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

(October 2021-April 2022, Phase V)

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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-Taiwan Bank fishing grounds since the 1980s and has been one of the most productive crab species in Fujian Province 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 a preliminary study, the CPUE and average size of *M. haanii* have shown a decline compared to the results in the 1990s.

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 are 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 the Phase I of the FIP. We 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 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 the Phase II of the FIP. We

continued our focus on trawl fishery 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 were examined. Longhai County was the location for the pilot TAC project of Fujian Province led by Fujian Province Fishery Research Institute.

In August-December 2019, O2 and QMCS launched the Phase III of the FIP. We continued our focus on the trawl fishery of *M. haanii* in Dongshan County. We had a good understanding on trap fishery operation pattern in Dongshan County after the surveys of Phases I and II. Therefore, we finally conducted trap vessel surveys for the *M. haanii* fishery in Phase III. Moreover, we started logbook data collection, including the capture volumes of *M. haanii* and latitude and longitude data for the fishing grounds.

In August-December 2020, O2 and QMCS launched the Phase IV of the FIP. We continued our focus 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 we continued the *M. haanii* trawl fishery surveys in Dongshan County in order to keep long term dataset available.

In October 2021-April 2022, O2 and QMCS launched the Phase V of the FIP. We continued our focus 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 *Portunus sanguinolentus* were examined again after the completion of the Phase III.

The specific objectives of Phase V are defined as follows:

(1) to document the species composition in catches from trawl fishery, including

those from the “feed fishes”;

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

(3) to determine the size, sex, number of females carrying eggs and spawning peak for *M. haanii* and *P. sanguinolentus*;

(4) to understand the seahorse bycatch pattern;

(5) to collect biological data of *Hippocampus trimaculatus* from trawl catches (2019.1-2019.4, 2019.8-2019.12);

(6) to provide recommendations for Fujian crab fisheries.

This report combined the trawl fishery data in January-April 2021 (not in project contract) and October 2021-April 2022 wherever it was available.

2. Materials and Methods

2.1. Survey dates and sampling sites

The trawl surveys were conducted at two major landing ports (Gongqian and Tongling) in January-April 2021 and October 2021-April 2022 in Dongshan County (Table 2-1; Fig. 2-1). Due to the fishing limitation of COVID pandemic, bad weather and Chinese New Year, the surveys were not available in February 2021 and February 2022.

Samples of two crab species (*M. haanii* and *P. sanguinolentus*) in October 2021-April 2022 and feed fishes were collected in January-April 2021 and October 2021-April 2022 during the trawl vessels surveyed.

Samples of seahorses were donated by captains and crews in January-April and August-December 2019; no samples from May-July because of summer fishing moratorium. Seahorses were from trawl vessel bycatch and did not sale with landing catches.

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

No.	Dates	Items
1	January 10th-16th, 2021	Trawl fishery survey and feed fish sample collection
2	February, 2021	No survey
3	March 25th-31st, 2021	Trawl fishery survey
4	April 11st-14th, 2021	Trawl fishery survey
5	October 17th-22nd, 2021	Trawl fishery survey, and feed fish sample and crab sample collection
6	November 1st-7th, 2021	Trawl fishery survey, and feed fish sample and crab sample collection

7	December 5th-12th, 2021	Trawl fishery survey, and feed fish sample and crab sample collection
8	January 10th-17th, 2022	Trawl fishery survey, and feed fish sample and crab sample collection
9	February, 2022	No survey
10	March 1st-4th, 2022	Trawl fishery survey, and feed fish sample and crab sample collection
11	April 9th-16th, 2022	Trawl fishery survey, and feed fish sample and crab sample collection

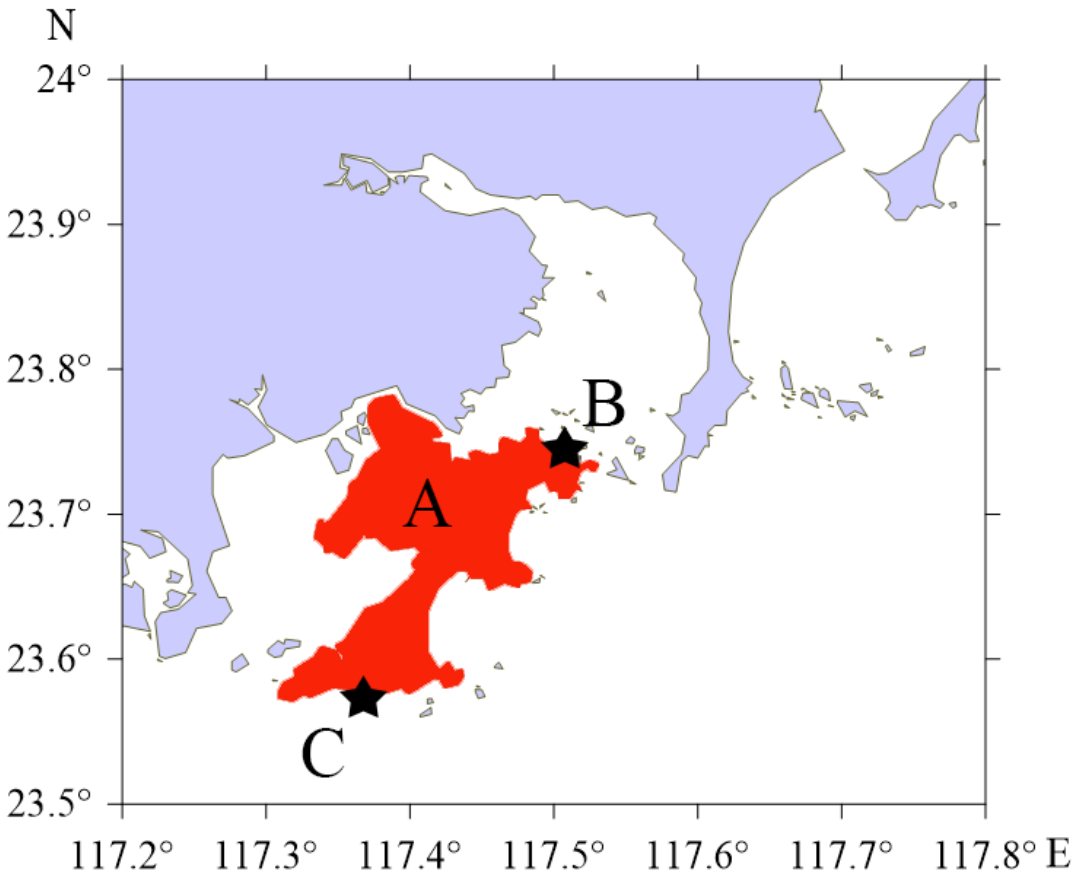

Fig. 2-1. Locations of the landing ports surveyed in Dongshan County (A).

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

2.2. Fishing vessel information collection

In Dongshan County, about 1,015 trawl vessels are registered. In January-April 2021 and October 2021-April 2022 (except February), 6-11 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, and hours per tow were collected.

2.3. Capture volume data collection

For the trawl vessels surveyed above, information on total capture volume, crab capture volume including *M. haanii* and *P. sanguinolentus*, capture volume of main species or species groups, capture volume of feed fishes, and capture volume of seahorses were estimated at the landing ports based on observation and interview in January-April 2021 and October 2021-April 2022 (except February). The capture per unit effort of each vessel was calculated.

2.4. Feed fish sampling

At least 1 kg feed fishes were randomly collected each month in January-April 2021 and October 2021-April 2022 (except February) from the trawl vessels surveyed for further species identification and size measurement.

2.5. 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 fisheries.

In October 2021-April 2022 (except February), *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). 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*

2.6. Species identification

To understand the species and species group diversity in Dongshan County 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.

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 Cuttlefishes and Squids of the World (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. For seahorses, the height was measured (Fig. 2-2).

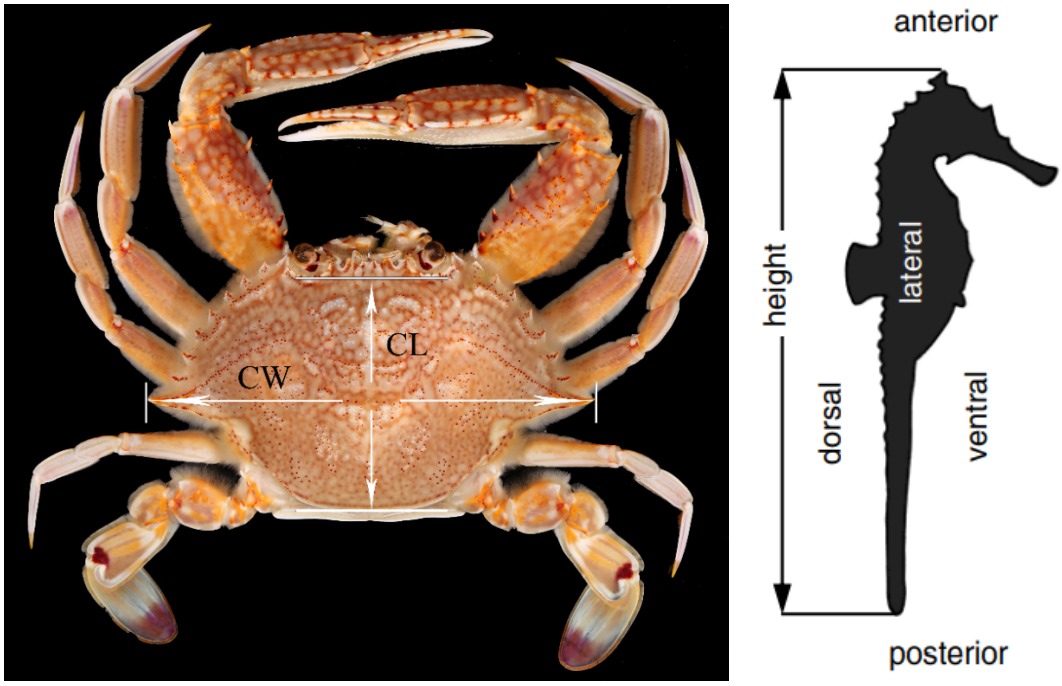

Fig. 2-2. Crab (left) and seahorse (right, from Lourie et al. 2004) size measurement. CL: carapace length; CW: carapace width.

