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ARTICLE

Investigation and Protection of Fishery Resources in the Middle of Bohai Sea

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ABSTRACT

In May and October 2017, 12 stations were set up in the Central Bohai Sea for fishery resources investigation. The results show that there are many dominant species in this area, and the inshore fishery resources are higher than those in the open sea because of the abundant nutrients from land, the high density of zooplankton and the food of swimming animals. In order to effectively protect the fishery resources in the Central Bohai Sea, this paper puts forward some suggestions, such as strengthening the protection propaganda, scientific and reasonable fishing, and strengthening the management of marine environment.

1. Introduction

The purpose of the investigation of fishery resources and fishery production status is to understand the fishery production environment, composition, distribution and quantity of fishery resources in the Central Bohai Sea area, analyze and master the distribution of fish eggs, larvae and juveniles, and the status quo of fishery production. In order to provide basic data for the possible impact of engineering construction period, operation period and unexpected accidents on biological resources [1], and put forward reasonable suggestions for the protection of marine fishery resources.

2. Materials and Methods

2.1 Survey Methods

It is carried out in accordance with the relevant methods such as the specification for marine monitoring, the specification for marine investigation, the Handbook for marine fishery resources survey and the technical specification for the assessment of the impact of construction projects on marine living resources (SC/T 9110-2007). Make a good record of the marine survey, and record the sampling, testing and analysis of all stations.

2.1.1 Fish Eggs, Larvae and Juveniles

The survey of fish eggs and larvae shall be carried out in accordance with the relevant requirements of gb12763.6 marine survey specification Part 6: marine biological survey. A shallow water plankton net (50 cm in diameter and 145 cm in length) was used for quantitative sampling from bottom to surface. Qualitative samples were collected using a large plankton net (80 cm in diameter and 280 cm in length) with a horizontal trawl for 10 min at a speed of 2 n miles/h. The collected samples

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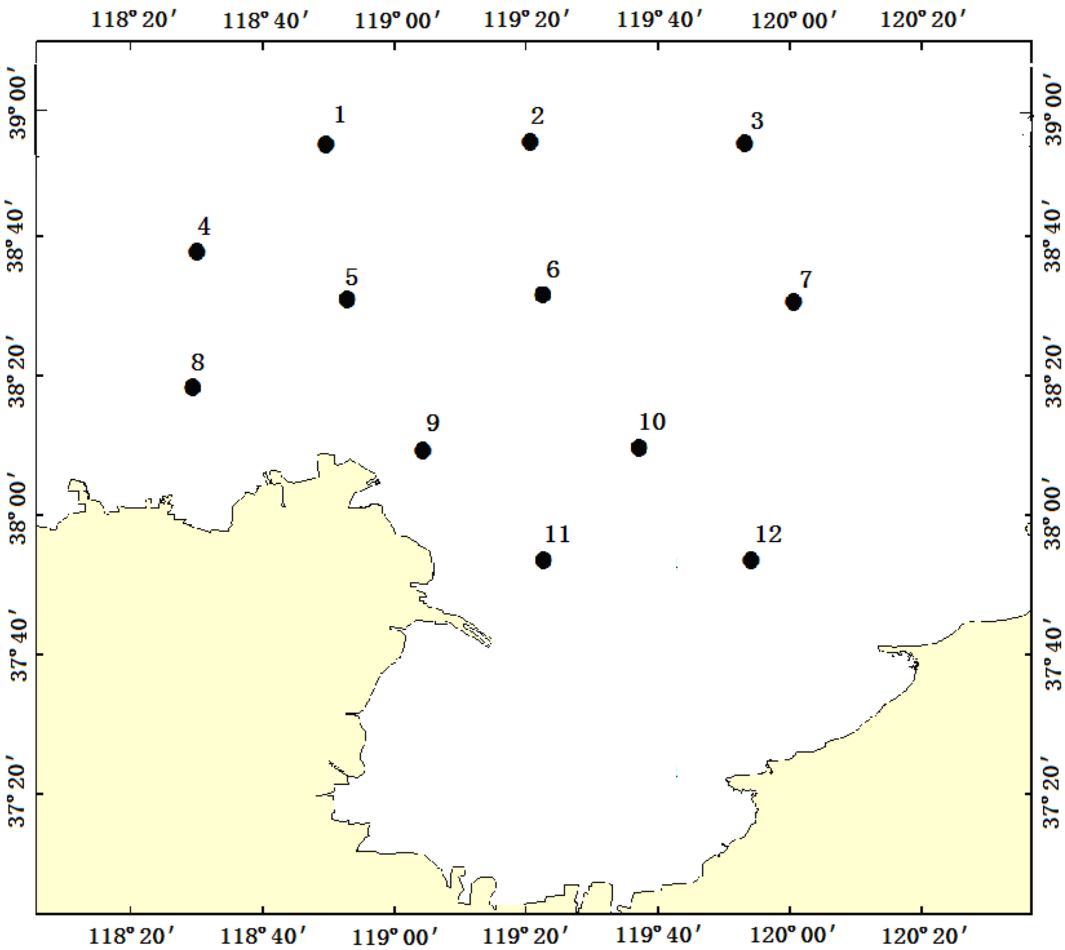

