Relationship Between Anchovy, *Engraulis japonica*, Egg and Larval Density and Environmental Factors in the Eastern Waters of Korea

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The relationship between distribution of eggs and larvae of anchovy, *Engraulis japonica*, and environmental factors were studied using the data on the ichthyoplankton and zooplankton sampled vertically by net, and water temperature and salinity observed by CTD in the eastern waters of Korea in every two month in 1985.

Anchovy eggs and larvae were occurred in June and August. They distributed in the warm water current which was high temperature and salinity in June. Egg and larval distribution area were moved to the offshore in August.

It is likely that distribution of anchovy eggs and larvae in June significantly correlate with hydroconditions in the eastern waters of Korea.

Introduction

Anchovy, *Engraulis japonica*, is an abundant pelagic schooling fish that occurs off Korean peninsula and Japan islands. It is one of most important fisheries resources in Korean waters in terms of not only annual harvest but also economic point of view in Korean fisheries sector. The annual catch of anchovy in Korean waters varies between 120,000 and 200,000 metric tons during 1974~1991, accounting for more than 10% of the total catch in Korea.

Anchovy is exploited by various fishing gears such as drag net, gill net, and set net, etc. In the eastern waters of Korea, this fish stock is taken by coastal gill net and set net fishery for a short period, spring and autumn seasons in the area mostly within 10 miles off seashore.

The anchovies spend winter season from December to March in the warm water area which extends to the south of the coastal front in the Korea strait and of the oceanic front in the Japan Sea (Chang *et al.*, 1980; Kim, 1983). However, the thermal barrier effect of the fronts are lessened from March to April by the increased influx of the Tsushima Warm Current along with the vernal warming of the South Korean Coastal Water. This leads the wintering stock of anchovy to migrate into the coastal waters of Korea through the frontal barriers(Chang *et al.*, 1980).

Water masses in the southern waters of Korea are found to exert extensive influences of the distribution of anchovy eggs and larvae(Kim, 1983).

In this study, the distribution patterns of anchovy early life stage, eggs and larvae and environmental factors, temperature, salinity, vertical temperature gradient, and zooplankton biomass were examined to analyse the relationship between spawning and nursery grounds of anchovy and oceanic condition in the eastern waters of Korea.

Materials and Methods

Ichthyoplankton samples were collected in the eastern waters of Korea in every two month, from

February to December, 1985. The samples were vertically obtained with 0.5~1.0 *m/sec* speed using plankton net with 45 *cm* in diameter, cylinder cone type of 0.333 *mm* mesh nylon from 100 *m* layer to the surface in the 27 sampling stations(Fig. 1).

Ichthyoplankton samples were fixed in 10% buffered formalin on board. Anchovy eggs and larvae were carried to the laboratory and identified under a dissecting microscope by following the methods described by Kim(1981) and Uchida *et al.*(1958). Egg and larval abundance per 1 m^2 sea surface were calculated(Smith and Richardson, 1977).

Temperature and salinity were observed by CTD for each station. The biomass of zooplankton were measured by wet weights of plankton sample.

Temperature stratification variables represented water column stability were created by taking the difference between 10 *m* and 50 *m* values.

Bivariate correlation between egg and larval density, hydrographic condition and zooplankton density through the whole sampling stations were analysed to access the effect of environmental factors in the distribution of anchovy eggs and larvae.

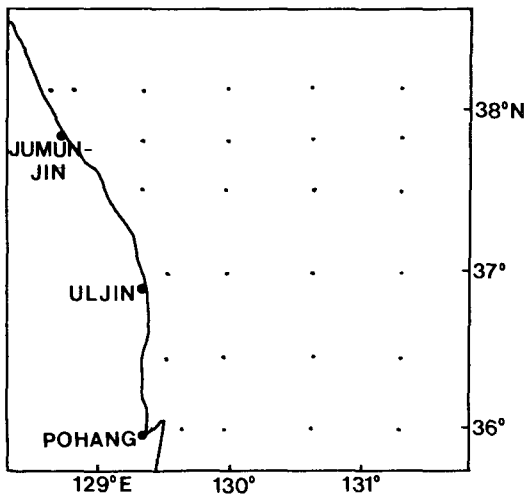

Fig. 1. Map showing study area and sampling stations, 1985.

Results

1. Eggs and larvae

Variation of abundance on anchovy eggs and larvae in every two month is shown in Fig. 2. Eggs and larvae were only occurred in June and August. No occurrence of eggs and larvae has shown from October to April in the eastern waters of Korea. Egg abundance was 62 eggs · m^{-2} sea surface in August, higher than in June. Larval abundance was higher in June with the density of 38 individuals · m^{-2} sea surface than in August.

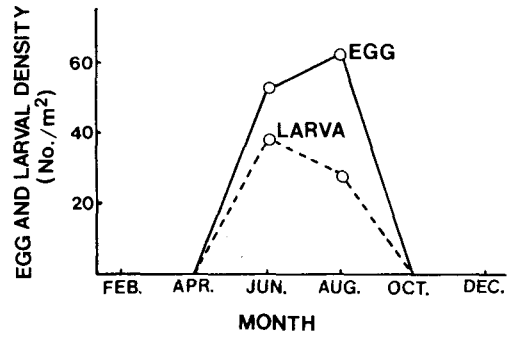

Fig. 2. Variation of abundance on anchovy eggs and larvae in every two month in the eastern waters of Korea.