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 (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 sex determination

Sex of *H. trimaculatus* was determined based on the existence of brood pouch (Fig. 2-5). For small individuals, dissection was necessary.

Fig. 2-5. Sex determination for *Hippocampus trimaculatus*.

Left: male; right: female.

3. Results

3.1 Number of trawl fishing vessels surveyed at the landing ports

A total of 79 trawl fishing vessels were surveyed at the landing ports of Dongshan County in January-April 2021 and October 2021-April 2022 (except February), 6-11 trawl vessels per month (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
January 2021	7
February 2021	0
March 2021	10
April 2021	6
October 2021	11
November 2021	11
December 2021	8
January 2022	10
February 2022	0
March 2022	6
April 2022	10

3.2 Species diversity

3.2.1 Species composition

In Dongshan County, a total of 253 species (at species or genus or family level) were identified from trawl fishery catches in January-April 2021 and October 2021-April 2022 (except February), including 180 fishes (71.15%), 55 crustaceans (21.74%) and 18 cephalopods (7.11%) (Table 4-2). Fishes come from 2 classes (Chondrichthyes

and Actinopterygii), 18 orders and 76 families, with almost half of the fish species from the order Perciformes. Crustaceans come from 2 orders and 15 families, and cephalopods come from 4 orders and 5 families.

Among 253 species, 47 species were found in both food and feed fishes, including 33 fishes, 8 crustaceans and 6 cephalopods; while 120 species were only found in feed fishes, including 75 fishes, 36 crustaceans and 9 cephalopods.

Table 4-2. Species recorded (N = 253) in trawl fishery in January-April 2021 and October 2021-April 2022 (except February) 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; DD, data deficient; EN, endangered; LC, least concern; NE, not evaluated; NT, near threatened; VU, vulnerable)

Order	Family	Species	Common name	No. of species	IUCN threatened category
Fishes					
Carcharhiniformes	Carcharhinidae	*Scoiliodon macrorhynchos*	Pacific spadenose shark	1	NT
		Carcharhinus melanopterus	Black-tip reef shark	2	VU
		Carcharhinus brachyurus	Cocktail shark	3	VU
	Shpyrnidae	*Sphyrna leiwi*	Scalloped hammerhead	4	CR
	Scyliorhinidae	**Cephaloscyllium umbratile*	Blotchy swell shark	5	NT
Torpediniformes	Narcinidae	*Narcine lingula*	Chinese numbfish	6	VU
		#*Narcine maculata*	Shortlip electric ray	7	VU
Rajiformes	Rhynchobatidae	*Rhynchobatus immaculatus*	Taiwanese wedgefish	8	CR
		Rhynchobatus australiae	Bottlenose wedgefish	9	CR
	Rhinobatidae	*Rhinobatos hynnicephalus*	Angel fish	10	EN
	Rajidae	*Okamejei boesemani*	Boeseman's skate	11	VU
Myliobatiformes	Platyrhinidae	#*Platyrhina tangi*	Yellow-spotted fanray	12	VU
		Platyrhina sinensis	Chinese fanray	13	EN
	Dasyatidae	*Dasyatis akajei*	Red stingray	14	NT

		Taeniurops meyeni	Round ribbontail ray	15	VU
Anguilliformes	Muraenidae	*#Gymnothrax reticularis*	Netted moray	16	NE
		Gymnothorax cribroris	Sieve-patterned moray	17	LC
		Gymnothorax reevesii	Reeves's moray	18	NE
	Ophichthidae	**Caecula pterygera*	Finny snake eel	19	NE
		**Ophichthus urolophus*	Snake eel	20	NE
		**Apterichtus klazingai*	Sharpsnout snake eel	21	NE
		**Pisodonophis cancrivorus*	Longfin snake-eel	22	NE
		#Pisodonophis boro	Rice-paddy eel	23	LC
		**Callechelys kuro*	Black ridge-fin eel	24	NE
		*Ophichthidae sp	Snake eel	25	-
	Muraenesocidae	*Muraenesox cinereus*	Daggertooth pike conger	26	LC
		**Oxyconger leptognathus*	Shorttail pike conger	27	NE
	Congridae	**Gnathophis nystromi*	Conger eel	28	NE
		**Gnathophis heterognathos*	Shorttail pike conger	29	LC
		**Uroconger lepturus*	Slender conger	30	LC
	Nettastomatidae	**Saurenchelys fierasfer*	Duckbill eel	31	LC
Clupeiformes	Clupeidae	**Sardinella aurita*	Round sardinella	32	NE
	Engraulidae	**Stolephorus* sp.	Anchovy	33	-
		**Thryssa kammalensis*	Kammal thryssa	34	DD
	Prisigasteridae	*Llisha elongata*	Elongate ilisha	35	LC

Gonorhynchiformes	Gonoruchidae	**Gonorychus abbreviatus*	beaked salmon	36	NE
Siluriformes	Plotosidae	*Plotosus lineatus*	Striped eel catfish	37	NE
Aulopiformes	Synodontidae	*#Trachinocephalus myops*	Snakefish	38	LC
		#Synodus fuscus	Lizardfish	39	LC
		**Synodus taiwanensis*	Taiwan Lizardfish	40	NE
		**Synodus* sp.	Lizardfish	41	-
		#Saurida elongata	Slender lizardfish	42	LC
		**Saurida tumbil*	Greater lizardfish	43	LC
		**Saurida undosquamis*	Brushtooth lizardfish	44	LC
		**Saurida* sp.	Lizardfish	45	-
Gadiformes	Bregmacerotidae	**Bregmaceros* sp.	Codlet	46	-
Ophidiiformes	Ophidiidae	**Ophidion muraenolepis*	Asiro brotula	47	LC
Mugiliformes	Mugilidae	*Planiliza affinis*	Mullet	48	NE
Beloniformes	Hemiramphidae	*Hyporhamphus* sp.	Garfish	49	-
Syngnathiformes	Syngnathidae	*Hippocampus trimaculatus*	Spotted seahorse	50	VU
		**Trachyrhamphus serratus*	Rough pipefish	51	DD
Scorpaeniformes	Scorpaenidae	*Pterois volitans*	Lionfish	52	LC
		**Apistus carinatus*	Ocellated waspfish	53	LC
		Parapterois heterura	Blackfoot Lionfish	54	LC
		#Sebastiscus marmoratus	False kelpfish	55	NE
		Scorpaenopsis macrochir	Flasher scorpionfish	56	LC

		#Scorpaena miostoma	Scorpionfish	57	NE
		**Minous pusillus*	Dwarf stingfish	58	NE
		**Minous monodactylus*	Grey stingfish	59	LC
	Aploactinidae	**Aploactis aspera*	Dusky velvetfish	60	NE
	Triglidae	*#Chelidonichthys spinosus*	Spiny red gurnard	61	NE
		**Lepidotrigla microptera*	Redwing searobin	62	NE
		**Lepidotrigla alata*	Forksnout searobin	63	NE
	Platycephalidae	**Onigocia spinosa*	Midget flathead	64	LC
		**Sorsogona tuberculata*	Tuberculated flathead	65	LC
		Platycephalus indicus	Bartail flathead	66	DD
		**Rogadius asper*	Olive-tailed flathead	67	LC
		**Thysanophrys celebica*	Celebes flathead	68	LC
Perciformes	Moronidae	*Lateolabrax japonicus*	Japanese seabass	69	NE
	Epinephelidae	*Epinephelus coioides*	Orange-spotted grouper	70	LC
		Epinephelus awoara	Yellow grouper	71	DD
	Pricanthidae	*Priacanthus macracanthus*	Red bigeye	72	LC
		Priacanthus tayenus	Purple-spotted bigeye	73	LC
	Apogonidae	**Ostorhinchus kiensis*	Rifle cardinal	74	NE
		**Ostorhinchus semilineatus*	Half-lined cardinal	75	DD
		#Ostorhinchus fasciatus	Broadbanded cardinalfish	76	NE
		**Apogonichthyoides niger*	Cardinalfish	77	NE

