Seasonal dynamics of juvenile fish community and its recruitment to the population: role of transport and fishing

1. Introduction

The transport of early life stages of fish from spawning grounds to nursery grounds influences the recruitment of fish population. Generally, recruitment variability is caused by interactions between the larval fish and their environment, including physical forcing, prey availability, predator pressure, and density-dependent competition. To study role on the larval fish transport is therefore crucial to understanding how biotic and abiotic parameters affect survival in early stages. Zhoushan archipelocho is a traditional spawning and nursery ground for many commercial fish species in East China Sea. The physical and biological process to control the fish recruitment from larval fish is still poorly studied in this area, we made some preliminary study to examine the various processes affecting their survival, and later population.

2. Materials and Methods

The larval samples were investigated during winter, spring, summer and autumn cruise in 2018-2019. Around 40 stations were located around 29° ~32° N, 121° ~125° E, in the East China Sea (Figure 1) . In each station, the larval fish were sampled by type I plankton net(mouth diameter 500 mm, net length 1450mm, 0.505mm), and were attached flow meter in the center of mouth. All the samples were preserved by 5% formalin. The species and numbers were identified and counted by microscope in the laboratory. The juvenile fish was sampled by bottom trawl (mouth opening 6 m height × 10 m wide), with 12 mm mesh size at the cod-end. Trawls were conducted for around one hour at each station; the average ship speed was 3.0 knots. All samples in the trawl net were preserved using fresh ice in the ship's refrigerator. In the laboratory, organisms were identified at the species level, counted. The numbers of samples belonging to each species was normalized by trawling hours to yield abundance.

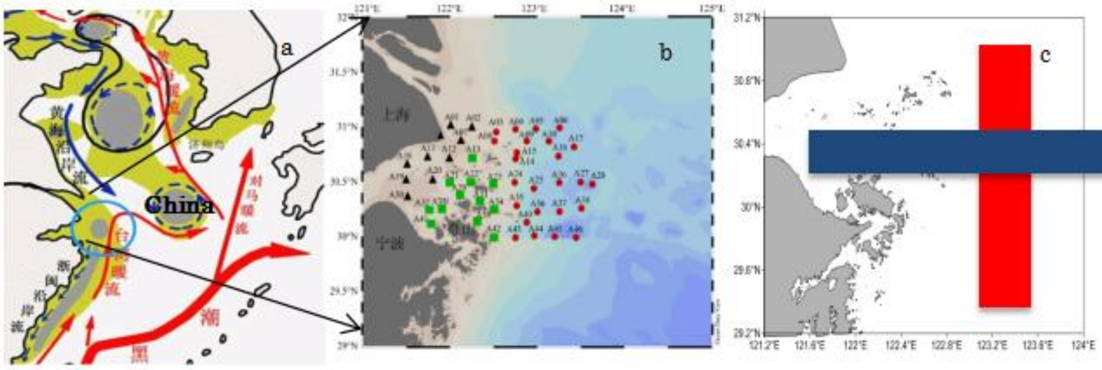

Figure 1 larval fish stations in the Zhoushan Archipelago seas (a) , cluster stations(b) and horizontal(blue)-vertical (red)migration routes

Note: the black triangle represents the water mass in Hangzhou bay（Area I, the green square represents upwelling water mass of Zhoushan islands (area II), and the red circle represents the offshore water mass of Zhoushan（Area III）

In the laboratory, organisms were identified at the species level, counted. The numbers of samples belonging to each species was normalized by trawling hours to yield abundance (individual per hour). As the limitation of laboratory condition and small individual samples, we measured the weight of total individuals in species level, rather than measuring individual each by each. Hence, average weight of each species in one station was determined as total weight divided by total counts of this species. As a proxy of length, average weight was used to indicate the average size of each species. Species with occurrence rates greater than 5 % were categorized into groups based on the trophic level (feeding habits) and living habitat (Table 1). Generally, the fish species were classified in to detritivores, planktivores and benthivores according to Zhang et al. (2007)

2.1 Data analysis

Functional group assemblage structure: Station clustering were conducted by hierarchical agglomerative cluster analysis (HACA) with temperature, salinity and turbidity in the two months using Euclidean distance measure and ward’s linkage method to identify spatial assemblages (Chen et al., 2014). Permutational multivariate analysis of variance (PERMANOVA) was performed to test for significant temporal and regional differences in the abundance and size composition of group assemblages, using pairwise tests with 999 random permutations, and habitat (bay/offshore) and month (spring/autumn) as fixed factors (Guan et al., 2017). Student t-tests were also used to evaluate the null hypothesis of no difference in abundance and size between offshore and bay areas in the same month, and between autumn and spring in the same habitat.

