Acta Oceanol. Sin., 2019, Vol. 38, No. 6, P. 18–24
https://doi.org/10.1007/s13131-018-1271-8
http://www.hyxb.org.cn
E-mail: hyxbe@263.net

Fishery biology of whitespotted conger *Conger myriaster* (Brevoort, 1856) in the Yellow Sea and East China Sea

Xiuxia Mu[1], Chi Zhang[1], Ying Xue[1], Chongliang Zhang[1], Binduo Xu[1], Yiping Ren[1, 2*]

[1] College of Fisheries, Ocean University of China, Qingdao 266003, China

[2] Laboratory for Marine Fisheries Science and Food Production Processes, Pilot National Laboratory for Marine Science and Technology (Qingdao), Qingdao 266237, China

Received 25 May 2018; accepted 18 July 2018

Abstract

Whitespotted conger *Conger myriaster* is a commercially important species in the seas around China, Korea and Japan. The coastal waters of China serve as an important feeding ground for congers, but the spatio-temporal variations in the fishery and biological characteristics of the population have been rarely evaluated and less well understood in this area. We studied the growth, spawning and feeding characteristics of *C. myriaster* on the basis of samples collected from October 2016 to April 2017 in the Yellow Sea and East China Sea. A total of 529 specimens were collected, with ages ranging from 1 to 6 years and total length ranging from 132 mm to 834 mm. The parameters of von Bertalanffy growth equation L_∞ and k were 1 026 mm and 0.226 a^{-1}, respectively; the sex ratio was 88:0 (female: male) in the East China Sea and 2.67:1 in the South Yellow Sea; the development stage of ovary ranged from peri-nucleolus stage to secondary yolk globule stage, and the testis of two males was at mid-meiotic stage; Crustacean was the major prey for conger of small length, and food source shift to fish with somatic growth. The results showed substantial differences from previous studies in Japan and Korean waters, as well as from China seas in the 1980s, suggesting potential spatiotemporal changes in the biological characteristics of *C. myriaster*. This study may improve current understanding of the fishery biology of *C. myriaster* in the Yellow Sea and East China Sea.

Key words: *Conger myrisater*, age and growth, gonad development, stomach contents, Yellow Sea and East China Sea

Citation: Mu Xiuxia, Zhang Chi, Xue Ying, Zhang Chongliang, Xu Binduo, Ren Yiping. 2019. Fishery biology of whitespotted conger *Conger myriaster* (Brevoort, 1856) in the Yellow Sea and East China Sea. Acta Oceanologica Sinica, 38(6): 18–24, doi: 10.1007/s13131-018-1271-8

1 Introduction

Whitespotted conger *Conger myriaster* is one of the most valuable fishery species in the Yellow Sea, East China Sea and the seas around Korean Peninsula and Japan (Yamada, 1986; Tokimura, 2001). There is a wide range of distribution of *C. myriaster* in China, from the estuary of Yalu River to Shacheng Harbor of Fujian Province of China (Zhang, 2010), and the annual commercial catch reach over 13 000 t in the Yellow Sea and East China Sea (local fishery statistics), according to the records of commercial catches in recent years. However, the population size of this species appears to fluctuate substantially, which draws increasing concerns in local fishery communities.

Most literatures of *C. myriaster* were conducted in Japanese and South Korea's waters, aiming to reveal early life history characteristics (Kimura et al., 2004; Yagi et al., 2010), spatial distribution (Okamura et al., 2000; Katayama et al., 2004; Harada et al., 2006), and growth and reproduction characteristics (Huh and Kwak, 1988; Utoh et al., 2003, 2004; Choi et al., 2008; Gorie et al., 2010; Kawazu et al., 2015). It should be noted that the coastal waters of China actually serve as an important feeding ground for congers (Chen, 1991), and the decline of *C. myriaster* in China seas may affect the recruitment of the whole species. However, the distribution and fishery biology of conger have been rarely studied in China seas, and the biological characteristics of the local population is less well understood. The biological information and distribution of *C. myriaster* were briefly reported in the 1970s and 1980s in the East China Sea (Zhang et al., 1977; Tang and Wu, 1988), whereas the research interest have largely changed in recent years, focusing on the size selectivity of eel pot (Tang et al., 2010) and feeding habits (Zhang and Tang, 2003; Liu et al., 2015). The up-to-date biological information of *C. myriaster* in the Chinese waters is desired not only for the fishery management in China but also for the sustainability of the total population.

Based on the fishery surveys of *C. myriaster* conducted by bottom trawl in the Yellow Sea and East China Sea form 2016 to 2017, the present study analyzed the biological characteristics of *C. myriaster*. We provide critical and updated information for the growth, maturity, and feeding characteristics of this species. In addition, we compared the biological characteristics of *C. myriaster* to their history records as well as to the studies in Japan and Korea, in order to examine the spatial and temporal variation in the biology of the species. This study aims to improve the understanding of the biology of *C. myriaster* in China seas.

