some cold-water calanoids from the lower cold stratum.

I. Introduction

The calanoid copepods such as *Calanus plumchrus* and *Metridia lucens* etc. are abundantly distributed in the boreal waters of the northern North Pacific (ANRAKU, 1952; 1954; MINODA, 1958). They are also abundant in the cold waters lying under the warm Tsushima Current in the Japan Sea (FURUHASHI, 1952; 1953; NISHIMURA, 1957). KIMURA and ODATE (1957) stated that *Calanus cristatus*, *C. plumchrus* and *M. lucens* etc. and other certain crustaceans are the good indicators of the cold waters off the Pacific coast of northern Japan. The occurrence of those copepods in the warm surface waters above the cold watermass in the Japan Sea may show the mixing of cold waters with warm waters. This paper deals with the seasonal distribution of cold-water calanoids with special reference to their occurrence in the warm months.

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II. Materials

The plankton samples were collected monthly by vertical hauls with “Marutoku” A type net (45 cm mouth, 100 cm side length, upper 30 cm with coarse nettings, lower 70 cm with bolting silk cloth GG 54, mesh apperture 0.33 mm × 0.33 mm) from the upper 50 m stratum at 13 stations off San'in District from April 1968 through September 1969, excluding June, July and August of 1968, and April and May of 1969, on board the “Shin-Tajima Maru”, Fisheries Experimental Station of Hyogo Prefecture. Additional samplings were made at 33 stations on board the ships of other three Fisheries Experimental Stations in June 1969. Location of the sampling stations is shown in Fig. 1. The time of samplings varied because of cruising process. The samples were fixed in about 10 % formalin solution imme-

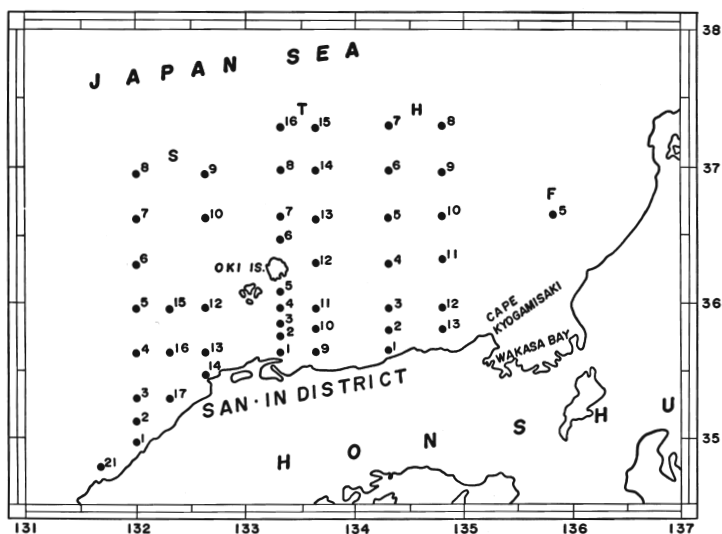


Fig. 1. Location of sampling stations.

- S-stations : M. S. “Shimane Maru”, June 1969
 T-stations : M. S. “Daiichi-Tottori Maru”, June 1969
 H-stations : M. S. “Shin-Tajima Maru”, April 1968–September 1969
 F-station : M. S. “Fukui Maru”, June 1969

diately after the hauls, and then sent to the author. The samples were examined under the dissecting microscope, and the abundance of cold-water calanoids was recorded being classified into three grades, dominant, common and rare. Their occurrences were observed in comparison with the distribution of temperature of 50 m depth at which net reached in the vertical hauls. The temperature in the lower description usually indicates the ones at 50 m depth except the case of special notification.

III. Results

Five cold-water calanoid species, *Calanus cristatus*, *C. plumchrus*, *Pseudocalanus elongatus*, *Scolecithricella minor* and *Metridia lucens*, were observed in the present samples. The occurrence of each species was as follows (Fig. 2, 3).

Calanus cristatus was most scarce among cold-water calanoids with occurrence at only two stations (Stas. H-8, H-9) in April 1968. The temperatures at which *C. cristatus* was captured were lower than 10°C.