Figure 1. Survey station location diagram

Table 1. Longitude and latitude of survey stations

STANCE	Latitude(N)	Longitude(E)	investigation item
1	38° 52’ 12”	118° 50’ 05”	
2	38° 53’ 00”	119° 21’ 10”	
3	38° 50’ 05”	119° 53’ 12”	
4	38°39’ 25”	118° 32’ 05”	
5	38° 30’ 00”	118° 53’ 05”	
6	38° 31’ 10”	119° 22’ 08”	
7	38° 30’ 00”	120° 00’ 15”	Fish eggs and young fish fishery resources
8	38° 15’ 17”	118° 32’ 15”	
9	38° 10’ 10”	119° 05’ 16”	
10	38° 10’ 14”	119° 38’ 45”	
11	37° 52’ 16”	119° 21’ 18”	
12	37° 52’ 14”	119° 54’ 14”	

were fixed in 5% formaldehyde seawater solution, and then classified, identified and counted in the laboratory.

2.1.2 Swimming Animals

The trawling survey of swimming animals shall be carried out in accordance with the relevant provisions of “gb12763.6 marine survey specification Part 6 marine biological survey”, “marine fishery resources survey manual” and “national coastal zone and tidal flat resources comprehensive survey concise regulations”. The single bottom trawl is used in the trawl survey of fishery resources. The mesh size is 5.6 cm, the perimeter of net mouth is 80 m, the mesh size of bag net is 20 mm, the width of net opening is 10.2 m and the height of net opening is 5.5 M. The trawl speed is 3.0 n mile/h, and the average sweeping area of each station is 0.05667 km^2. The species of the catch were identified on board, and the weight and mantissa were recorded according to the species. The samples were frozen and brought back to the laboratory for detailed determination of biological data.

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2.3 Evaluation Method

2.3.1 Swimming Animals

The method of sweeping area is used to calculate the density of swimming animal resources. The basic principle is to calculate the existing absolute resource density of unit area through the number of swimming animals captured in unit area swept by the net when trawling. The formula is as follows:

$\rho = D/(p \cdot a)$

Where: ρ is the existing resources; D is the relative resource density, i.e. the average catch; a is the sweeping area of the net times; P is the catch rate of the net. The capture rate is calculated as 50%.

2.3.2 fish eggs and juveniles

The formula for calculating the density of eggs and juveniles is as follows

$G=N/V$

Where G is the individual number of fish eggs, larvae and juveniles per unit volume of seawater (ind./m^3); n is the individual number of eggs, larvae and juveniles in the whole net, the unit is ind.; and V is the filtering water volume, in cubic meters (M^3).

3. Results

3.1 Fish Resources

3.1.1 Species Composition

A total of 39 species of fish belonging to 20 families and 7 orders were captured in the survey area. The list of fish is shown in Table 2. A total of 29 species of fish belonging to 17 families and 5 orders were captured in the survey area in spring. A total of 28 species of fish were captured in autumn, belonging to 13 families and 5 orders.