		**Jaydia lineatus*	Indian perch	78	NE
		**Jaydia ellioti*	Elliot's cardinalfish	79	NE
	Sillaginidae	*#Sillago sihama*	Silver sillago	80	LC
	Rachycentridae	*Rachycentron canadum*	Cobia	81	LC
	Carangidae	*Alectis ciliaris*	African pompano	82	LC
		#Selaroides leptolepis	Yellowstripe scad	83	LC
		Parastromateus niger	Black pomfret	84	LC
		Alepes kleinii	Razorbelly scad	85	LC
		#Decapterus maruadsi	Japanese scad	86	LC
		#Trachurus japonicus	Japanese jack mackerel	87	NT
		Seriola dumerili	Yellowtail amberjack	88	LC
	Leiognathidae	**Secutor ruconius*	Deep pugnose ponyfish	89	NE
		**Equulites rivulatus*	Ponyfish	90	NE
		**Leiognathus berbis*	Scrawled ponyfish	91	NE
	Lutjanidae	*Lutjanus erythopterus*	Crimson snapper	92	LC
		Lutjanus monostigma	Onespot snapper	93	LC
	Haemulidae	*Hapalogenys analis*	Broadbanded velvetchin	94	NE
		Hapalogenys nigripinnis	Black grunt	95	NE
		Plectorhinchus pictus	Trout sweetlips	96	LC
		Parapristipoma trilineatum	Chicken grunt	97	NE
	Nemipteridae	**Scolopsis vosmeri*	Whitecheek monocle bream	98	LC

	Lethrinidae	*Lethrinus atkinsoni*	Pacific yellowtail emperor	99	LC
		Lethrinus nebulosus	Spangled emperor	100	LC
	Sparidae	*Acanthopagrus latus*	Yellowfin seabream	101	DD
		Acaanthopagrus schelegeli	Blackhead seabream	102	LC
		Pagrus major	Red seabream	103	LC
		Rhabdosargus sarba	Goldlined seabream	104	LC
		#Evynnis cardinalis	Threadfin porgy	105	EN
	Polynemidae	*Eleutheronema tetradactylum*	Fourfinger threadfin	106	NE
		#Polydactylus sextarius	Sixfinger threadfin	107	NE
	Sciaenidae	**Johnius distinctus*	Croaker	108	LC
		#Johnius trewavasae	Trewavas croaker	109	LC
		Larimichthys crocea	Large yellow croaker	110	CR
		#Pennahia macrocephalus	Big-head pennah croaker	111	LC
		**Pennahia anea*	Truncate-tail croaker	112	LC
		**Pennahia argentata*	Silver croaker	113	LC
		Miichthys miiuy	Mi-iuy croaker	114	DD
	Mullidae	*#Upeneus japonicus*	Japanese goatfish	115	NE
		Parupeneus biaculeatus	Pointed goatfish	116	NE
		Mulloidichthys flavolineatus	Yellowstripe goatfish	117	LC
	Kyphosidae	*Microcanthus strigatus*	Stripey	118	LC
	Chaetodontidae	*#Roa modestus*	Triple-banded butterflyfish	119	LC

	Pomacanthidae	*Chaetodontoplus septentrionalis*	Bluestriped angelfish	120	LC
	Pomacentridae	*#Teixeirichthys jordani*	Jordan's damsel	121	LC
	Cepolidae	*Acanthocepola indica*	Bandfish	122	NE
	Labridae	*Choerodon azurio*	Scarbreast tuskfin	123	DD
		**Suezichthys gracilis*	Slender wrasse	124	LC
		Iniistius verrens	Rosed razorfish	125	LC
	Champsodontidae	*Champsodon guentheri*	Günther's gaper	126	NE
	Pinguipedidae	*Parapercis pulchella*	Harlequin sandsmelt	127	NE
		**Parapercis ommatura*	Sandperch	128	NE
	Callionymidae	*#Callionymus doryssus*	Dragonet	129	NE
		#Callionymus planus	Dragonet	130	NE
		**Callionymus curvicornis*	Izu ruddertail dragonet	131	NE
	Creediidae	**Limnichthys orientalis*	Sandburrower	132	NE
	Trichonotidae	**Trichonotus setiger*	Spotted sand-diver	133	LC
		**Trichonotus filamentosus*	Black-spot sand-diver	134	LC
	Ammodytidae	*#Bleekeria viridianguilla*	Sand lance	135	NE
		#Bleekria mitsukurii	Sand lance	136	NE
	Uranoscopidae	**Uranoscopus chinensis*	Marbled stargazer	137	NE
		**Uranoscopus bicinctus*	Chinese stargazer	138	NE
		**Ichthyscopus lebeck*	Longnosed stargazer	139	NE
	Gobiidae	**Oxyurichthys microlepis*	Maned goby	140	LC

		*Gobiidae sp.	Goby	141	-
	Eleotridae	**Valenciennea wardi*	Ward's sleeper	142	LC
		**Valenciennea immaculata*	Immaculate glidergoby	143	NE
	Ptereleotridae	**Ptereleotris hanae*	Blue hana goby	144	LC
	Ephippidae	*Platax teria*	Longfin batfish	145	LC
	Siganidae	#*Siganus fuscescens*	Mottled spinefoot	146	LC
	Sphyraenidae	*Sphyraena jello*	Seapike	147	NE
	Trichiuridae	#*Trichiurus haumela*	Largehead hairtail	148	LC
		**Trichiurus* sp.	Hairtail	149	-
	Scombridae	#*Scomber japonicus*	Chub mackerel	150	LC
		Scomberomorus niphonius	Japanese Spanish mackerel	151	DD
		Scomberomorus commerson	Narrow-barred Spanish mackerel	152	NT
		Auxis thazard	Bullet mackerel	153	LC
	Centrolophidae	#*Psenopsis anomala*	Pacific rudderfish	154	LC
	Stromateidae	*Pampus argenteus*	Butterflyfish	155	NE
Pleuronectiformes	Paralichthyidae	*Pseudorhombus cinnamoneus*	Cinnamon flounder	156	LC
		Pseudorhombus arsius	Largetooth flounder	157	NE
		**Tarphops oligolepis*	Large-tooth flounder	158	LC
	Bothidae	**Psettina tosana*	Lefteye flounder	159	LC
		**Psettina* sp.	Flounder	160	-
		**Engyprosopon grandisquama*	Largescale flounder	161	LC

		**Engyprosopon maldivensis*	Lefteye flounder	162	DD
		**Engyprosopon multisquama*	Lefteye flounder	163	LC
		*Bothidae sp.	Flounder	164	-
	Pleuronectidae	**Pleurinichthys cornutus*	Ridged-eye flounder	165	NE
	Samaridae	**Samaris cristatus*	Crested flounder	166	LC
	Soleidae	*Zebrias zebra*	Zebra sole	167	NE
		**Liachirus melanospilos*	Blackspotted sole	168	LC
	Cynoglossidae	**Cynoglossus joyneri*	Red tonguesole	169	NE
		**Cynoglossus kopsi*	Tonguefish	170	LC
		**Cynoglossus puncticeps*	Speckled touguesole	171	LC
		*Cynoglossus sp.	Tonguefish	172	-
Tetraodontiformes	Monacanthidae	*Aluterus monoceros*	Unicorn leatherjacket filefish	173	LC
		#Stephanolepis cirrhifer	Threadsail filefish	174	LC
		#Paramonacanthus sulcatus	Mudbank filefish	175	LC
		Chaetodermis peniciligera	Prickly leatherjacket	176	LC
	Tetraodontidae	*#Lagocephalus wheeleri*	Blowfish	177	NE
		Takifugu oblongus	Lattice blaasop	178	LC
		Takifugu poecilonotus	Pufferfish	179	LC
		Takifugu xanthopterus	Yellowfin puffer	180	LC
Crustaceans					
Stomatopoda	Squillidae	**Oratosquilla fabricii*	Japanese squillid mantis shrimp	181	NE

		**Lophosquilla costata*	Mantis shrimp	182	NE
		**Erugosquilla woodmasoni*	Smooth squillid mantis shrimp	183	NE
		**Carinosquilla multicarinata*	Mantis shrimp	184	NE
		**Oratosquillina interrupta*	Mantis shrimp	185	NE
		**Odontodactylus japonicus*	Mantis shrimp	186	NE
Decapoda	Sicyoniidae	**Sicyonia lancifer*	Knight rock shrimp	187	NE
	Solenoceridae	**Solenocera crassicornis*	Udang merah	188	NE
	Penaeidae	*Penaeus japonicus*	Kuruma shrimp	189	NE
		Penaeus merguiensis	Chinese white prawn	190	NE
		Penaeus latisulcatus	Western king prawn	191	NE
		Penaeus semisulcatus	Green tiger prawn	192	NE
		#Trachysalambria curvirostris	Southern rough shrimp	193	NE
		#Parapenaeopsis hardwickii	Spear shrimp	194	NE
		**Kishinouyepenaeopsis amicus*	Coral shrimp	195	NE
		#Kishinouyepenaeopsis cornuta	Coral shrimp	196	NE
		**Mierspenaeopsis cultrirostris*	Shrimp	197	NE
		**Batepenaeopsis tenella*	Smoothshell shrimp	198	NE
		**Parapenaeus longipes*	Flamingo shrimp	199	NE
		#Metapenaeopsis barbata	Whiskered velvet shrimp	200	NE
		**Metapenaeopsis dalei*	Kishi velvet shrimp	201	NE
		Metapenaeopsis lamellata	Humpback prawn	202	NE