Calanus plumchrus occurred in April and May of 1968 and June 1969. This species was one of the most abundant calanoids and sometimes dominant among all

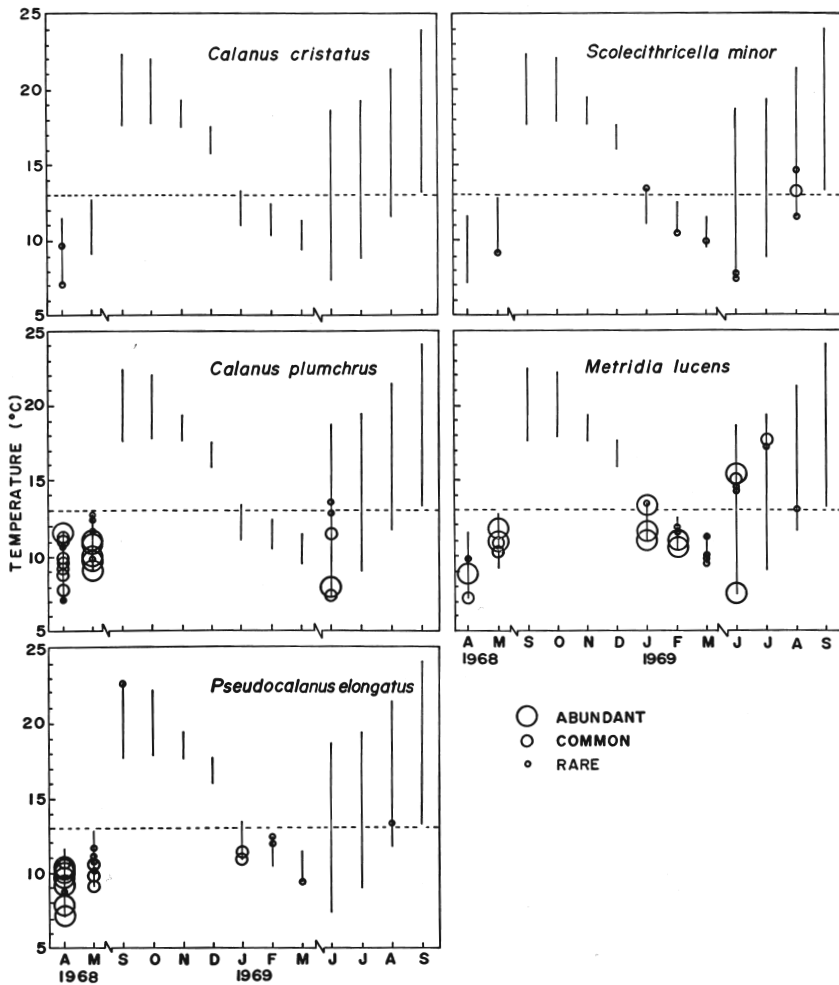


Fig. 2. Seasonal variation of temperature at 50m depth and the occurrence of cold-water calanoids in 50-0m hauls, off San'in in the Japan Sea, April 1968-September 1969. Vertical line shows the temperature range encountered in survey area in each month.

plankters in the samples examined. In April and May of 1968, a number of individuals of this species were captured at nearly all stations where temperature was lower than 12°C. This species also appeared at stations with relatively high temperature as high as 13.5°C (Sta. T-6) in June 1969.

Pseudocalanus elongatus was found not only in the cold months (April and May of 1968, January, February and March of 1969) but also in the warm months. A few individuals of this species were obtained in September 1968 and August 1969. The temperature were 22.5°C at Sta. H-13 in former month and 13.2°C at Sta. H-9 in latter month.

Scolecithricella minor occurred, though small in number, in May of 1968, and January, February, March, June and August of 1969. They occurred sometimes at stations of relatively higher temperature; 13.3°C (Sta. H-9) in January, 13.2°C (Sta. H-9) and 14.6°C (Sta. H-11) in August of 1969.

Metridia lucens frequently showed dominant occurrence in the cold months. They also occurred in summer of 1969, June, July and August. During these months, the species was abundantly found at the considerably warmer stations where the temperature ranged between 14° and 17°C (Stas. S-7, T-12, H-6 and H-7 in June and Stas. H-7 and H-8 in July). Besides, the species occurred at rather warmer stations with temperature 13.3°C in winter (Stas. H-1 and H-9 in January 1969).

