Red Swimming Crab (Monomia haanii) Fishery Improvement Project (FIP) in Zhangzhou City, Fujian Province, China

(August 2022-April 2023, Phase VI)

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Contents

1. Introduction

The red swimming crab (*Monomia haanii*, Portunidae) is widely distributed in the Indo-Pacific, and in China it is commonly found in the East and South China Seas (Dai et al., 1986). *M. haanii* is characterized with a dark purple spot on the distal tips of the propodus of the fifth pereopod and the distal one-third of the dactylus of the fifth pereopod is colored dark purple (Windsor et al., 2019) (Fig. 1). *M. haanii* lives in sandy and gravelly bottom within 100 m (Dai et al., 1986) and feeds on demersal fishes and crustaceans with Macrura and Brachyura species dominant (Huang, 2004).

Fig. 1-1. Red swimming crab *Monomia haanii*.

The *M. haanii* fishery has been important in Minnan fishing ground and Taiwan Bank fishing ground since the 1980s and has been one of the most productive crab

species in Fujian Province fisheries since the 1990s, and it can be caught year-round (Zhang, 1997). Catches of *M. haanii* come mainly from bottom trawlers, baited crab traps, and gill nets. The estimated annual capture volume of *M. haanii* in the 1990s was 30,000-35,000 tons (t) in Minnan-Taiwan Bank fishing grounds, and the capture volume of *M. haanii* contributed to 16-23% of the total capture volume in bottom trawl fishery (Zhang, 1997), and 30,000-40,000 t in 2009-2018, contributing to 60-70% of the annual crab catch in Fujian Province (Ocean Outcomes, 2018; OFBFJ, 2010-2018). Based on the results of this project (in previous reports), the CPUE and average size of *M. haanii* have shown a decline compared to the results in the 1990s (Zhang, 1997).

Dongshan County (Zhangzhou City, Fujian Province) is the most important area for *M. haanii* process, contributing to approximate 80% and 65% of Fujian total volume (20,646 t) and value (48.34 million US dollars), respectively. Export products are mainly as canned lump crab meat, frozen crab body, and frozen raw claw meat in Dongshan County. The processed products of *M. haanii*' exported from Fujian Province included about 18 countries and 2 areas, with USA, Hong Kong, Taiwan and South Korea were the main export destinations (Chinese Customs Datasets, 2008-2018).

In an effort to ensure the sustainability of *M. haanii* fishery and process industry, the China Aquatic Products Processing and Marketing Alliance (CAPPMA), its local affiliate, the Zhangzhou Aquatic Products Processing and Marketing Alliance (ZAPPMA), the US based National Fisheries Institute (NFI) and Ocean Outcomes (O2) have launched together the fisheries improvement project (FIP) since 2018 in Dongshan County.

In August-December 2018, O2 launched Phase I of the FIP. The project focused on understanding the trawl and trap fisheries of *M. haanii* and the biology of *M. haanii* in Dongshan County. The information of the trawl and trap catch volumes, main species and species group catch volumes, and species composition on the landing ports in Dongshan County was collected. Biology of *M. haanii* and other three main crab species (*Portunus sanguinolentus*, *Charybdis nataor* and *Calappa philargius*) were examined. However, the trap vessel surveys in Dongshan County were not very

successful because the low number of trap vessels surveyed.

In January-April 2019, O2 and QMCS launched Phase II of the FIP. The project still focused on the trawl and trap fisheries of *M. haanii* in Dongshan County, with an extension to nearshore one-day-trip trap fishery in Longhai County of Zhangzhou City. The information of the trawl and trap catch volumes, main species and species group catch volumes, and species composition on the landing ports in Dongshan County was collected. Biology of *M. haanii* and other three main crab species (*Portunus sanguinolentus*, *Charybdis nataor* and *Calappa philargius*) were examined. Longhai County was the location for the pilot TAC project of Fujian Province led by Fujian Province Fishery Research Institute. Briefly, the trap fishery surveys were challenging in Dongshan County because the trap catches were mainly sold alive at sea and *M. haanii* was processed at sea.

In August-December 2019, O2 and QMCS launched Phase III of the FIP. The project continued our focus on the trawl and trap fisheries of *M. haanii* in Dongshan County. Based the information collected in Phases I and II during the surveys and interviews, the trap fishery operation pattern in Dongshan County started to be clear. Trap vessel surveys for the *M. haanii* fishery was finally completed for the first time in Dongshan County in Phase III.

In August-December 2020, O2 and QMCS launched Phase IV of the FIP. The project still focused on the *M. haanii* trawl fishery in Dongshan County. Moreover, we also paid attention on the domestic and international trade dynamics of *M. haanii* in Dongshan County and Longhai County to evaluate the impacts of the trade war between China and USA, and the COVID-19 pandemic.

In January-April 2021, without financial support from O2 and QMCS, the surveys on the *M. haanii* trawl fishery in Dongshan County continued in order to keep long term dataset available.

In October 2021-April 2022, O2 and QMCS launched Phase V of the FIP. The project continued the focuses on the trawl fishery of *M. haanii* in Dongshan County. The information on catch volumes, main species and species group catch volumes, and

species composition was collected. Biology of *M. haanii* and *P. sanguinolentus* were examined again after the completion of Phases I-III. In addition, the logbook data collection were conducted, including the capture volumes of *M. haanii* and latitude and longitude data for the fishing grounds.

In August 2022-April 2023, O2 and QMCS launched Phase VI of the FIP. The project continued the focuses on the trawl fishery of *M. haanii* in Dongshan County. The information on catch volumes, species composition, proportions of main economic species and "feed fishes" (See definition in Zhang & Liu, 2020) were collected. The biological study of two swimming crabs, *M. haanii* and *P. sanguinolentus*, continued. The logbook data collection continued, including the capture volumes of *M. haanii* and bycatch of seahorse species, with latitude and longitude recorded.

The specific objectives of Phase VI were assigned as follows:

(1) to document the species composition in catches from trawl fishery monthly, including those from the "feed fishes";

(2) to estimate the total catch volumes, and the catch volume proportions of main taxonomic groups (including crabs) and feed fishes monthly;

(3) to determine the size classes, sex ratio, number of females carrying eggs and spawning peaks for *M. haanii* and *P. sanguinolentus* based on the random samples collected from landing port monthly;

(4) to estimate the seahorse bycatch species and volumes, and to identify the habitats of seahorses in the southern Taiwan Strait based on logbook data collection.

2. Materials and Methods

2.1 Survey dates

The trawl surveys were conducted at two major landing ports (Gongqian and Tongling) monthly in August 2022-April 2023 in Dongshan County (Table 2-1; Fig. 2-1).

Table 2-1. Survey dates in Dongshan County, Zhangzhou City, Fujian Province, China.

No.	Dates	Items
1	August 20th-25th, 2022	Trawler survey and crab sample collection
2	September 20th-24th,2022	Trawler survey and crab sample collection
3	October 21st-26th, 2022	Trawler survey and crab sample collection
4	November 10th-15th, 2022	Trawler survey and crab sample collection
5	December 9th-14th, 2022	Trawler survey and crab sample collection
6	January 2nd-4th, 2023	Trawler survey and crab sample collection
7	February 15th-20th, 2023	Trawler survey and crab sample collection
8	March 10th-15th, 2023	Trawler survey and crab sample collection
9	April 15th-20th, 2023	Trawler survey and crab sample collection

2.2 Fishing vessel information collection

In Dongshan County, about 650 trawl vessels are registered. In August 2022-April 2023, 9-15 trawl vessels each month were surveyed at the landing ports of Dongshan County (Fig. 2-1). For each trawl vessel surveyed, information on vessel registration number, fishing areas, number of days at sea, number of tows per day, and hours per tow were collected.

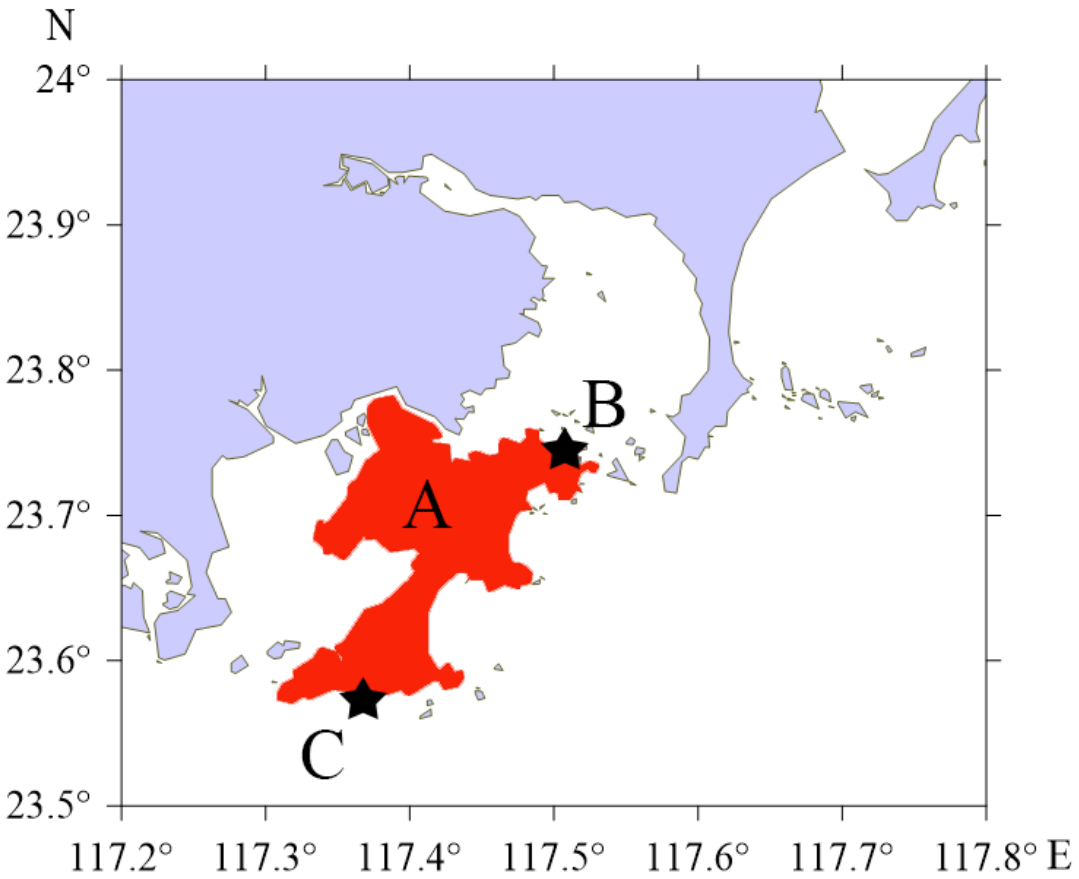

Fig. 2-1. Locations of the landing ports surveyed in Dongshan County (A).

B: Tongling Landing Port; C: Gongqian Landing Port.

2.3 Capture volume data collection

For each trawl vessel surveyed above, information on the total capture volume, crab capture volume including *M. haanii* and *P. sanguinolentus*, capture volume of main species or species groups, and capture volume of feed fishes were estimated at the landing ports based on observation and interview. The capture per unit effort (CPUE) of each vessel was calculated.

The seahorse trade was no longer observed at the landing port since all seahorses (wild populations) were listed as Category Two of national protected wild animals in China in 2021. The bycatch seahorse information were obtained via logbook, including species, number of individuals and the locations.

2.4 Crab sampling

In Dongshan County, four crab species (*M. haanii*, *P. sanguinolentus*, *Charybdis nataor* and *Calappa philargius*) made up a great proportion of crab catches and were usually separated in catch landings in trawl fishery.

In August 2022-April 2023, *M. haanii* and *P. sanguinolentus*, about one basket (about 20 kg) each species, were collected randomly and monthly for measurement and examination (Table 2-2) during the trawl vessels surveyed. Baskets are the uniform containers used to hold catches by local fishermen on board in Dongshan County. Small *M. haanii* and *P. sanguinolentus* samples came from the feed fish samples.

Table 2-2. Two crab species sampled.

No.	Photo	Species name
1		Red swimming carb *Monomia haanii*
2		Three-spot swimming crab *Portunus sanguinolentus*

2.5 Feed fish sampling

At least 1 kg feed fishes were randomly collected monthly in August 2022-April 2023 from the trawl vessels surveyed for further species identification and size measurement.

2.6 Species identification

To understand the species and species group diversity in Dongshan County trawl fishery, common and commercially important species of fishes, crustaceans and cephalopods were noted and photos were taken at the landing ports for taxonomic use. If necessary, specimens were collected for further identification in the laboratory. For feed fishes, species were identified to species, genus or family levels in laboratory in terms of the size and reserve condition of the specimens.

Fish classification and identification was based on Fishes of The World (Nelson 2006), Marine Fishes of Southern Fujian, China (Volume 1) (Liu et al., 2013), Marine Fishes of Southern Fujian, China (Volume 2) (Liu et al., 2014), www.fishbase.org, and fishdb.sinica.edu.tw. In addition, DNA barcoding technique was applied for fish species identification if necessary.

Crustacean identification followed Marine Crabs of China (Dai et al., 1986), A Catalog of the Mantis Shrimps (Stomatopoda) of Taiwan (Ahyong et al., 2008), and Penaeidae Shrimps of the South China Sea (Liu et al., 1988).

Cephalopod identification followed Fauna Sinica Vol. 4: Phylum Mollusca Class Cephalopode (Dong, 1988), and Cuttlefished and Squids of the World [New Edition] (Takashi, 2015).

2.7 Sample measurement

For *M. haanii* and *P. sanguinolentus*, the carapace size (cm) and body weight (BW, g) were measured individually in the laboratory. The carapace width (CW) was the straight line distance between the two tips of the most lateral carapace spines, while the

carapace length (CL) was the straight midline between the frontal notch and the posterior margin of the carapace (Fig. 2-2).

For fishes, crustaceans and cephalopods in feed fish samples, measurements were also conducted individually for standard length (SL, cm) and total length (TL, cm) and body weight (BW, g) in the laboratory, with a maximum of 30 individuals each species per batch.

Fig. 2-2. Crab size measurement.

CL: carapace length; CW: carapace width.

2.8 Crab sex determination

Crab sex was determined based on the morphology of abdomen (Fig. 2-3). The

spawning season of crabs is determined by the high proportions of the females bearing eggs by month (Fig. 2-4). Gonads develop within the carapaces of female and male crabs. When ovaries mature, the eggs are released and attached to the belly of the females. The eggs are fertilized and develop until the larvae are released into the sea.

Fig. 2-3. Sex determination for crabs.

Fig. 2-4. A female crab bearing eggs.

2.9 Seahorse bycatch volume and habitat analysis

In this report, the findings on seahorse bycatch fishery in the southern Taiwan Strait were summarized based on two data sources:

First, a total of 178 bottom trawling vessels operated in the southern Taiwan Strait were surveyed at landing ports of Dongshan County from January 2019 to December 2020 (except the summer fishing moratorium from May to July every year). For the trawling vessels with seahorse bycatch, the volumes were estimated.

Second, the logbook data from 3-7 bottom trawling vessels monthly from October 2021 to April 2023 (except May to July 2022) were collected including the location (latitude and longitude) of each tow (start and end), operating time and water depth of each tow, and the number of seahorse individuals each tow. The location data was used for mapping on ARCGIS 10.2.

2.10 Subsidies for fishery resources conservation

In order to know about the implementation of subsidies for fishery resources, interviews were conducted with the captains and crews at the landing ports of Dongshan County during monthly surveys.

3. Results

3.1 Number of trawl fishing vessels surveyed

A total of 101 trawl fishing vessels were surveyed at the landing ports of Dongshan County in August 2022-April 2023 (Table 3-1).

Table 3-3. Number of trawl fishing vessels surveyed at the landing ports of Dongshan County, Zhangzhou City, Fujian Province, China.

Survey month	Number of vessels surveyed
August 2022	11
September 2022	10
October 2022	11
November 2022	10
December 2022	11
January 2023	12
February 2023	15
March 2023	12
April 2023	9

3.2 Species diversity

3.2.1 Species composition

A total of 368 species (at species, genus or family level) were identified from trawl fishery catches from October 2021 to April 2023 (in Phases V and VI), including 280 fishes (76.1%), 69 crustaceans (18.8%) and 19 cephalopods (5.1%) (Table 4-2). Fishes came from 22 orders and 93 families, with almost half of the species from the order Perciformes. Crustaceans came from 2 orders and 19 families, and cephalopods from 4 orders and 4 families. Among 368 species, 78 species were found in both food and feed fishes, including 57 fishes, 11 crustaceans and 10 cephalopods; 151 species were only found in feed fishes, including 102 fishes, 44 crustaceans and 5 cephalopods.

Table 4-2. Species recorded (N = 368) in trawl fishery in October 2021-April 2023 (in Phase V & VI) at landing ports of Dongshan County. (#: species found in both food and feed fish samples; *: species only found in feed fish samples; CR, critically endangered; EN, endangered; VU, vulnerable; NT, near threatened; LC, least concern; NE, not evaluated; DD, data deficient)

Order	Family	No. of species	Common name	Species name	IUCN threatened category
Fishes (N = 280)					
Carcharhiniformes	Carcharhinidae	1	Pacific spadenose shark	*Scoliodon macrorhynchos*	NT
		2	Cocktail shark	*Carcharhinus brachyurus*	VU
		3	Spot-tail shark	*Carcharhinus sorrah*	NT
		4	Hardnose shark	*Carcharhinus macloti*	NT
	Galeocerdonidae	5	Tiger shark	*Galeocerdo cuvier*	NT
	Shpyrnidae	6	Scalloped hammerhead	*Sphyrna lewini*	CR
	Scyliorhinidae	7	Blotchy swell shark	**Cephaloscyllium umbratile*	NT
Torpediniformes	Narcinidae	8	Chinese numbfish	*Narcine lingula*	VU
		9	Shortlip electric ray	*Narcine maculata*	VU
Rajiformes	Rhynchobatidae	10	Taiwanese wedgefish	*Rhynchobatus immaculatus*	CR
		11	Bottlenose wedgefish	*Rhynchobatus australiae*	CR
	Rhinobatidae	12	Angel fish	*Rhinobatos hynnicephalus*	EN
		13	Brown guitarfish	*Rhinobatos schlegelii*	CR
	Rajidae	14	Boeseman's skate	*Okamejei boesemani*	VU
Myliobatiformes	Platyrhinidae	15	Yellow-spotted fanray	#*Platyrhina tangi*	VU

		16	Chinese fanray	*Platyrhina sinensis*	EN
	Dasyatidae	17	Red stingray	*Dasyatis akajei*	NT
		18	Pale-edged stingray	*Telatrygon zugei*	VU
		19	Round ribbontail ray	*Taeniurops meyeni*	VU
		20	Japanese butterflyray	*Gymnura japonica*	VU
	Myliobatidae	21	Longheaded eagle ray	*Aetobatus flagellum*	EN
Anguilliformes	Muraenidae	22	Netted moray	*#Gymnothrax reticularis*	LC
		23	Sieve-patterned moray	*Gymnothorax cribroris*	LC
		24	Reeves's moray	*Gymnothorax reevesii*	LC
		25	-	*Gymnothorax* sp.	-
		26	-	*Strophidon* sp.	-
	Ophichthidae	27	Finny snake eel	**Caecula pterygera*	DD
		28	Longtailed sand-eel	**Bascanichthys kirki*	LC
		29	Snake eel	**Ophichthus urolophus*	LC
		30	Sharpsnout snake eel	**Apterichtus klazingai*	LC
		31	Longfin snake-eel	*#Pisodonophis cancrivorus*	LC
		32	Rice-paddy eel	*#Pisodonophis boro*	LC
		33	Black ridge-fin eel	*#Callechelys kuro*	DD
		34	Chinese eel	**Cirrhimuraena chinensis*	LC
		35	-	**Ophichthidae* sp	-
	Muraenesocidae	36	Daggertooth pike conger	*#Muraenesox cinereus*	LC
		37	Shorttail pike conger	*#Oxyconger leptognathus*	LC
	Congridae	38	Shorttail pike conger	*Gnathophis heterognathos*	LC

		39	Eel	#*Ariosoma megalops*	DD
		40	-	#*Ariosoma* sp.	-
		41	Slender conger	#*Uroconger lepturus*	LC
		42	-	*Congridae sp.	-
	Nettastomatidae	43	Duckbill eel	**Saurenchelys fierasfer*	LC
Clupeiformes	Clupeidae	44	Round sardinella	**Sardinella aurita*	LC
		45	Bali sardinella	*Sardinella lemuru*	NT
	Engraulidae	46	-	**Stolephorus* sp.	-
		47	Kammal thryssa	**Thryssa kammalensis*	DD
		48	Common hairfin anchovy	**Setipinna tenuifilis*	DD
	Prisigasteridae	49	Elongate ilisha	*Ilisha elongata*	LC
		50	Buccaneer anchovy	**Encrasicholina punctifer*	LC
Gonorhynchiformes	Gonoruchidae	51	beaked salmon	**Gonorychus abbreviatus*	NE
Siluriformes	Plotosidae	52	Striped eel catfish	*Plotosus lineatus*	NE
Aulopiformes	Synodontidae	53	Snakefish	#*Trachinocephalus myops*	LC
		54	Lizardfish	#*Synodus fuscus*	LC
		55	Taiwan Lizardfish	**Synodus taiwanensis*	NE
		56	-	**Synodus* sp.	-
		57	Bombay-duck	*Harpadon nehereus*	NT
		58	Slender lizardfish	#*Saurida elongata*	LC
		59	Greater lizardfish	#*Saurida tumbil*	LC
		60	Brushtooth lizardfish	#*Saurida undosquamis*	LC
Myctophiformes	Myctophidae	61	Skinnycheek lanternfish	**Benthosema pterotum*	LC