Fig. 3 shows the horizontal distributions of anchovy eggs and larvae in June and August in the eastern waters of Korea. In June, the high density area of anchovy eggs was appeared on the seashore region from Uljin to Pohang, 36~37°N latitude, with the density of above 300 eggs · m^{-2} sea surface. The greatest number of eggs collected from a sampling was 528 eggs · m^{-2} sea surface. The greatest number of eggs collected from a sampling was 528 eggs · m^{-2} sea surface in the station of 103/05.

Larval distribution area was similar to that of eggs. They are abundant in the adjacent waters of Uljin and Pohang, and absent in the coast of Jumunjin and offshore of Pohang and Uljin, east of 131° 30′ longitude. The greatest number of larvae in a single station is 264 individuals · m^{-2} sea surface. Distribution patterns of anchovy eggs and larvae during June indicated that spawning was apparent throughout coast as far north as 38°N latitude even though available data are very limited.

In August eggs and larvae had local distribution

patterns in the areas near offshore and more northward than in June. Egg distribution was spreaded to the north of 38°N latitude and 103/11, east of 130° 40′. Larval abundance were extended to the coast of Pohang and Jumunjin. High density of larvae were located in the station of 103/09 and 103/11. Eggs and larvae were not found in the coast and offshore of Uljin.

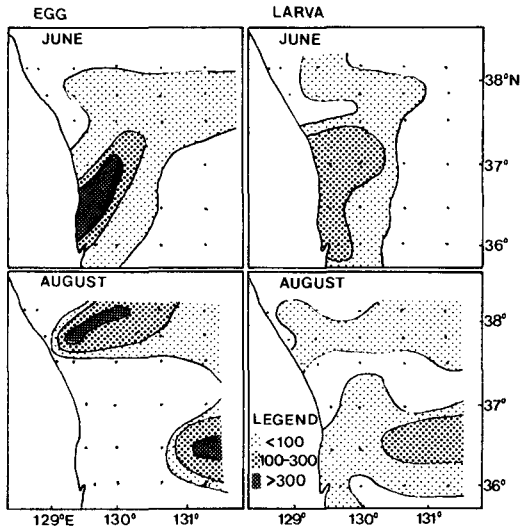

Fig. 3. Distribution of anchovy eggs and larvae in the eastern waters of Korea in June and August, 1985.

2. Environmental variables

Fig. 4 shows the distributions of water temperature at 10 *m* and 50 *m* layer, respectively, salinity at 10 *m* layer, and zooplankton biomass.

Water temperature was ranged from 14 ℃ to 19 ℃ at 10 *m* layer and from 4 ℃ to 15 ℃ at 50 *m* layer in June. There were high temperature above 17 ℃ at 10 *m* layer and 10 ℃ at 50 *m* layer along the coast from Uljin to Pohang and Jumunjin offshore, and low temperature below 10 ℃ at 50 *m* layer in both the adjacent waters of Jumunjin and the eastern area from 130° 30′. Salinity was ranged from 34.2 to 34.6‰.

There were high salinity in the coastal area from Uljin to Pohang. Zooplankton biomass distribution showed that high density was appeared in the adjacent waters of Uljin and Pohang. In the coast of Jumunjin zooplankton was appeared at low density below 50 mg/m^3.

In August, temperature was ranged from 17 ℃ to 26 ℃ at 10 *m* layer and from 4 ℃ to 16 ℃ at 15 *m* layer(Fig. 4). There were low temperature below 20 ℃ at 10 *m* layer, and 10 ℃ at 50 *m* layer along the coast from Jumunjin to Pohang. High temperature above 25 ℃ at 10 *m* layer and 14 ℃ at 50 *m* layer were occurred in offshore of the eastern waters of Korea. Salinity was ranged from 33.4‰ to 34.0‰. Low salinity, below 33.6‰, was appeared in the coast and offshore of Pohang and Uljin. High density area of zooplankton was placed in the 38° latitude from coast to offshore, and coast and offshore of Pohang sporadically.

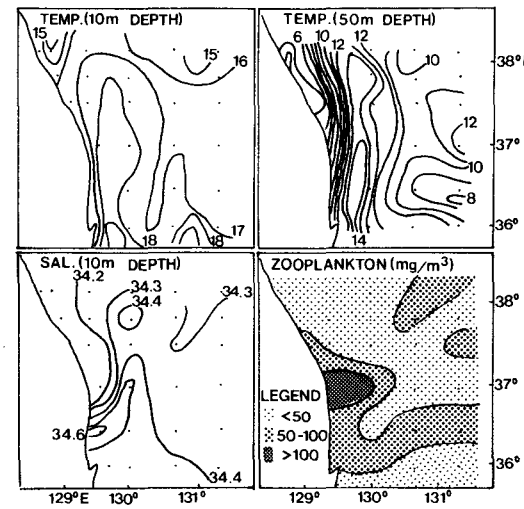

Fig. 4. Distribution of temperature(10*m* and 50*m* depth), salinity(10*m* depth), and zooplankton biomass in June, 1985.