3.1.2 catch

(1) spring

The average catch of fish in spring was 904 fish/h, 12.414 kg/h. According to the analysis of catches, the number of juveniles accounted for 30.20% of the total number, 273 fish/h, and the biomass was 1.082 kg/h. The average catch of adult fishery resources was 631 fish/h, 11.332 kg/h.

(2) autumn

The average catch was 303.9 kg/h in autumn. According to the analysis of catches, the number of juveniles in this survey accounted for 26.73% of the total number, which was 81 fish/h and the biomass was 0.265 kg/h. The average catch of adult fishery resources was 222 tails/h, 3.664 kg/h.

3.1.3 Resource Density Assessment

(1) spring

In spring, the average catch of fish was 904 fish/h, 12.414 kg/h; the average catch of young fish was 273 fish/h, and the biomass was 1.082 kg/h; the average catch of adult fish was 631 fish/h, 11.332 kg/h. After conversion, the average stock density of adult fish is 399.75 kg/km^2, and that of juvenile fish is 9630 fish/km^2.

(2) autumn

In autumn, the average catch of fish was 303 fish/h, 3.929 kg/h; the average catch of young fish was 81 fish/h, the biomass was 0.265 kg/h; the average catch of adult fish was 222 fish/h, 3.664 kg/h. After conversion, the average resource density of adult fish is 129.25 kg/km^2 in autumn, and the average resource density of juvenile fish is 2857 fish/km^2. According to the above results, the average stock density of adults and juveniles is 171.86 kg/km^2 in spring and autumn, and 3924.5 fish/km^2 in juveniles.

3.2 Cephalopod Resources

3.2.1 Species Composition

There are mainly two types of cephalopods in the investigated sea area. One is coastal species, which mostly inhabit in the coastal shallow waters, with small individuals, slow swimming speed and only short-distance movement. This type of squid, octopus octopus and octopus Octopus [2]. The other type is inshore species, which mostly inhabit in the coastal waters where the coastal water and the outer sea water meet. They have larger individuals, faster swimming speed and longer migration distance. They have better adaptability to the environment and have a wide spatial distribution range.

According to the investigation results in spring and autumn, three species of cephalopods were captured in the survey area. Among them, 2 species of cephalopods were captured in spring, including sepia japonicus and Octopus ocellatus, and 3 species of cephalopods were captured in autumn (Table 3).

In spring, sepia japonicus is the dominant species. Octopus ocellatus is an important species. In autumn, sepia japonicus is the dominant species, Octopus ocellatus is an important species, and Octopus ocellatus is a common species.

3.2.2 catch

(1) spring

Two species of cephalopods, sepia japonicus and

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Table 2. list of fish species in spring and Autumn

Serial number	name	order	section	spring	autumn
1	*Harengula zunasi*	Clupeiformes	Clupeidae	+	+
2	*Clupanodon punctatus*				+
3	*Thrissa kammalensis*		Engraulidae	+	+
4	*Engraulis japonicus*			+	+
5	*Thrissa mystax*			+	+
6	*Setipinna taty*			+	+
7	*Pseudosciaena polyactis*	Perciformes	Sciaenidae		+
8	*Argyrosomus argentatus*			+	+
9	*Johnius belengerii*			+	+
10	*Sillago sihama*		Sillaginidae	+	+
11	*Enedrias fangi*		pholidae	+	+
12	*Lateolabrax maculatus*		serranidae	+	
13	*Liza haematocheila*		Sphyraenidae	+	
14	*Chaeturichthys hexanema*		Gobiidae	+	+
15	*Cryptocentrus filifer*				+
16	*Chaeturichthys stigmatias*			+	+
17	*Parachaeturichthys polynema*				+
18	*Tridentiger barbatus*			+	
19	*Triaenopogon barbatus*				+
20	*Odontamblyopus lacepedii*			+	
21	*Odontamblyopus rubicundus*				+
22	*Amoya pflaumi*			+	
23	*Ctenotrypauchen chinensis*			+	+
24	*Callionymus beniteguri*		Perchidae	+	+
25	*Trichiurus lepturus*		trichiuridae		+
26	*Eupleurogrammus muticus*			+	+
27	*Acanthopagrus schlegelii*		sparidae		+
28	*Sawara niphonia*		CYBIIDAE	+	
29	*Platycephalus indicus*	Scorpaeniformes	Scorpaenidae	+	+
30	*Sebastods schlegelii*			+	+
31	*Hexagrammos otakii*		Hexapodae	+	
32	*Cynoglossus joyneri*	Flatfish	Cynoglossidae	+	+
33	*Cynoglossus joyneri*			+	
34	*Paralichthys olivaceus*		Paralichthyidae		+
35	*Kareius bicoloratus*		pleuronectidae	+	
36	*akifugu vermicularis*	Tetraodontiformes	Tetraodontidae		+
37	*Fugu pseudommus*			+	+
38	*Saurida elongata*	Lantern fishes	Dactylogynidae	+	
39	*Syngnathus acus Linnaeus*	Gillinidae	Sauridae	+	