Lophiomus	Lophiidae	62	Blackmouth angler	*Lophiomus setigerus*	LC
Gadiformes	Bregmacerotidae	63	False lance codlet	**Bregmaceros pseudolanceolatus*	NE
		64	-	**Bregmaceros* sp.	-
Ophidiiformes	Ophidiidae	65	Asiro brotula	**Ophidion muraenolepis*	LC
		66	Yellow pigmy brotula	**Dinematichthys iluocoeteoides*	LC
Mugiliformes	Mugilidae	67	Mullet	*Planiliza affinis*	NE
		68	-	*Mugilidae sp.	-
Beloniformes	Hemiramphidae	69	-	*Hyporhamphus* sp.	-
Beryciformes	Holocentridae	70	Redcoat	**Sargocentron rubrum*	LC
Zeiformes	Zeidae	71	Cape dory	**Zeus capensis*	LC
Syngnathiformes	Syngnathidae	72	Longnose seahorse	#*Hippocampus trimaculatus*	VU
		73	Great seahorse	*Hippocampus kelloggi*	VU
		74	Japanese seahorse	*Hippocampus mohnikei*	VU
		75	Hedgehog seahorse	*Hippocampus spinosissimus*	VU
		76	Rough pipefish	#*Trachyrhamphus serratus*	DD
	Pegasidae	77	Sea moth	**Pegasus laternarius*	DD
	Fistularidae	78	Red cornetfish	#*Fistularia petimba*	LC
		79	Bluespotted cornetfish	*Fistularia commersonii*	LC
Scorpaeniformes	Scorpaenidae	80	Lionfish	*Pterois volitans*	LC
		81	Ocellated waspfish	**Apistus carinatus*	LC
		82	Blackfoot Lionfish	*Parapterois heterura*	LC
		83	False kelpfish	#*Sebastiscus marmoratus*	NE
		84	Yellowfin scorpionfish	*Scorpaenopsis neglecta*	LC

		85	Scorpionfish	#*Scorpaena miostoma*	NE
		86	Korean rockfish	*Sebastes schlegelii*	NE
		87	Dwarf stingfish	**Minous pusillus*	NE
		88	Grey stingfish	**Minous monodactylus*	LC
	Aploactinidae	89	Dusky velvetfish	**Aploactis aspera*	NE
	Triglidae	90	Spiny red gurnard	#*Chelidonichthys spinosus*	LC
		91	Redwing searobin	**Lepidotrigla microptera*	NE
		92	Forksnout searobin	**Lepidotrigla alata*	NE
	Platycephalidae	93	Midget flathead	**Onigocia spinosa*	LC
		94	Tuberculated flathead	**Sorsogona tuberculata*	LC
		95	Bartail flathead	*Platycephalus indicus*	DD
		96	Olive-tailed flathead	**Rogadius asper*	LC
		97	Japanese flathead	**Inegocia japonica*	LC
		98	Spotted flathead	**Inegocia guttata*	NE
		99	-	**Platycephalidae* sp.	-
Perciformes	Moronidae	100	Japanese seabass	*Lateolabrax japonicus*	NE
	Acropomatidae	101	Glowbelly	**Acropoma japonicum*	NE
	Epinephelidae	102	Orange-spotted grouper	*Epinephelus coioides*	LC
		103	Yellow grouper	*Epinephelus awoara*	DD
		104	Duskytail grouper	*Epinephelus bleekeri*	DD
		105	Longfin grouper	*Epinephelus quoyanus*	LC
		106	Hong Kong grouper	*Epinephelus akaara*	EN
	Pricanthidae	107	Red bigeye	#*Priacanthus macracanthus*	LC

		108	Purple-spotted bigeye	*#Priacanthus tayenus*	LC
	Apogonidae	109	Rifle cardinal	**Ostorhinchus kiensis*	LC
		110	Half-lined cardinal	**Ostorhinchus semilineatus*	DD
		111	Broadbanded cardinalfish	*#Ostorhinchus fasciatus*	NE
		112	Cardinalfish	**Apogonichthyoides niger*	LC
		113	Flagfin cardinalfish	**Jaydia truncata*	NE
		114	Indian perch	**Jaydia lineata*	LC
	Sillaginidae	115	Japanese sillago	*Sillago japonica*	LC
		116	Bay sillago	*#Sillago ingenuua*	NE
		117	-	**Sillaginidae* sp.	-
	Coryphaenidae	118	Common dolphinfish	*Coryphaena hippurus*	LC
	Rachycentridae	119	Cobia	*Rachycentron canadum*	LC
	Carangidae	120	African pompano	*Alectis ciliaris*	LC
		121	Bigeye scad	*Selar crmenophthalmus*	LC
		122	Yellowstripe scad	*#Selaroides leptolepis*	LC
		123	Black pomfret	*Parastromateus niger*	LC
		124	Whitefin trevally	**Carangoides equula*	LC
		125	Razorbelly scad	*Alepes kleinii*	LC
		126	Japanese scad	*#Decapterus maruadsi*	LC
		127	Shortfin scad	*Decapterus macrosoma*	LC
		128	Japanese jack mackerel	*#Trachurus japonicus*	NT
		129	Snubnose pompano	*Trachinotus blochii*	LC
		130	Needlescaled queenfish	*Scomberoides tol*	LC

		131	Yellowtail amberjack	*Seriola dumerili*	LC
		132	Blackbanded trevally	*Seriolina nigrofasciata*	LC
	Menidae	133	Moonfish	*Mene maculata*	NE
	Leiognathidae	134	Deep pugnose ponyfish	**Secutor ruconius*	NE
		135	Ponyfish	**Equulites rivulatus*	NE
		136	Scrawled ponyfish	**Leiognathus berbis*	NE
		137	Orangefin ponyfish	**Photopectoralis bindus*	NE
	Lutjanidae	138	Crimson snapper	*Lutjanus erythopterus*	LC
		139	Russell's snapper	*Lutjanus russellii*	LC
		140	Mangrove red snapper	*Lutjanus argentimaculatus*	LC
	Gerreidae	141	Whipfin silver-biddy	*Gerres filamentosus*	LC
	Haemulidae	142	Broadbanded velvetchin	*Hapalogenys analis*	NE
		143	Black grunt	*Hapalogenys nigripinnis*	NE
		144	Trout sweetlips	*Plectorhinchus pictus*	LC
		145	Crescent sweetlips	*Plectorhinchus cinctus*	LC
		146	Chicken grunt	*Parapristipoma trilineatum*	NE
	Nemipteridae	147	Whitecheek monocle bream	**Scolopsis vosmeri*	LC
		148	Golden threadfin bream	*Nemipterus virgatus*	VU
		149	Yellowbelly threadfin bream	**Nemipterus bathybius*	LC
		150	Japanese threadfin bream	#*Nemipterus japonicus*	LC
	Lethrinidae	151	Pacific yellowtail emperor	*Lethrinus atkinsoni*	LC
		152	Spangled emperor	*Lethrinus nebulosus*	LC
	Sparidae	153	Yellowfin seabream	*Acanthopagrus latus*	DD

		154	Blackhead seabream	*Acaanthopagrus schelegeli*	LC
		155	Red seabream	*Pagrus major*	LC
		156	Goldlined seabream	*Rhabdosargus sarba*	LC
		157	Threadfin porgy	*#Evynnis cardinalis*	EN
	Polynemidae	158	Fourfinger threadfin	*Eleutheronema tetradactylum*	NE
		159	Sixfinger threadfin	*#Polydactylus sextarius*	NE
	Sciaenidae	160	Reeve's croaker	*Chrysochir aureus*	LC
		161	Croaker	**Johnius distinctus*	LC
		162	Trewavas croaker	*#Johnius trewavasae*	LC
		163	Belanger's croaker	*Johnius belangerii*	LC
		164	-	**Johnius* sp.1	-
		165	-	*J*ohnius sp.2*	-
		166	Large yellow croaker	*Larimichthys crocea*	CR
		167	Yellow drum	*Nibea albiflora*	LC
		168	Big-head pennah croaker	*#Pennahia macrocephalus*	LC
		169	Truncate-tail croaker	*#Pennahia anea*	LC
		170	Silver croaker	*#Pennahia argentata*	LC
		171	Pawak croaker	**Pennahia pawak*	LC
		172	Mi-iuy croaker	*Miichthys miiuy*	DD
		173	-	*Sciaenidae sp.	-
	Glaucosomatidae	174	West Australian dhufish	*Glaucosoma hebraicum*	NE
	Mullidae	175	Japanese goatfish	*#Upeneus japonicus*	NE
		176	Pointed goatfish	*Parupeneus biaculeatus*	NE

		177	Whitesaddle goatfish	*Parupeneus ciliatus*	LC
		178	Yellowstripe goatfish	*Mulloidichthys flavolineatus*	LC
	Kyphosidae	179	Stripey	*Microcanthus strigatus*	LC
	Drepaneidae	180	Spotted sicklefish	**Drepane punctata*	LC
	Terapontidae	181	Jarbua terapon	**Terapon jarbua*	LC
		182	Fourlined terapon	**Pelates quadrilineatus*	NE
	Oplegnathidae	183	Spotted knifejaw	**Oplegnathus punctatus*	NE
	Chaetodontidae	184	Triple-banded butterflyfish	#*Roa modestus*	LC
	Pomacanthidae	185	Bluestriped angelfish	*Chaetodontoplus septentrionalis*	LC
	Pomacentridae	186	Jordan's damsel	#*Teixeirichthys jordani*	LC
	Cepolidae	187	Bandfish	*Acanthocepola indica*	NE
	Labridae	188	Scarbreast tuskfin	*Choerodon azurio*	DD
	Scaridae	189	Multicolorfin rainbowfish	*Parajulis poecilepterus*	LC
		190	Slender wrasse	**Suezichthys gracilis*	LC
		191	Rosed razorfish	*Iniistius verrens*	LC
		192	Blackspot razorfish	*Iniistius dea*	LC
		193	Blue-barred parrotfish	*Scarus ghobban*	LC
	Champsodontidae	194	Günther's gaper	**Champsodon guentheri*	NE
	Pinguipedidae	195	Harlequin sandsmelt	#*Parapercis pulchella*	NE
		196	Sandperch	**Parapercis ommatura*	NE
	Callionymidae	197	Dragonet	#*Callionymus hugueninii*	NE
		198	Dragonet	#*Callionymus planus*	NE
		199	Izu ruddertail dragonet	**Callionymus curvicornis*	LC

		200	-	**Callionymus* sp.	-
	Percophidae	201	-	*Percophidae sp.	-
	Trichonotidae	202	Black-spot sand-diver	*#Trichonotus filamentosus*	LC
		203	Spotted sand-diver	*#Trichonotus setiger*	LC
		204	Long-rayed sand-diver	*#Trichonotus elegans*	LC
	Ammodytidae	205	Sand lance	*#Bleekeria viridianguilla*	NE
		206	Sand lance	*#Bleekria mitsukurii*	NE
	Uranoscopidae	207	Naked-nape stargazer	*Uranoscopus oligolepis*	LC
		208	Chinese stargazer	**Uranoscopus bicinctus*	NE
		209	Japanese stargazer	*#Uranoscopus japonicus*	LC
		210	Longnosed stargazer	**Ichthyscopus lebeck*	NE
		211	Oriental fringe stargazer	**Ichthyscopus pollicaris*	NE
	Gobiidae	212	Burrowing goby	*Trypauchen vagina*	LC
		213	Maned goby	**Oxyurichthys microlepis*	LC
		214	-	*Gobiidae sp.	-
	Eleotridae	215	Ward's sleeper	**Valenciennea wardi*	LC
		216	Immaculate glidergoby	**Valenciennea immaculata*	LC
	Ptereleotridae	217	Blue hana goby	**Ptereleotris hanae*	LC
	Ephippidae	218	Longfin batfish	*Platax teria*	LC
	Siganidae	219	Mottled spinefoot	*#Siganus fuscescens*	LC
	Sphyraenidae	220	Seapike	*Sphyraena jello*	NE
		221	Red barracuda	*Sphyraena pinguis*	NE
		222	-	*Sphyraena* sp.	-

	Trichiuridae	223	Largehead hairtail	#*Trichiurus lepturus*	LC
		224	Japanese hairtail	**Trichiurus japonicus*	NE
		225	Chinese short-tailed hairtail	**Trichiurus brevis*	NE
		226	-	**Trichiurus* sp.	-
	Scombridae	227	Chub mackerel	#*Scomber japonicus*	LC
		228	Japanese Spanish mackerel	*Scomberomorus niphonius*	DD
		229	Narrow-barred Spanish mackerel	*Scomberomorus commerson*	NT
		230	Indo-Pacific king mackerel	*Scomberomorus guttatus*	DD
		231	Bullet mackerel	*Auxis thazard*	LC
		232	Bonito	*Euthynnus affinis*	LC
		233	Striped bonito	*Sarda orientalis*	LC
	Centrolophidae	234	Pacific rudderfish	#*Psenopsis anomala*	LC
	Stromateidae	235	Butterflyfish	*Pampus argenteus*	NE
		236	Chinese silver pomfret	*Pampus chinensis*	NE
Pleuronectiformes	Paralichthyidae	237	Cinnamon flounder	*Pseudorhombus cinnamoneus*	LC
		238	Largetooth flounder	*Pseudorhombus arsius*	NE
		239	Taiwan-ganzôbirame	*Pseudorhombus levisquamis*	LC
		240	Roughscale flounder	*Pseudorhombus oligodon*	LC
		241	Large-tooth flounder	**Tarphops oligolepis*	LC
	Bothidae	242	Lefteye flounder	**Psettina tosana*	LC
		243	-	**Psettina* sp.	-
		244	Largescale flounder	**Engyprosopon grandisquama*	LC
		245	Lefteye flounder	**Engyprosopon maldivensis*	DD

		246	Lefteye flounder	**Engyprosopon multisquama*	LC
		247	-	**Engyprosopon* sp.	-
		248	Blue flounder	**Crossorhombus azureus*	LC
		249	-	**Crossorhombus* sp.	-
		250	Many-spotted lefteye flounder	**Arnoglossus polyspilus*	LC
		251	Large-crested lefteye flounder	**Arnoglossus macrolophus*	LC
		252	Dwarf lefteye flounder	**Arnoglossus tenuis*	LC
		253	-	**Arnoglossus* sp.	-
		254	-	*Bothidae sp.	-
	Pleuronectidae	255	Ridged-eye flounder	*#Pleurinichthys cornutus*	NE
	Samaridae	256	Crested flounder	**Samaris cristatus*	LC
	Soleidae	257	Ovate sole	**Solea ovata*	LC
		258	Zebra sole	*Zebrias zebra*	NE
		259	Unicorn sole	*Aesopia cornuta*	LC
		260	Flounder	**Zebrias crossolepis*	DD
		261	Wavyband sole	**Pseudaesopia japonica*	LC
		262	-	*Soleidae sp.	-
		263	Blackspotted sole	*#Liachirus melanospilos*	LC
	Cynoglossidae	264	Red tonguesole	**Cynoglossus joyneri*	NE
		265	Speckled tougue sole	**Cynoglossus puncticeps*	LC
		266	Speckled tongue sole	**Cynoglossus itinus*	LC
		267	Genko sole	**Cynoglossus interruptus*	LC
		268	-	**Cynoglossus* sp.	-

		269	Black cow-tongue	*Paraplagusia japonica*	LC
Tetraodontiformes	Monacanthidae	270	Unicorn leatherjacket filefish	*Aluterus monoceros*	LC
		271	Threadsail filefish	#*Stephanolepis cirrhifer*	LC
		272	Mudbank filefish	#*Paramonacanthus sulcatus*	LC
		273	Faintstripe filefish	#*Paramonacanthus pusillus*	LC
		274	Prickly leatherjacket	*Chaetodermis peniciligera*	LC
	Tetraodontidae	275	Blowfish	#*Lagocephalus wheeleri*	LC
		276	Smooth blaasop	*Lagocephalus inermis*	LC
		277	Lattice blaasop	*Takifugu oblongus*	LC
		278	Pufferfish	*Takifugu poecilonotus*	LC
		279	Yellowfin puffer	*Takifugu xanthopterus*	LC
		280	Guineafowl puffer	*Arothron meleagris*	LC
Crustaceans (N = 69)					
Stomatopoda	Squillidae	281	Japanese squillid mantis shrimp	**Oratosquilla fabricii*	NE
		282	Mantis shrimp	**Lophosquilla costata*	NE
		283	Smooth squillid mantis shrimp	**Erugosquilla woodmasoni*	NE
		284	Mantis shrimp	**Carinosquilla multicarinata*	NE
		285	Mantis shrimp	**Oratosquillina interrupta*	NE
		286	Mantis shrimp	#*Odontodactylus japonicus*	NE
Decapoda	Sicyoniidae	287	Shrimp	**Sicyonia* sp.	-
	Palaemonidae	288	Shrimp	*Palaemonidae sp.	-
	Solenoceridae	289	Udang merah	#*Solenocera crassicornis*	NE
	Penaeidae	290	Kuruma shrimp	*Penaeus japonicus*	NE

		291	Chinese white prawn	*Penaeus merguiensis*	NE
		292	Western king prawn	*Penaeus latisulcatus*	NE
		293	Green tiger prawn	*Penaeus semisulcatus*	NE
		294	Southern rough shrimp	#*Trachysalambria curvirostris*	NE
		295	Rough shrimp	**Trachysalambria longipes*	NE
		296	Spear shrimp	#*Parapenaeopsis hardwickii*	NE
		297	Coral shrimp	#*Kishinouyepenaeopsis cornuta*	NE
		298	Shrimp	**Mierspenaeopsis cultrirostris*	NE
		299	Smoothshell shrimp	**Batepenaeopsis tenella*	NE
		300	Flamingo shrimp	**Parapenaeus longipes*	NE
		301	Whiskered velvet shrimp	#*Metapenaeopsis barbata*	NE
		302	Kishi velvet shrimp	**Metapenaeopsis dalei*	NE
		303	Humpback prawn	*Metapenaeopsis lamellata*	NE
		304	Southern velvet shrimp	**Metapenaeopsis palmensis*	NE
		305	Mogi velvet shrimp	**Metapenaeopsis mogiensis*	NE
		306	-	**Metapenaeopsis* sp.1	-
		307	-	**Metapenaeopsis* sp.2	-
		308	-	*Penaeidae sp.1	-
		309	-	*Penaeidae sp.2	-
	Pasiphaeidae	310	Lesser glass shrimp	**Leptochela gracilis*	NE
	Scyllaridae	311	Slipper lobster	**Scyllarus cultrifer*	LC
	Albuneidae	312	-	**Albunea* sp.	-
	Dromiidae	313	Japanese sponge crab	**Lauridromia dehaani*	NE

		314	Crab	**Conchoecetes artificiosus*	NE
	Dorippidae	315	Granulated mask crab	**Paradorippe granulata*	NE
	Majidae	316	-	**Pugettia* sp.	-
		317	-	*Majidae sp.	-
	Leucosiidae	318	Pebble crab	*Leucosia craniolaris*	NE
		319	Painted pebble crab	*Leucosia anatum*	NE
		320	Fleeting purse crab	**Myra fugax*	NE
		321	-	**Myra* sp.	-
		322	-	*Leucosiidae sp.	-
	Calappidae	323	Box crab	*#Calappa philargius*	NE
		324	Spotted box crab	*Calappa lophos*	NE
		325	Reef box crab	**Calappa hepatica*	NE
		326	Crab	**Cycloes granulosa*	NE
	Parthenopidae	327	Strong elbow crab	**Enoplolambrus validus*	NE
	Corystidae	328	Crab	J*onas distincta*	NE
	Matutiodea	329	Spotted moon crab	**Matuta planipes*	NE
		330	Yellow moon crab	**Matuta banksi*	NE
	Portunidae	331	Mud crab	*Scylla paramamosain*	NE
		332	Swimming crab	**Portunus hastatoides*	NE
		333	Japanese blue crab	*#Portunus trituberculatus*	NE
		334	Swimming crab	**Portunus gracilimanus*	NE
		335	Three-spot swimming crab	*#Portunus sanguinolentus*	NE
		336	Swimming crab	**Portunus argentatus*	NE

		337	Flower crab	*Portunus pelagicus*	NE
		338	Red swimming crab	#*Monomia haanii*	NE
		339	Swimming crab	**Charybdis bimaculata*	NE
		340	Swimming crab	**Charybdis acuta*	NE
		341	Crucifix crab	*Charybdis feriatus*	NE
		342	Rock crab	#*Charybdis nataor*	NE
		343	Swimming crab	**Charybdis variegata*	NE
		344	Soldier swimming crab	*Charybdis miles*	NE
		345	-	**Charybdis* sp.	-
	Porcellanidae	346	Crab	**Porcellana pulchra*	NE
		347	-	*Porcellanidae sp.	-
	Xanthidae	348	Mosaic reef crab	*Lophozozymus pictor*	NE
	Pilumnidae	349	-	**Heteropilumnus* sp.	-
Cepholopods (N = 19)					
Sepiida	Sepiidae	350	Spineless cuttlefish	#*Sepiella maindroni*	DD
		351	Golden cuttlefish	#*Sepia esculenta*	DD
		352	Kisslip cuttlefish	*Sepia lycidas*	DD
		353	-	#Sepiidae sp.	-
	Sepiolidae	354	Bobtail Squid	#*Sepiola berryi*	NE
		355	Koch's bottletail squid	**Sepiadarium kochii*	LC
		356	-	**Sepiola* sp.	-
Teuthida	Loliginidae	357	Squid	*Loligo japonicus*	DD
		358	Squid	*Uroteuthis duvaucelii*	DD

		359	Southern dumpling squid	*Uroteuthis chinensis*	DD
		360	Swordtip squid	**Uroteuthis edulis*	DD
		361	Little squid	*#Loliolus uyii*	DD
		362	-	*Loliginidae sp.	-
Octopoda	Octopodidae	363	Whiparm octopus	*#Octopus variabilis*	DD
		364	Webfoot octopus	*#Octopus ocellatus*	LC
		365	Octopus	*#Amphioctopus aegina*	LC
		366	Stareye octopus	*#Amphioctopus kagoshimensis*	LC
		367	Greater blue-ringed octopus	**Hapalochlaena lunulata*	LC
		368	-	#Octopodidae sp.	-

3.2.2 Endangered, threatened and protected species

All Carcharhinidae species were listed in CITES Appendix II in 2022, and three species (*Sphyrna lewini*, *Scoliodon macrorhynchos*, *Carcharhinus sorrah* and *C. macloti*) were recorded at the landing ports of Dongshan County according to the surveys from August 2022 to April 2023 (Fig. 3-1). *S. macrorhynchos* was the most common species of Carcharhinidae species that was spotted in October 2022, December 2022, January 2023 and April 2023, with a total of about 30 individuals. Both *C. sorrah* and *C. macloti* had a low occurrence at the landing ports, with one *C. sorrah* individual in August 2022, one *C. macloti* individual in December 2022 and one *C. macloti* individual in April 2023.