Foundation item: The National Natural Science Foundation of China under contract No. 31772852; the Fundamental Research Funds for the Central Universities under contract No. 201562030.

*Corresponding author, E-mail: renyip@ouc.edu.cn

2 Materials and methods

2.1 *Specimen collection*

The conger specimens were collected using a bottom trawl in three survey areas located in the Yellow Sea and East China Sea (Fig. 1). A total of 529 specimens were included in this study, mostly coming from the central Yellow Sea (Table 1). Specimens sampling in October 2016 and January 2017 were conducted with the trawl net of 15 m width and cod end mesh size of 20 mm, and samples from other time were collected by local commercial bottom trawls with cod end mesh size of 24 mm.

We measured the body size of conger. Total length (TL, mm), pre-anal length (AL, mm), body weight (BW, g), net weight (NW, g), stomach wet weight (g) and gonad weight (g) for each specimen were recorded. The relationship between total length and weight was described by Eq. (1) (Ricker, 1975):

$$W = aL^b, \tag{1}$$

where W is the body weight and L is the total length. The parameter a represents the condition factor and b is the growth exponential coefficient. Logarithm transformation was applied to the equation, and the parameters a and b were estimated using the linear least squares method (Ricker, 1975). The hypothesis of isometric growth was tested against b=3 using t-test.

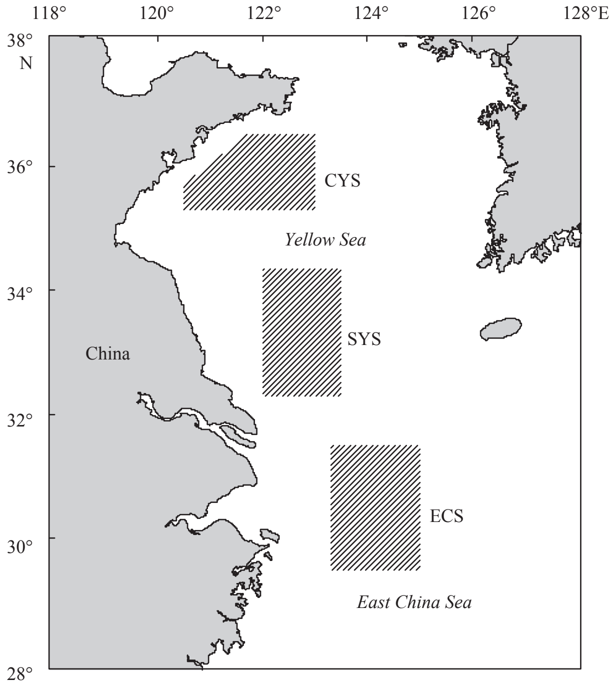

Fig. 1. Survey areas for *C. myriaster* in the Yellow Sea and East China Sea. The different areas were sampled at different time: CYS (central Yellow Sea), spring, autumn and winter; SYS (southern Yellow Sea), spring; ECS (East China Sea), spring.

2.2 *Age determination and growth*

Sagittal otoliths were dissected through the gills for age determination by examining burn otoliths under UV light (Katayama et al., 2002). Estimates of age were determined by rings within the sectioned otoliths (Fig. 2). Individuals were divided into Groups according to the results of age determination (e.g., age Group 1 for the individuals of age one). A total of 255 specimens were used for aging, in which the right otolith was heated at 200°C for 5–10 min, then embedded in epoxy resin (EpoThin, Buehler) and sectioned along the dorsal-ventral axis across the core with a diamond circular saw (Isomet low speed, Buehler). The sections (0.3 mm) were mounted on glass slides and polished with 800–1 200 grit grinding paper (Minimet 1000 grinder-polisher, Buehler). Ages were randomly read twice with an interval of half month, and conflicting results were judged by a well-experienced reader with fish size information.

Table 1. Number of *C. myriaster* specimens collected in the Yellow Sea and East China Sea

Sample area	Survey time	Number of specimens	TL range/mm	Mean TL±SD/mm
Central Yellow Sea	Oct. 2016	237	132–575	317±129
	Jan. 2017	94	195–440	252±45
	Apr. 2017	41	158–632	417±97
Southern Yellow Sea	Feb. 2017	13	395–770	631±125
	Apr. 2017	25	140–749	424 ±132
East China Sea	Feb. 2017	18	241–726	587±129
	Mar. 2017	28	492–785	547±86
	Apr. 2017	73	457–834	583±97

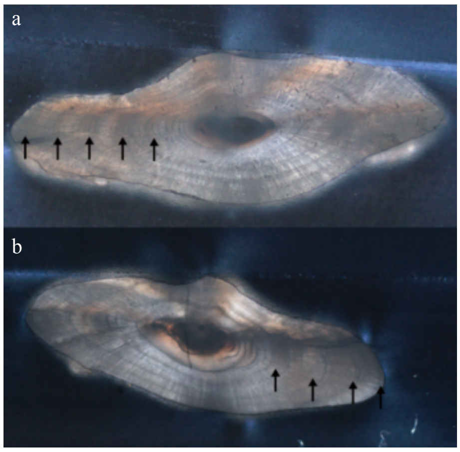

Fig. 2. Transverse sectioned otolith of *C. myriaster*. a. Age 5, 745 mm TL and b. Age 4, 623 mm TL