Table 3. list of cephalopods

Serial number	Chinese name	Latin name	Latin name
1	Loligo japonica	*Loligo japonica*	Sepieidae
2	Octopus ocellatus	*Octopus ocellatus*	Octopodidae
3	Octopus ocellatus	*Octopus variabilis*	Octopodidae

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octopus octopus, were captured in spring. The average density was 855 tail/h, 9.61kg/h. The highest is station 10, followed by station 8, and the lowest is station 12. According to the analysis of catches, the mantissa of cephalopods accounted for 24.18% of the total mantissa, 207 tails/h, biomass of 0.87 kg/h, and the average catch of cephalopod adults was 8.74 kg/h, 648 tails/h.

(2) autumn

Three species of cephalopods were captured in autumn, which were sepia japonicus, Octopus ocellatus and Octopus ocellatus. The average resource density was 113 tails/h, 1.723 kg/h. The biomass of cephalopods ranged from 0.112 to 6.900 kg/h, with the highest at station 10, followed by station 12 and station 1 with the lowest.

According to the analysis of catches, the mantissa of cephalopods accounted for 22.81% of the total mantissa, 26 tails/h, and the biomass was 0.093 kg/h. The average catch of adult cephalopods was 1.63 kg/h and 87 tails/h.

3.2.3 Resource Density Assessment

(1) spring

In spring, the average catch of cephalopods was 855 tails/h, 9.61 kg/h; the average catch of juveniles was 207 tails/h, and the biomass was 0.87 kg/h; the average catch of adults was 648 tails/h, 8.74 kg/h. After conversion, the average resource density of cephalopods was 308.35 kg/km^2 for adults and 7292 tails/km^2 for juveniles.

(2) autumn

In autumn, the average catches of cephalopods were 113 tails/h, 1.723 kg/h; the average catches of juveniles were 26 tails/h and the biomass was 0.093 kg/h; the average catches of adults were 87 tails/h, 1.630 kg/h. After conversion, the average resource density of cephalopod adults was 57.91 kg/km^2, and that of juveniles was 909 tails/km^2. According to the above results of cephalopod survey, the average resource density of cephalopods in spring and autumn is 183.13 kg/km^2 for adults and 4100 tails/km^2 for juveniles.

3.3 crustacean Resources

3.3.1 Species Composition

(1) spring

In spring, 15 species of crustaceans were captured, including 9 species of shrimps, 5 species of crabs and 1 species of Stomatopoda. See Table 4 for details. In terms of economic value, there are 5 species with higher economic value, accounting for 33.3% of the total species, 4 species with general economic value, accounting for 26.7% of the total species, and 6 species with low economic value, accounting for 40.0% of the total species.

The dominant species of crustaceans were Oratosquilla in spring, Portunus trituberculatus and Litopenaeus ternatus. The common species were Charybdis japonica, drum shrimp and drum shrimp. The others were common species and rare species.