		**Metapenaeopsis palmensis*	Southern velvet shrimp	203	NE
		**Metapenaeopsis* sp.	Velet shrimp	204	-
	Pasiphaeidae	**Leptochela gracilis*	Lesser glass shrimp	205	NE
	Dromiidae	**Conchoecetes artificiosus*	Crab	206	NE
	Majidae	**Pugettia* sp.	Kelp crab	207	-
		**Doclea ovis*	Crab	208	NE
	Leucosiidae	**Myra affinis*	Crab	209	NE
		**Myra fugax*	Fleeting purse crab	210	NE
		*Leucosiidae sp.	Crab	211	-
	Calappidae	*#Calappa philargius*	Box crab	212	NE
		Calappa lophos	Spotted box crab	213	NE
		**Cycloes granulosa*	Crab	214	NE
	Parthenopidae	**Enoplolambrus validus*	Strong elbow crab	215	NE
	Matutiodea	**Matuta planipes*	Spotted moon crab	216	NE
		**Matuta banksi*	Yellow moon crab	217	NE
	Portunidae	*Scylla paramamosain*	Mud crab	218	NE
		**Portunus hastatoides*	Swimming crab	219	NE
		**Portunus trituberculatus*	Japanese blue crab	220	NE
		**Portunus gracilimanus*	Swimming crab	221	NE
		#Portunus sanguinolentus	Three-spot swimming crab	222	NE
		**Portunus argentatus*	Swimming crab	223	NE

		Portunus pelagicus	Flower crab	224	NE
		#Monomia haanii	Red swimming crab	225	NE
		**Charybdis bimaculata*	Swimming crab	226	NE
		**Charybdis acuta*	Swimming crab	227	NE
		Charybdis feriatus	Crucifix crab	228	NE
		#Charybdis nataor	Rock crab	229	NE
		Charybdis acuta	Swimming crab	230	NE
		**Charybdis variegata*	Swimming crab	231	NE
		**Charybdis* sp.	Swimming crab	232	-
	Polybiidae	**Liocarcinus corrugatus*	Wrinkled swimcrab	233	NE
	Xanthidae	*Lophozozymus pictor*	Mosaic reef crab	234	NE
	Pilumnidae	**Heteropilumnus* sp.	Crab	235	-
Cepholopods					
Sepiida	Sepiidae	*#Sepiella maindroni*	Spineless cuttlefish	236	DD
		Sepia esculenta	Golden cuttlefish	237	DD
		Sepia lycidas	Kisslip cuttlefish	238	DD
		*Sepiidae sp.	Cuttlefish	239	-
	Sepiolidae	**Sepiola berryi*	Bobtail Squid	240	NE
		**Sepiadarium kochii*	Koch's bottletail squid	241	LC
		**Sepiola* sp.	Squid	242	DD
Teuthida	Loliginidae	**Loligo japonicus*	Squid	243	DD

		#Uroteuthis duvaucelii	Squid	244	DD
		Uroteuthis chinensis	Southern dumpling squid	245	DD
		**Uroteuthis edulis*	Swordtip squid	246	-
		#Loliolus uyii	Little squid	247	DD
		*Loliginidae sp.	Squid	248	-
Oegopsida	Ommastrephidae	**Todarodes pacificus*	Japanese Common Squid	249	LC
Octopoda	Octopodidae	*#Octopus variabilis*	Whiparm octopus	250	NE
		#Octopus ocellatus	Webfoot octopus	251	LC
		#Amphioctopus aegina	Octopus	252	NE
		*Octopodidae sp.	Octopus	253	-

3.2.2 Endangered, threatened and protected species

Three cartilaginous fishes (Scalloped hammerhead shark *Sphyrna lewini*, Taiwanese wedgefish *Rhynchobatus immaculatus* and Bottlenose wedgefish *Rhynchobatus australiae*) and one bony fish (Longnose seahorse *Hippocampus trimaculatus*) found in trawl fishery at the landing ports of Dongshan County were CITES Appendix II species.

S. lewini was listed in CITES Appendix II in 2014. *S. lewini* had a low occurrence at the landing ports of Dongshan County (Fig. 3-1). In January-April 2021 and October 2021-April 2022 (except February) surveys, a total of three individuals from three trawl vessels were found and all were sold to the local markets for food; one individual was found in October 2021, and two individuals in November 2021.

Fig. 3-1. Scalloped hammerhead shark *Sphyrna lewini* found in trawl fishery catches in Dongshan County.

R. immaculatus and *R. australiae* were listed in CITES Appendix II in 2019. Both species had a low occurrence at the landing ports of Dongshan County (Fig. 3-2). A total of nine individuals were found in January-April 2021, October-December 2021 and January-April 2022 (except February) surveys; one in November 2021 and eight in December 2021.

Fig. 3-2. Bottlenose wedgefish *Rhynchobatus australiae* and Taiwanese wedgefish *Rhynchobatus immaculatus* found in trawl fishery catches in Dongshan County.

All *Hippocampus* species were listed in CITES Appendix II in 2004. In China, all *Hippocampus* species occur in Chinese waters were listed as Category II of National Wildlife Protected Species in January 2021 (www.forestry.gov.cn/html/main/main_5461/20210205122239482485322/file/20210205122347636743107.pdf). In Dongshan County, *H. trimaculatus* is the absolutely dominant landing species in seahorse catches from trawl fishery (Fig. 2-5). During the surveys in October 2021-April 2022 (except February), only *H. trimaculatus* was found and the total seahorse capture volumes were much less than before according to the interviews with fishermen at the landing ports of Dongshan County.

Among the 253 species identified aforementioned in Dongshan County in January-April 2021 and October 2021-April 2022 (except February) surveys, a total of 15 fish

species were listed as threatened in the International Union for Conservation of Nature (IUCN) Red List (Table 4-2). Among the 15 fish species, four species (*S. lewini*, *R. immaculatus*, *R. australiae* and *Larimichthys crocea*) were listed as "Critically Endangered", three species (*Rhinobatos hynnicephalus*, *Platyrhina sinensis* and *Evynnis cardinalis*) were listed as "Endangered", and eight species (*Carcharhinus melanopterus*, *C. brachyurus*, *Narcine lingual*, *N. maculate*, *Okamejei boesemani*, *Platyrhina tangi*, *Taeniurops meyeni* and *H. trimaculatus*) were as "Vulnerable". *E. cardinalis* is one of the most important food fishes in terms of catch volume proportion and number.

3.3 Fishing areas

The fishing grounds remained unchanged in January-April 2021 and October 2021-April 2022 (except February) surveys. 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. 3-3).

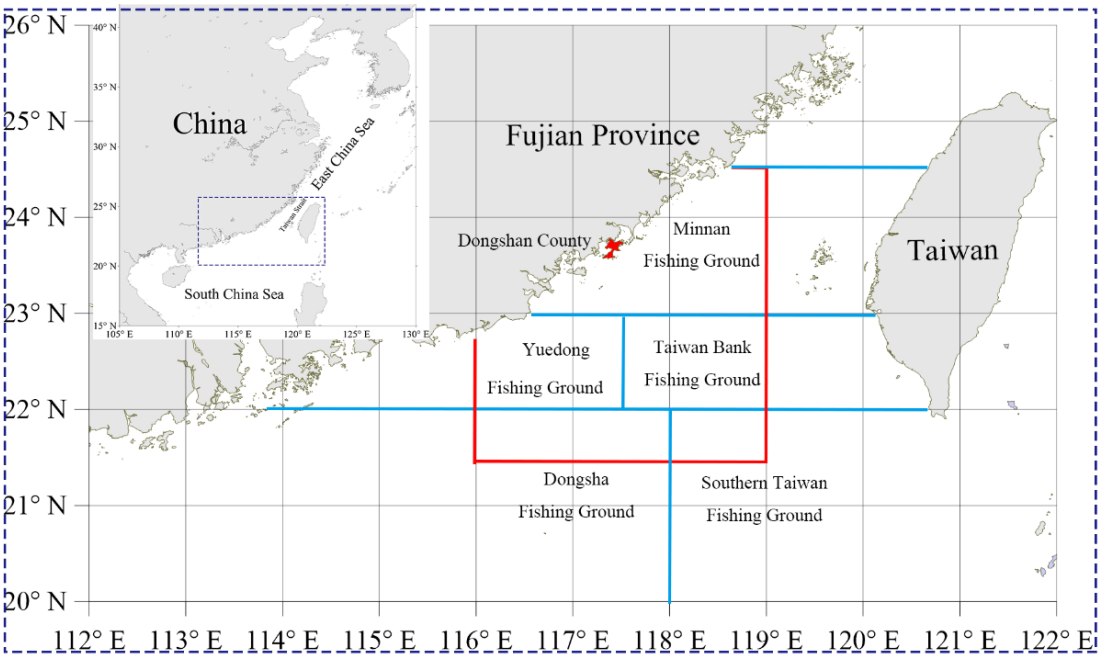

Fig. 3-3. Offshore fishing areas (red line) of trawl vessels from Dongshan County (red area), covering five fishing grounds of southern Taiwan Strait.