2.2 Species assemblage dynamics and its factors

To investigate the driving force of marine community structure dynamics, canonical correspondence analysis (CCA) was employed to study the functional group assemblages in two months using software CANOCO (version 5.0). Abundance and size of all fish and crustacean species were (log or square-root) transformed, and rare species were down-weighted. The relationship between marine community structure and spatial and temporal factors was examined by CCA. CCA triplot scaling with focus on inter-species distances were used. Significance of the canonical model was assigned using Monte Carlo test (Ter Braak and Smilaeur, 2002). Forward selection and Monte Carlo permutation test (1000 permutations) were performed to determine which variables were statistically significant in determining fish and macro-crustacean groups community structure (Xiong et al., 2016). Inter-set correlation coefficients were used to assess the importance of the environmental variables; variables were considered to be biologically important when inter-set correlation greater than or equal to |0.4| (Ramos et al., 2017).

3. Results and discussions

3.1 Seasonal dynamics of larval and juvenile fish ecological groups

The larval fish abundance showed significant seasonal dynamics, with summer the most, and winter the least numbers. From winter toward autumn, the species diversity increased until summer then decreased until autumn. The dominant species are belong to taxa of *Gobiidae*, *acanthogobius ommaturus*, and *amblycheturichthys hexanema*

(Figure 1). From winter to autumn, the dominant juvenile fish were *Gobiidae*, *acanthogobius ommaturus* and *amblycheturichthys hexanema,* respectively.

Table 1 dominant species in winter, spring, summer and autumn, respectively

Order	Family	March	April	July	November
Perciformes	Gobiidae	Acanthogobius ommaturus 、 Amblychaeturichthys hexanema	Acanthogobius ommaturus 、 Amblychaeturichthys hexanema、 Glossogobius giuris 、 Parachaeturichthys polynema	Mugilogobius abei、 Tridentiger trigonocephalus、 Trypauchen vagina 、 Odontamblyopus lacepedii	Odontamblyopus lacepedii
	Sciaenidae	Pseudosciaena polyactis	Pseudosciaena polyactis	Nibea albiflora、 Argyrosomus argentatus	Pseudosciaena crocea
	Sillaginidae			Sillago japonica	
	Scombridae		Japonicus		
	Trichiurid			Tentoriceps	
	Serranidae		Lateolabrax maculatus		
	Callionymidae		Repomucenus olidus		
	Sparidae	Sparidae			
	Stromateidae		Pampus argenteus		
Pleuronectiformes	Cynoglossidae		Cynoglossus semilaevis	Cynoglossus joyneri	
	Pleuronectidae		Pleuronectidae		
Scorpaeniformes	Scorpaenidae		Sebastiscus marmoratus	Scorpaenidae	Scorpaenidae
	Triglidae		Lepidotrigla		
Clupeiformes	Engraulidae		Stolephorus	Engraulis japonicus	Coilia mystus、 Stolephorus chinensis、 Stolephorus
Anguilliformes	Ophichthyidae			Brachysomophis crocodilinus	
	Moringuidae			Moringuidae	
Aulopiformes	Synodontidae			Harpadon nehereus	Harpadon nehereus
Cypriniformes	Cyprinidae			Hemiculter leucisculus	
Myctophiformes	Myctophidae	Myctophidae	Myctophidae	Benthosema pterotum	Benthosema pterotum
Mugiliformes	Mugilidae		Mugil cephalus、 Liza haematocheila		
Salmoniformes	Salangidae				Salangidae