(2) autumn

In autumn, 13 species of crustaceans were captured, including 6 species of shrimps, 6 species of crabs and 1 species of Stomatopoda, as shown in Table 5. In terms of economic value, there are 5 species with higher economic

Table 4. list of crustacean species in Spring

Serial number	Chinese name	section	economic value		
			higher	Commonalty	Lower
1	*Fenneropenaeus chinensis*	Penaeidae	√		
2	*Trachypenaeus curvirostris*		√		
3	*Alpheus heterocarpus*	Palaemonidae		√	
4	*Alpheus japonicus*			√	
5	*Palaemon gravieri*	Palaemonidae		√	
6	*C rangon crangon*	Crangonidae		√	
7	*Lysmata vittata*	Hippolytidae			√
8	*Latreutes planirostris*				√
9	*Leptochela gracilis*	Hyalinidae			√
10	*Portunus trituberculatus*	Portunulidae	√		
11	*Charybdis japonica*		√		
12	*Carcinoplax vestita*	Goneplacidae			√
13	*Eucrate crenata*				√
14	*Dorippe japonica*	Dorippidae			√
15	*Oratosquilla oratoria*	Squillidae	√		

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value, accounting for 30.8% of the total species, 3 species with general economic value, accounting for 23.1% of the total species, and 6 species with low economic value, accounting for 46.2% of the total species.

Among the swimming animal communities surveyed, the dominant species were gobia japonica and crayfish crayfish; the important species were Portunus trituberculatus, Charybdis japonica, carinata nipponensis; the common species were Brachionus kryptonii; the others were common species and rare species.

3.3.2 catch

(1)spring

In spring, 15 species of crustaceans were captured, including 9 species of shrimps, 5 species of crabs and 1 species of Stomatopoda. The average resource density of crustaceans was 1536 individuals/h and the average biomass of crustaceans was 18.28 kg/h. According to the catch analysis, the mantissa of shrimps accounted for 23.64% of the total number of shrimps, 355 tails/h, biomass of 1.256 kg/h, adult shrimps of 1147 tails/h, biomass of 16.014 kg/h; the mantissa of crabs accounted for 26.47% of the total number of crabs, 9 tails/h, biomass of 0.102 kg/h, and 25 tails/h of crabs, with biomass of 0.91 kg/h.

(2) autumn

In autumn, 13 species of crustaceans were captured, including 6 species of shrimps, 6 species of crabs and 1 species of Stomatopoda. The average catch of crustaceans was 1483 fish/h, 11.835 kg/h. According to the survey, the total biomass of the shrimp is 92.6 kg/h, which is 92.6 kg/h of the adult shrimp.

3.3.3 Resource Density Assessment

(1) spring

In spring, 15 species of crustaceans were captured. Among them, the larvae of shrimps were 355 individuals/h, the biomass was 1.256 kg/h, the adult shrimp was 1147 tails/h, the biomass was 16.014 kg/h, the crab larvae were 9 tails/h, the biomass was 0.102 kg/h, and the adult crabs were 25 tails/h, and the biomass was 0.91 kg/h. After conversion, the average resource density of shrimp adults is 564.96 kg/km^2, 40456 $tails/km^2$; larva is 12525 $tails/km^2$; crab adult resource density is 32.10 kg/km^2, 2882 $tails/km^2$, larva is 317 $tails/km^2$.

(2) autumn

In autumn, 13 species of crustaceans were captured. Among them, the larvae of shrimps were 308 tails/h, the biomass was 0.986 kg/h, the adult shrimp was 1134 tails/h, the biomass was 8.927 kg/h, and the crabs were all adults with the biomass of 1.922 kg/h. After conversion, the average resource density of shrimp adults is 314.90 kg/km^2, 3997 ind/km^2, larva is 10865 ind/km^2, and crab adult resource density is 67.80 kg/km^2, 1446 $tail/km^2$.

According to the above results of spring and autumn survey, the average resource density of shrimp in spring and autumn is 439.93 kg / km^2 for adult and 11695 tail / km^2 for larva; the average resource density for crab is 49.95 kg / km^2 for adult and 159 / km^2 for larva.