3.4 Fishery operation patterns

Based on 79 trawl vessels surveyed at the landing ports of Dongshan County in January-April 2021 and October 2021-April 2022 (except February), they generally spent 1-14 days/trip at sea (mean = 6.34, N = 79). The variation of fishing days at sea highly depended on the weather conditions and most of trawl vessels surveyed spent about 6-10 days/trip at sea. The fishery operation patterns are similar with the findings in Phases I-IV surveys (August 2018-December 2020).

3.5 Capture volumes and proportions by trawl vessels at Dongshan County

3.5.1 Capture volumes and proportions of different taxonomic groups

Based on the trawl vessels surveyed (N = 79) at the landing ports of Dongshan County in January-April 2021 and October 2021-April 2022 (except February), the average total capture volume was about 8751.28 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):

(1) The most dominant capture taxonomic group was the fishes (including food fish and feed fish), contributed to 76.92% (average of 6731.53 kg/vessel/trip) of the estimated average total capture volume (average of 8751.28 kg/vessel/trip).

(2) The average total food capture volume was 4039.44 kg/vessel/trip, which contributed to 46.16% of the estimated total capture volume.

(3) High volume and proportion of fish capture were the feed fishes (average of 2692.09 kg/vessel/trip), contributed to 30.76% of the total capture volume.

(4) The average total crustacean capture volume (1132.84 kg/vessel/trip) contributed to 12.94% of the estimated average total capture volume, with the estimated average 772.71 kg/vessel/trip (8.83%) for crabs and 360.13 kg/vessel/trip (4.12%) for shrimps.

(5) The average total cephalopod capture volume was 886.91 kg/vessel/trip, which contributed to 10.13% of the estimated total capture volume.

Table 3-3. Capture volumes and proportions from trawl vessels surveyed (N = 79) in January-April 2021 and October 2021-April 2022 (except February) at the landing ports of Dongshan County.

Parameters	**Mean (N = 79)**	
Fishing days per trip	6.34 days/trip	
Average total capture volume per trip	8751.28 kg/vessel/trip	
Average total crustacean capture volume per trip	1132.84 kg/vessel/trip	
	Shrimps: 360.13 kg/vessel/trip	Crabs: 772.71 kg/vessel/trip
Total crustacean volume/total capture volume	12.94%	
	Shrimps: 4.12%	Crabs: 8.83%
Average total fish capture volume per trip	6731.53 kg/vessel/trip	
Total fish volume/total capture volume	76.92%	
Average total food fish capture volume per trip	4039.44 kg/vessel/trip	
Total food fish volume/total capture volume	46.16%	
Average total feed fish capture volume per trip	2692.09 kg/vessel/trip	
Total feed fish volume/total capture volume	30.76%	
Average total cephalopod capture volume per trip	886.91 kg/vessel/trip	
Total cephalopod volume/total capture volume	10.13%	

3.5.2 Crabs

The crab capture volume proportions in the total capture volumes of trawl fishery

(N = 79) in Dongshan County in January-April 2021 and October 2021-April 2022 (except February) were further analyzed (Table 3-3 and 3-4; Fig.3-4 to 3-6). The findings were summarized:

(1) Crab proportions in total capture volumes of trawl fishery in Dongshan County ranged from 3.00% in March 2021 to 15.50% in October 2021, including four main crab species, *M. haanii*, *P. sanguinolentus*, *C. nataor* and *C. philargius*.

(2) Among the estimated average total crab capture volume of 772.71 kg/vessel/trip, *M. haanii* was 530.34 kg/vessel/trip, *P. sanguinolentus* was 190.34 kg/ vessel/trip, *C. nataor* was 14.49 kg/ vessel/trip and *C. philargius* was 37.08 kg/ vessel/trip, contributed to 6.06%, 2.17%, 0.17% and 0.42% of the total capture volume, respectively.

(3) The dominant cab species in trawl fishery was *M. haanii*, contributed around 70% of the total crab production. The *M. haanii* proportions in the total capture volumes varied monthly, ranged from 2.44% in March 2021 to 13.35% in October 2021. The capture volumes of *M. haanii* ranged from 151.67 kg/vessel/trip to 910.00 kg/vessel/trip.

(4) Based on the average fishing days at sea, the average CPUE of *M. haanii* ranged from 39.82 kg/vessel/day in March 2021 to 161.31 kg/vessel/day in October 2021 (mean = 88.36 kg/vessel/day).

(5) Based on the average fishing days at sea, the average CPUE of *P. sanguinolentus* ranged from 6.70 kg/vessel/day in March 2021 to 48.38 kg/vessel/day in January 2021 (mean = 30.93 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 = 79) in January-April 2021 and October 2021-April 2022 (except February) at the landing ports of Dongshan County.

Crab species	**Average volume (kg/vessel/trip)**	**Proportion (%)**
Monomia haanii	530.34	6.06%
Portunus sanguinolentus	190.34	2.17%
Charybdis nataor	14.49	0.17%
Calappa philargius	37.08	0.42%
Other crabs	0.46	0.01%

Total	772.71	8.83%

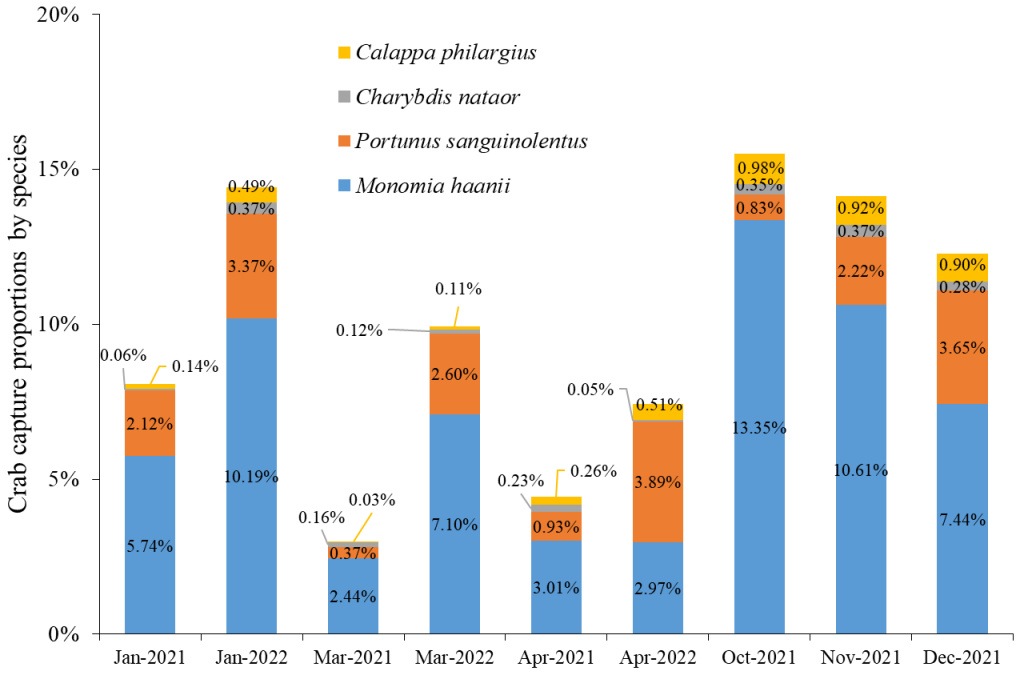

Fig. 3-4. Crab capture proportions in the total capture volume by species from trawl vessels surveyed in January-April 2021 and October 2021-April 2022 (except February) at the landing ports of Dongshan County.