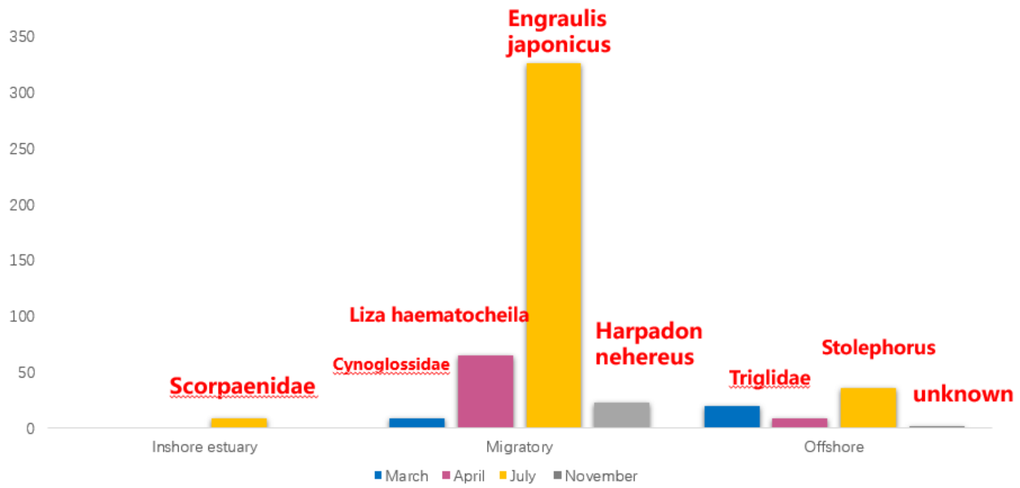

Figure 2 seasonal variation of larval fish community and dominant species

The estuary larval fish groups were mainly identified in winter, spring and summer, with the dominant species were Sparidae in winter, Gobiidae in spring and Gobiidae in summer, the offshore species were mainly found offshore species, with the Lanternfish the most during all seasons except autumn. The two abundance of GSciaenidae species and Harpadon nehereus showed different seasonal patters. As described in figure 3. We used the contours of season-longitude, season-latitude to study the migration of each dominant juvenile fish species.

3.2 Latitudinal migration of SYC. and Hn. species

Average size showed opposite seasonal pattern, with the Small yellow croaker (SYC) size decrease, while Harpadon nehereus(Hn.) increase. SYC. spawn in April-May, while, Hn. Spawn during summer, so the spawning time is the time with big size, recruitment after spawning 2-3 months, which will make the numbers reaching peak, but with smallest size.Fishing probably significantly influences the SYC, while not Hn., because the SYC abundance rebound suddenly when the fishing close, however, the Hn. decrease with the fishing gone, and increase with the fishing reopen (Figure 3).

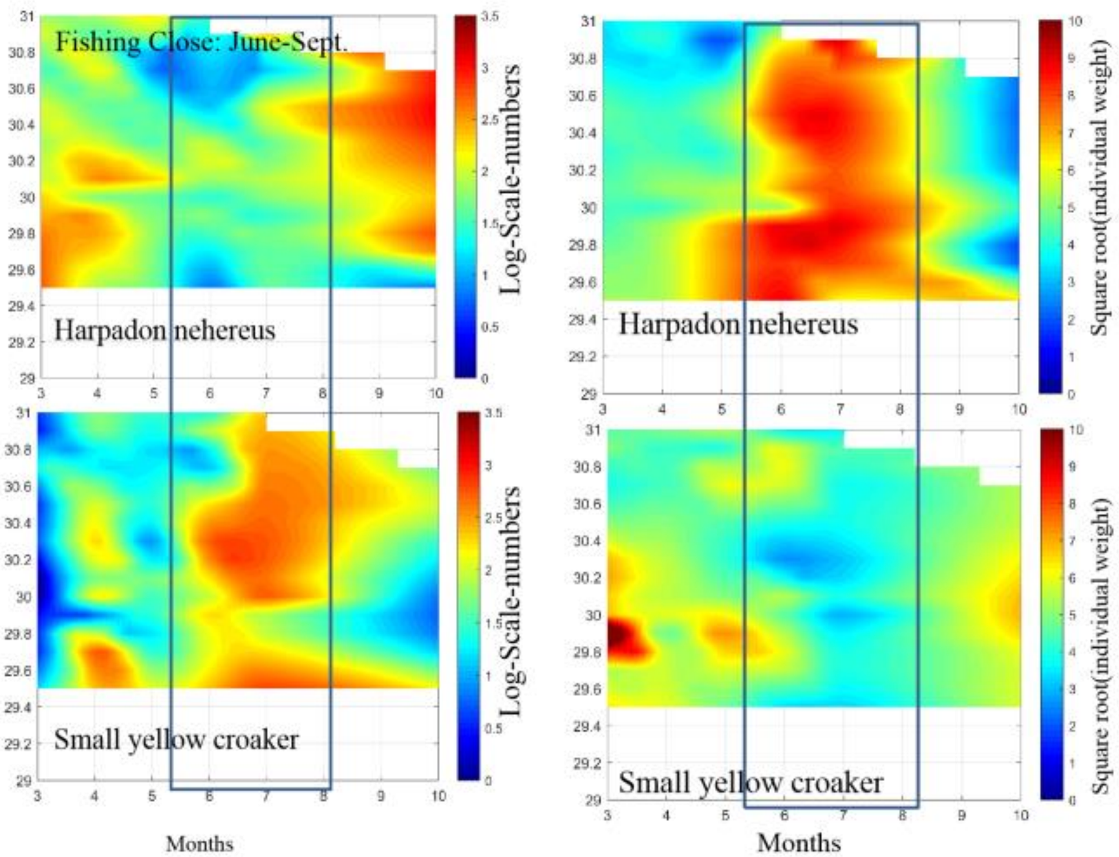

Figure 3. Latitude-temporal distribution of two species Hn. And Syc.

