Diel vertical distribution of larvae and juveniles of pelagic and mesopelagic fishes by a newly developed frame trawl in the Kuroshio-Oyashio Transition Area in spring

HIROSHI KUBOTA,^{1*} AKIYO TSUCHIYAMA,² YOSHIOKI OOZEKI,¹ RYO KIMURA,¹ RYUSUKE KADO,² HISAO OGAWA,² HU FUXIANG,³ AND KOMATSUDA³

¹National Research Institute of Fisheries Science, Kanazawa, Yokohama 236-8648, Japan (miles@affrc.go.jp), ²Kitasato University, Sanriku, Iwate 022-0101, Japan, and ³Tokyo University of Fisheries, Minato, Tokyo 108-8477, Japan

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INTRODUCTION

Stock abundance of pelagic fishes around Japan, such as *Sardinops melanostictus*, *Engraulis japonicus* and *Scomber japonicus* have fluctuated drastically, associated with the dynamics of young of the year (YOY). The fluctuations of mortality after the post-larval stage are important as a determinant of the YOY abundance. For the assessment of the geographical distribution, abundance, mortality and physical drift of fish in the larval and juvenile stages, it is necessary to use appropriate sampling gears for the fish size coupled with knowledge of their vertical distribution. The Kuroshio-Oyashio Transition Area is considered to be an important nursery area for pelagic fishes¹⁾. Limitation of food due to the abundant competitors will have an impact on the growth and mortality of larvae and juveniles of pelagic fishes, and the competition will be a possible determinant of their YOY abundances.

In this paper, we used a newly developed frame trawl and clarified the diel vertical distribution of late larvae and juveniles of abundant pelagic fishes (*E. japonicus* and *Scomber* spp.) which have not been previously fully reported owing to the low catch efficiency of sampling gears, and also describe the vertical distribution of some abundant mesopelagic fishes as potential competitors.

MATERIALS AND METHODS

Samples were collected during the cruise of RV Soyo-maru (Natl. Res. Inst. Fish. Sci.) at four stations in the Kuroshio-Oyashio Transition Area from 13 to 31 May 2000 (Fig. 1). Pre-samplings were carried out to find dense patches of late larvae of pelagic fishes by oblique tows using a frame trawl at the warm water near the thermal front found using NOAA-AVHRR images and vertical profiles of the temperature measured by XBTs. One or three floating GPS buoys each with a cylindrical drogue (diameter 1.6m, height 5m) at 1m or 30m were set to track the water mass where dense larval patches were found. All samples were collected within 4km from the floating buoys. Each set

consisted of four horizontal tows by the newly developed frame trawl²⁾ (mouth opening 5m², 1.59mm mesh, towed at 4kt) for target layers (1-30m, 30-50m, 50-70m, 70-90m), and a surface tow by a neuston net³⁾ (mouth opening 0.975m², 0.45mm mesh, towed at 4kt) both day and night, and finished within 24hrs (Fig. 1). All layers except for surface were sampled horizontally with four steps in the target layer. Temperature and salinity were measured with CTD 2-7 hours before each set. Samples were fixed in 10% buffered formalin. All fish were sorted, classified at least to the order, and counted. Standard lengths (SLs) of all or a minimum of 200 anchovy and mackerels in each tow were measured to the nearest 0.1mm.

RESULTS AND DISCUSSION

At all stations, the thickness of the surface mixed layer was 10 to 20m, and the pycnocline was observed under the mixed layers to 30-40m depths.

Mean filtered volume per tow was 15,005±2120m³ for the frame trawl and 688±209m³ for the neuston net. Deployments of the frame trawl were stable except for unusual clogging, and the differences between target and actually towed depth was less than 9m at most.

A total of 248,353 fish were collected, and identified as 73 families, 110 genera and 119 species. The five most abundant species were *E. japonicus* (87.0% of total), *Diaphus* spp. (2.9%, Myctophidae), *Myctophum asperum* (2.9%, Myctophidae), *Scomber* spp. (0.9%) and *Ceratoscopelus warmingii* (0.6%, Myctophidae).

E. japonicus less than 10mm distributed in the upper 50m layer at daytime, and distributed intensively at the surface at night (Fig. 2). Larvae of 10-20mm occurred in largest numbers in the 10-40m layers both day and night. Larvae of 20-30mm mainly occurred at 10-30m layer at night, while at daytime, distributed in 10-50m layers at St. 1 and 4, and often occurred in largest number at the surface (St. 1, 2 and 3). *Scomber* spp. less than 10mm distributed

Fig. 1 Location of Stations. Sea Surface Temperature was cited from the Quick Report of Oceanography and Fishery of Pacific Ocean (from 17 to 23, May, 2001), published by Japan Fisheries Information Service Center.