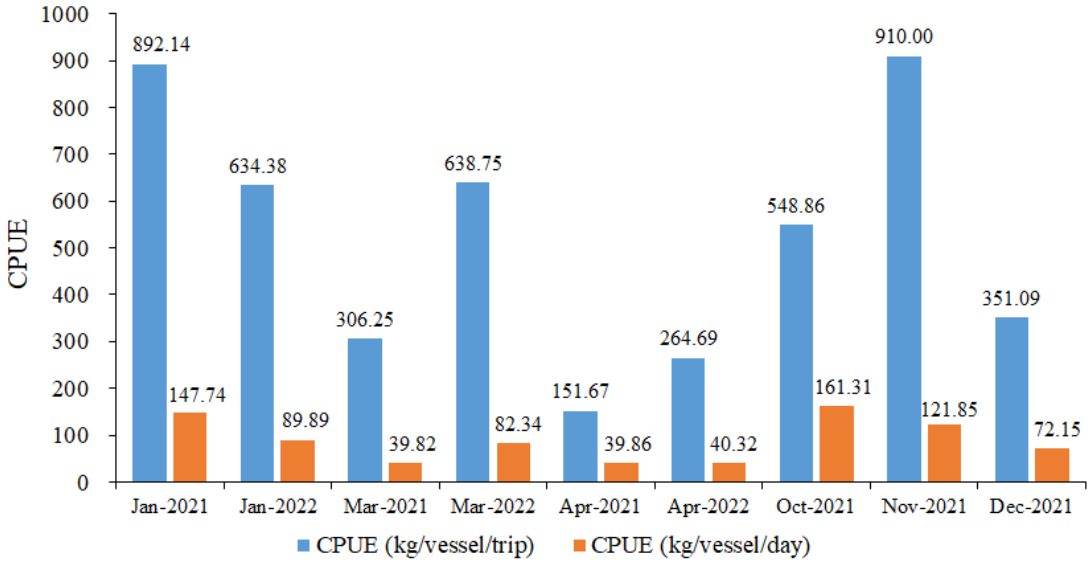

Fig. 3-5. Monthly average CPUE of *Monomia haanii* by kg/vessel/trip (blue bars) and by kg/vessel/day (orange bars) (values shown at the tops of the bars), surveyed in January-April 2021 and October 2021-April 2022 (except February) at the landing

ports of Dongshan County.

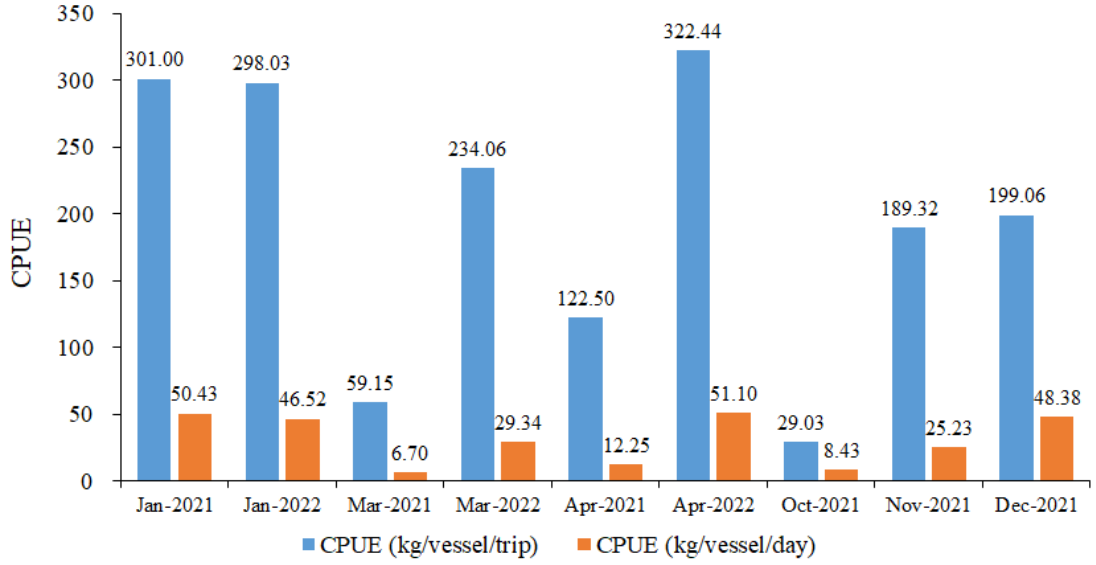

Fig. 3-6. Monthly average CPUE of *Portunus sanguinolentus* by kg/vessel/trip (blue bars) and by kg/vessel/day (orange bars) (values shown at the tops of the bars), surveyed in January-April 2021 and October 2021-April 2022 (except February) at the landing ports of Dongshan County.

3.5.3 Food fishes

In January-April 2021 and October 2021-April 2022 (except February), the dominant food fish species or species groups in trawl fishery in Dongshan County were *Evynnis cardinalis*, *Trachinocephalus myops*, *Saurida* spp. (mostly *Saurida elongata*), *Decapterus maruadsi*, *Trachurus japonicus*, Sillaginidae spp. (mostly *Sillago sihama*), Mullidae spp. (mostly *Upeneus japonicus*), *Siganus fuscescens*, Trichiuridae spp. (mostly *Trichiurus haumela*), Callionymidae spp., Ammodytidae spp. (*Bleekeria viridianguilla* and *Bleekria mitsukurii*), Monacanthidae spp. (mostly *Paramonacanthus sulcatus* and *Stephanolepis cirrhifer*) and Tetraodontidae spp. (mostly *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).

Table 3-5. Dominant fish species or species groups in capture proportions of the total capture volumes in trawl vessels surveyed (N = 79) in January-April 2021 and October 2021-April 2022 (except February) at the landing ports of Dongshan County.

Fish species/groups	**Jan-2021**	**Jan-2022**	**Mar-2021**	**Mar-2022**	**Apr-2021**	**Apr-2022**	**Oct-2021**	**Nov-2021**	**Dec-2021**
Total fish%	79.94%	65.72%	82.23%	76.28%	81.86%	78.03%	66.54%	68.56%	68.23%
Trachinocephalus myops & *Saurida* spp.	9.79%	10.35%	8.44%	5.47%	9.92%	10.29%	4.27%	8.88%	5.74%
Evynnis cardinalis	18.07%	3.33%	2.53%	0.97%	2.42%	0.54%	18.91%	10.22%	1.65%
Sillaginidae spp.	2.21%	3.80%	1.26%	4.71%	1.54%	2.00%	7.59%	3.86%	2.64%
Decapterus maruadsi & *Trachurus japonicus*	5.50%	0.96%	2.66%	6.74%	8.14%	2.52%	7.46%	6.12%	4.59%
Mullidae spp.	1.47%	3.31%	1.56%	0.89%	1.11%	1.70%	1.10%	1.12%	2.26%
Ammodytidae spp.	0.00%	1.32%	30.45%	0.81%	18.16%	31.71%	3.24%	0.67%	0.00%
Trichiuridae spp.	0.82%	1.08%	0.21%	0.44%	0.00%	0.11%	1.89%	3.67%	2.00%
Tetraodontidae spp.	2.37%	0.00%	0.37%	1.41%	0.62%	0.03%	5.34%	2.15%	3.67%

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 79 trawl vessels surveyed at the landing ports of Dongshan County in January-April 2021 and October 2021-April 2022 (except February), feed fishes contributed to 0.00%-50.52% of the total capture volumes; no feed fishes in October 2021 (Fig. 3-7).

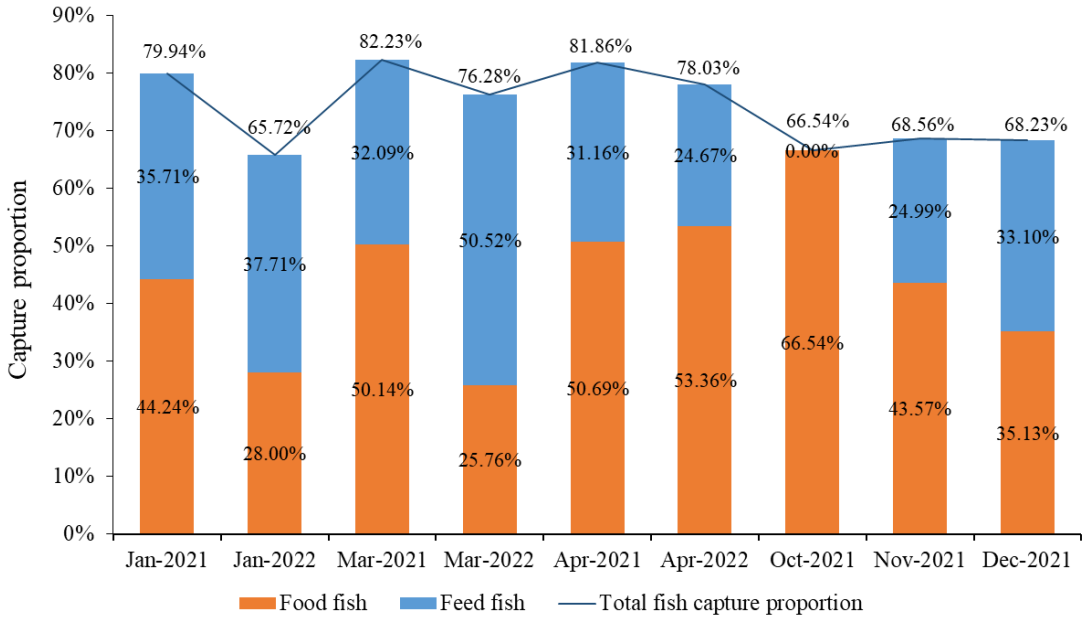

Fig. 3-7. Food and feed fish capture proportions (values on the tops of the bars) in the total capture volumes from trawl vessels surveyed (N = 79) in January-April 2021 and October 2021-April 2022 (except February) at the landing ports of Dongshan County.