3.3 Longitudinal migration of SYC. and Hn. species

The migration of both Hn and SYC are complex, both of Hn and SYC have a large distribution across the Yellow Sea and East China sea, the two species have spawning, overwinter and feeding migration in the ECS areas. The zhoushan areas is a good spawning and nursery ground for diverse species. For Hn, the abundance is low in the large ECS scale probably due to movement to the island for spawning. Our data along the longitude also showed the high numbers of Hn moved toward the island from March to June. And, after summer spawning, the recruitment was initiated since fall, as seen the numbers increase in October. After spawning during summer, they start for the feeding nearby, and migrating more disperse. This is can be saw from large numbers along all the longitude during the fall. The Hn. size increase to peak until summer due to matured and large fish, it decrease during fall due to recruitment of young. The large size seems prefer to stay offshore rather than coast side, probably reflected the good nursery in the coast (Figure 4).

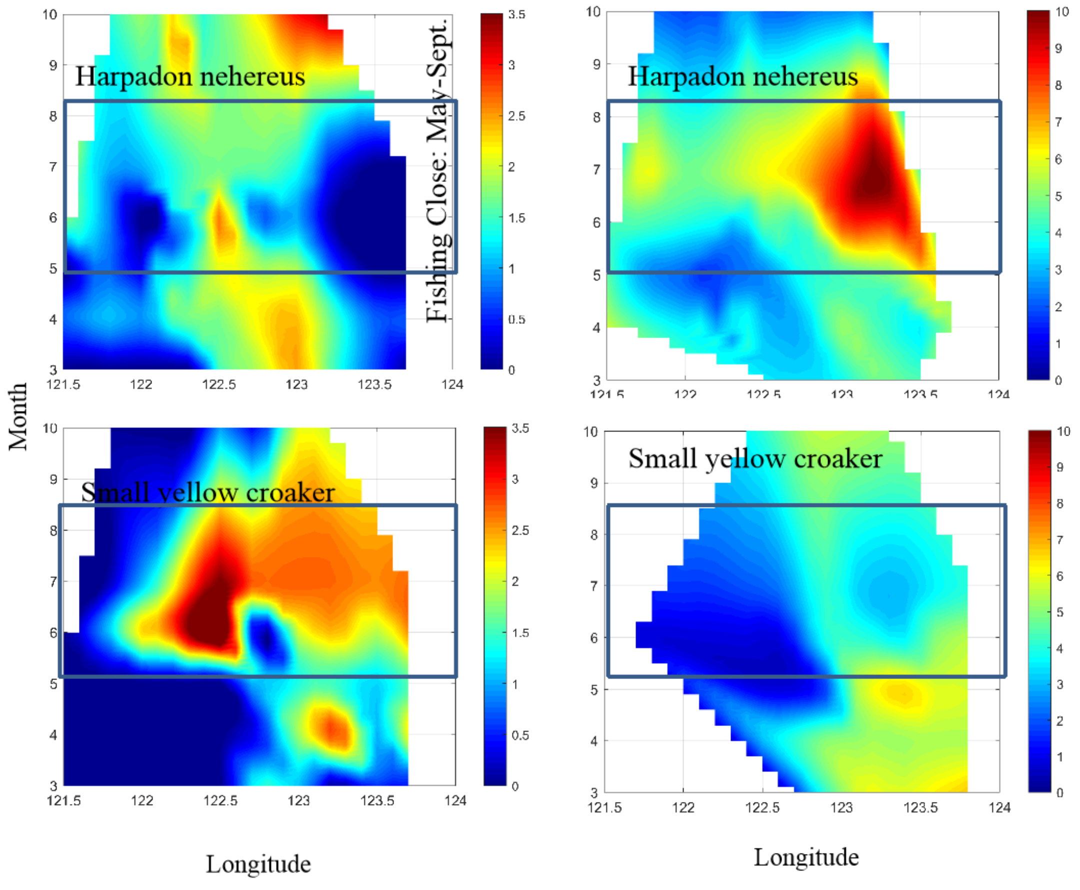

Figure 4. Longitude-temporal distribution of two species Hn. And Syc.

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