Fig. 2 Diel vertical distributions of larvae and juveniles of dominant pelagic fishes. Symbols indicate densities of each species and medians of the actually towed depth.

at upper 70m layer and was most abundant at 30-50m at daytime, and concentrated at surface at night (Fig. 2). *Scomber* spp. more than 10mm mainly distributed in the mixed layer and pycnocline at daytime, while occurring in and below the pycnocline (30-90m layers) at night. Average of SL was significantly larger in the lower layers by U-test ($p < 0.05$) at St. 1, 2 and 4 at night (ex. SL were 7.2 ± 2.2 - 9.3 ± 12.6 mm at 10-30m layer and 11.2 ± 6.1 - 13.8 ± 23.1 mm at 70-90m).

Nealotus tripes, which was one of the abundant pelagic larvae and juveniles, principally distributed within the upper 50m layer both day and night (Fig. 2). *Trachurus japonicus* and Nomeidae spp. distributed under the surface layer at daytime, and concentrated at the surface at night (Fig. 2). Juveniles of the 5 most abundant mesopelagic fishes distributed in the upper 90m only at night, whereas

Table 1 Density of larvae and juveniles of dominant mesopelagic fishes in the water column from surface to the maximum towed depth (76-131m)

Family	Larvae/ Juveniles	Density (ind./100m ²)			
		range	average	range	average
Microstomatidae	L	0 - 2.6	1.2	0.3 - 8.6	3.4
Gonostomatidae	L	0.8 - 16.4	8.3	0 - 44.4	26.3
Phosichthyidae	L	0 - 1.0	0.4	0.1 - 9.8	3.7
Myctophidae	L	155.9 - 221.2	191.0	125.8 - 310.4	224.2
Notosudidae	L	0 - 24.8	7.0	9.2 - 88.7	52.0
Microstomatidae	J	0	0	0.6 - 23.8	6.7
Gonostomatidae	J	0 - 0.3	0.1	1.7 - 30.5	14.6
Phosichthyidae	J	0 - 0.1	0.03	4.2 - 134.3	43.4
Myctophidae	J	0 - 1.8	0.9	309.6 - 483.9	406.1
Notosudidae	J	0	0	0 - 8.6	2.7

larvae of them were caught 13-66% of the night even during the day (Table 1). Mesopelagic fishes were principally abundant under the pycnocline, but Myctophidae and Phosichthyidae (*Vinciguerria nimbaria* was more than 99%) often distributed in and above the pycnocline.

We could successfully collect late larvae of *E. japonicus* and early juveniles of *Scomber* spp. using the newly developed frame trawl, and described their diel vertical distributions. To evaluate quantitatively the abundance of larvae and juveniles of pelagic fishes in the Kuroshio-Oyashio Transition Area, it is sufficient to sample upper 50m layer for *E. japonicus* both day and night and for *Scomber* spp. at daytime, but at night not sufficient for *Scomber* spp. since it is often distributed under the pycnocline to 90m layers especially larger individuals. In the case of *T. japonicus*, it will be most efficient to sample surface by a neuston net at night. Considerable competition for food was assumed among Mictophidae, *V. nimbaria* and pelagic fishes, and the predation on *E. japonicus* by *Scomber* spp. and *N. tripes* was also expected considering their feeding habits^{4,5}, since their modes of vertical distribution were often observed simultaneously in the surface mixed layer or pycnocline.

REFERENCES

- Kubota H, Oozeki Y, Kimura R. Horizontal distribution of larvae and juveniles of small pelagic fishes collected by a MIKT at the northern edge of warmer water in the Kuroshio-Oyashio Transition Area in spring. *Bull. Natl. Res. Inst. Fish. Sci.* 2001; 16: 57-73.
- Hu F, Oozeki Y, Tokai T, Matsuda K. Scale model of a new midwater trawl system for sampling pelagic larval and juvenile fish. *Fish. Sci.* 2001; 67: 254-259.
- Oozeki Y, Kimura R, Kubota H, Ishida M. Modified neuston net for collecting larvae and juveniles of Pacific saury, *Cololabis saira*. *Bull. Jpn. Fish. Oceanogr.* 2001; 65: 1-5.
- Grave H. Food and feeding of mackerel larvae and early juveniles in the North Sea. *Rapp. P.-v. Reun. Cons. Int. Explor. Mer.* 1981; 178: 454-459.
- Matsuzaki K, Ozawa T. Development of feeding-related morphologies and feeding ecology of larvae of *Nealotus tripes* (Gempylidae, Scombroidei). *Japan. J. Ichthyol.* 1998; 45: 77-85.