3.5.4.2 Species diversity in feed fishes

Based on the monthly and randomly samplings of feed fishes (mean 1.92 kg/month, range of 1.24-3.09 kg) at the landing ports of Dongshan County in January-April 2021 and October 2021-April 2022 (except February), 154 species with 100 fishes, 41 crustaceans and 13 cephalopods were identified (Table 3-6).

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 January-April 2021 and October 2021-April 2022 (except February) in Dongshan County.
(*species only found in feed fishes) (Red: the first three dominant species or species group each month)

No.	Species name	Jan-2021		Jan-2022		Mar-2021		Mar-2022		Apr-2021		Apr-2022		Oct-2021		Nov-2021		Dec-2021	
		%	Size (cm)	%	Size (cm)	%	Size (cm)	%	Size (cm)	%	Size (cm)	%	Size (cm)	%	Size (cm)	%	Size (cm)	%	Size (cm)
1	*Platyrhina tangi*	0.56	5.5	0.33	5.0														
2	*Gymnothrax reticularis*					3.44	35.6									2.30	38.8		
3	**Caecula pterygera*											0.79	25.2-32.8			0.54	39.3		
4	**Ophichthus urolophus*					0.78	28.9												
5	**Apterichtus klazingai*			0.37	42.2			0.34	38.4										
6	**Pisodonophis cancrivorus*			5.28	35.5-46.0											0.48	27.3	2.95	3.4-31.2
7	*Callechelys kuro*					0.32	24.5					1.59	34.8						
8	*Ophichthidae* sp.					0.67	5.9-7.3												
9	**Oxyconger leptognathus*													1.47		2.75			
10	**Gnathophis nystromi*											0.68	16.1	1.71		0.38	17.1	1.69	24.0
11	**Gnathophis heterognathos*							0.23	14.2			1.83	13.0-18.5			0.37	6.5-12.6		
12	**Uroconger lepturus*																	1.43	24.1-28.9

13	**Saurenchelys fierasfer*													0.98	25.8-42.5			
14	**Sardinella aurita*													1.26	13.2			
15	**Stolephorus* sp.																0.17	3.9-5.7
16	**Thryssa kammalensis*							0.79	7.4-8.0									
17	**Gonorychus abbreviatus*			0.32	7.0-76.0	1.45	7.9-9.4			4.64	7.6-11.9	0.65	9.1-9.2					
18	*Trachinocephalus myops*	5.48		3.38	5.5-11.2	0.76	5.9-9.4	3.94	7.3-11.9	0.96	7.5-9.5	1.58	7.0-11.1	0.66	5.7-7.4	3.68	5.2-11.7	5.69	7.9-13.8
19	*Synodus fuscus*			0.26	7.7-8.1													4.76	1.0-13.3
20	**Synodus taiwanensis*					1.66	8.4-9.6												
21	*Saurida elongata*													0.93	13.2			
22	**Saurida tumbil*													0.44	6.6-8.2	1.82	1.4-13.2	
23	**Saurida undosquamis*	7.79		2.98	11.4-14.0			1.12	8.2-12.1					1.33	4.9-8.0	2.22	6.5-1.5	
24	**Saurida* sp.															0.79	3.5	
25	**Bregmaceros* sp.	0.85	4.9-6.6	7.34		0.39	5.3-7.8			2.35	4.5-6.5	0.56	4.7-6.1	0.24	5.0-6.1	0.26		0.42	5.3-6.3
26	**Ophidion muraenolepis*													0.35	3.8-8.5	0.18	9.0		

27	**Trachyrhamphus serratus*											0.97	7.8						
28	**Apistus carinatus*	0.30	4.0-5.3	2.74	3.1-11.2			4.20	5.5-11.1	0.13	3.9-4.5	4.71	5.5-8.9	0.28	5.6	0.49	6.1-6.2	0.29	2.5-4.8
29	*Sebastiscus marmoratus*									0.83	6.5								
30	*Scorpaena miostoma*							0.47	4.2-5.1										
31	**Minous pusillus*			0.25	5.6														
32	**Minous monodactylus*	0.23	6.0																
33	**Aploactis aspera*					0.69	8.6												
34	*Chelidonichthys spinosus*					0.94	28.9												
35	**Lepidotrigla microptera*															1.98	9.6-1.9	2.74	11
36	**Lepidotrigla alata*			0.82	9.5														
37	**Onigocia spinosa*			0.73	7.8-8.7														
38	**Sorsogona tuberculata*			2.20	6.0-11.6			0.77	6.2-7.4			7.73	6.1-12.5	0.61	3.0-8.0	3.88	3-11.7	0.72	8.6
39	**Rogadius asper*									1.41	7.3-1.4								
40	**Thysanophrys celebica*	1.40	5.9-7.0			1.73	8.2-9.3												
41	**Ostorhinchus kiensis*									0.15	3.4-4.0			0.17	3.2-5.2	0.35			

42	**Ostorhinchus semilineatus*													0.87	4.6				
43	*Ostorhinchus fasciatus*			0.17	5.4													0.31	4.9
44	**Apogonichthyoides niger*	1.72				0.97	5.8-5.9	0.33	4.2-4.6	0.43	5.5	1.94	5.5-5.8	1.13	3.7-5.7	0.29	5.5	0.69	4.1-5.3
45	**Jaydia lineatus*			0.53	3.4			0.65	3.8-4.9	0.66	6.5					0.29	2.8-4.8		
46	**Jaydia ellioti*															0.22	5.6		
47	*Sillago sihama*	1.93		2.93	6.0-11.2			2.48	5.5-9.6					4.63	4.8-12.0	4.26	3.4-9.3	4.69	6.6-12.3
48	*Selaroides leptolepis*													0.31	7.2				
49	*Decapterus maruadsi*					12.17													
50	*Trachurus japonicus*									4.66	5.3-8.9	0.75	4.7-7.0						
51	**Equulites rivulatus*	0.68	3.9-4.5	0.47	4.9-6.0	0.60	3.1	2.89	4.0-5.6	0.30	3.5-4.8	0.68	4.6-5.5			0.64	2.5-5.6	3.61	3.6-5.8
52	**Leiognathus berbis*													0.32	6.6				
53	**Scolopsis vosmeri*													0.93	4.2				
54	*Evynnis cardinalis*					18.77				12.35		8.22	3.7-6.4	0.99	8.8				
55	*Polydactylus sextarius*															0.66	8.9	1.00	8.2
56	**Johnius distinctus*													0.73	9.9				
57	*Johnius trewavasae*																	4.89	6.9-

																			11.0
58	*Pennahia macrocephalus*													1.26	8.2-8.9	4.88	2.8-7.5	3.73	6.1-8.8
59	**Pennahia anea*													1.39	11.6				
60	**Pennahia argentata*																	1.23	3.1-8
61	*Upeneus japonicus*	1.92		2.45	3.6-6.0			3.66	6.4-10.0	1.58	1.2	1.55	4.3-10.0	1.57	2.9-1.9	0.36		2.92	5.3-7.5
62	*Teixeirichthys jordani*	1.74	9.1	1.80	8.0-9.5			5.94	8.2-1.2	1.49	8.7	4.18	8.3-9.9			0.47	6.4		
63	**Suezichthys gracilis*	0.35	5.1-6.1					0.39	8.1			2.93	8.3-9.1			1.27	7.3-1.3		
64	**Parapercis ommatura*			0.42	5.5-6.5					0.22	7.5			0.53	4.3-6.2	0.21	3.4-6.5		
65	*Callionymus doryssus*	15.82		7.35		2.65	11.9-12.2	21.29	4-11.5	1.52	5.6-9.1	9.86	4.4-11.3	2.94		1.68	3.5-8.1	1.89	5.7-11.8
66	*Callionymus planus*			4.65		14.14		5.93	4.3-8	8.89	2.4-8.9	9.23	6.5-1.2	0.43	2.5-3.2	0.21	1.8-6.3		
67	**Callionymus curvicornis*									1.47	6.4-8.2								
68	**Limnichthys orientalis*					0.34	4												
69	**Trichonotus setiger*	1.55	1.0-13.1	1.19		7.30	7.6-14.2	6.42	6.1-14.5	1.96	1.2-12.9	1.73	1.5-12.4	3.81	7.9-15.1	3.11	7.1-12.7	4.74	9.4-16.2
70	**Trichonotus filamentosus*			0.94	6.0-10.6	0.35		0.39	8.1-9.4			0.12	8.5	0.22	9.6-10.0	2.93	8.2-15.2		