Growth was presented by the von-Bertalanffy growth function (VBGF) Eq. (2) (Von Bertalanffy, 1951; Pauly, 1981):

$$L_t = L_\infty \left(1 - e^{-k(t-t_0)}\right), \tag{2}$$

where L_t is the total length at age t, L_∞ is the asymptotic total length, k is the growth coefficient, and t_0 is the hypothetical age at zero length. Growth model was implemented using the packages FSA in R 3.3.3 (Ogle, 2016).

2.3 *Sex and gonad developmental stages*

Gonads were fixed in 4% formalin and preserved in 70% ethanol for determination of sex and developmental stage. Gonad somatic index (GSI) values (%) were calculated by Eq. (3):

$$\mathrm{GSI} = \text{gonad wet weight}/\text{net weight} \times 100. \tag{3}$$

There were 99 specimens from the South Yellow Sea and East

China Sea used to identify the gonad development stages. Each gonad was embedded in paraffin and stiffened as a block. The paraffin block was then sectioned (7–8 μm thickness) with a rotary microtome (LEICA RM 2155, Leica Microsystems Nussloch GmbH), stained with Hematoxylin-Eosin, and examined by optical microscope (ECLIPSE E600, Nikon Corporation). Oocyte development of the *C. myriaster* are divided into eight stages: chromatin nucleolus stage, peri-nucleolus stage, oil droplet stage, primary yolk globule stage, secondary yolk globule stage, tertiary yolk globule stage, migratory nucleus stage, and maturation stage (Utoh et al., 2003). Spermatogenesis of the *C. myriaster* could be divided into seven stages: early spermatogonial proliferation stage, late spermatogonial proliferation stage, early meiotic stage, mid meiotic stage, late meiotic stage, maturation stage, functional maturation stage, and spent stage (Utoh et al., 2004). Sex and gonad developmental stages were determined with tissue structures according previous studies (Utoh et al., 2003, 2004).

2.4 *Stomach contents analysis*

The stomachs were frozen before analyses. A total of 452 samples were used for stomach content analysis. The stomach contents were identified and sorted into major food items with stereoscopic microscope. The main prey taxa were classified into five categories: fish, crustacean, cephalopoda, polychaeta and others. The number and wet weight of each prey category were measured.

3 Results

3.1 *Weight-length relationship*

The TL of *C. myriaster* ranged from 132 to 834 mm with a mean of 431 mm (SD=191 mm), and AL ranged from 56 to 321 mm with a mean of 167 mm (SD=191 mm). The BW ranged from 6.0 to 1 121.2 g with a mean of (211.7±248.0) g. The relationship between TL and BW for individuals was: $BW=1.74\times10^{-7}TL^{3.35}$ (N=529, R^2=0.99). The t-test suggested that *C. myriaster* showed positive allometric growth (p<0.01).

3.2 *Age and growth*

Otoliths reading showed six age groups from 1 to 6 years, and the age Group 2 was the dominant group, which accounted for 35.91% of the total collected individuals, followed by age Group 1. Individuals of 1 and 2 years old were mainly from the coastal waters of the central Yellow Sea. Individuals of 3 years old were mainly found in the South Yellow Sea, East China Sea and offshore water of the central Yellow Sea. Individuals of 4 and 5 years old were mainly from the South Yellow Sea and East China Sea. A few 6 age individuals were sampled in the East China Sea (Fig. 3).

There was a wide variation in TL and BW within the same age class (Table 2). The mean total length at age was described by the von Bertalanffy equation: $L_t=1\ 026\times(1-e^{-0.226\times(t+0.031\ 5)})$, in which

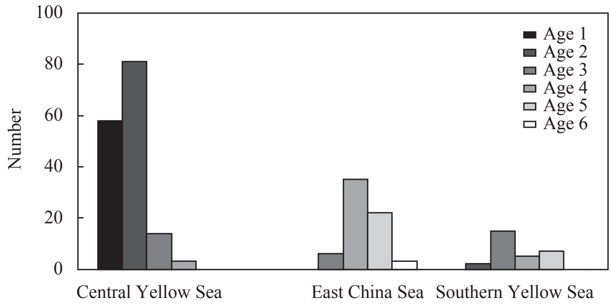

Fig. 3. Age structure of *C. myriaster* in the central Yellow Sea, South Yellow Sea and East China Sea.

L_∞, t_0 and k were estimated as 1 026 mm, –0.031 5 and 0.226, respectively.

3.3 *Gonad development*

The sex ratio of conger was 2.67:1 (female: male) in the South Yellow Sea and 88:0 in the East China Sea. The development stage of ovary ranged from peri-nucleolus stage to secondary yolk globule stage, while testis of two males was at mid-meiotic stage (Fig. 4). Pre-vitellogenesis females, primary yolk globule stage females and mid-meiosis males were collected in the South Yellow Sea, and secondary yolk globule stage females were all collected in the East China Sea in April 2017.