Fig. 3-1 Pacific spadenose shark *Scoliodon macrorhynchos* (top), Spot-tail shark *Carcharhinus sorrah* (middle), Hardnose shark *Carcharhinus macloti* (bottom) found in trawl catches in Dongshan County.

Sphyrna lewini (Shpyrnidae) was listed as CITES Appendix II in 2014. *S. lewini* had a low occurrence at the landing ports of Dongshan County according to the surveys from August 2022 to April 2023, only one individual in October 2022 and one in March 2023 (Fig. 3-2).

Fig. 3-2. Scalloped hammerhead shark *Sphyrna lewini* found in trawl catches in Dongshan County.

All *Rhynchobatus* species (Rhynchobatidae) were listed as CITES Appendix II in 2019. One species, Taiwan wedgefish *Rhynchobatus immaculatus*, was recorded according to the surveys from August 2022 to April 2023 (Fig. 3-3). Only one individual of *R. immaculatus* was observed in October 2022 (Fig. 3-3).

Fig. 3-3. Taiwan wedgefish *Rhynchobatus immaculatu* found in trawl catches in Dongshan County.

All *Hippocampus* species were listed in CITES Appendix II in 2004. In Dongshan County, *H. trimaculatus* is the absolutely dominant landing species in seahorse bycatches from trawl fishery. During the surveys from August 2022 to April 2023, only *H. trimaculatus* was found at the landing ports of Dongshan County.

To summary, a total of nine cartilaginous fishes (*S. macrorhynchos*, *C. melanopterus*, *C. brachyurus*, *C. sorrah*, *C. macloti*, *C. leucas*, *Sphyrna lewini*,

Rhynchobatus immaculatus and *R. australiae*) and four bony fishes (*H. trimaculatus*, *H. spinosissimus*, *H. kelloggi* and *H. mohnikei*), all listed as CITES Appendix II species, were found in trawl catches of Dongshan County throughout the surveys from August 2018 to April 2023 (in Phase I-VI).

The four seahorse species aforementioned were also listed as Category II of National Wildlife Protected Species in January 2021 (www.forestry.gov.cn/html/main/main_5461/20210205122239482485322/file/20210205122347636743107.pdf).

Among the 368 species identified aforementioned in Dongshan County from October 2021-April 2023, a total of 23 fish species were listed as threatened in the International Union for Conservation of Nature (IUCN) Red List (Table 4-2). Among the 23 fish species, 5 species (*S. lewini*, *R. immaculatus*, *R. australiae, Rhinobatos schlegelii* and *Larimichthys crocea*) were listed as "Critically Endangered", 5 species (*Rhinobatos hynnicephalus*, *Platyrhina sinensis, Aetobatus flagellum, Epinephelus akaara* and *Evynnis cardinalis*) were listed as "Endangered", and 13 species (*C. brachyurus*, *Narcine lingual*, *N. maculate*, *Okamejei boesemani*, *Platyrhina tangi*, *Telatrygon zugei*, *Taeniurops meyeni, Gymnura japonica, H. kelloggi, H. mohnikei, H. spinosissimus*, *H. trimaculatus* and *Nemipterus virgatus*) were as "Vulnerable". *E. cardinalis* is one of the most important food fishes in terms of catch volume proportion and number documented in this study.

3.3 Fishing areas

The fishing grounds remained unchanged during the surveys from August 2022 to April 2023. Based on the captain and crew interviews, trawl vessels from Dongshan County mainly operate in offshore fishing grounds, including Minnan Fishing Ground, Taiwan Bank Fishing Ground, Yuedong Fishing Ground, Dongsha Fishing Ground and Southern Taiwan Fishing Ground within 116º-119º E and 21º50'-24º50' N or more extended (Lin et al., 2021) (Fig. 3-4).

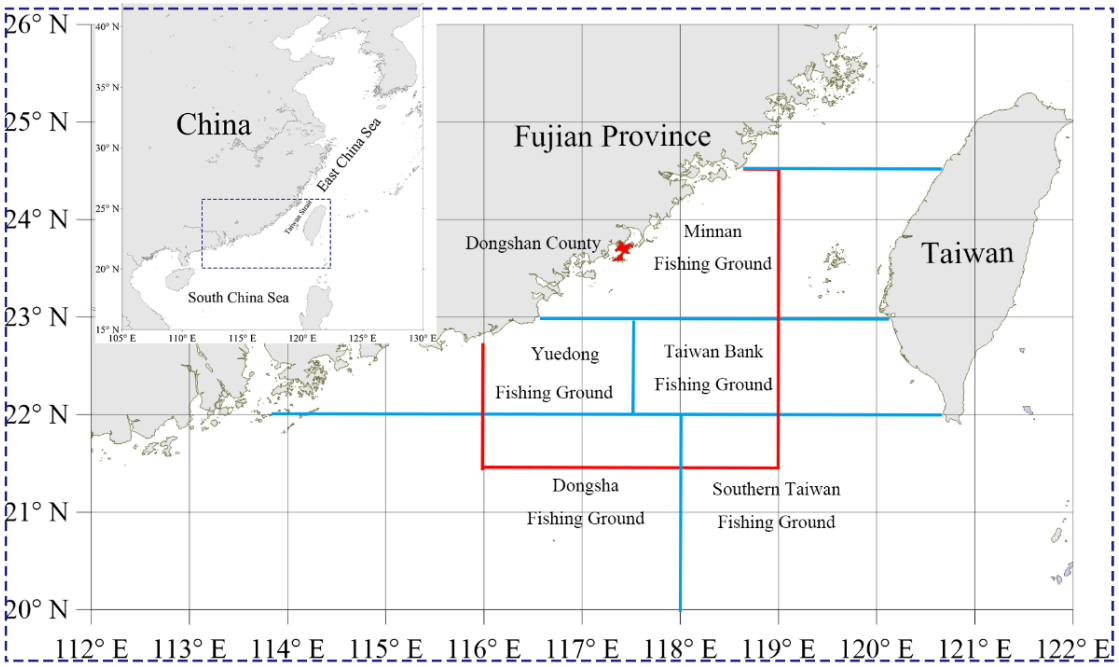

Fig. 3-4. Offshore fishing areas (within red line) of trawl vessels from Dongshan County (red area), covering five fishing grounds of southern Taiwan Strait.

3.4 Fishery operation patterns

Based on 101 trawl vessels surveyed at the landing ports of Dongshan County during the surveys from August 2022 to April 2023, they generally spent 1-14 days/trip at sea (mean = 6.22, N = 101). The variation of fishing days at sea highly depended on the weather conditions. Over 60% of trawl vessels surveyed spent more than 5 days/trip at sea. Almost all of the trawl vessels surveyed in October 2022 and February 2023 spent less than 3 days/trip at sea due to bad weather. The fishery operation patterns are similar with the findings in August 2018-April 2022 surveys (in Phases I-V).

3.5 Capture volumes and proportions by trawl vessels

3.5.1 Capture volumes and proportions of different taxonomic groups

Based on the trawl vessels surveyed (N = 101) at the landing ports of Dongshan County from August 2022 to April 2023, the average total capture volume was about 8179.90 kg/vessel/trip, and the capture volumes and proportions of different taxonomic groups were estimated (**错误!未找到引用源。**3-3). The findings were summarized as below:

(1) The most dominant capture taxonomic group was the fishes (including food fish and feed fish), contributed to 71.83% (average of 5875.85 kg/vessel/trip) of the

estimated average total capture volume (average of 8179.90 kg/vessel/trip).

(2) The average total food fish capture volume was 3802.60 kg/vessel/trip, which contributed to 46.49% of the estimated total capture volume.

(3) The proportion of feed fishes was high (average of 2073.25 kg/vessel/trip), contributed to 25.35% of the total capture volume.

(4) The average total crustacean capture volume (1489.73 kg/vessel/trip) contributed to 18.21% of the estimated average total capture volume, with the estimated average 1249.90 kg/vessel/trip for crabs and 239.83 kg/vessel/trip for shrimps.

(5) The average total cephalopod capture volume was 814.32 kg/vessel/trip, which contributed to 9.96% of the estimated total capture volume.

Table 3-3. Capture volumes and proportions from trawl vessels surveyed (N = 101) in August 2022-April 2023 at the landing ports of Dongshan County.

Parameters	**Mean (N = 101)**	
Fishing days per trip	6.22 days/trip	
Average total capture volume per trip	8179.90 kg/vessel/trip	
Average total crustacean capture volume per trip	1489.73 kg/vessel/trip	
	Shrimps: 239.83 kg/vessel/trip	Crabs: 1249.90 kg/vessel/trip
Total crustacean volume/total capture volume	18.21%	
	Shrimps: 2.93%	Crabs: 15.28%
Average total fish capture volume per trip	5875.85 kg/vessel/trip	
Total fish volume/total capture volume	71.83%	
Average total food fish capture volume per trip	3802.60 kg/vessel/trip	
Total food fish volume/total capture volume	46.49%	
Average total feed fish capture volume per trip	2073.25 kg/vessel/trip	

Total feed fish volume/total capture volume	25.35%
Average total cephalopod capture volume per trip	814.32 kg/vessel/trip
Total cephalopod volume/total capture volume	9.96%

3.5.2 Crabs

The crab capture volume proportions in the total capture volumes of trawl fishery (N = 101) in Dongshan County in August 2022-April 2023 were further analyzed (Table 3-4; Fig.3-5 to 3-7). The findings were summarized as below:

(1) Crab proportions in the total capture volumes of trawl fishery in Dongshan County ranged from 2.93% in April 2023 to 29.64% in August 2022, including four main crab species, *M. haanii*, *P. sanguinolentus*, *C. nataor* and *C. philargius*.

(2) Among the estimated average total crab capture volume of 1249.90 kg/vessel/trip, *M. haanii* was 954.63 kg/vessel/trip, *P. sanguinolentus* was 218.14 kg/vessel/trip, *C. nataor* was 14.49 kg/vessel/trip and *C. philargius* was 37.08 kg/vessel/trip, contributed to 11.67%, 2.67%, 0.28% and 0.65% of the total capture volume, respectively.

(3) The dominant crab species in trawl fishery was *M. haanii*, contributed around 80% of the total crab production. The *M. haanii* proportions in the total capture volumes varied monthly, ranged from 2.36% in April 2023 to 24.01% in August 2022. The capture volumes of *M. haanii* ranged from 190.56 kg/vessel/trip to 2154.09 kg/vessel/trip.

(4) Based on the average fishing days at sea, the average CPUE of *M. haanii* ranged from 20.14 kg/vessel/day in April 2023 to 355.72 kg/vessel/day in August 2021 (mean = 173.28 kg/vessel/day).

(5) Based on the average fishing days at sea, the average CPUE of *P. sanguinolentus* ranged from 1.48 kg/vessel/day in April 2023 to 77.04 kg/vessel/day in January 2023 (mean = 37.50 kg/vessel/day).

Table 3-4. Average capture volumes (kg/vessel/trip) and proportions (%) of four main crab species in the total capture volumes from trawl vessels surveyed (N = 101) in August 2022-April 2023 at the landing ports of Dongshan County.

Crab species	Average volume (kg/vessel/trip)	Proportion (%)
Monomia haanii	954.63	11.67%
Portunus sanguinolentus	218.14	2.67%
Charybdis nataor	23.23	0.28%
Calappa philargius	52.93	0.65%
Other crabs	0.96	0.01%
Total	1249.90	15.28%

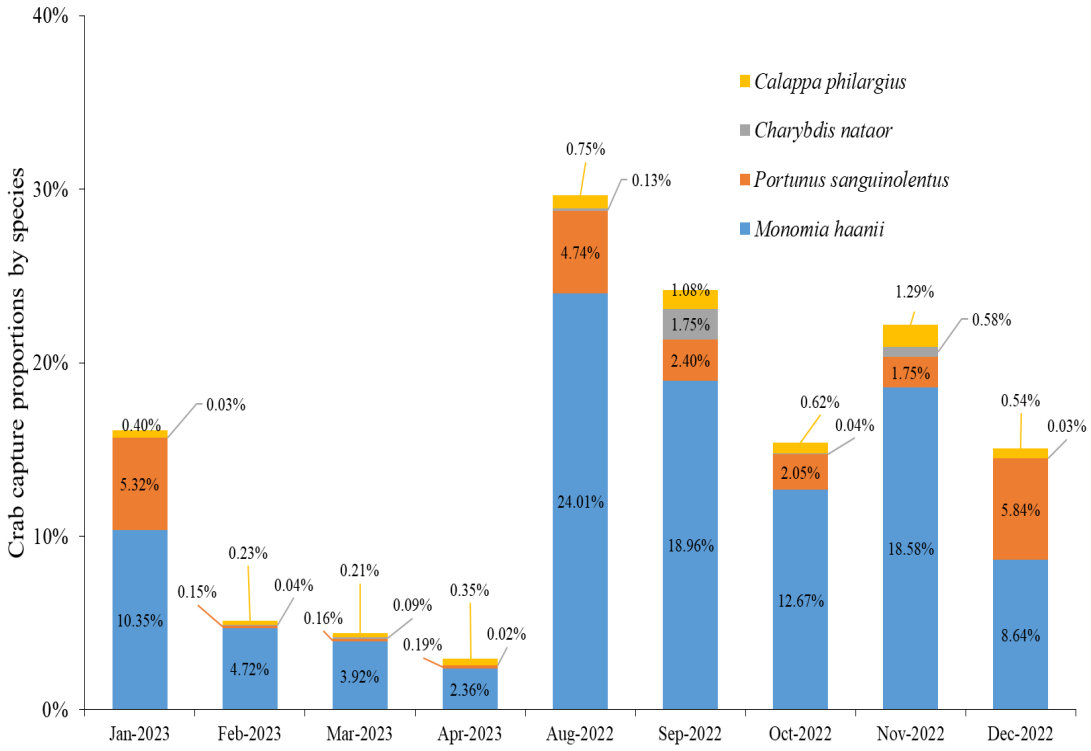

Fig. 3-5. Crab capture proportions in the total capture volume by species from trawl vessels surveyed in August 2022-April 2023 at the landing ports of Dongshan County.

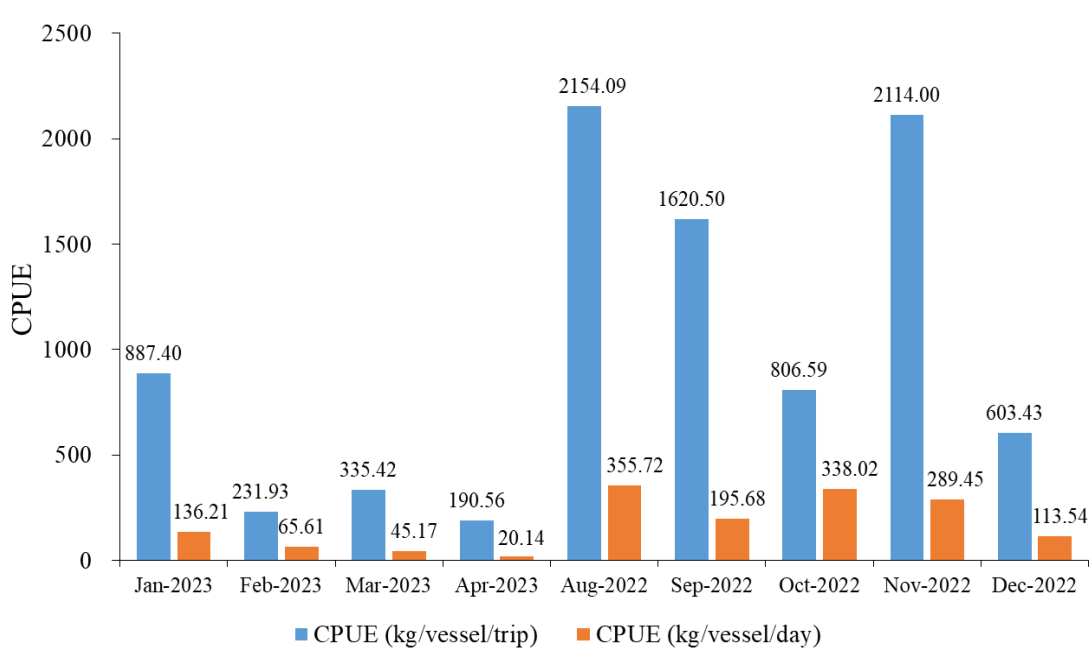

Fig. 3-6. Monthly average CPUE of *Monomia haanii* by kg/vessel/trip and by kg/vessel/day (values shown at the tops of the bars), surveyed in August 2022-April 2023 at the landing ports of Dongshan County.

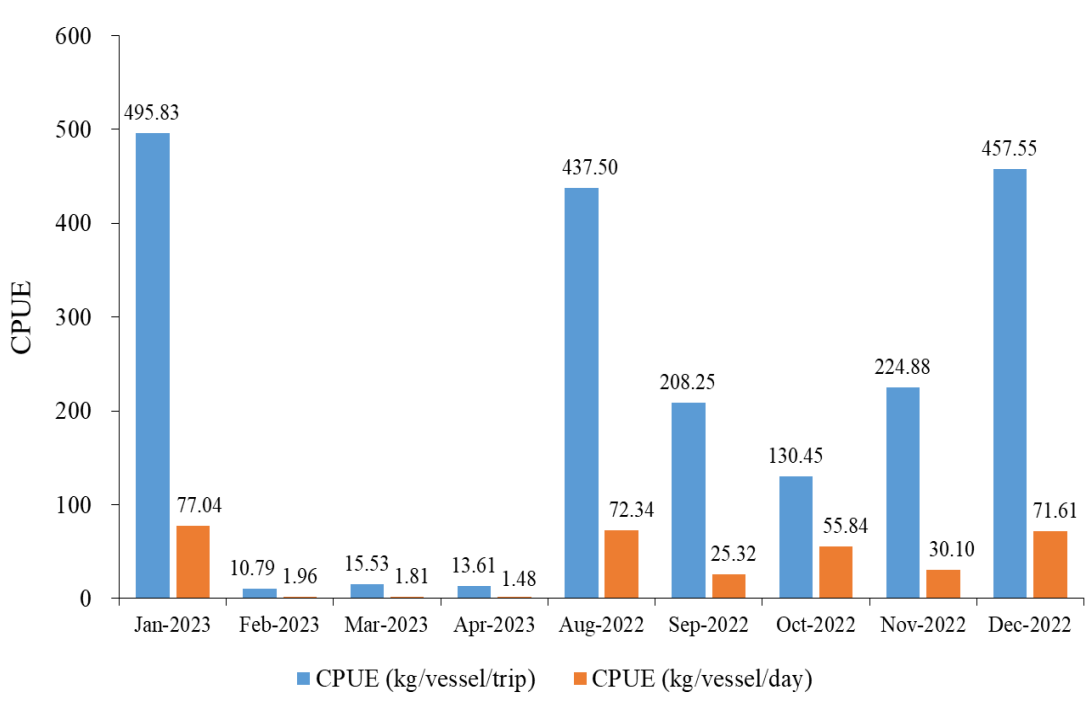

Fig. 3-7. Monthly average CPUE of *Portunus sanguinolentus* by kg/vessel/trip and by kg/vessel/day (values shown at the tops of the bars), surveyed in August 2022-April 2023 at the landing ports of Dongshan County.

3.5.3 Food fishes

In August 2022-April 2023, the dominant food fish species or species groups in trawl fishery in Dongshan County were *Evynnis cardinalis*, *Trachinocephalus myops*, *Saurida* spp. (mainly *Saurida elongata*), *Decapterus* spp. (mainly *D. maruadsi*), *Trachurus japonicus*, Sillaginidae spp. (mainly *Sillago sihama*), Mullidae spp. (mainly *Upeneus japonicus*), *Siganus fuscescens*, Trichiuridae spp., Callionymidae spp., Ammodytidae spp. (*Bleekeria viridianguilla* and *Bleekria mitsukurii*), Monacanthidae spp. (mainly *Paramonacanthus sulcatus* and *Stephanolepis cirrhifer*) and Tetraodontidae spp. (mainly *Lagocephalus wheeleri* and *Takifugu oblongus*).

For dominant food fish species and species groups, their capture volume proportions in the total capture volumes showed monthly variation (Table 3-5).

Based on the 101 trawl vessels surveyed at the landing ports of Dongshan County in August 2022-April 2023, food fishes contributed to 26.37% (in January 2023)-61.17% (in March 2023) of the total capture volumes (Fig. 3-8).