IV. Discussion

FURUHASHI (1953) proposed provisionally that the 11°C isotherm is a boundary of the occurrence of cold-water calanoids in the near-shore waters off San'in District in summer. NAKAI *et al.* (1966) have shown the criteria of physico-chemical sea conditions which make cold water plankters possible to appear, dealing with the examples off Choshi on central Pacific coast of Japan in summer: certain cold water forms of euphausiids, copepods, chaetognaths and medusae affirmatively occur under the circumstances of temperature lower than 12°C, chlorinity lower than 19.1‰, and *dt* larger than 26. 20. The present author and his colleague obtained the upper limit of the temperature for the occurrence of certain cold-water calanoids, about 12°C,

Table 1. Highest temperatures those which each cold-water calanoid encountered during diel vertical migration, off San'in in the Sea of Japan, April 1972

Species	Stage, Sex	Temperature (°C)
<i>Calanus cristatus</i>	IV, V	9.6
<i>Calanus plumchrus</i>	III, IV, V	12.0
<i>Pseudocalanus elongatus</i>		12.4
<i>Scolecithricella minor</i>	V, VI ♀	12.0
<i>Metridia lucens</i>	IV, V, VI ♀	12.5

through the results of the simultaneous horizontal tows in detailed depths in the stratified area off San'in District in spring (Table 1). In this paper the upper limit of temperature of the distribution of cold-water species is placed at 13°C estimating it highest as a temporary threshold.

In the present survey, cold-water calanoids were commonly distributed in the area with temperatures lower than 12°C in those cold months, January through May. They also occurred at stations warmer than about 13°C in winter and even in summer as summarized in Table 2. Vertical mixing may have encountered in winter

Table 2. Occurrence of cold-water calanoids under abnormally warm circumstances off San'in, April 1968-September 1969

Species	1968	1969			
	Sep.	Jan.	June	July	Aug.
<i>Calanus plumchrus</i>	—	—	+	—	—
<i>Pseudocalanus elongatus</i>	+	—	—	—	+
<i>Scolecithricella minor</i>	—	+	—	—	+
<i>Metridia lucens</i>	—	+	+	+	+

by cooling of the surface water in the whole area surveyed. *Scolecithricella minor* and *Metridia lucens* were probably transported from the deep cold layer to shallow layer by the mixing in January of 1969 (Fig. 3D). It seems to be the result of the direct influence of the upwelling of cold water that *Calanus plumchrus* and *M. lucens* occurred in June of 1969, and *Pseudocalanus elongatus*, *S. minor* and *M. lucens* in August of 1969. The stations at which they occurred were located at the edge of the cold watermass (Fig. 3F, H). But the occurrence of *P. elongatus* in September of 1968 and *M. lucens* in July of 1969 (Fig. 3C, G) is unable to be explained in the same version as above, owing to the absence of cold watermass close to the stations where they appeared. This may reflect the succession of the cold watermass.

The stational San'in-Wakasa Cold Watermass is usually situated north to the Wakasa Bay, and shows fairly large-scaled variations in demension and location from season to season and from year to year (SHIMOMURA and MIYATA, 1957). In July 1968 it was located to the north of Wakasa Bay (Fig. 3A), and its center shifted northward in August remaining a tongue-shaped trace off the Cape Kyogamisaki (Fig. 3B). *P. elongatus* may be left an orphan through the complicated spatial sequence of the Cold Watermass and its mixing with near-shore water bodies (Fig. 3C). In May and June of 1969, the Cold Watermass was located around Stas. H-7, H-8 and H-9 (Fig. 3E, F). *M. lucens* may be left behind the independent cold watermass which approached to the Wakasa Bay (Fig. 3G), throughout complicated process of water movement as similar to the case of *P. elongatus*. However, an attention has to be paid upon the followings; *M. lucens* is a strong migrant, and