Conger myriaster began maturation at 3 years old in the Yellow Sea and East China Sea, and the AL of the mid-vitellogenesis females (primary yolk globule stage to the second yolk globule stage) was longer than 200 mm (Table 3). Mean GSI value were 1.22% for pre-vitellogenesis females (peri-nucleolus stage to oil droplet stage), 5.86% for mid-vitellogenesis females, and 0.41% for mid-meiotic male. The mean GSI value of *C. myriaster* increased with pre-anal length and time during the survey period from 24 February to 30 April (Fig. 5).

3.4 *Feeding habits*

Conger myriaster fed upon 65 prey species in our samples (Table 4), and fish and crustaceans were the main prey groups, accounting for 70.66% and 22.56% of the total food weight, respectively. According to the relative weight, *Engraulis japonicus, Larimichthys polyactis* and *Pholis fangi* were the most important prey species, while *Leptochela gracilis, Alpheus distinguendus* and *Acetes chinensis* were major preys according to the relative number.

The diet composition of *C. myriaster* showed clear ontogenetic variations (Fig. 6). Crustacea were the major prey groups for *C. myriaster* with AL<80 mm, whereas shrimps and fish were the major prey groups for individuals of 81–120 mm. Fish became the major prey group for *individuals* with AL>140 mm, and the proportion of fish prey increased with AL (Fig. 6).

Table 2. The TL, AL, BW of *C. myriaster* in each age class

Age	Number of specimens	TL range/mm	Mean TL±SD/mm	AL range/mm	Mean AL±SD/mm	BW range/g	Mean BW±SD/g
1	59	176–359	241±31	56–137	91±13	6.0–64.3	18.6±8.9
2	84	193–493	336±52	88–189	129±21	14.5–190.3	55.7±31.5
3	36	322–764	497±102	124–333	206±47	50.8–645.9	257.2±152.0
4	43	447–787	643±74	173–294	252±27	127.9–915.5	473.8±156.2
5	30	572–834	700±64	230–321	270±22	335.8–112 1.2	580.5±184.8
6	3	643–745	711±59	261–290	277±15	370.1–755.6	596.8±201.6
Total	255	176–834	436±183				