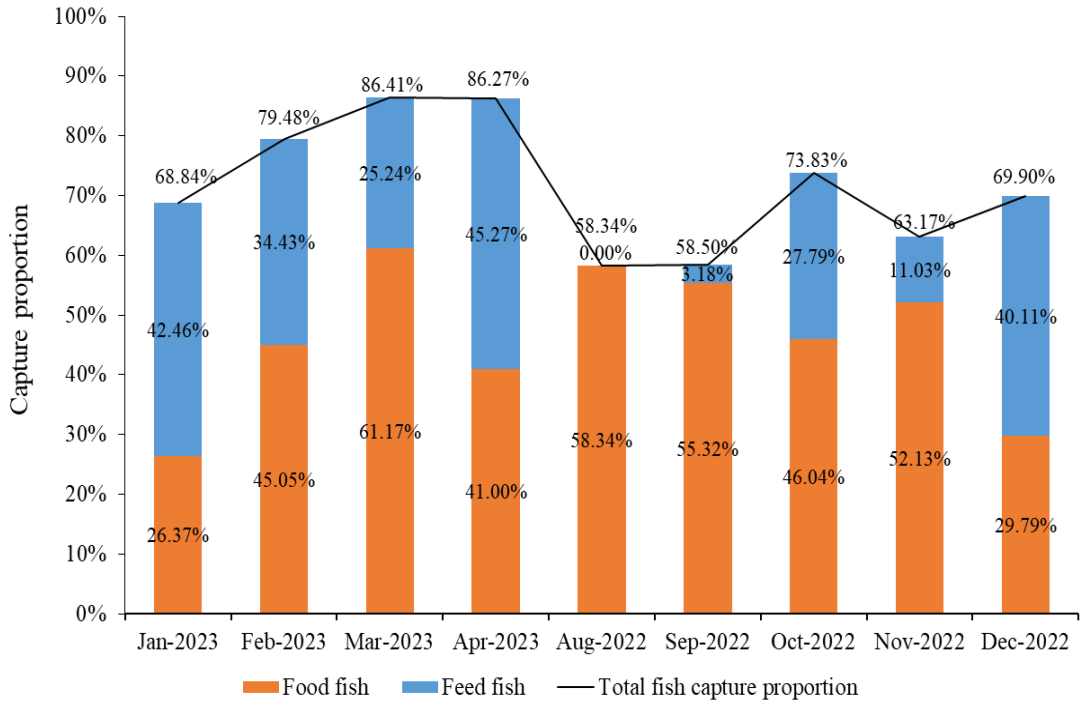

Fig. 3-8. Food and feed fish capture proportions (values on the tops of the bars) in the total capture volumes from trawl vessels surveyed (N = 101) in August 2022-April 2023 at the landing ports of Dongshan County.

Table 3-5. Dominant fish species or species groups in capture proportions of the total capture volumes in trawl vessels surveyed (N = 101) in August 2022-April 2023 at the landing ports of Dongshan County.

Fish Species/Groups	**Jan-2023**	**Feb-2023**	**Mar-2023**	**Apr-2023**	**Aug-2022**	**Sep-2022**	**Oct-2022**	**Nov-2022**	**Dec-2022**
Total fish%	68.84%	79.48%	86.41%	86.27%	58.34%	58.50%	73.83%	63.17%	69.90%
Trachinocephalus myops & *Saurida* spp.	3.03%	3.32%	3.60%	7.55%	5.34%	16.26%	2.88%	5.33%	4.39%
Evynnis cardinalis	1.15%	1.09%	1.35%	0.36%	21.41%	7.79%	8.14%	13.17%	1.22%
Sillaginidae spp.	0.99%	2.58%	2.94%	1.97%	4.21%	3.34%	2.03%	4.17%	0.51%
Decapterus spp. & *Trachurus japonicus*	9.05%	0.44%	0.58%	2.77%	14.58%	3.18%	20.14%	15.88%	6.04%
Mullidae spp.	1.32%	2.12%	0.96%	0.77%	3.59%	3.33%	1.31%	2.06%	2.86%
Ammodytidae spp.	0.00%	29.84%	50.59%	21.97%	0.00%	5.85%	1.50%	1.53%	0.00%
Trichiuridae spp.	2.40%	0.04%	0.08%	0.00%	0.43%	0.16%	2.37%	1.66%	1.35%
Tetraodontidae spp.	0.19%	0.89%	0.86%	0.08%	0.10%	0.81%	0.35%	1.13%	0.54%
Monacanthidae spp.	1.28%	0.45%	0.24%	1.00%	4.96%	11.49%	1.54%	1.17%	0.81%
Siganus fuscescens	1.27%	0.19%	0.05%	3.02%	0.12%	0.23%	0.09%	0.72%	5.60%
Callionymidae spp.	0.11%	1.45%	0.31%	0.45%	0.35%	0.09%	0.11%	0.11%	0.53%

3.5.4 Feed fishes

3.5.4.1 Capture proportions of feed fishes

The "feed fishes" in this report were those small-sized, low-valued, poorly preserved, fishes (also including crustaceans and cephalopods), with their destination to aquaculture farms, mentioned by the captains of the trawl vessels surveyed (Zhang et al., 2018).

Based on the 101 trawl vessels surveyed at the landing ports of Dongshan County in August 2022-April 2023, feed fishes contributed to 0.00% (August 2022)-45.27% (April 2023) of the total capture volumes; no feed fishes in August 2022 (Fig. 3-8).

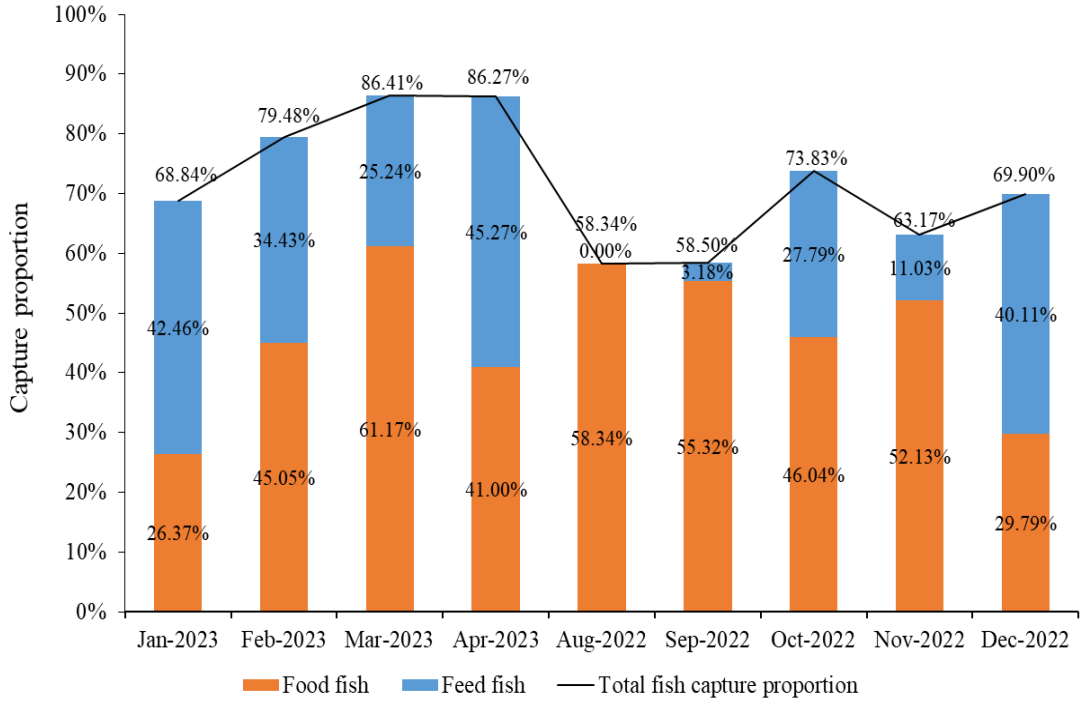

Fig. 4-8. Food and feed fish capture proportions (values on the tops of the bars) in the total capture volumes from trawl vessels surveyed (N = 101) in August 2022-April 2023 at the landing ports of Dongshan County.

3.5.4.2 Species diversity in feed fishes

Based on the monthly and randomly samplings of feed fishes (mean 1.70 kg/month, range of 1.43-2.30 kg) at the landing ports of Dongshan County from August 2022 to April 2023, 167 species with 118 fishes, 39 crustaceans and 10 cephalopods were identified (Table 3-6). There were 12 species dominated in feed fishes including fishes, crabs and squids, and some were commercially important.

Table 3-6. Species diversity, size range (standard length for fishes and cephalopods, carapace width for crabs) and proportions in feed fishes of trawl catches in August 2022-April 2023 in Dongshan County.

(*species only found in feed fishes) (Red: the first three dominant species or species group each month)

No.	Species name	Jan-2023		Feb-2023		Mar-2023		Apr-2023		Aug-2022		Sep-2022		Oct-2022		Nov-2022		Dec-2022	
		%	Size (cm)	%	Size (cm)	%	Size (cm)	%	Size (cm)	%	Size (cm)	%	Size (cm)	%	Size (cm)	%	Size (cm)	%	Size (cm)
1	*Caecula pterygera*	0.77	40.6	-	-	-	-	-	-	-	-	-	-	-	-	0.60	36.9	0.89	28.6-39.5
2	*Bascanichthys kirki*	-	-	-	-	-	-	-	-	-	-	1.72	50.0	-	-	-	-	-	-
3	*Pisodonophis cancrivorus*	-	-	-	-	-	-	0.56	28.6	-	-	-	-	-	-	-	-	-	-
4	*Pisodonophis boro*	-	-	-	-	-	-	-	-	-	-	-	-	-	-	1.01	34.4	-	-
5	*Callechelys kuro*	-	-	0.89	28.1-30.9	0.60	34.5	0.29	26.4	-	-	-	-	-	-	1.50	40.0	1.12	34.9
6	*Cirrhimuraena chinensis*	0.47	28.0	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
7	*Muraenesox cinereus*	-	-	-	-	-	-	-	-	1.67	22.9	-	-	-	-	-	-	-	-
8	*Oxyconger leptognathus*	-	-	-	-	-	-	1.29	29.8	-	-	-	-	5.99	22.0-26.0	-	-	1.03	27.0
9	*Ariosoma megalops*	-	-	-	-	-	-	0.38	13.5-13.6	0.39	13.1	-	-	0.70	18.6	-	-	0.33	13.4
10	*Uroconger lepturus*	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	0.32	15.0

11	*Congridae sp.	-	-	-	-	-	-	-	-	-	-	-	-	-	-	2.75	23.0-23.1	-	-
12	*Saurenchelys fierasfer*	-	-	-	-	-	-	-	-	-	-	0.54	35.4	0.61	36.6	-	-	-	-
13	*Thryssa kammalensis*	0.90	10.4	-	-	-	-	-	-	-	-	-	-	-	-	-	-	1.18	8.9-9.8
14	*Setipinna tenuifilis*	-	-	-	-	-	-	-	-	-	-	-	-	-	-	0.34	8.1	1.10	8.9-9.7
15	*Encrasicholina punctifer*	0.08	5.2	-	-	-	-	-	-	-	-	-	-	0.07	6.0	-	-	1.30	5.3-6.5
16	*Gonorynchus abbreviatus*	-	-	0.08	7.5	0.39	7.2-7.9	0.90	7.5-11.9	-	-	-	-	-	-	-	-	-	-
17	*Plotosus lineatus*	-	-	-	-	-	-	-	-	-	-	-	-	4.01	14.5-17.0	-	-	-	-
18	*Trachinocephalus myops*	2.04	7.1-9.2	8.70	3.5-15.0	3.93	6.9-10.6	1.81	4.9-8.2	-	-	2.14	2.6-9.8	0.82	4.6-5.9	0.79	4.5-5.0	1.78	5.4-7.0
19	*Synodus fuscus*	-	-	0.77	11.5	-	-	-	-	5.27	7.5-12.6	3.34	6.8-13.4	0.87	8.1-8.5	-	-	1.73	9.5-11.0
20	*Harpadon nehereus*	-	-	-	-	-	-	-	-	-	-	-	-	-	-	0.13	6.1-7.0	-	-
21	*Saurida elongata*	-	-	-	-	-	-	-	-	-	-	-	-	0.46	9.5	-	-	-	-
22	*Saurida undosquamis*	-	-	-	-	1.00	5.8-12.2	-	-	-	-	0.17	4.6-5.1	3.05	6.5-10.5	0.56	9.9	5.60	9.0-13.5
23	* *Benthosema pterotum*	0.10	3.3	-	-	-	-	-	-	-	-	-	-	-	-	0.17	2.4-3.2	-	-
24	*Bregmaceros pseu	-	-	-	-	-	-	-	-	-	-	-	-	-	-	0.32	7.8	-	-

	dolanceolatus																		
25	**Bregmaceros* sp.	0.30	4.2-6.1	-	-	0.12	6.8	2.97	4.2-7.3	-	-	0.06	4.9	-	-	0.10	5.6	0.79	4.9-5.9
26	**Ophidion muraenolepis*	0.35	9.3	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
27	**Dinematichthys iluocoeteoides*	-	-	-	-	0.02	3.5	0.04	4.3	-	-	-	-	-	-	-	-	-	-
28	*Hippocampus trimaculatus*	-	-	0.21	10.6	-	-	0.08	8.7	-	-	-	-	-	-	-	-	-	-
29	**Pegasus laternarius*	-	-	-	-	-	-	-	-	-	-	-	-	0.15	5.2	-	-	0.12	4.7
30	*Fistularia petimba*	-	-	-	-	-	-	-	-	-	-	-	-	0.45	24.5	-	-	-	-
31	**Apistus carinatus*	2.17	2.4-5.0	1.37	4.0-5.7	3.98	3.9-11.1	4.41	3.4-7.2	0.03	2.4	1.35	2.4-9.1	4.55	4.6-11.5	1.17	4.4-6.4	1.14	2.0-5.9
32	**Minous pusillus*	-	-	-	-	-	-	0.34	6.1	-	-	0.37	5.9	-	-	-	-	-	-
33	**Minous monodactylus*	-	-	-	-	-	-	-	-	-	-	0.08	2.7	-	-	0.10	3.6	0.11	3.9
34	**Aploactis aspera*	-	-	-	-	0.45	8.0	-	-	-	-	-	-	-	-	-	-	-	-
35	*Chelidonichthys spinosus*	-	-	-	-	-	-	-	-	-	-	-	-	-	-	1.46	10.5	-	-
36	**Lepidotrigla alata*	-	-	-	-	-	-	-	-	1.53	-	-	-	-	-	-	-	-	-
37	**Onigocia spinosa*	-	-	-	-	0.70	8.7	-	-	-	-	0.49	7.6	-	-	-	-	0.44	4.9-6.5
38	**Sorsogona tuberculata*	1.07	6.7-8.5	2.12	5.5-8.8	1.94	4.5-7.6	3.65	6.7-12.3	-	-	8.07	10.6-14.0	0.26	5.0-5.2	-	-	0.43	5.6-6.4
39	**Rogadius asper*	-	-	-	-	-	-	-	-	-	-	0.52	8.2	-	-	-	-	-	-

40	**Inegocia japonica*	-	-	-	-	-	-	-	-	4.79	18.5	-	-	-	-	-	-	-	-
41	**Inegocia guttata*	-	-	2.63	16.9	-	-	-	-	2.55	13.4	-	-	-	-	-	-	-	-
42	*Platycephalidae sp.	-	-	-	-	0.14	6.1	-	-	-	-	-	-	-	-	-	-	-	-
43	**Acropoma japonicum*	-	-	-	-	-	-	-	-	-	-	-	-	-	-	0.36	2.5-4.6	0.10	4.1
44	*Priacanthus macracanthus*	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	0.04	3.0
45	*Priacanthus tayenus*	-	-	-	-	-	-	-	-	-	-	-	-	1.69	10.0	-	-	0.16	4.2
46	**Ostorhinchus kiensis*	-	-	-	-	-	-	-	-	0.61	3.8-4.1	-	-	-	-	-	-	-	-
47	*Ostorhinchus fasciatus*	-	-	-	-	-	-	-	-	-	-	-	-	-	-	0.50	3.1-5.9	-	-
48	**Apogonichthyoides niger*	-	-	1.49	6.2-6.7	0.81	5.5-6.5	-	-	-	-	0.04	2.7	0.45	4.2-4.8	-	-	1.13	4.2-5.5
49	**Jaydia truncata*	-	-	-	-	-	-	-	-	-	-	-	-	-	-	0.65	4.9-6.4	-	-
50	*Sillago ingenuua*	4.72	5.4-12.9	4.63	6.5-10.0	0.95	8.9-10.1	-	-	15.30	7.4-10.2	12.28	6.3-9.3	1.04	3.1-10.6	3.44	9.5-11.9	8.12	5.5-9.5
51	*Sillaginidae sp.	-	-	-	-	-	-	0.10	4.9	-	-	-	-	-	-	-	-	-	-
52	*Selaroides leptolepis*	-	-	-	-	-	-	-	-	-	-	-	-	1.10	4.5-7.8	-	-	-	-
53	**Carangoides equula*	-	-	-	-	0.16	5.1	-	-	-	-	-	-	-	-	-	-	-	-
54	*Decapterus maruadsi*	-	-	-	-	-	-	1.45	5.9-13.4	-	-	-	-	-	-	-	-	-	-

55	*Trachurus japonicus*	-	-	-	-	2.53	3.5-6.2	1.04	5.7-8.1	-	-	-	-	-	-	-	-	-	-
56	**Secutor ruconius*	1.29	3.5-5.2	-	-	-	-	-	-	-	-	-	-	-	-	-	-	0.62	4.0-5.1
57	**Equulites rivulatus*	0.56	4.0-4.5	2.67	5.0-6.4	1.35	4.5-6.5	0.11	5.1	0.48	2.7-4.4	6.05	2.3-4.5	-	-	-	-	2.39	4.0-6.4
58	**Photopectoralis bindus*	-	-	-	-	-	-	-	-	0.22	4.6	-	-	0.09	3.9	-	-	-	-
59	**Scolopsis vosmeri*	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	1.69	8.9
60	**Nemipterus bathybius*	-	-	-	-	-	-	-	-	-	-	0.14	4.7	-	-	-	-	-	-
61	*Nemipterus japonicus*	-	-	-	-	-	-	-	-	-	-	-	-	1.40	10.1	-	-	-	-
62	*Evynnis cardinalis*	-	-	-	-	0.65	2.3-4.0	3.73	3.4-5.8	2.42	-	-	-	-	-	-	-	-	-
63	*Polydactylus sextarius*	-	-	-	-	-	-	-	-	-	-	-	-	-	-	2.44	5.5-7.9	-	-
64	**Johnius distinctus*	0.78	8.5	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
65	*Johnius trewavasae*	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	1.39	10.2
66	**Johnius* sp.1	-	-	-	-	-	-	-	-	-	-	-	-	-	-	0.37	6.6	-	-
67	**Johnius* sp.2	-	-	-	-	-	-	-	-	-	-	-	-	-	-	1.19	9.8	-	-
68	*Pennahia macrocephalus*	0.61	3.4-5.5	-	-	-	-	-	-	-	-	-	-	-	-	18.71	2.9-8.0	1.96	6.5-7.5
69	*Pennahia argentata*	1.32	2.9-9.6	-	-	-	-	-	-	-	-	-	-	-	-	3.66	5.5-9.4	-	-
70	**Pennahia pawak*	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	0.75	7.9

71	*Sciaenidae sp.	-	-	-	-	-	-	-	-	-	-	-	-	-	-	0.05	3.7	-	-
72	*Upeneus japonicus*	1.48	7.8-8.1	0.68	8.5	-	-	0.98	3.5-9.9	6.01	7.1-9.5	4.57	4.4-8.2	4.56	4.7-11.5	1.21	10.2	3.44	4.4-6.9
73	*Teixeirichthys jordani*	0.97	7.5	1.68	7.5-7.9	10.79	7.9-9.5	1.43	9.6	4.85	7.1-8.5	9.68	2.3-9.0	1.17	8.1	-	-	1.72	9.3
74	**Suezichthys gracilis*	0.50	7.9	-	-	-	-	-	-	-	-	-	-	-	-	-	-	0.30	7.2
75	**Champsodon guentheri*	-	-	-	-	0.12	3.5-4.8	-	-	0.56	5.0-6.9	0.17	4.7-4.8	-	-	-	-	-	-
76	**Parapercis ommatura*	0.15	5.8	-	-	0.24	6.9	-	-	-	-	-	-	-	-	-	-	-	-
77	*Callionymus huguenini*	6.10	3.9-11.0	8.26	2.9-65.0	2.99	7.9-13.4	4.43	4.3-11.4	6.80	5.5-9.5	1.22	5.1-9.4	4.56	4.0-11.5	1.82	6.6-9.3	4.66	4.0-10.2
78	*Callionymus planus*	0.12	3.7-4.2	2.35	3.8-7.5	2.77	4.5-9.5	9.40	5.9-10.6	1.16	7.9-8.6	-	-	-	-	-	-	-	-
79	**Callionymus curvicornis*	0.77	9.9	-	-	-	-	-	-	-	-	-	-	-	-	1.76	14.6	-	-
80	**Callionymus* sp.	-	-	-	-	-	-	-	-	2.26	13.6	-	-	-	-	-	-	-	-
81	**Percophidae* sp.	-	-	0.10	3.9-4.4	0.04	3.6-4.1	0.02	3.3-3.5	-	-	0.07	5.4	-	-	0.15	3.6-5.6	-	-
82	*Trichonotus filamentosus*	0.77	7.6-9.9	0.55	6.2-9.6	0.89	6.1-9.8	0.66	6.4-9.1	0.23	9.6	1.13	9.9-10.8	0.31	8.5-9.0	1.05	8.6-10.4	0.14	8.5
83	*Trichonotus setiger*	3.65	6.0-12.5	4.24	9.9-14.1	7.15	7.0-14.3	3.95	10.0-13.5	1.71	9.3-13.4	0.78	7.3-10.8	0.49	13.5	2.32	11.5-15.0	0.90	11.5-13.7
84	*Trichonotus elegans*	0.95	6.0-9.5	3.18	7.0-	3.13	5.7-	2.91	5.1-	-	-	-	-	1.97	10.5-	1.04	6.2-	0.45	6.7-