3. Relationship between egg and larval density and oceanographic factors

Values of bivariate correlation between anchovy eggs, larvae, and other oceanographic variables were presented in Table 1. Correlations between eggs and larval density, temperature, and salinity at a depth of 10 *m* had high significance in June, but in August, no significance existed between parameters except the relationship between eggs and larvae of anchovy.

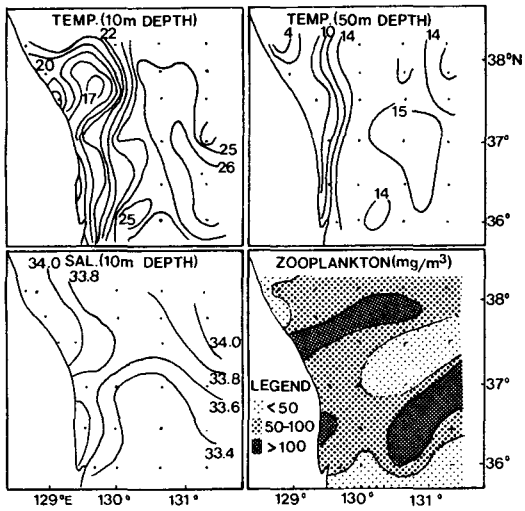

Fig. 5. Distribution of temperature(10*m* and 50*m* depth), salinity(10*m* depth), and zooplankton biomass in August, 1985.

Table 1. Bivariate correlations between anchovy eggs, larvae, and other variables. Eggs(Ind. No.·m^{-2}); Larvae(Ind. No.·m^{-2}); Zoop.(Zooplankton, $g \cdot m^{-3}$); Temp.(10*m* depth layer temperature, ℃); Sali.(Salinity, ‰); Te.Gr.(Temperature gradient between 10*m* and 50 *m* depth)

Month	June		August	
	Eggs	Larvae	Eggs	Larvae
Larvae	0.406*		0.613**	
Zoop.	0.261	0.383	0.156	0.268
Temp.	0.526**	0.665**	0.091	0.254
Te. Gr.	-0.241	-0.353	-0.037	0.013
Sali.	0.640**	0.443*	0.067	-0.190

* Significant at P=0.05
** Significant at P=0.01

Discussion

Anchovy eggs and larvae were appeared in June and August in the eastern waters of Korea(Fig. 1). Lim *et al.*(1970) described anchovy eggs and larvae occurred mostly throughout the year in the southern waters of Korea. In this study, major spawning season was detected during June and August in the eastern waters of Korea. This implies that anchovy migrate to the eastern waters of Korea in June and spawn mostly during June~August.

Many environmental factors can affect the formation of spawning grounds and nursery grounds (Lasker, 1975; Smith and Lasker, 1978). The main water mass of the eastern waters of Korea is consisted of North Korean Cold Water and of the subsurface Warm Water off the east coast of Korea (Gong and Park, 1969; Na *et al.*, 1990). In the subsurface layer, it is governed by the interaction of the warm current water with the cold water and by the heat transfer process from the upper layer (Chang *et al.*, 1988). These suggests that temperature and salinity is very important factors affecting to the anchovy egg and larval distribution. It was found in this study that anchovy eggs and larvae favor warm water and a little bit high salinity.

In analysis of bivariate correlation between anchovy eggs, larvae, and other oceanographic variables, correlations between eggs and larvae, temperature, and salinity in 10 *m* layer had high significance in June. Northern anchovy eggs and larval abundance was positively associated with surface temperature, temperature stratification, and negatively correlated with zooplankton density(McGowan, 1986). Kim (1983) reported anchovy egg patch was appeared in the coastal waters and warm current. It seemed from this study that anchovy egg and larval density in the eastern waters of Korea could be associated largely with temperature and salinity factors.

This study only covered the distribution patterns of anchovy with oceanographic characteristics along inshore off the east coast of Korea. Accordingly, the study is very limited to describe the details of relationship between nature of density in the early life stage and environmental factors. Further work should be followed expanding toward the offshore region where anchovy eggs and larvae possibly distribute.

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한국 동해의 멸치난·자어 밀도와 환경요인과의 관계

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1985년 한국 동해에서 격월로 수직채집된 어류 난·자어와 동물부유생물, 그리고 동시에 관측된 수온과 염분자료를 이용하여 멸치난·자어분포와 그 분포에 영향을 미치는 환경요인과의 관계를 연구하였다.

멸치난과 자어는 6월과 8월에 채집되었는데, 6월에는 고수온과 고염분역인 난수역에 분포하였다. 8월에는 난과 자어분포역이 외해역으로 이동하였다. 멸치난과 자어분포 및 수온, 염분, 동물부유생물 밀도의 관계를 분석한 결과 6월의 멸치 난과 자어의 분포밀도는 수온 및 염분의 분포와 정상관관계에 있다고 분석되었다.