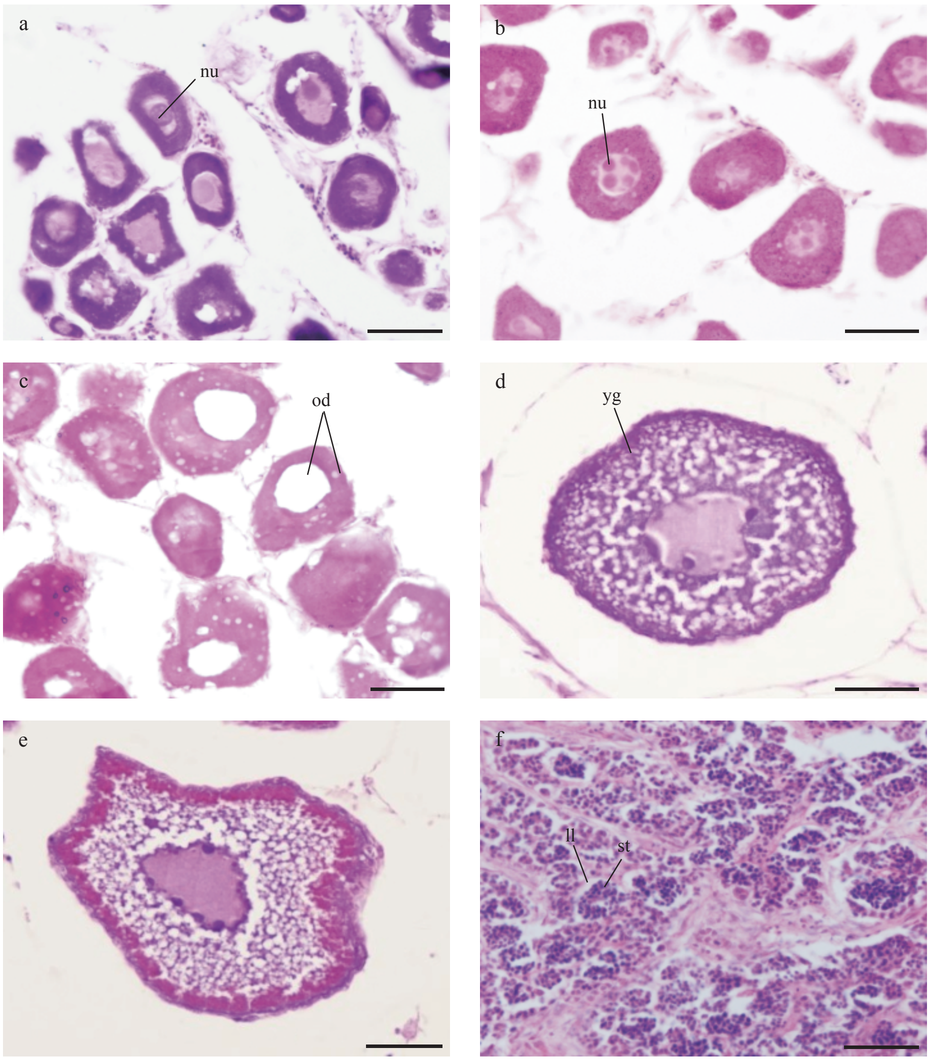

Fig. 4. Gonad developmental stages of *C. myriaster* in the East China Sea and South Yellow Sea. a. Early-nucleolus stage (159 mm AL), b. late-nucleolus stage (169 mm AL), c. oil droplet stage (178 mm AL), d. primary yolk globule stage (216 mm AL), e. secondary yolk globule stage (268 mm AL), and f. mid-meiosis stage (151 mm AL); nu in a and b indicate nucleus, od in c oil droplets, yg in d yolk globule, ll in f lobule lumen, and st in f spermatids. Scale bars: 50 μm.

Table 3. The TL, AL, age, GSI values for each gonad development stage of *C. myriaster*

Gonad development stage	Age	AL range/mm	Mean AL/mm	TL range/mm	Mean TL±SD	GSI range/%	Mean GSI±SD/%	Number of specimens
Peri-nucleolus stage	2–3	146–169	158±16	401–431	416±20	0.49–0.62	0.55±0.42	3
Oil droplet stage	3	174–190	181±8	462–504	481±67	1.79–1.96	1.89±0.25	3
Primary yolk globule stage	3–6	200–295	256±22	545–751	678±72	1.87–8.01	5.17±1.41	64
Second yolk globule stage	3–6	243–321	271 ±19	560–834	682±76	4.53–13.11	7.55±2.13	26
Mid-meiotic stage	3	145–151	148±3	391–401	396±7	0.39–0.42	0.41±0.37	3

4 Discussion

This is the first study in recent decades on the fishery biology of *C. myriaster* in the Yellow Sea and East China Sea, and may improve the understanding of growth, maturation, and feeding of *C. myriaster*. We systematically analyzed the biological characteristics of conger in the Yellow Sea and East China Sea, and found that the biological characters in this area tend to be different from previous studies in other areas. For example, the maximum age vary among study regions, and the maximum age was 4 years old in the Seto Inland Sea of Japan (Gorie et al., 2004), 13 years old in the southern waters of Korea (Bae et al., 2018), and 7 years old in the coastal waters of Korea (Kim et al., 2011). Besides, the VBGE parameters in the present study were estimated as L_∞=1 026 mm and k=0.226. Kim et al. (2011) used the specimens collected in the southern coastal waters of Korea and reported the values of L_∞=1 006 mm and k=0.146. Bae et al. (2018) reported the values of L_∞=1 438 mm and k=0.081 used the otolith weight at age data in the southern waters of Korea. The L_∞ in the southern waters of Korea was higher than our study, but value of k was lower. The results suggested a faster growth rate of *C. myriaster* in China seas. These may be attributed to the absence of elder individuals in our study, while it is also possible that a different growth char-

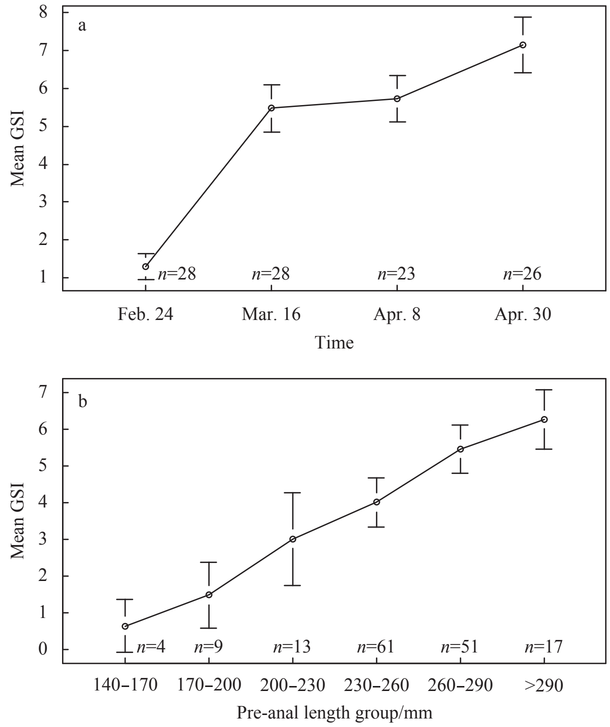

Fig. 5. Change of mean GSI of *C. myriaster* with time (a) and anal length (b) in the South Yellow Sea and East China Sea.