					11.0		11.0		10.4						12.3		10.6		10.4
85	*Bleekeria viridianguilla*	4.97	8.2-11.2	26.48	4.1-10.9	14.30	6.5-11.5	22.49	4.8-12.3	-	-	8.72	7.4-13.3	19.38	9.0-12.1	11.60	3.7-14.5	5.37	8.9-14.1
86	*Bleekria mitsukurii*	2.59	8.4-11.4	11.82	7.9-11.4	9.85	8.0-13.5	4.85	5.2-10.5	4.24	8.2-10.0	8.49	8.4-10.2	1.42	8.5-9.7	4.07	7.3-11.0	2.83	8.7-10.2
87	**Uranoscopus bicinctus*	2.55	10.2	1.11	2.0-8.9	-	-	-	-	-	-	1.22	8.4	-	-	-	-	-	-
88	*Uranoscopus japonicus*	-	-	0.30	5.9	2.12	10.5	0.29	3.5-4.7	-	-	-	-	3.30	12.2	-	-	0.12	2.2-2.8
89	**Ichthyscopus pollicaris*	-	-	-	-	-	-	-	-	-	-	-	-	0.03	2.4	-	-	-	-
90	**Oxyurichthys microlepis*	-	-	-	-	-	-	-	-	-	-	-	-	0.12	8.6	-	-	-	-
91	**Valenciennea wardi*	-	-	-	-	-	-	-	-	0.78	7.8	-	-	1.16	8.1-8.8	-	-	-	-
92	*Siganus fuscescens*	-	-	-	-	-	-	-	-	5.03	13.0	-	-	-	-	-	-	-	-
93	*Trichiurus lepturus*	-	-	-	-	-	-	-	-	-	-	-	-	2.67	-	-	-	-	-
94	**Trichiurus japonicus*	2.36	19.2-32.6	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
95	**Trichiurus brevis*	1.48	38.9	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
96	*Scomber japonicus*	-	-	-	-	3.95	4.7-9.8	-	-	-	-	-	-	-	-	-	-	-	-
97	**Tarphops oligolepis*	-	-	-	-	-	-	-	-	2.30	4.4-6.5	2.35	4.5-6.9	-	-	-	-	-	-
98	**Engyprosopon*	2.77	6.4-8.1	5.56	5.4-	8.72	5.5-	4.72	5.0-9.7	1.96	5.5-8.0	9.41	4.4-	-	-	-	-	0.10	4.8

	multisquama				9.0		9.1						10.4						
99	**Engyprosopon* sp.	-	-	-	-	-	-	0.31	7.2	-	-	-	-	-	-	-	-	-	-
100	**Crossorhombus azureus*	-	-	-	-	-	-	-	-	-	-	1.17	9.4	-	-	-	-	-	-
101	**Crossorhombus* sp.	-	-	-	-	0.02	2.8	-	-	-	-	-	-	-	-	-	-	-	-
102	**Arnoglossus macrolophus*	-	-	-	-	-	-	-	-	-	-	-	-	-	-	0.23	6.8	-	-
103	**Arnoglossus tenuis*	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	0.40	8.1
104	**Arnoglossus* sp.	0.14	5.6	-	-	-	-	-	-	-	-	-	-	0.13	5.0	-	-	-	-
105	*Bothidae sp.	-	-	-	-	-	-	0.01	2.6	-	-	-	-	-	-	-	-	-	-
106	*Pleurinichthys cornutus*	2.18	8.9-9.1	-	-	-	-	-	-	0.97	7.5	-	-	-	-	4.27	8.1-10.9	0.64	8.0
107	**Solea ovata*	0.53	6.5	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
108	**Zebrias crossolepis*	-	-	-	-	-	-	-	-	-	-	-	-	0.17	5.6	-	-	-	-
109	**Pseudaesopia japonica*	-	-	-	-	-	-	-	-	-	-	-	-	-	-	0.30	6.6	-	-
110	*Soleidae sp.	-	-	-	-	-	-	-	-	-	-	1.23	11.5	-	-	-	-	-	-
111	*Liachirus melanospilos*	1.76	10.5	-	-	3.92	8.9-10.4	-	-	-	-	-	-	-	-	0.45	6.6	0.25	5.5
112	**Cynoglossus itinus*	0.13	5.5	0.72	11.7	0.71	5.5-7.1	3.19	5.5-11.5	3.33	15.1	-	-	-	-	0.66	10.0	-	-
113	**Cynoglossus interruptus*	0.14	5.0	-	-	-	-	-	-	-	-	-	-	-	-	1.30	10.2	-	-
114	**Cynoglossus* sp.	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	0.52	9.5

115	*Stephanolepis cirrhifer*	-	-	-	-	-	-	-	-	-	-	0.44	2.1-2.8	-	-	-	-	-	-
116	*Paramonacanthus sulcatus*	1.16	6.2-7.0	-	-	-	-	0.75	8.2	-	-	-	-	21.26	4.6-8.0	5.76	4.2-6.5	4.23	5.9-7.3
117	*Paramonacanthus pusillus*	-	-	-	-	-	-	-	-	-	-	0.23	4.5	-	-	-	-	-	-
118	*Lagocephalus wheeleri*	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	1.28	8.4
119	**Oratosquilla fabricii*	0.80	9.2	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
120	**Lophosquilla costata*	0.48	6.0-6.3	-	-	-	-	0.56	5.9-7.5	-	-	-	-	0.15	5.8	-	-	0.07	4.3
121	**Carinosquilla multicarinata*	0.19	5.5	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
122	**Oratosquillina interrupta*	-	-	-	-	-	-	-	-	-	-	-	-	-	-	0.30	6.4	-	-
123	*Odontodactylus japonicus*	-	-	-	-	-	-	-	-	-	-	2.49	-	-	-	-	-	-	-
124	**Sicyonia* sp.	-	-	-	-	-	-	-	-	-	-	0.10	3.9	0.10	4.1	-	-	-	-
125	*Palaemonidae sp.	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	0.04	3.4
126	*Trachysalambria curvirostris*	3.34	5.7-7.5	0.13	5.5	-	-	-	-	-	-	0.31	4.5-6.0	0.48	5.8-6.2	-	-	2.19	4.5-8.7
127	**Trachysalambria longipes*	-	-	-	-	-	-	-	-	-	-	-	-	-	-	1.08	5.4-6.4	-	-
128	*Parapenaeopsis*	0.54	5.9-6.9	-	-	-	-	-	-	-	-	-	-	-	-	0.78	5.5-	0.12	-

	hardwickii															6.7		
129	*Kishinouyepenaeopsis cornuta*	1.54	5.4-7.0	0.07	5.1	0.49	4.8-7.3	-	-	-	-	-	-	-	-	1.74	4.3-6.5	3.20	4.5-7.5
130	**Batepenaeopsis tenella*	-	-	-	-	-	-	-	-	-	-	-	-	0.07	2.3-4.2	-	-	-	-
131	*Metapenaeopsis barbata*	4.41	6.1-8.1	0.33	6.5-6.6	-	-	-	-	-	-	-	-	1.64	5.5-7.3	0.28	7.1	0.95	8.0
132	**Metapenaeopsis* sp.1	1.53	3.6-6.5	0.68	3.5-5.7	0.90	3.4-5.4	1.18	0.2-5.3	-	-	0.13	3.1-4.0	0.10	3.0-4.2	0.09	2.4-3.8	2.19	3.3-5.1
133	**Metapenaeopsis* sp.2	-	-	-	-	0.16	7.2	0.44	7.0-7.5	-	-	0.29	#NUM!	-	-	0.44	4.0-6.8	2.40	5.4-7.2
134	*Penaeidae sp.1	-	-	-	-	-	-	-	-	0.24	1.7	-	-	-	-	-	-	-	-
135	*Penaeidae sp.2	-	-	-	-	-	-	-	-	0.49	0.8-1.0	-	-	-	-	-	-	-	-
136	**Leptochela gracilis*	0.01	2.3	-	-	-	-	-	-	-	-	-	-	-	-	0.01	2.2	0.03	1.8-3.1
137	**Scyllarus cultrifer*	-	-	-	-	-	-	-	-	-	-	-	-	0.04	2.4	-	-	-	-
138	**Albunea* sp.	-	-	-	-	-	-	-	-	0.09	1.3	-	-	-	-	-	-	-	-
139	**Lauridromia dehaani*	-	-	-	-	-	-	-	-	-	-	-	-	-	-	0.32	2.1	-	-
140	**Paradorippe granulata*	-	-	-	-	0.08	1.3	-	-	-	-	-	-	-	-	-	-	-	-
141	*Majidae sp.	-	-	-	-	-	-	-	-	0.03	1.2	-	-	-	-	-	-	-	-
142	**Myra* sp.	-	-	-	-	-	-	0.03	1.3	-	-	-	-	-	-	-	-	0.13	1.8
143	*Leucosiidae sp.	-	-	0.06	0.8-1.0	-	-	-	-	-	-	-	-	-	-	-	-	-	-

144	*Calappa philargius*	1.42	2.8-4.2	-	-	-	-	0.23	4.3	0.30	1.2-2.0	0.15	1.4-2.0	0.14	2.3	0.11	2.1	1.00	2.0-2.6
145	**Calappa hepatica*	-	-	-	-	-	-	-	-	0.35	2.7	-	-	-	-	-	-	-	-
146	**Cycloes granulosa*	-	-	-	-	1.05	3.7	0.08	0.9-1.9	-	-	-	-	-	-	-	-	-	-
147	**Matuta planipes*	0.05	1.6	0.25	1.9-2.2	0.53	2.6-3.4	1.17	2.4-3.8	-	-	-	-	-	-	-	-	0.05	1.9
148	**Portunus hastatoides*	2.12	3.5-4.4	-	-	-	-	-	-	-	-	-	-	-	-	0.33	3.1-3.6	0.09	3.1
149	**Portunus gracilimanus*	1.37	4.4	-	-	0.04	1.4	-	-	-	-	-	-	1.13	1.4-3.3	3.06	2.9-4.1	0.70	3.1-3.5
150	*Portunus sanguinolentus*	0.04	2.1	-	-	-	-	0.04	2.7	0.16	1.8-3.2	0.07	1.7-2.5	0.05	2.5	-	-	0.98	2.2-6.7
151	**Portunus argentatus*	-	-	-	-	-	-	2.33	2.8-6.2	0.18	2.8	-	-	0.42	1.9-3.0	-	-	-	-
152	*Monomia haanii*	20.67	1.6-5.9	1.50	1.7-4.2	2.38	1.2-5.3	7.29	1.2-5.8	4.63	2.1-6.3	3.65	1.4-8.0	1.68	2.6-4.9	8.47	2.1-5.0	10.14	2.7-6.6
153	**Charybdis bimaculata*	0.62	2.1-2.6	-	-	-	-	-	-	-	-	-	-	-	-	0.83	1.9-2.8	0.27	1.9-2.2
154	*Charybdis nataor*	-	-	-	-	-	-	-	-	-	-	-	-	0.06	1.8	-	-	-	-
155	**Charybdis variegata*	0.45	1.6-2.3	0.92	2.4-3.3	0.59	0.9-2.9	0.22	1.7-2.2	0.27	1.4-1.7	-	-	0.94	1.2-2.4	0.05	1.7	0.45	1.6-2.3
156	**Porcellana pulchra*	-	-	-	-	-	-	0.01	0.6	-	-	-	-	-	-	-	-	-	-
157	*Porcellanidae sp.	-	-	-	-	-	-	0.04	1.4	-	-	-	-	-	-	-	-	-	-
158	*Sepia esculenta*	-	-	-	-	-	-	-	-	-	-	0.63	4.9	-	-	-	-	-	-
159	*Sepiola berryi*	1.59	1.9-3.6	1.86	1.8-3.7	1.33	1.7-3.8	-	-	-	-	-	-	-	-	1.08	5.0-8.1	3.07	5.7-9.2

160	**Sepiadarium kochii*	0.09	1.8	0.07	2.0	0.61	1.6-2.5	0.77	1.8-2.6	-	-	-	-	-	-	0.28	7.2-8.2	-	-
161	**Sepiola* sp.	-	-	-	-	-	-	1.38	1.3-3.9	-	-	-	-	-	-	-	-	-	-
162	*Loliolus uyii*	-	-	0.24	3.5-4.5	-	-	-	-	-	-	-	-	-	-	-	-	-	-
163	*Loliginidae spp.	2.29	2.5-5.4	1.33	4.5-8.0	0.41	7.0	0.53	13.4	11.16	2.8-7.5	3.95	4.0-7.0	0.56	6.0	0.38	2.9-4.4	5.94	6.8-22.6
164	*Octopus ocellatus*	-	-	-	-	-	-	-	-	4.66	4.1-4.8	-	-	1.99	2.3-3.0	-	-	-	-
165	*Amphioctopus aegina*	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	0.63	15.5
166	**Hapalochlaena lunulata*	-	-	-	-	-	-	0.18	2.3	-	-	-	-	-	-	-	-	-	-
167	Octopodidae sp.	0.68	4.4	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-

3.5.4.3 *Monomia haanii* in feed fishes

M. haanii was one of the few common species found in feed fish samples from trawl catches in Dongshan County and contributed to 1.50%-20.67% of the total feed fish volumes in August 2022-April 2023 (Table 3-6).

Based on the size for 50% female maturity (6.3 cm CW) of *M. haanii* (Lin et al., 2021), up to 97.30% individuals (n = 148) of *M. haanii* were juveniles in feed fishes, and the juvenile proportions were in 66.67%-100.00% in August 2022-April 2023. The smallest size of *M. haanii* in feed fishes was 1.2 cm CW, caught in March 2023.

3.5.5 Average capture proportions from 2018 to 2023 (Phases I-VI)

Based on the trawl vessels surveyed at the landing ports of Dongshan County from August 2018 to April 2023 (Phases I-VI), the highest average total capture volume was about 10813.98 kg/vessel/trip in August 2020-December 2020 (Phase IV) and the lowest was about 7855 kg/vessel/trip estimated from surveys in August 2018-December 2018 (Phase I) (Table 3-7). The largest proportion of total capture volume was fish, over 70% in each phase, followed by crustacean, then by cephalopod. The proportions of feed fish in 2019-2020 (< 17%) was lower than in 2021-2022 (>25%).

Table 3-7. Average capture volumes and proportions from trawl vessels surveyed from 2018 to 2023 (in Phase I-VI) at the landing ports of Dongshan County.

Phase		**VI**	**V**	**IV**	**II-III**	**I**
Survey period		2022.8-2023.4	2021.10-2022.4	2020.8-2020.12	2019.1-2019.4 & 2019.8-2019.12	2018.8-2018.12
Number of vessels surveyed		101	79	54	79	61
Fishing days(days/trip)		6.22	6.34	6.48	7.16	7.67
Total capture volume(kg/vessel/trip)		8179.9	8751.28	10813.89	8153.79	7855
Crustacean	volume(kg/vessel/trip)	1489.73	1132.84	1621.48	1202.46	-
	proportion	18.21%	12.94%	14.99%	14.75%	-
Shrimp	volume(kg/vessel/trip)	239.83	360.31	212.38	271.49	-
	proportion	2.93%	4.12%	1.96%	3.46%	-
Crab	volume(kg/vessel/trip)	1249.90	772.71	1409.09	920.33	1603.00
	proportion	15.28%	8.83%	13.03%	11.29%	20.41%
Fish	volume(kg/vessel/trip)	5875.85	6731.53	8290.82	5805.80	-
	proportion	71.83%	76.92%	76.67%	71.20%	-
Food fish	volume(kg/vessel/trip)	3802.60	4039.44	7128.06	4435.31	-
	proportion	46.49%	46.16%	65.92%	54.39%	-
Feed fish	volume(kg/vessel/trip)	2073.25	2692.09	1162.76	1370.49	-

	proportion	25.35%	30.76%	10.75%	16.81%	-
Cephalopod	volume(kg/vessel/trip)	814.32	886.91	901.00	1145.54	-
	proportion	9.96%	10.13%	8.33%	14.05%	-

3.6 Biology of *Monomia haanii*

Monomia hannii samplings were conducted from trawl catches monthly from August 2022 to April 2023. A total of 2,122 individuals were collected and measured.

3.6.1 Size variation by month

Sizes (carapace width, CW in cm) of *M. haanii* ranged from 1.2 to 12.2 cm CW, and monthly average sizes ranged from 6.4 cm CW in April 2023 to 8.5 cm CW in February 2023 (Table 3-8; Fig. 3-9).

The minimum sizes of *M. haanii* in Phases I-V (August 2018-April 2022) were larger than those in Phase VI, the minimum size was 2.2 cm CW in Phases I-III, the minimum size was 1.7 cm CW in Phase V, and the minimum size was 1.2 cm CW in Phase VI (Table 3-8).

The dominant size classes of *M. haanii* in August 2022-April 2023 showed monthly variation (Fig. 3-9):

(1) Proportions of larger sizes (≥ 10.0 cm CW) were the highest in December 2022 at 20.28%, relatively higher in January 2023, February 2023 and November 2022 at 10%-15% and less than 5% in the rest of months.

(2) Proportions of the sizes smaller than 8.0 cm CW (the minimum size for catch regulation in Fujian Province, 2018) in the total catch of *M. haanii* were high; > 80% in April 2023 (81.56%) and August 2022 (95.02%), and >50% in January 2023 (54.75%) and March 2023 (62.03%). Proportions were relatively low in September 2022 (44.95%), October 2022 (42.92%), November 2022 (31.02%) and December 2022 (36.79%). The lowest proportion was recorded in February 2023 (17.99%).

(3) Sizes smaller than 6.0 cm CW (around the size at 50% sexual maturity) were found in all months, and mainly in January 2023 (22.17%) and April 2023 (38.44%).

Table 3-8. Number of samples and size (carapace width, CW, cm) of *Monomia haanii* from trawl fishery in Dongshan County in August 2022-April 2023

Month	Number	Range of CW (cm)	Average CW (cm)
Jan-2023	221	1.6-11.5	7.6
Feb-2023	189	1.7-11.5	8.5
Mar-2023	237	1.2-10.4	7.2

Apr-2023	385	1.2-11.5	6.4
Aug-2022	281	2.1-11.2	6.6
Sep-2022	198	1.4-10.1	8.0
Oct-2022	212	2.6-10.7	8.1
Nov-2022	187	2.1-11.4	8.0
Dec-2022	212	2.7-12.2	8.1

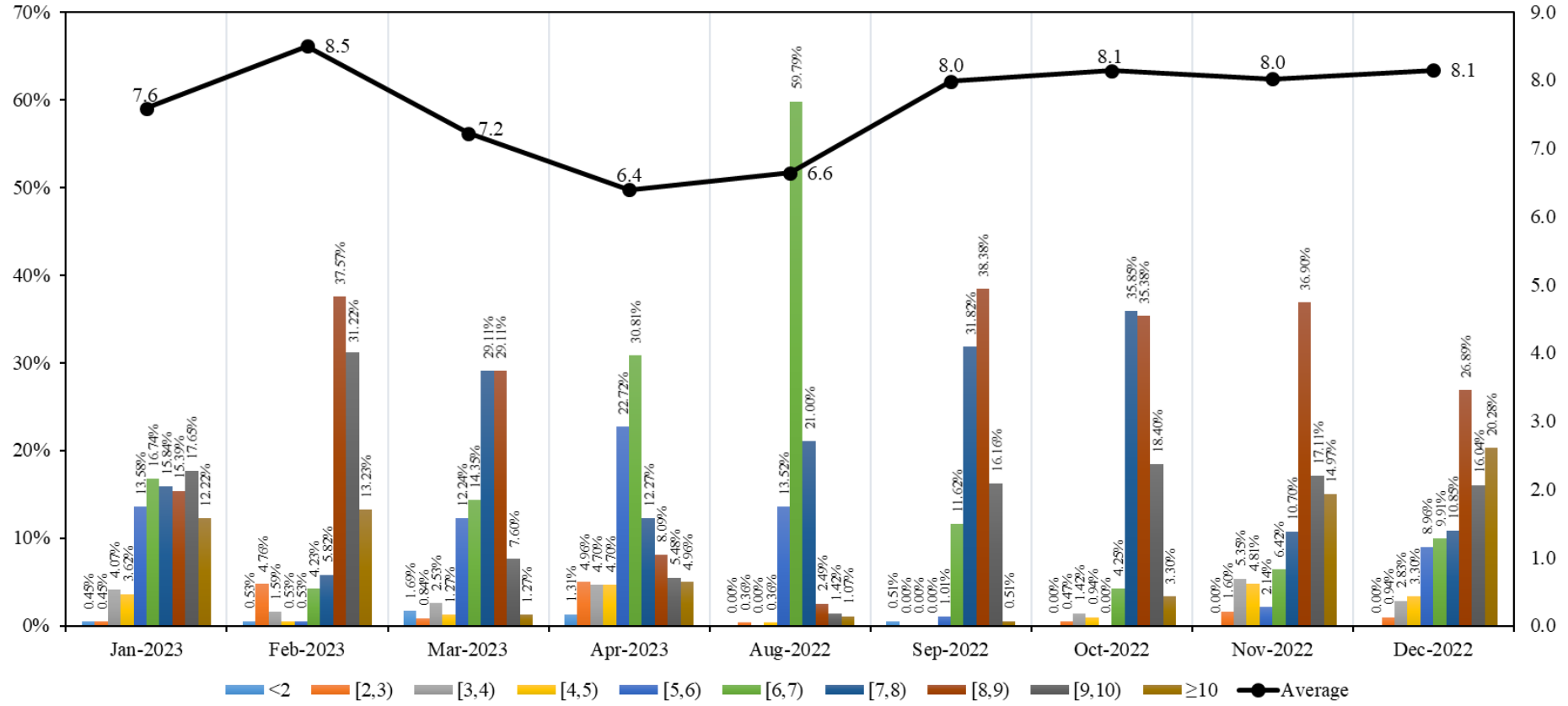

Fig. 3-9. Proportions of different size classes (cm in carapace width) of *Monomia haanii* (left Y-axis) and the trends of the monthly average sizes (right Y-axis) in trawl catches of Dongshan County from August 2022 to April 2023.