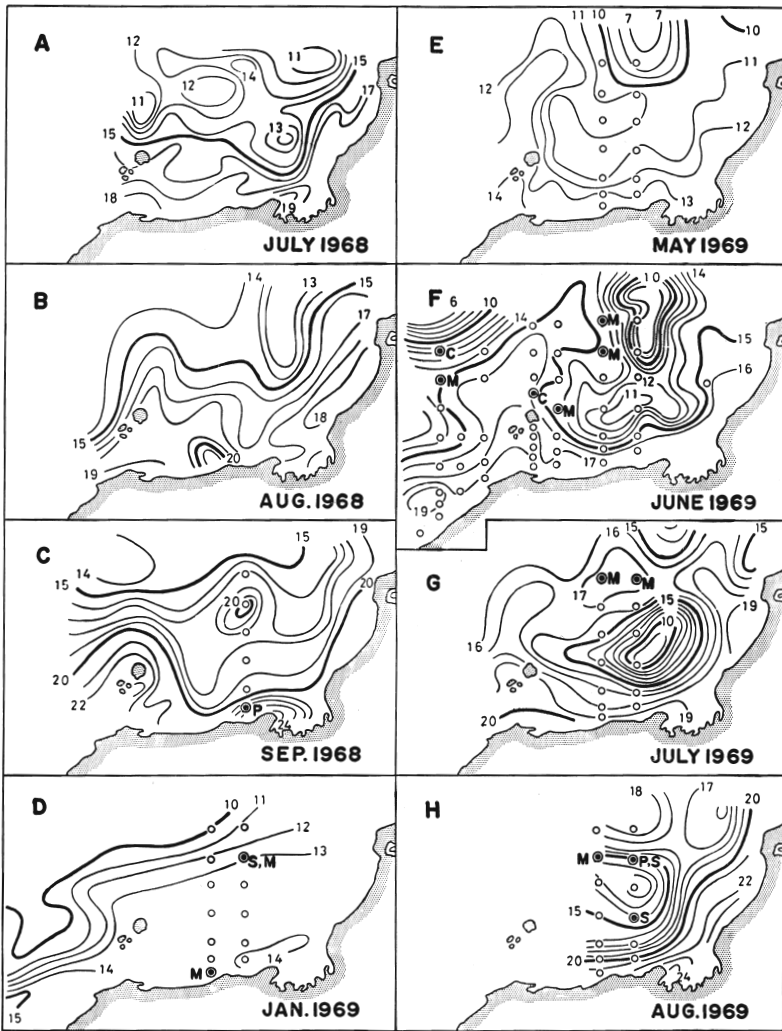


Fig. 3. Isotherms (°C) at 50 m depth (after JAPAN SEA REGIONAL FISHERIES RESEARCH LABORATORY, 1968; 1969) and the occurrence of cold-water calanoids off San'in in selected months.

C : *Calanus plumchrus* S : *Scolecithricella minor*
 P : *Pseudocalanus elongatus* M : *Metridia lucens*

sometimes reaches at the subsurface layer where the temperature is higher than that ever reported as the upper limit hitherto (author's unpublished datum). In discussing the distribution of an animal in general, its life history has to be taken into consideration, because the animal may have several life historical phases in a year and may have each most favourable niche in the respective phase.

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山陰沿岸域における寒海性橈脚類の出現

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要 約

1968年4月から1969年9月の間に山陰沿岸域において月に1回ずつ罾ネットによる50m一表面の垂直曳が行われ、その試料から5種の寒海性橈脚類、*Calanus cristatus*, *Calanus plumchrus*, *Pseudocalanus elongatus*, *Scolecithricella minor* および *Metridia lucens* の出現状況が記録された。これらの種の出現は一般に寒冷的な季節に限られ、冷水塊の消長と密接に関連していた。しかしまた、*C. cristatus* 以外の種は、ときには温暖

な季節にそれぞれの種がもつ一般的な出現温度の上限をはるかに超える高温の地点にも出現した。生物の分布と環境要因との関係は、それぞれの種の詳細な生活史の知見に立脚して論ぜられねばならないが、ここで得られた結果は、対馬暖流域において成層している暖・冷両水塊の複雑な過程による混合・移動を示唆していると思われる。