Table 4. Diet composition of *C. myriaster* in the Yellow Sea and East China Sea

Prey item	W/%	N/%
Pisces	70.66	29.80
Engraulis japonicus	33.80	5.86
Larimichthys polyactis	16.62	1.00
Enedrias fangi	5.91	4.11
Johnius belengerii	2.86	0.37
Thrissa kammalensis	2.48	0.87
Apogon lineatus	1.91	2.00
unidentified pisces	1.20	3.99
Trichiurus lepturus	1.07	0.62
Amblychaeturichthys hexanema	1.05	0.87
Syngnathus acus	0.63	4.61
Syngnathus acus	0.54	2.12
Thryssa mystax	0.51	0.50
Cynoglossus joyneri	0.35	0.25
Callionymus beniteguri	0.32	0.12
Collichthys lucidus	0.33	0.87
Callionymus sagitta	0.31	0.12
Coilia mystus	0.23	0.12
Rhinogobius pflaumi	0.20	0.87
Engraulidae	0.19	0.12
Tridentiger barbatus	0.12	0.12
Champsodon snyderi	0.02	0.12
Hippocampus japonicas	0.01	0.12
Crustacea	22.56	53.49
Charybdis bimaculata	3.70	3.12
Charybdis japonica	3.49	0.37
Alpheus distinguendus	3.27	10.47

to be continued

Continued from Table 4

Prey item	W/%	N/%
Oratosquilla oratoria	2.68	0.62
Crangon affinis	1.53	4.24
Penaeidae sp.	1.30	1.00
Alpheus japonicus	1.30	2.24
Leptochela gracilis	1.29	8.6
Metapenaeopsis dalei	0.84	3.12
unidentified decapoda	0.80	3.99
Trachypenaeus curvirostris	0.58	0.37
unidentified crabs	0.45	1.00
Eucrate crenata	0.43	0.12
Palaemon gravieri	0.32	0.50
Acetes chinensis	0.22	7.86
Heptacarpus futilirostris	0.21	2.37
Latreutes planirostris	0.05	2.37
Alpheus	0.05	0.62
Pugettia quadridens	0.03	0.12
Pinnotheres sinensis	0.01	0.12
Eualus sinensis	0.01	0.12
Austinogebia edulis	0.00	0.12
Cephalopoda	4.16	4.36
Loligo sp.	2.95	1.12
Euprymna morsei	0.46	1.37
Sepiola birostrat	0.45	0.87
Octopus variabilis	0.25	0.37
Octopus ocellatus	0.05	0.37
unidentified Cephalopoda	0.00	0.24
Polychaeta	1.22	4.24
Nereididae sp.	0.83	3.62
Trichechu	0.39	0.62
Others	1.40	8.10
Cirolana japonensis	0.68	3.87
Gammarus sp.	0.02	1.37
Philine kinglipini	0.29	0.75
Unidentified stomach contents	0.37	1.00
Pectinidae	0.01	0.12
Ophiopholis mirabilis	0.03	0.12
Temanella turrita	0.00	0.12
Ophiura sarsii vadicola	0.00	0.37
Opossum shrimp	0.00	0.12
Corophium sinensis	0.00	0.12
unidentified Bivalvia	0.00	0.12

Note: *W* represents weight (mg) and *N* number.

acteristic exist for *C. myriaster* in the Yellow Sea and East China Sea.

It should be noted that maturing males (mid-meiotic stage) were captured in this study, and this is the first report that maturing males were found in China seas. In addition, sex ratio was 88:0 (female: male) in the East China Sea and 2.67:1 in the South Yellow Sea. This sex ratio basis were also reported in other areas for this species (Okamura et al., 2000; Kim et al., 2011; Kawazu et al., 2015), and also other species, such as *Conger conger* (Correia et al., 2009), suggesting that males and females may show differences in the habitat selection, time of maturation, and migration behaviors (Okamura et al., 2000; Kawazu et al., 2015). Our study revealed that the gonads of females began maturing at 3 years

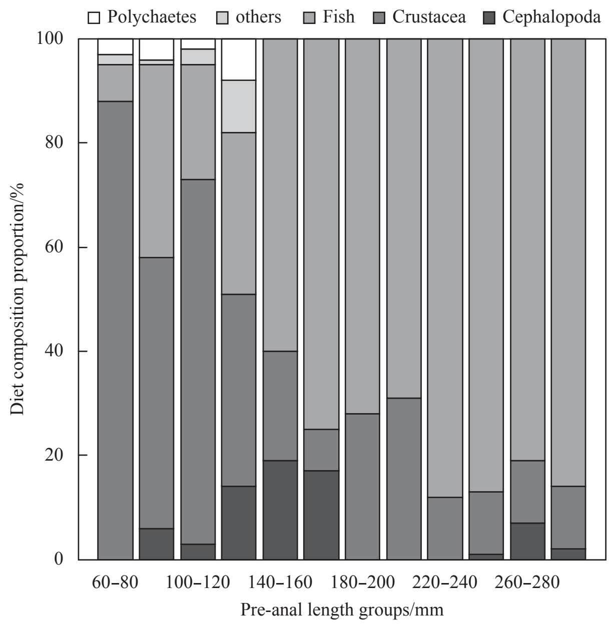

Fig. 6. Ontogenetic changes in the diet compositions of *C. myriaster* in the Yellow Sea and East China Sea.