3.6.2 Size variation by sex

The sizes ranged from 1.2 to 11.5 cm CW for females (mean = 7.2, SD = 1.5, N = 1331), and from 1.2 to 12.2 cm CW for males (mean = 7.9, SD = 2.2, N = 791) (Fig. 3-10). Males were significantly larger than females in CW (W = 399,570, p < 0.01). Females dominated in size classes of 5.0-9.0 cm CW, and males in size classes of 6.0-11.0 cm CW.

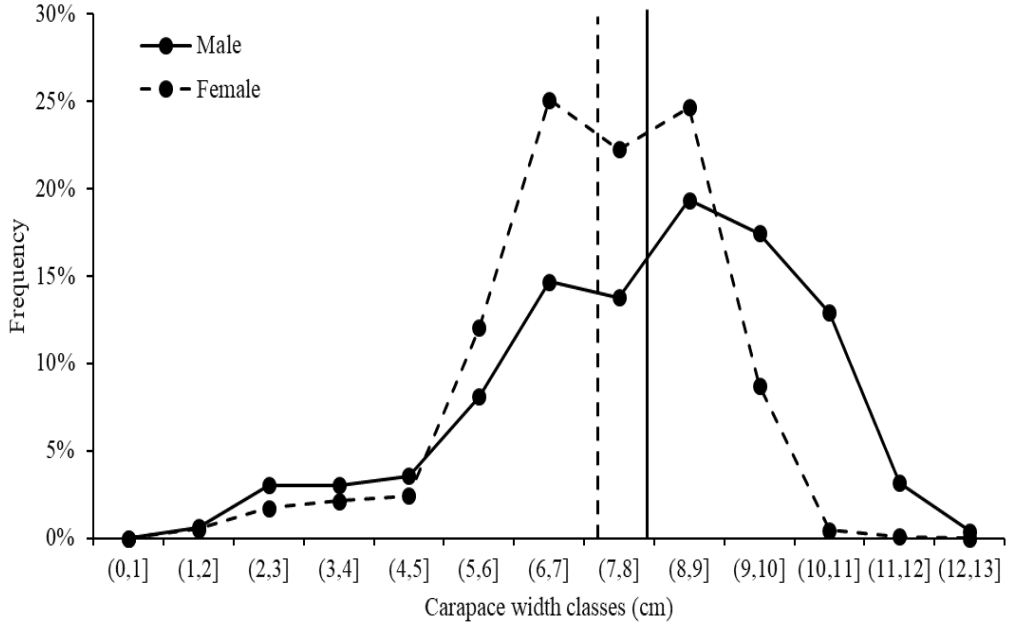

Fig. 3-10. Size (carapace width, CW) frequency (%) of *Monomia haanii* males (N = 791) and females (N = 1331), collected from August 2022 to April 2023. Vertical lines indicate the average sizes of males and females.

3.6.3 Sex ratio

Sex ratios of *M. haanii* showed monthly variation. From the 2,122 individuals randomly sampled, the overall sex ratio of *M. haanii* was 1:1.68 (male: female, N = 791 for males, N = 1,331 for females), showing a significant female-bias (p <0.05). Significant female-bias sex ratios were observed in February 2023, March 2023, April 2023, August 2022, November 2022 and December 2022 (p <0.05) (Fig. 3-11).

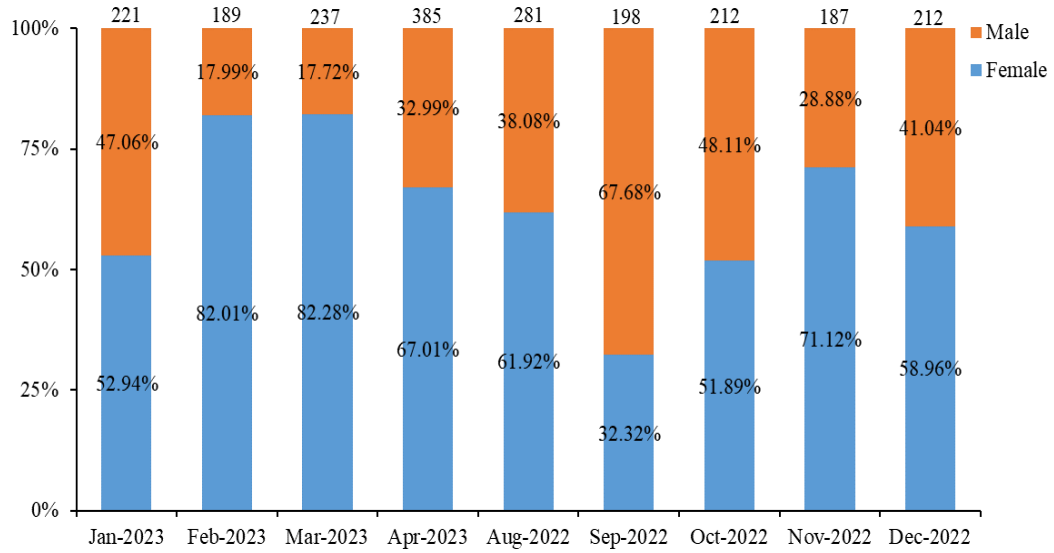

Fig. 3-11. Proportions of males and females of *Monomia haanii* (N = 2,122) in trawl catches of Dongshan County in August 2022-April 2023.
(Total number of samples showed at the top of the bars)

3.6.4 Spawning season

M. haanii females carrying eggs were found in most of sampling months except September 2022 and December 2022. The spawning peak was in February and March 2023, determining by the high proportions (%) of number of females carrying eggs/number of females (Fig. 3-12).

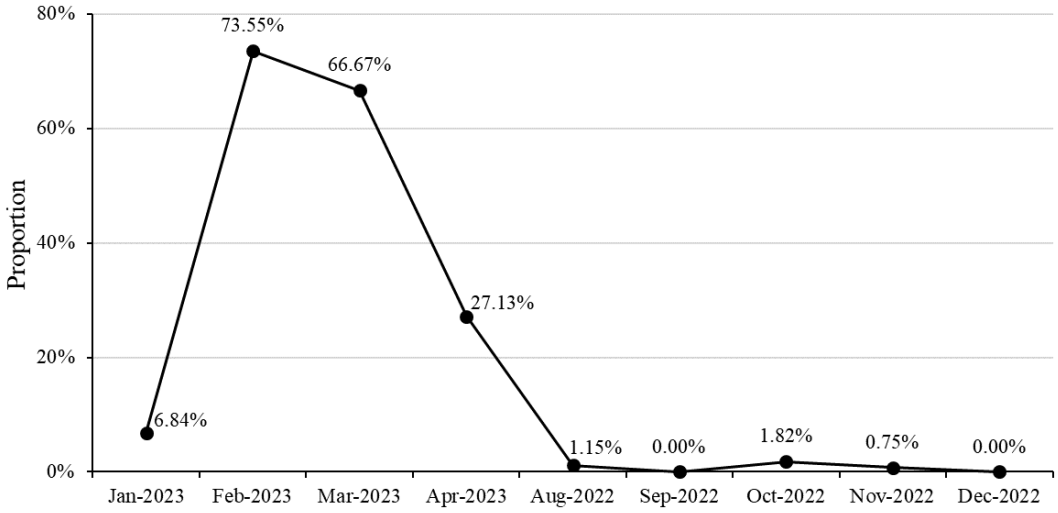

Fig. 3-12. Proportions of *Monomia haanii* females carrying eggs in trawl catches of Dongshan County in August 2022-April 2023.

3.6.5 Spawning season from 2018 to 2023 (Phases I-VI)

According to the surveys from 2018 to 2023 (Phases I-VI), *M. haanii* females carrying eggs were found in most of sampling months. The proportions of individuals carrying eggs was high in January-April, indicating the consistent spawning peak of *M. haanii*. In addition, there may have another spawning peak in August (2018 and 2019) (Fig. 3-13).

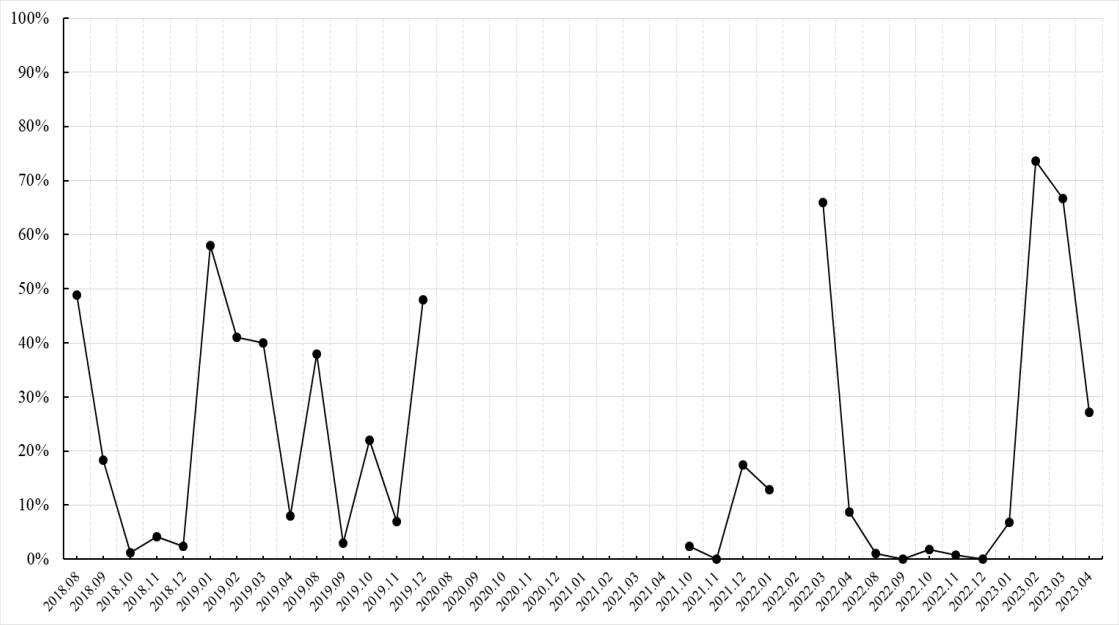

Fig. 3-13. Proportions of *Monomia haanii* females carrying eggs in trawl fishery in Dongshan County from 2018 to 2023 (Phases I-VI).

3.6.6 Sizes for female maturity

The minimum size for female carrying eggs was 4.6 cm CW, caught in March 2023. Females collected in February and March 2023 (the spawning peak) were used to calculate the size at 50% female maturity (CW_{50}), and the estimated CW_{50} was 6.0 cm CW (Fig. 3-14), smaller than 6.3 cm CW estimated from 2019 samples (Lin et al., 2021).

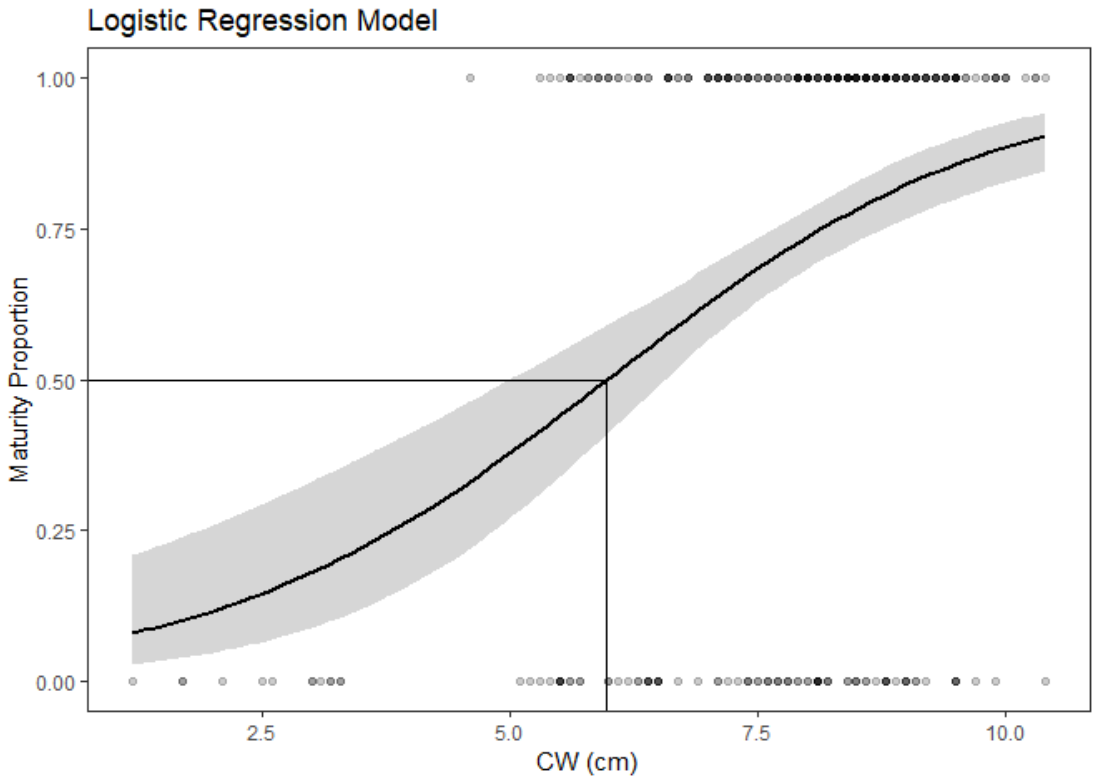

Fig. 3-14. Size (carapace width, CW) at 50% female maturity of *Monomia haanii* based on all females sampled in the spawning peak determined, i.e. February and March 2023 (N = 350). The fitting curve was suggested by the black solid line with 95% CI. The circle represented the individuals that were mature (proportion = 1) or not (proportion = 0).

3.6.7 Size-weight and size-size relationships

The relationship of size (carapace width, CW) and weight (whole body weight, BW) for *M. haanii* was: $BW = 0.0761 \times CW^{3.1728}$ ($R^2 = 0.9753$; N = 2,122); for females was: $BW = 0.075 \times CW^{3.1907}$ ($R^2 = 0.9665$; N = 1,331); for males was: $BW = 0.0753 \times CW^{3.1617}$ ($R^2 = 0.9826$; N = 791) (Fig. 3-15).

The relationship of carapace length (CL)-carapace width (CW) for *M. haanii* was: $CL = 0.551 \times CW + 0.0884$ ($R^2 = 0.9634$; N = 2,122); for females was: $CL = 0.5578 \times CW + 0.0603$ ($R^2 = 0.9461$; N = 1,331); for males was $CL = 0.5485 \times CW + 0.0743$ ($R^2 = 0.977$; N = 791) (Fig. 3-16).

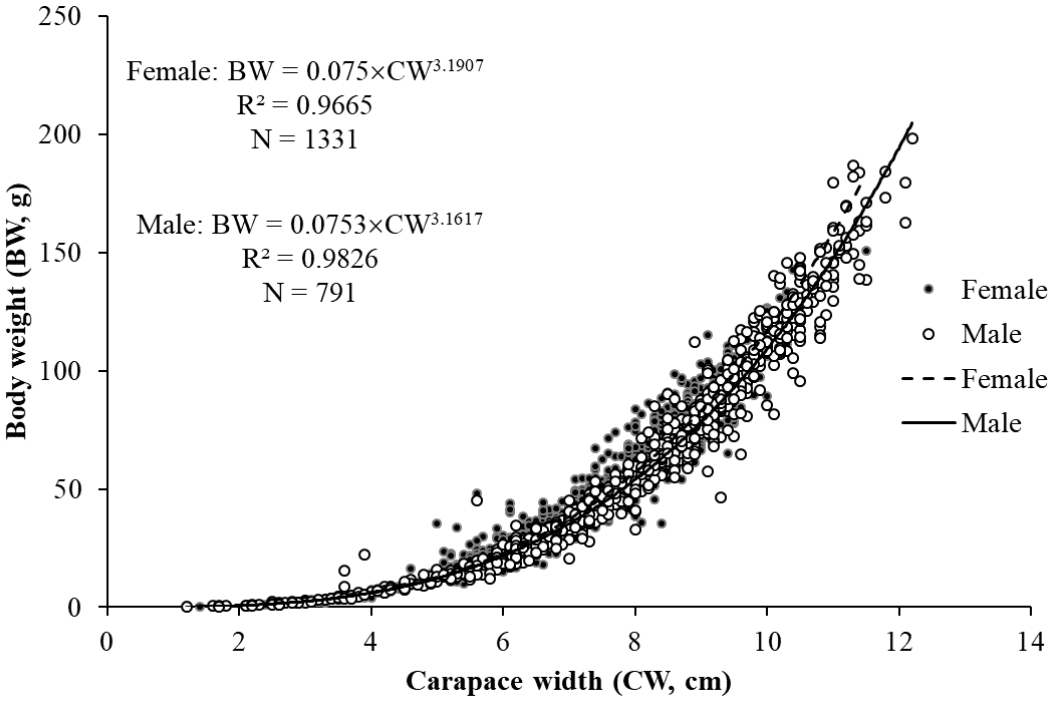

Fig. 3-15. Size (carapace width, CW)-weight (whole body weight, BW) relationship of *Monomia haanii* in August 2022-April 2023.

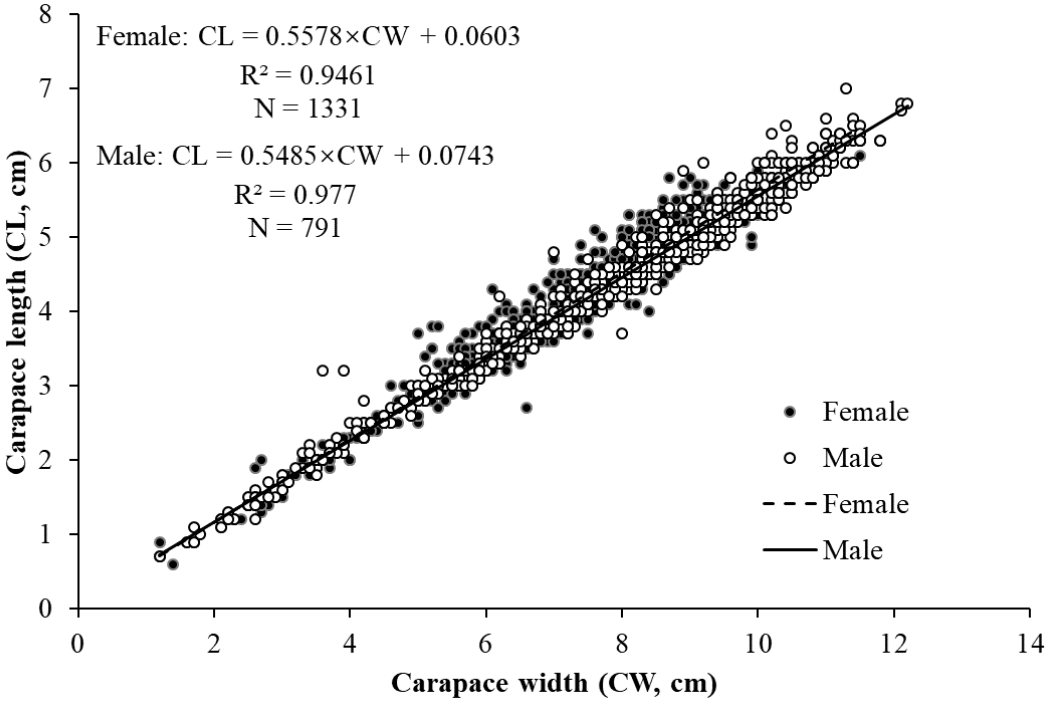

Fig. 3-16. Carapace length (CL)-carapace width (CW) relationship of *Monomia haanii* in August 2022-April 2023.

3.7 Biology of *Portunus sanguinolentus*

P. sanguinolentus samplings were conducted from trawl catches of Dongshan County from August 2022 to April 2023. A total of 826 individuals were collected and measured.

3.7.1 Size variation by month

Sizes (carapace width, CW in cm) of *P. sanguinolentus* ranged from 1.7 to 19.0 cm CW, and monthly average sizes ranged from 11.4 cm CW in August and December 2022 to 14.6 cm CW in February 2023 (Table 3-9, Fig. 3-17). The minimum sizes (< 2 cm CW) was found in August and September 2022 (Table 3-9).

The dominant size classes of *P. sanguinolentus* showed monthly variation:

(1) Proportions of larger sizes (≥ 15.0 cm CW) were high in February 2023 and September 2022, accounting for 36.91% and 50.67%, respectively, and were less than 15% in January and March 2023, and in August and December 2022.

(2) Proportions of the sizes smaller than 12.0 cm CW (the minimum size for catch regulation in Fujian Province) in the total catch of *P. sanguinolentus* were high; > 60% in August 2022 (63.43%) and December (69.93%), around 40-45% in January 2023 (42.34%) and March 2023 (41.79%). Low proportions were recorded in February 2023 (16.00%), April 2023 (25.40%), September 2022 (10.71%), October 2022 (16.28%) and November 2022 (19.05%).

Table 3-9. Number of samples and sizes (carapace width, CW, cm) of *Portunus sanguinolentus* from trawl fishery in Dongshan County in August 2022-April 2023.