4. Discussion

According to the survey results in spring and autumn, the average density of fish eggs is 0.143 ind/M ~ 3, and

Table 5. list of crustacean species in autumn

Serial numbere	Chinese name	section	economic value		
			higher	Commonalty	Lower
1	*Trachypenaeus curvirostris*	Penaeidae	√		
2	*Alpheus heterocarpus*	Palaemonidae		√	
3	*Alpheus japonicus*			√	
4	*Palaemon gravieri*	Palaemonidae		√	
5	*Lysmata vittata*	Hippolytidae			√
6	*Latreutes planirostris*				√
7	*Portunus trituberculatus*	Portunulidae	√		
8	*Charybdis japonica*		√		
9	*Carcinoplax vestita*	Goneplacidae			√
10	*Eucrate crenata*				√
11	*Pinnothere*.sp	Leguminosae			√
12	*Paguridae*	Hermit crabs			√
13	*Oratosquilla oratoria*	Squillidae	√		

the average density of larvae and juveniles is 0.065 ind/M ~ 3. The average stock density of adult fish is 264.50 kg/km^2, and that of juvenile fish is $6244/km^2$. The average resource density of cephalopods was 183.13 kg/km^2 for adults and 4100 $tails/km^2$ for juveniles. The average adult resource density of shrimp is 439.93 kg/km^2, larva is 11695 $tail/km^2$; the average adult resource density of crab is 49.95 kg/km^2, larva is 159 $tail/km^2$.

5. Conclusions

5.1 Current Situation of Fishery Resources

It is clearly defined in the supplementary provisions of Chapter 10 and Article 20 of Chapter 3 of China's marine environmental protection law that spawning grounds, feeding grounds, wintering grounds, migration channels and breeding grounds of fish, shrimp and shellfish are all "fishery waters", and the fishery waters are the objects of marine ecological protection, especially the shallow waters of Bohai Bay, which are the spawning grounds and nursery grounds of main economic fishery organisms In particular, larval stage is more sensitive to environmental pollution than adult stage. Once these waters are seriously polluted, it will bring heavy consequences to fishery resources. The sea area around the assessment area is the spawning ground and feeding ground for many kinds of fishes in Bohai Sea, and there are many national and local aquatic germplasm resources protection areas, which should be the primary sensitive protection target.

According to the relevant research results [3], according to the ecological types, the main economic fish resources in the evaluation area basically belong to two ecological types.

The first is the warm temperature widely distributed population, which has strong adaptability to the changeable hydrological environment, does not carry out long-distance migration, winters in the Bohai Sea, inhabits in estuaries, reefs and shallow waters, and moves seasonally in deep and shallow water with the change of environment. Generally, they swim to the shore to lay eggs in spring and summer, and swim to deeper waters in autumn and winter. The other is that the species with long-distance migration are mostly warm temperate and warm water species, with a large distribution range and obvious migration routes, while a few species migrate for a long distance.

5.2 Protection Suggestions

(1) The importance of strengthening publicity on the protection of fish resources

Fishery resources are precious natural wealth, and also the important material basis for human survival, with important scientific, ecological and economic value. Bohai Sea is known as the "cradle of hundreds of fish", but in recent years, the fishery resources have shown a trend of exhaustion, so it is imperative to protect fish [4].

(2) The fishing structure of Bohai Sea should be adjusted scientifically and reasonably

We should appropriately reduce the number of offshore vessels, actively and steadily develop offshore operations, and gradually stabilize and restore the fishery resources in the Bohai Sea.

(3) Strengthen the management of marine environment

In recent years, the pollution sources of the Bohai Sea are increasing. As the Bohai Sea is a closed inner bay, the marine environment is deteriorating and the pollution is aggravating [5]. The competent state departments should strengthen the management of the marine environment, focusing on routine monitoring of fishing areas, trend monitoring of important sea areas, emergency monitoring of red tide prone areas and pollution accidents, and monitoring of marine nature reserves.

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