old, consistent with previous studies in the coastal waters of China (Tang and Wu, 1988; Chen, 1991), but different with the species in the continental shelf of East China Sea off Kuyushu Island of Japan (Kawazu et al., 2015). This may be result from different environmental conditions among studies, such as water temperature and current, which should be examined in further studies. It is note that, sampling gears was longlines in the previous studies (Tang and Wu, 1988), different sampling gears may affect the results of biological characteristics.

The spawn ground of *C. myriaster* was believed along the Kyushu-Palau Ridge, approximately 380 km south of Okinotorishima Island (Kurogi et al., 2012), and previous surveys in the Yellow Sea and East China Sea recorded large individuals began migrating southward in autumn, reaching the edge of the continental shelf in spring and summer (Tokimura, 2001; Zhang, 2010). This implies that the individuals in China seas may have a southward spawning migration. The hypothesis was supported by our results that gonad development stages for individuals captured in the East China Sea were higher than that in the Yellow Sea. In addition, the GSI increased from 16 March to 30 April in the East China Sea, when mean GSI value of mid–vitellogesis females were 5.86%, which supported the postulation that females develop their gonads from the primary to secondary yolk globule stage from winter to summer in the East China Sea (Kawazu et al., 2015). Previous study suggested that the mean GSI values of mid-vitellogenesis females were 4.40% in winter and 7.04% in summer in the East China Sea (Kawazu et al., 2015), generally agreed with our results.

Conger myriaster is a generalist predator (Choi et al., 2008) and preyed upon 65 prey species in this study. Fishes and crustacean were the most important food organisms in our observation. This was consistent with studies in the southern waters of Korea and Japanese waters (Huh and Kwak, 1998; Choi et al., 2008; Gorie and Nagasawa, 2010), except the difference in the food composition of smaller individuals. Compared with the studies during 1980–1990, there was obvious difference in the food composition (Chen, 1991), although the sample sits have slightly different. Some dominant prey species, such as *Loligo chinensis*, *Thryssa kammalensis* and *Trachypenaeus curvirostris*, were no longer main prey species for *C. myriaster* in this study. This result might correspond to the fact that some small fish species, such as *Johnius belengerii*, *Enedrias fangi*, have become dominant species in the Yellow Sea fisheries (Liu and Ning, 2011), and the *C. myriaster* is an opportunistic feeder that exploited the available prey in habitat area (Choi et al., 2008). The changes of food organisms for *C. myriaster* in recent years could contribute to the variations of individual growth characteristic. In addition, crustacean was the major prey groups for the smaller individuals, and then their diets shift to fish as the main food source with body growth. The diets changed at the AL longer than 140 mm and the GSI increased gradually with AL. The result might suggest that large individuals in the East China Sea were accumulating nutrition by changing diets for the spawn migration, when the density of food resources would be critical for the survival and successful reproduction of the population.

References

Bae J H, Bae H J, Park H M, et al. 2018. Age determination and growth estimates of the white-spotted conger eel, *Conger myriaster* (Brevoort, 1856) in marine waters of South Korea. Journal of Applied Ichthyology, 34(3): 542–549

Chen Dagang. 1991. Fish Ecology in the Yellow Sea and Bohai Sea (in Chinese). Beijing: China Ocean Press, 218–221

Choi J H, Choi S H, Kim J B, et al. 2008. Feeding ecology of the white-spotted conger eel (*Conger myriaster*) in the Southern Sea of Korea. Korean Journal of Fisheries and Aquatic Sciences (in Korean), 41(4): 282–288

Correia A T, Manso S, Coimbra J. 2009. Age, growth and reproductive biology of the European conger eel (*Conger conger*) from the Atlantic Iberian waters. Fisheries Research, 99(3): 196–202

Gorie S, Nagasawa K. 2010. Habitat preference and feeding habits of juvenile whitespotted conger *Conger myriaster* in the western Seto Inland Sea, Japan. The Aquaculture (in Japanese), 58(2): 167–179

Gorie S, Tanda M, Katayama S. 2004. Age and growth of white-spotted conger *Conger myriaster* collected in northeast Harima Nada, Seto Inland Sea. Aquaculture Science (in Japanese), 52(4): 407–411

Gorie S, Tanda M, Nagasawa K. 2010. Movement and growth of whitespotted conger *Conger myriaster* in the western Seto Inland Sea, Japan. Aquaculture Science (in Japanese), 58(2): 233–242

Harada M, Tokai T, Uchida K, et al. 2006. Distribution of white-spotted conger eel *Conger myriaster* and hagfish Eptatretus burgeri in the shallow region of Tokyo Bay. Nippon Suisan Gakkaishi (in Japanese), 72(5): 894–904