Month	Number	Range of CW (cm)	Average CW (cm)
Jan-2023	111	2.1-16.5	12.3
Feb-2023	75	9.5-19.0	14.6
Mar-2023	67	9.2-17.2	12.4
Apr-2023	63	2.7-18.0	13.2
Aug-2022	134	1.8-16.1	11.4
Sep-2022	84	1.7-18.7	13.9
Oct-2022	86	2.5-16.9	13.4
Nov-2022	63	8.7-17.4	13.3
Dec-2022	143	2.2-14.2	11.4

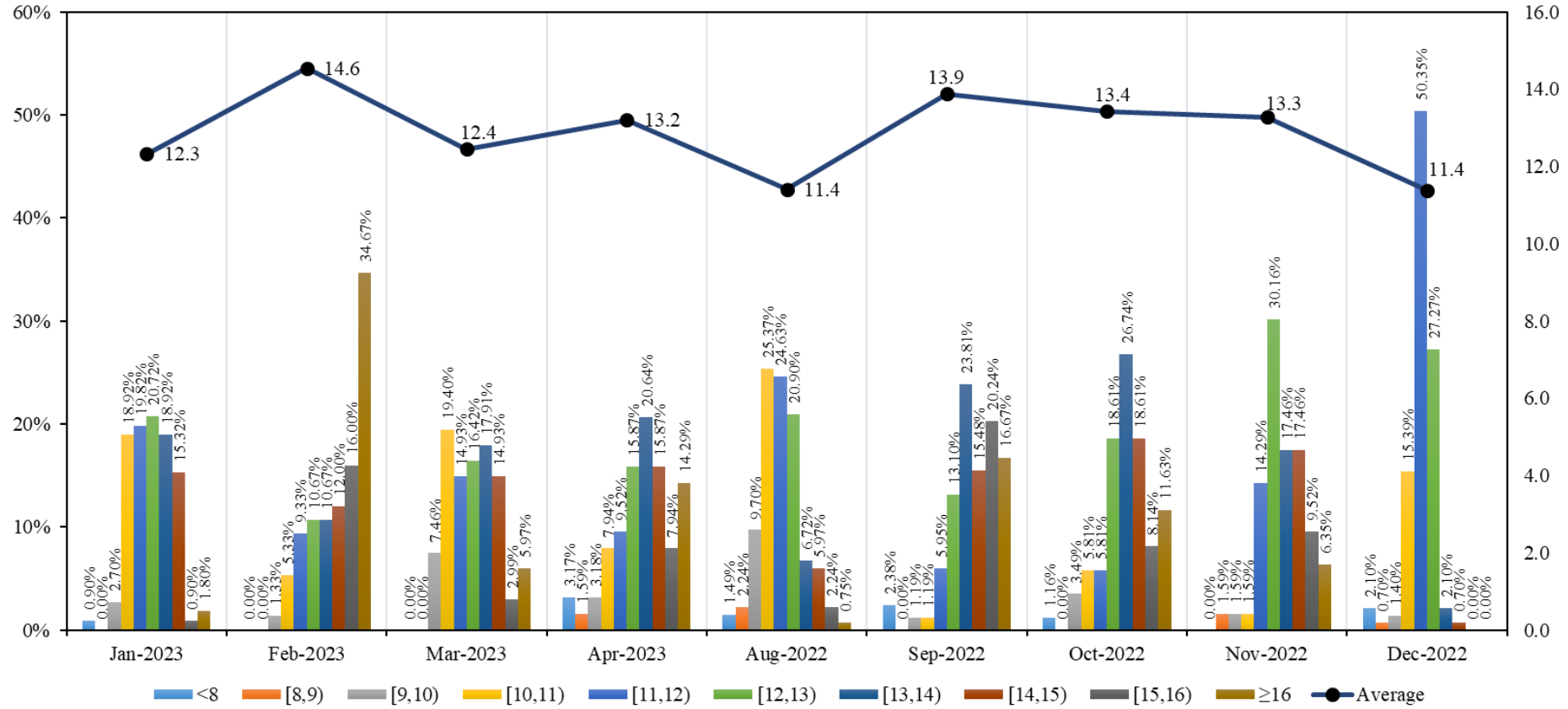

Fig. 3-17. Proportions of different size classes (cm in carapace width) of *Portunus sanguinolentus* (left Y-axis) and the trends of the monthly average sizes (right Y-axis) in trawl catches of Dongshan County from August 2022 to April 2023.

3.7.2 Size variation by sex

The sizes ranged from 2.2 to 17.4 cm CW for females (mean = 12.2, SD = 1.8, N = 434), and from 1.7 to 19.0 cm CW for males (mean = 13.1, SD = 2.6, N = 392) (Fig. 3-18). Males were significantly larger than females in CW (W = 62,939, p < 0.01).

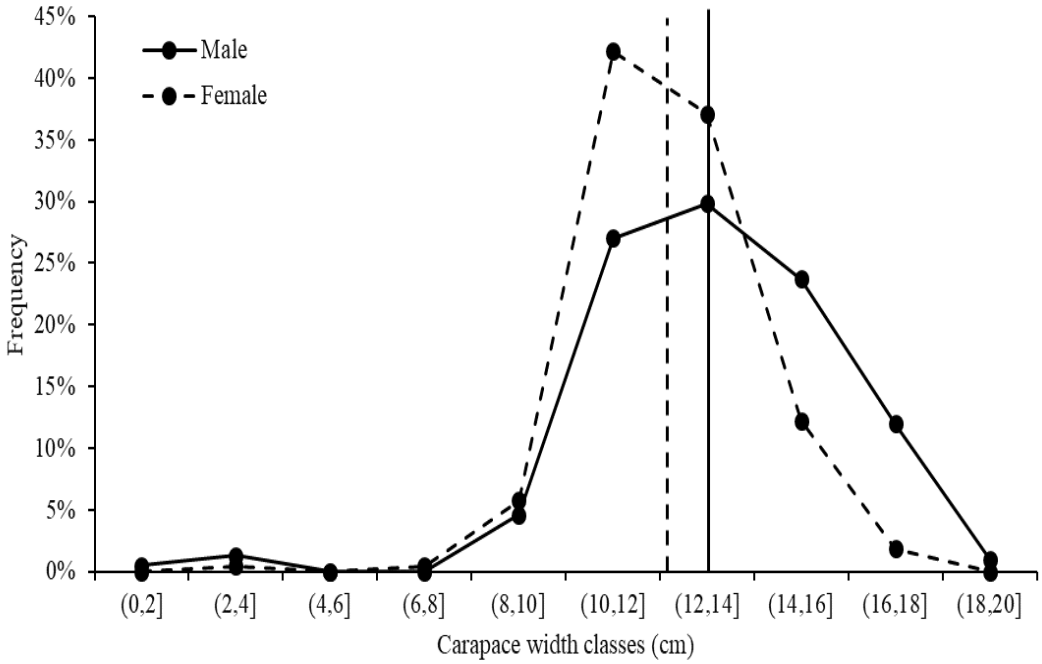

Fig. 3-18. Size (carapace width, CW) frequency (%) of *Portunus anguinolentus* males (N = 392) and females (N = 434), collected from August 2022 to April 2023. Vertical lines indicate the average sizes of males and females.

3.7.3 Sex ratio

Sex ratios of *P. sanguinolentus* showed monthly variation. From the 826 individuals randomly sampled, the overall sex ratio of *P. sanguinolentus* was 1: 1.11 (male: female, N = 826), showing no significant difference from 1:1 (p = 0.15). Female-bias sex ratios were significant in January 2023 and September 2022 (p <0.05) and male-bias sex ratio was significant in December 2022 (p <0.05) (Fig. 3-19).

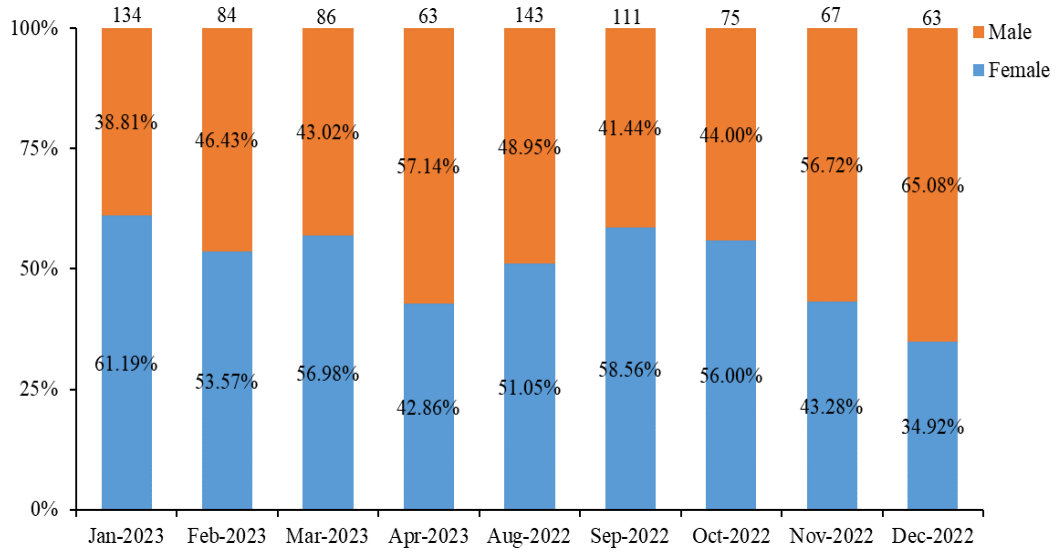

Fig. 3-19. Proportions of males and females of *Portunus sanguinolentus* (N = 826) in trawl fishery in Dongshan County in August 2022-April 2023.
(Number of samples at the top of the bars)

3.7.4 Spawning season

P. sanguinolentus females carrying eggs were found in most of sampling months except October 2022 (Fig. 3-20). The spawning peak was in February-April 2023, determining by the proportions (%) of number of females carrying eggs/number of females.

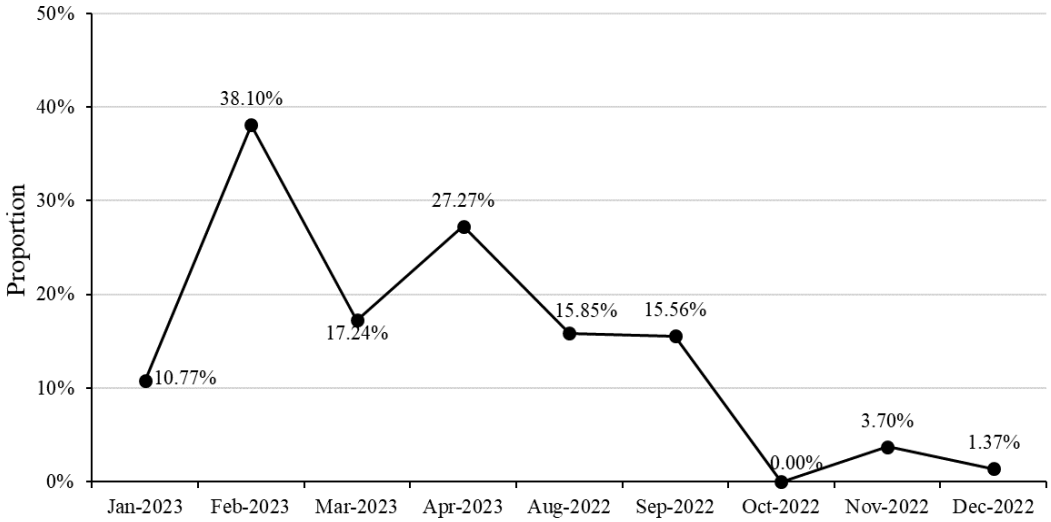

Fig. 3-20. Proportions of *Portunus sanguinolentus* females carrying eggs from trawl catches of Dongshan County in August 2022-April 2023.

3.7.5 Spawning season from 2018 to 2023 (Phases I-VI)

According to the surveys from 2018 to 2023 (Phases I-VI), the proportion of individuals carrying eggs was high in February-April, indicating the consistent spawning peak of *P. sanguinolentus*. In addition, there may have another spawning peak in August-September (Fig. 3-21).

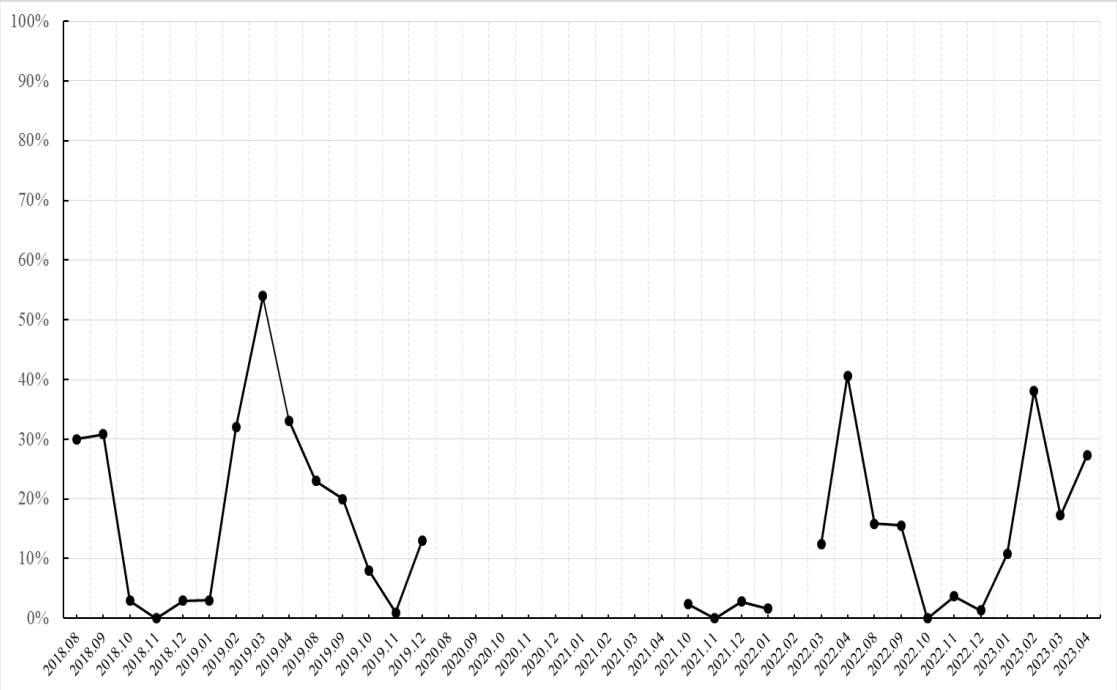

Fig. 3-21. Proportions of *Portunus sanguinolentus* females carrying eggs from trawl catches of Dongshan County from 2018 to 2023 (Phases I-VI).

3.7.6 Sizes for female maturity

The minimum size for female carrying eggs was 10.7 cm CW for *P. sanguinolentus*, caught in January 2023, which was larger than 5.6 cm CW in January 2022, 9.6 cm CW in September 2019 and 8.0 cm CW in 1998 (Ye, 1998).

Females collected in February-April (the spawning peak) were used to calculate the size at 50% female maturity (CW_{50}), and the estimated CW_{50} was 15.5 cm CW (Fig. 3-22).

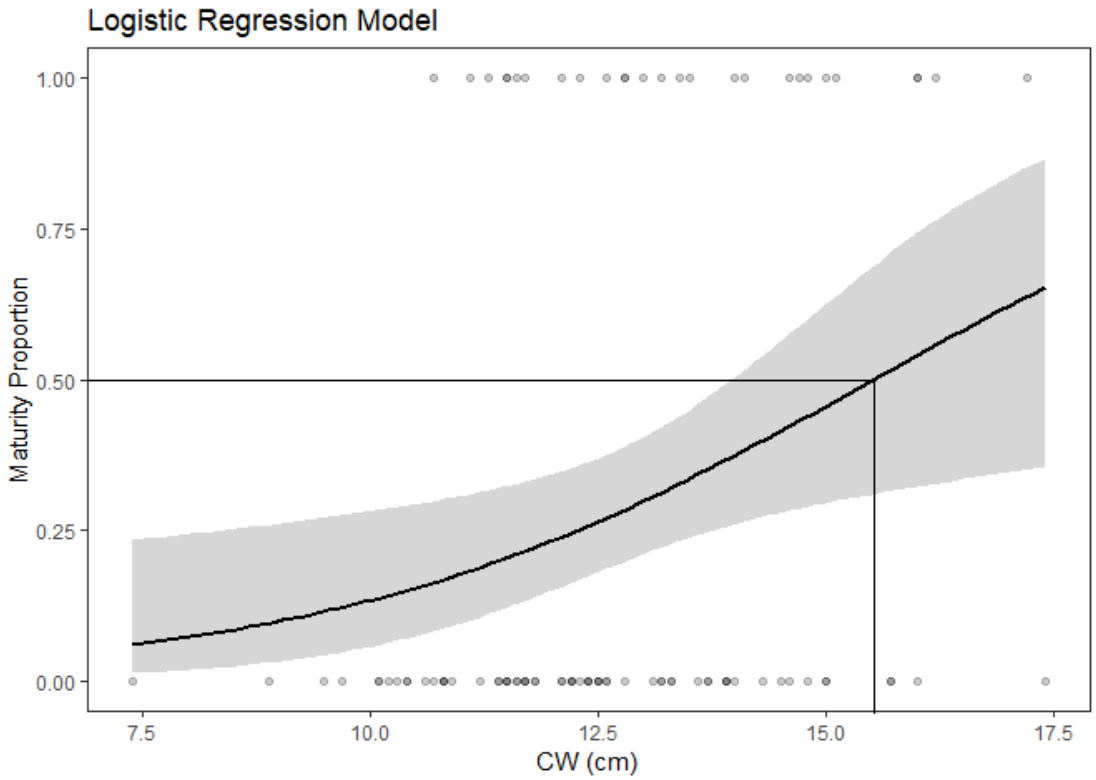

Fig. 3-22. Size (carapace width, CW) at 50% female maturity of *Portunus sanguinolentus* based on all females sampled in spawning peak determined, i.e. February-April 2023 (N = 93). The fitting curve was suggested by the black solid line with 95% CI. The circle represented the individuals that were mature (proportion = 1) or not (proportion = 0).

3.7.7 Size-weight and size-size relationships

The relationship of size (carapace width, CW) and weight (whole body weight, BW) for *P. sanguinolentus* was: $BW = 0.058 \times CW^{3.0172}$ ($R^2 = 0.9489$; N = 826); for females was: $BW = 0.0661 \times CW^{2.9567}$ ($R^2 = 0.9055$; N = 434); for males was: $BW = 0.058 \times CW^{3.026}$ ($R^2 = 0.9669$; N = 392) (Fig. 3-23).

The relationship of carapace length (CL)-carapace width (CW) for *P. sanguinolentus* was: $CL = 0.4258 \times CW + 0.2039$ ($R^2 = 0.9427$; N = 826); for females was: $CL = 0.4295 \times CW + 0.156$ ($R^2 = 0.9225$; N = 434); for males was: $CL = 0.4233 \times CW + 0.2415$ ($R^2 = 0.9502$; N = 392) (Fig. 3-24).

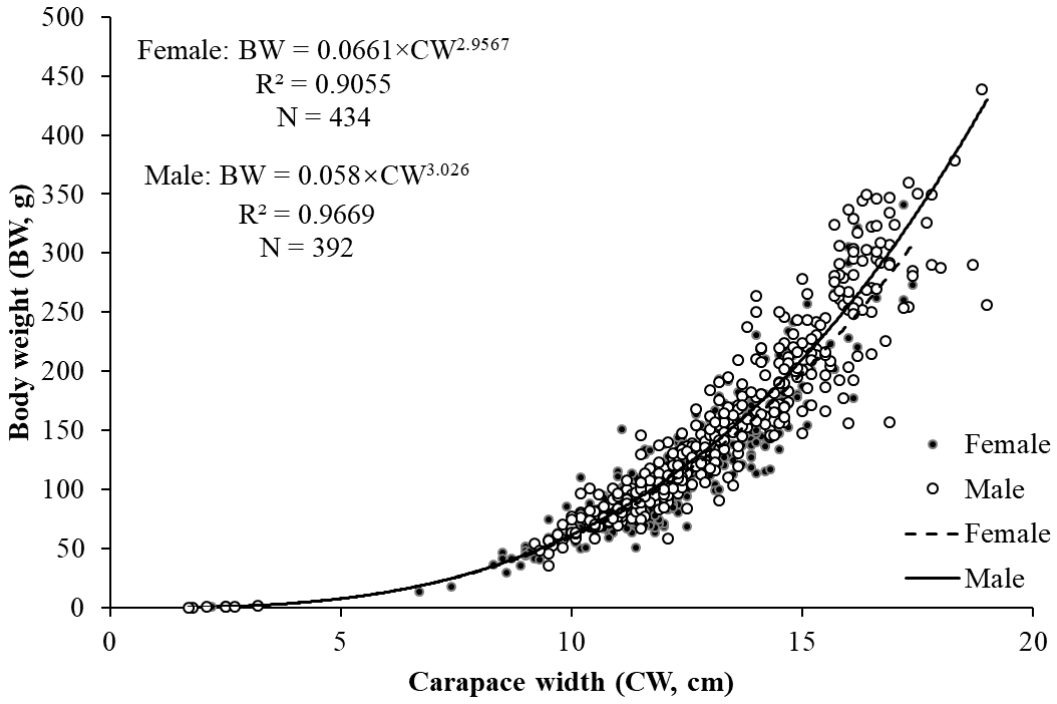

Fig. 3-23. Size (carapace width, CW)-weight (whole body weight, BW) relationship of *Portunus sanguinolentus* in August 2022-April 2023.

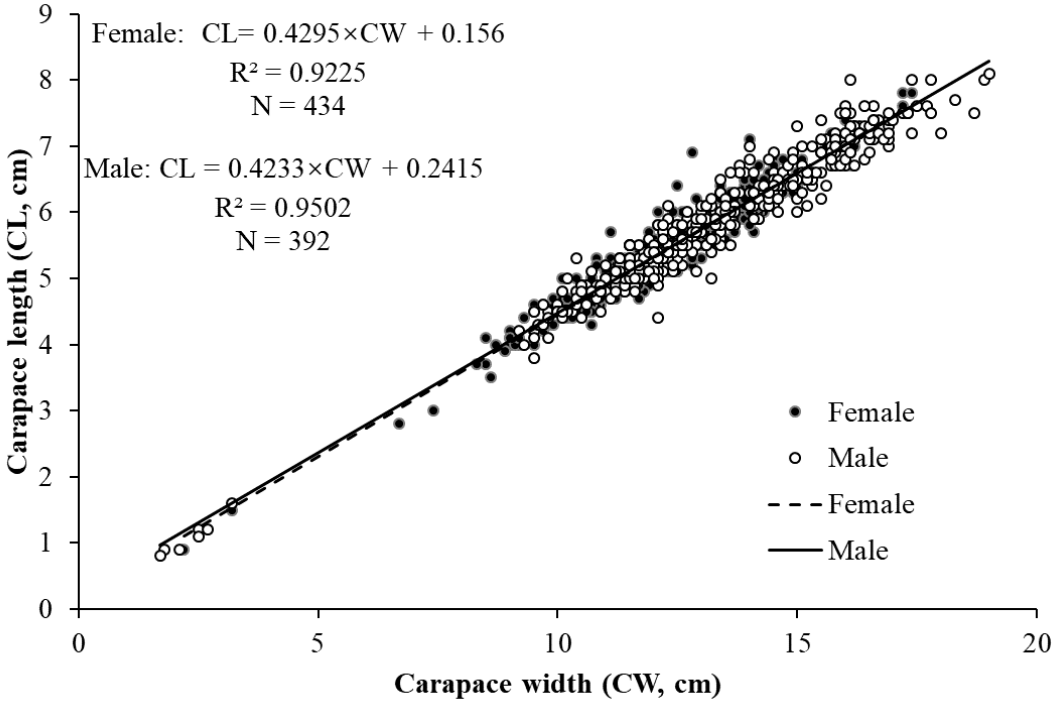

Fig. 3-24. Carapace length (CL)-carapace width (CW) relationship of *Portunus sanguinolentus* in August 2022-April 2023.

3.8 Seahorse bycatch and habitat identity in Taiwan Strait

3.8.1 Seahorse species

A total of four seahorse species were found in trawl fishery operating in the southern Taiwan Strait, including *H. trimaculatus*, *H. spinosissimus*, *H. kelloggi* and *H. mohnikei*. In the trawl fishery, the bycatch volume of *H. trimaculatus* was the highest, followed by *H. spinosissimus*, with low occurrence of *H. kelloggi* and *H. mohnikei*.

3.8.2 Capture volume

According to the data collected from logbook, the operating time of trawling was 0.9-5.5 hours/tow (mean = 3.0 hours/tow, N = 2008) and the seahorse bycatch volume was 0-253.0 g/tow (mean = 9.03 g/tow, N = 2008), namely 0-55 ind./tow (mean = 1.96 ind./tow, N = 2008).

According to the data collected from landing ports and logbook, the bycatch volume of seahorses had monthly variation; high in August-September and low in January-April. The estimated bycatch volumes in Dongshan County were 144.6 kg/vessel/year (31,426 ind./vessel/year) in 2019, 88.1 kg/vessel/year (19,143 ind./vessel/year) in 2020, and 631 ind./vessel/year (2.9 kg/vessel/year) in 2021-2023 (Table 3-10).

Table 3-10. Estimated seahorse bycatch volume (wet weight: kg/vessel; number: ind./vessel) at Dongshan County.

Survey time	Landing port survey			Logbook		
	2019		2020		2021-2023	
	Wet weight	Number	Wet weight	Number	Wet weight ($\times 10^{-3}$)	Number
January	12.7 (0.0-81.0)	2,762 (0-17,609)	5.3 (0.0-13.5)	1,141 (0.0-2,935)	16.9 (4.6-32.2)	4 (1-7)
February	0.6 (0.0-2.7)	138 (0-589)	-	-	0.0 (0.0)	0.0 (0.0)
March	1.6 (0.0-6.5)	343 (0-1,408)	2.6 (0.7-5.8)	576 (145-1,256)	55.2 (0.0-165.6)	12 (0.0-36)
April	4.3 (0.0-12.5)	925 (0-2,717)	17.8 (0.8-54.7)	3,871 (165-11,889)	107.3 (0.0-322)	23 (0.0-70)
August	39.2 (6.9-88.2)	8,525 (1,501-19,176)	33.3 (21.8-52.4)	7,244 (4,728-11,383)	900.0 (0.0-2097.6)	196 (0.0-456)
September	28.6 (5.5-81.1)	6,210 (1,197-17,629)	19.8 (12.6-30.8)	4,304 (2,742-6,703)	1275.7 (0.0-2263.2)	277 (0.0-492)
October	5.0 (0.6-14.3)	1,094 (136-3,111)	3.9 (1.3-17.0)	841 (272-3,696)	482.0 (0.0-2608.2)	105 (0.0-567)
November	34.8 (2.1-61.4)	7,557 (462-13,357)	2.9 (0.7-8.8)	634 (154-1,917)	36.8 (0.0-110.4)	8 (0.0-24)
December	17.8 (9.0-31.5)	3,873 (1,957-6,848)	2.5 (1.1-7.9)	533 (245-1,712)	27.6 (0.0-73.6)	6 (0.0-16)
Total (kg/vessel/year or ind./vessel/year)	144.6 (24.2-379.2)	31,426 (5,252-82,443)	88.1 (38.9-190.9)	19,143 (8,451-41,490)	2901.6 (4.6-7672.8)	631 (1-1,668)
Total number of trawl vessels registered in	650					

Dongshan County						
Estimated annual seahorse bycatch volume ($\times 10^4$ kg/year or $\times 10^4$ ind./year)	9.4 (1.6-24.7)	2,043 (341-5,359)	5.7 (2.5-12.4)	1,244 (549-2,697)	0.2 (0.0-0.5)	41 (0.0-108)

Note: estimated wet weight is 4.6 g for each seahorse individual.

3.8.3 Critical habitat

High seahorse bycatch rate (the number of nets that caught seahorses / the total number of nets) indicates that the seahorse habitats overlapped largely with fishing areas in the southern Taiwan Strait by trawlers. The bycatch rates were higher in August-October 2022 than those in November 2022-April 2023 (Fig. 3-25).

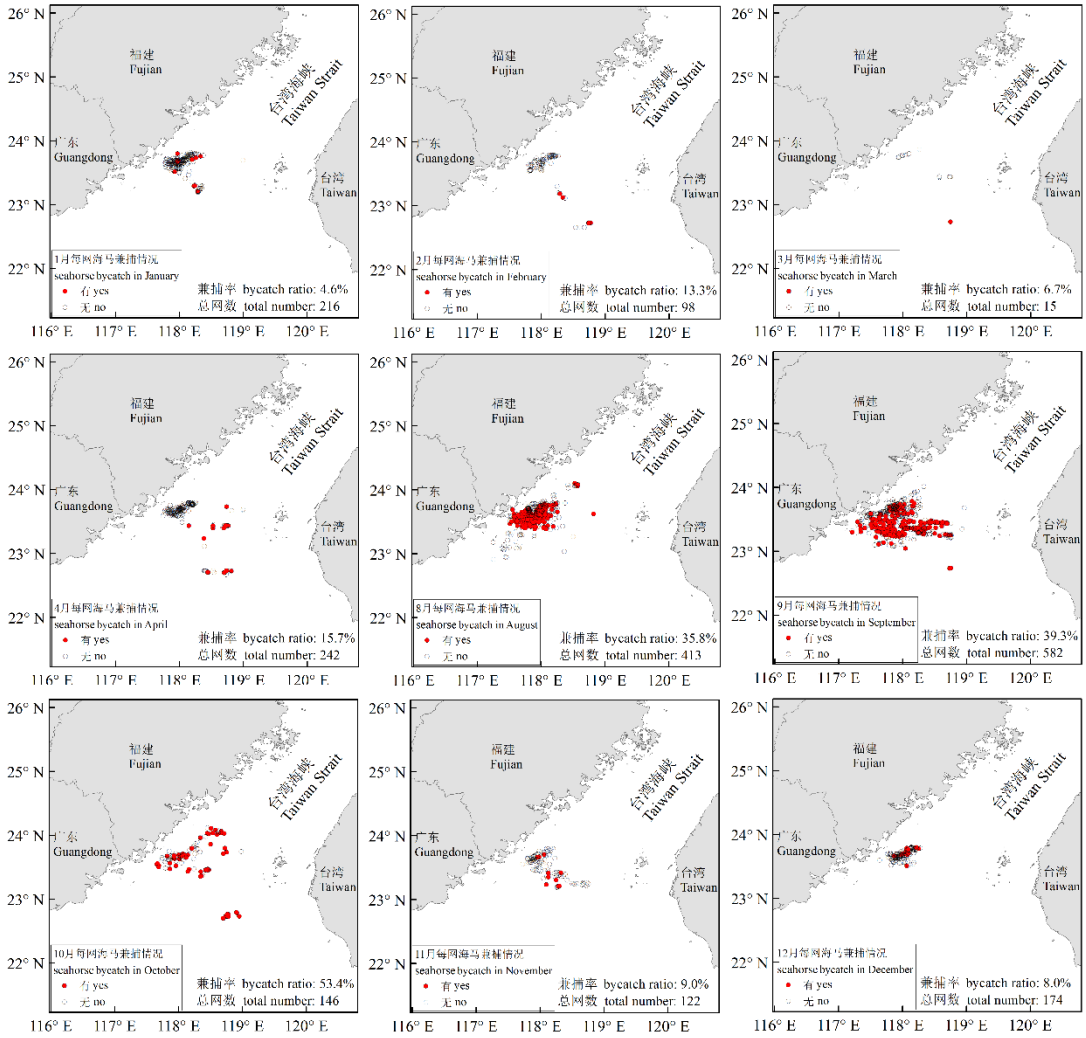

Fig. 3-25. The trawl fishing areas and seahorse bycatch areas in the southern Taiwan Strait (black open circles for the nets without seahorse bycatch and red solid circles for the net with seahorse bycatch).

Seahorses in the southern Taiwan Strait (mainly *H. trimaculatus*) prefer relatively flat, sandy and muddy bottoms within the water depth of 50 m in the southern Taiwan Strait. The two most critical seahorse habitats were in the southwestern Minnan fishing ground (118.40°N-118.49°N，23.43°E-23.49°E) and in the northern Taiwan Bank

fishing ground (118.71°N-118.79°N, 22.70°E -22.77°E) (Fig. 3-26).

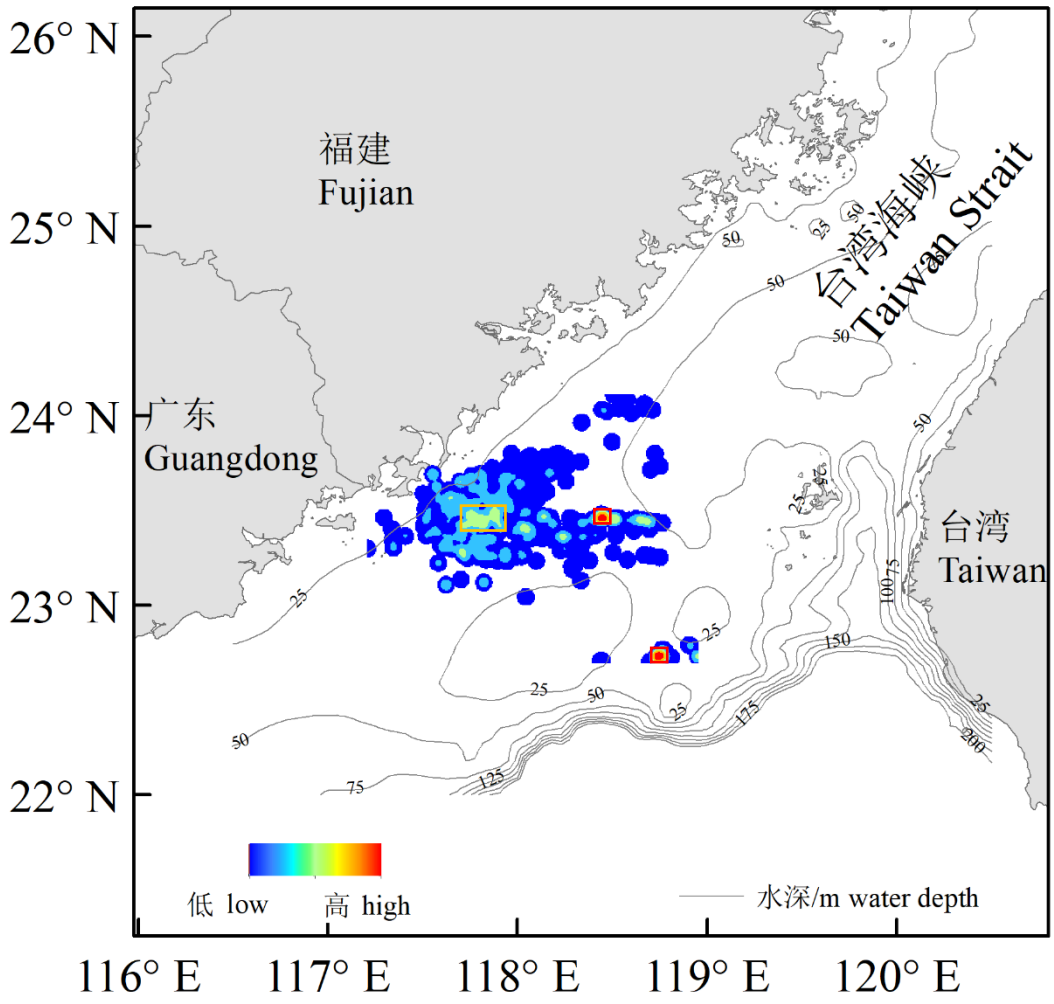

Fig. 3-26. Distribution kernel density of seahorses in the southern Taiwan Strait.

4. Significant findings

(1) The species diversity in the southern Taiwan Strait is high. A total of 368 species were identified in October 2021-April 2023, including 280 fishes (76.09%), 69 crustaceans (18.76%) and 29 cephalopods (5.16%).

(2) The species in feed fishes is diverse. A total of 167 species with 118 fishes, 39 crustaceans and 10 cephalopods were identified in feed fishes in August 2022-April 2023. Among these species, 104 species were only found in feed fishes including 70 fishes, 30 crustaceans and 4 cephalopods.

(3) The CPUE for *M. haanii* in the trawl fishery in Dongshan County was higher from August to December than from January to April, and showed similar trends from 2018 to 2023. The CPUE were higher in August-November 2022 than those in other years (Figs. 4-1 & 4-2).

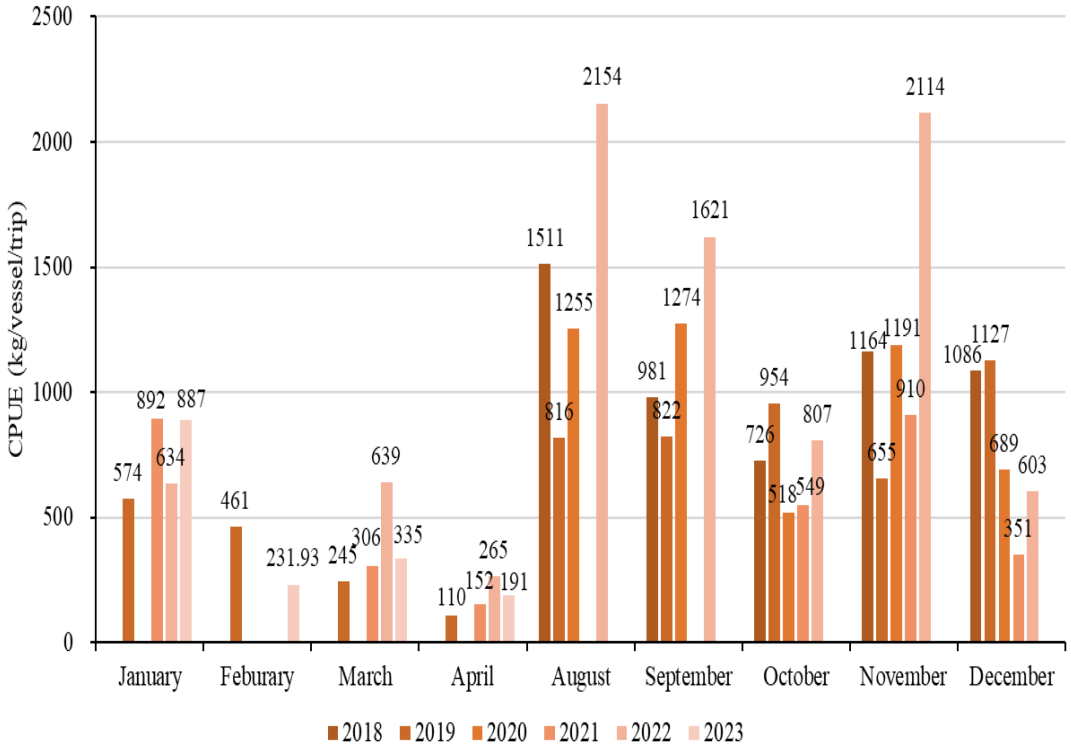

Fig. 4-1. Monthly average CPUE of *Monomia haanii* by kg/vessel/trip (values shown at the tops of the bars), surveyed at the landing ports of Dongshan County from 2018 to 2023 (Phases I-VI).

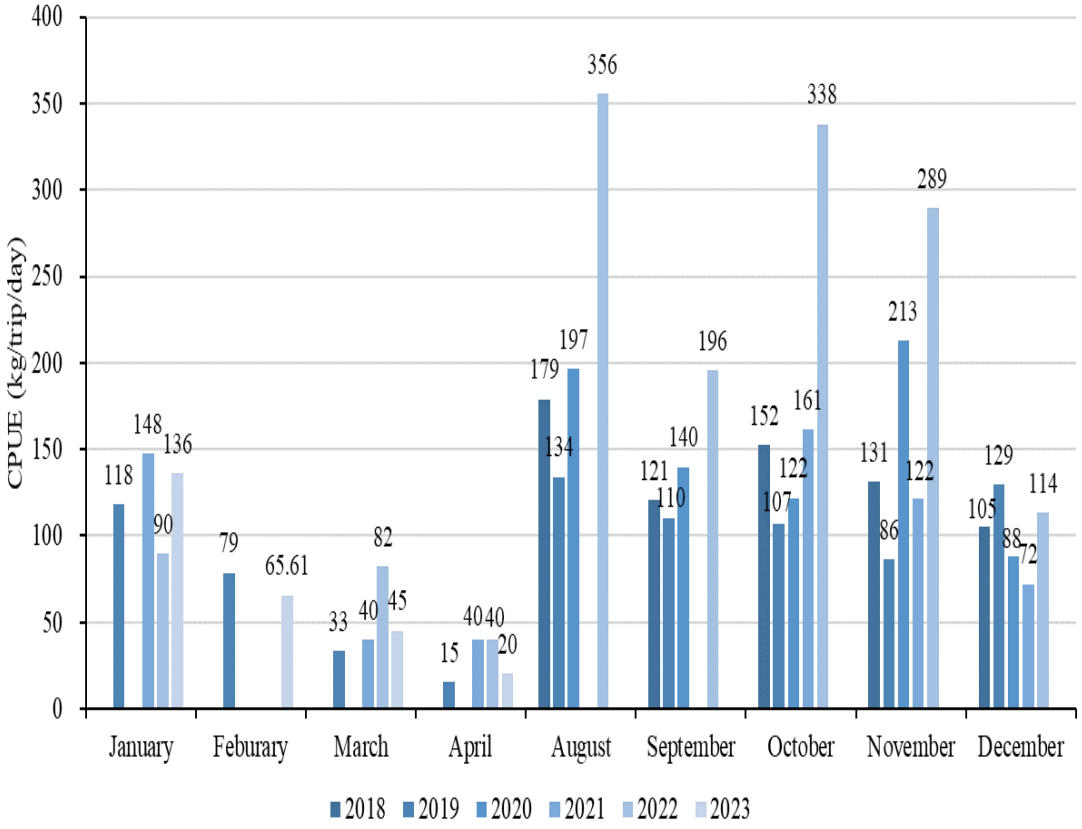

Fig. 4-2. Monthly average CPUE of *Monomia haanii* by kg/vessel/day (values shown at the tops of the bars), surveyed at the landing ports of Dongshan County from 2018-2023 (Phases I-VI).

(4) High proportions of *M. haanii* < 8 cm CW and *P. sanguinolentus* < 12 cm CW were recorded in trawl catches, i.e. smaller than the minimum sizes for catch regulation in Fujian Province.

(5) Based on the monthly sampling from 2018 to 2023, one spawning peak before the national summer fishing moratorium was identified and relatively consistent for *M. haanii* and *P. sanguinolentus*; in January-April for *M. haanii* and in February-April for *P. sanguinolentus*. There may have another spawning peak in August and September for *M. haanii* and *P. sanguinolentus*.

(6) The minimum sizes and the sizes at 50% female maturity of *M. haanii* and *P. sanguinolentus* in 2018-2023 showed annual variations and declines (Table 4-1).

Table 4-1. Sizes (carapace width, CW, cm) for female maturity of *M. haanii* and *P. sanguinolentus*..

Year	*Monomia haanii*		*Portunus sanguinolentus*	
	CWmin	**CW50**	**CWmin**	**CW50**
2018	5.5	-	11.6	-
2019	4.6	6.3	9.6	12.6
2022	4.0	5.3	5.6	12.8
2023	4.6	6.0	10.7	15.5

-: no data

CW_{min}: the minimum size for female bearing eggs

CW_{50}: the size at 50% female maturity

(7) Seahorse bycatches declined drastically. The estimated bycatch volume was 144.6 kg/vessel/year (31,426 ind./vessel/year) in 2019, 88.1 kg/vessel/year (19,143 ind./vessel/year) in 2020, and 631 ind./vessel/year (2.9 kg/vessel/year) in 2021-2022.

(8) The seahorse habitats overlapped heavily with fishing grounds in the southern Taiwan Strait. The critical habitats were in the southwestern Minnan fishing ground (118.40°N-118.49°N，23.43°E-23.49°E) and in the northern Taiwan Bank fishing ground (118.71°N-118.79°N, 22.70°E -22.77°E).

5. Acknowledgements

We would like to thank O2 (Ocean Outcome) and Qingdao Marine Conservation Society of China (QMCS) for funding support the Phase VI of the FIP. Great thanks to Chenrui Jiang, Chen Wang, Jiahao Song, Guohan Yang and Qing Xu from Fish Biology Laboratory, Xiamen University for sample collection, interviews and laboratory work, to Qisi Cai and Shengyao Sun from Dongshan Swire Marine Station, Xiamen University for logistics. Great thanks to anonymous captains and crews for logbook data collection.

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