Huh S H, Kwak S N. 1998. Feeding habits of *Conger myriaster* in the eelgrass (*Zostera marina*) bed in Kwangyang Bay. Korean Journal of Fisheries and Aquatic Sciences (in Korean), 31(5): 665–672

Katayama S, Ishida T, Goto K, et al. 2002. A new aging technique by UV light observation of burnt otoliths for the conger eel *Conger myriaster* (Brevoort). Ichthyological Research, 49(1): 81–84

Katayama S, Ishida T, Shimizu Y, et al. 2004. Seasonal change in distribution of Conger eel *Conger myriaster* off the Pacific coast south of Tohoku, north-western Japan. Fisheries Science, 70(1): 1–6

Kawazu M, Kameda T, Kurogi H, et al. 2015. Biological characteristics of *Conger myriaster* during the initial stage of spawning migration in the East China Sea. Fisheries Science, 81(4): 663–671

Kim Y H, Lee E H, Kim J N, et al. 2011. Age and growth of whitespotted conger *Conger myriaster* in the southern Coastal Waters of Korea. Korean Journal of Fisheries and Aquatic Sciences (in Korean), 44(6): 689–694

Kimura Y, Ishikawa S, Tokai T, et al. 2004. Early life history characteristics and genetic homogeneity of *Conger myriaster* leptocephali along the east coast of central Japan. Fisheries Research, 70(1): 61–69

Kurogi H, Mochioka N, Okazaki M, et al. 2012. Discovery of a spawning area of the common Japanese conger *Conger myriaster* along the Kyushu-Palau Ridge in the western North Pacific. Fisheries Science, 78(3): 525–532

Liu Jing, Ning Ping. 2011. Species composition and faunal characteristics of fishes in the Yellow Sea. Biodiversity Science (in Chinese), 19(6): 764–769

Liu Xifang, Liu He, Xue Ying, et al. 2015. Feeding ecology of *Conger myriaster* in Haizhou Bay. Journal of Fishery Sciences of China (in Chinese), 22(3): 517–527

Ogle D H. 2016. Introductory Fisheries Analyses with R. Boca Raton: CRC Press

Okamura A, Utoh T, Zhang Huan, et al. 2000. Seasonal changes in maturity in the conger eel *Conger myriaster* at the Pacific coast of Atsumi Peninsula, central Japan. Nippon Suisan Gakkaishi (in Japanese), 66(3): 412–416

Pauly D. 1981. The relationships between gill surface area and growth performance in fish: a generalization of von Bertalanffy's theory of growth. Meeresforschung, 28(4): 251–282

Ricker W E. 1975. Computation and interpretation of biology statistics of fish populations. Bulletin of the Fisheries Research Board of Canada, 191: 200

Tang Yanli, Sun Guowei, Zhao Tongyang, et al. 2010. Mesh size selectivity of *Conger myriaster* pot. Journal of Fishery Sciences of China (in Chinese), 17(1): 136–142

Tang Yimin, Wu Changwen. 1988. On biologic habits and resources distribution of common Japanese conger *Astroconger myriaster* (Brevoort). Journal of Zhejiang College of Fisheries (in Chinese), 7(1): 19–26

Tokimura M. 2001. Conger-eel fisheries and fisheries resources in the East China Sea. Nippon Suisan Gakkaishi (in Japanese), 67(1): 125–126

Utoh T, Horie N, Okamura A, et al. 2003. Oogenesis in the common Japanese conger *Conger myriaster*. Fisheries Science, 69(1): 181–188

Utoh T, Okamura A, Yamada Y, et al. 2004. Reproductive cycle in reared male common Japanese conger, *Conger myriaster*. Aquaculture, 240(1–4): 589–605

Von Bertalanffy L. 1951. Theoretische Biologie: II. Band, Stoffwechsel, Wachstum. 2nd ed. Bern, Switzerland: A Francke AG Verlag, 418

Yagi Y, Kodono N, Kinoshita I, et al. 2010. Late-stage metamorphosing *Conger myriaster* leptocephali collected in a river estuary of Ariake Bay, Japan. Ichthyological Research, 57(3): 310–313

Yamada U. 1986. *Conger myriaster*. In: Okamura O, ed. Fishes of the East China Sea and the Yellow Sea (in Japanese). Nagasaki: Seikai National Fisheries Research Laboratory, 68–69

Zhang Bo, Tang Qisheng. 2003. Feeding habits of six species of eels in East China Sea and Yellow Sea. Journal of Fisheries of China (in Chinese), 27(4): 307–314

Zhang Chunguang. 2010. Fauna Sinica: Osteichthyes, Anguilliformes and Notacanthiformes (in Chinese). Beijing: Science Press, 199–203

Zhang Shiyi, Xiao Zhenyi, Zhang Youwei. 1977. Leptocephalus of the Aetro *conger myriaster* from the East China Sea. Acta Zoologica Sinica (in Chinese), 1: 117–118