71	*Bleekeria viridianguilla*	8.51		6.86		12.99		7.47	6.1-13.0	26.14				27.27		13.84		8.37	6.8-13.5
72	*Bleekria mitsukurii*	2.69	8.1-11.2	1.63	9.7-11.7			4.55	9.4-11.7	3.00	6.2-1.3	1.84	7.0-11.6	13.18		4.83	8.8-11.2	2.62	9.6-11.4
73	**Uranoscopus chinensis*	0.18	2.8-2.9	0.27	2.3-5.1	2.34	9.2	1.32	4.3-8.8	0.35	5.3-5.9	0.35	2.6-4.2	0.18	3.1-3.2	0.31	2.7		
74	**Ichthyscopus lebeck*													0.16	2				
75	**Oxyurichthys microlepis*													0.13	3-4.5				
76	**Gobiidae* sp.			0.45	3.3-3.7							0.16	5.8						
77	**Valenciennea wardi*													0.77	6.2-8.4				
78	**Valenciennea immaculata*													0.18	7.7				
79	**Ptereleotris hanae*															0.83	6.4		
80	*Siganus fuscescens*													2.39	8.5-12.3			3.00	12.4
81	*Trichiurus haumela*	9.65	27.9-44											0.59	34.7	2.36			
82	**Trichiurus* sp.			2.64	28.1-38.8														
83	*Scomber japonicus*					1.31	12.6					1.35	11.6						
84	*Psenopsis anomala*					0.12	3.8												
85	**Tarphops oligolepis*	0.32	4.4-	0.21	4.8-					0.47	4.5-			1.73	4.7-	0.38	4.9-	0.41	4.8-

			5.5		5.7						5.1				5.8		5.6		5.6
86	**Psettina tosana*															0.19	6.5		
87	**Psettina* sp.			0.13	6.7														
88	**Engyprosopon grandisquama*							0.47	7.9			1.67	1.2	1.53	6.1-11.7	4.83	5.5-9.2		
89	**Engyprosopon maldivensis*			1.40	8.4-9.3														
90	**Engyprosopon multisquama*			0.73	5.1	2.13	7.5-1.3	0.89	5.5-6.8	3.91	6.3-9	1.82	7.4-7.7	0.13	4.4-4.7	1.37	4.1-6.2		
91	**Bothidae* sp.													0.34	4.0				
92	**Pleurinichthys cornutus*			1.22	11.1									0.42	7.4				
93	**Samaris cristatus*															0.33	4.8-7.6		
94	**Liachirus melanospilos*			0.69	6.5-8.8			0.33	6.5					0.13	3.5-4.8	0.79	9.9		
95	**Cynoglossus joyneri*			0.70	12.9														
96	**Cynoglossus kopsi*	5.57	6.9-14.3	3.28	6.6-12.2					1.57	6.6-1.5					2.90	5.7-12.4		
97	**Cynoglossus puncticeps*					0.14	6.6												
98	**Cynoglossus* sp.							2.73	4.8-11.4			0.74	8.0-8.1						
99	*Paramonacanthus sulcatus*	1.15	6.4-6.9	0.40	6.9					3.95	8.9-16.6			7.24		0.54	7.3		

100	*Lagocephalus wheeleri*							1.92	1.5					2.18	27.3-39.3				
101	**Lophosquilla costata*	0.62	5.9-6.9	0.33	5.1-6.3	0.46	1.2-1.4			1.00	5.3-8.7	1.32	6.3-6.8	0.28	5.1-7.3	0.23	3.7-5.0	0.37	4.8-5.9
102	**Erugosquilla woodmasoni*											1.98	11.2			0.25	7.1		
103	**Carinosquilla multicarinata*	0.32	7.1	0.17	7.0									0.38	5.3-6.3	0.73	4.7		
104	**Oratosquillina interrupta*											0.49	8.0					0.14	5.2
105	**Odontodactylus japonicus*	2.57	13.7													2.55	14.4		
106	**Sicyonia lancifer*													0.50	2.5-2.9				
107	**Solenocera crassicornis*													0.59	5.1-7.1	0.15	6.5		
108	*Trachysalambria curvirostris*			0.42	5.4-6.3							0.54	7.5	0.89	4.7-6.0	0.47		0.83	4.2-6.3
109	*Parapenaeopsis hardwickii*																	0.70	4.7-7.7
110	**Kishinouyepenaeopsis amicus*																	0.59	6.5-7.3
111	*Kishinouyepenaeopsis cornuta*	0.15	7.1	0.50	4.4-6.7	0.35	1.9-6.4	0.65	5.1-8.3					0.20	5.0-6.5	0.37			
112	**Mierspenaeopsis cultrirostris*																	0.15	3.2-4.1

113	**Batepenaeopsis tenella*			0.48	3.0-3.4								0.75	3.1-4.0				
114	**Parapenaeus longipes*												0.18	3.1				
115	*Metapenaeopsis barbata*	2.49				3.32				1.14			1.55	4.1-9.3	0.55		0.92	5.3-7.3
116	**Metapenaeopsis dalei*			5.39				2.83	3.7-6.0			1.33	3.9-6.0	1.51	3.0-6.8	1.77	3.1-6.8	1.63	3.6-6.4
117	**Metapenaeopsis palmensis*									0.49	3.8-6.0								
118	**Metapenaeopsis sp.*			0.29	7.9			0.55	9.5									
119	**Leptochela gracilis*			0.66	1.7-2.7													
120	**Conchoecetes artificiosus*					0.93	1.6											
121	**Pugettia* sp.												0.46	1.5				
122	**Doclea ovis*												0.11	0.8				
123	**Myra affinis*			0.39	1.5													
124	**Myra fugax*	0.19	1.2			0.46	1.2						0.55	1.3	0.36	1.3		
125	**Leucosiidae* sp.			0.14	0.9			0.46	1.1									
126	*Calappa philargius*	0.17	2.0	0.29	2.7								0.64	2.3	1.91	3-5.7	0.28	2.4
127	**Cycloes granulosa*									0.22	2.0						0.76	1.3
128	**Enoplolambrus validus*									0.22	2.4							
129	**Matuta planipes*			0.94	1.2-	0.94	3.4-			1.36	3.0-	1.31	3.4-	0.28	3.3		0.40	1.7-

					2.7		3.6				4.0		3.7						2.4
130	**Matuta banksi*							0.53	1.6										
131	**Portunus hastatoides*															0.93	1.4-4.0	0.13	3.2
132	**Portunus gracilimanus*	0.64	11.6											0.57	1.4-2.7	1.84	2.3-3.5	5.19	2.3-3.9
133	*Portunus sanguinolentus*	2.35	2.1-8.0	2.38	2.1-7.1	0.52	1	1.28	2.9-5.3	0.52	3.1-5.5					0.85	4.2-6.6		
134	**Portunus argentatus*			0.24	2.1			2.83	2.2-5.8			2.34	3.0-4.3	0.56	2.4-3.2	0.55	1.5-3.6		
135	*Monomia haanii*	11.46		6.78	2.0-6.5	5.63	2.0-5.5	9.13	2.9-5.6	8.12		6.13	1.8-6.6	3.44	1.7-5.8	7.14	2.5-6.4	18.45	2.6-6.2
136	**Charybdis bimaculata*															0.27	1.6-3.4		
137	*Charybdis nataor*			1.98	6.8											1.18	5		
138	**Charybdis variegata*	2.44	1.6-2.9	0.47	1.0-3.3	0.83	1.0-1.9	0.38	1.4-2.1	0.24	2.4-2.6	4.28	2.1-8.4	1.42		0.65	1.1-2.7	0.13	2.4
139	**Charybdis* sp.			0.34	1.5-2.0														
140	**Liocarcinus corrugatus*									0.57	1.5								
141	**Heteropilumnus* sp.			0.22	1.1														
142	**Sepiidae* sp.															0.25	4.8		
143	**Sepiola berryi*	5.63	2.0-4.0	1.42	1.0-2.9			1.59	2.6-4.0	0.22	1.2-2.2	2.59	2.5-3.5	0.45	2.0	0.75	2.8-3.7		

144	**Sepiadarium kochii*											0.51	3.5						
145	**Sepiola* sp.	0.24	2.5							0.35	1.6-3.2					0.30	2.8		
146	*Uroteuthis duvaucelii*																	5.33	3.8-7.0
147	**Uroteuthis edulis*															0.97	5.7-7.5		
148	*Loliolus uyii*			0.97	4.0-6.6														
149	**Loliginidae* sp.	0.45	4.0											0.73	3.0	0.12	3.0-3.5		
150	**Todarodes pacificus*					1.75				1.66	11.3								
151	*Octopus variabilis*															0.72	3.5	0.57	3.9
152	*Octopus ocellatus*											1.41	2.5-2.6						
153	*Amphioctopus aegina*	1.29	4.5	0.43	4.0							0.88	3.1			1.43	5.9		
154	**Octopodidae* sp.							0.96	4.0										

3.5.4.3 *Monomia haanii* in feed fishes

M. haanii was one of the few species commonly found in feed fish samples in trawl fishery in Dongshan County and contributed to 3.44%-18.45% of the total feed fish volumes in January-April 2021 and October 2021-April 2022 (except February) (Table 3-6).

Based on the size for 50% female maturity (6.3 cm CW) of *M. haanii* (Lin et al., 2021), up to 97.20% individuals (n = 208) of *M. haanii* were juveniles in feed fishes, and the juvenile proportions were in 90.00%-100.00% in January-April 2021 and October 2021-April 2022 (except February) (Table 3-6).

3.6 Biology of *Monomia haanii*

Monomia hannii samplings were conducted in October 2021-April 2022 (except February). A total of 1,229 individuals were collected and measured from trawl fishery.

3.6.1. Size variation by month

Sizes (carapace width, CW in cm) of *M. haanii* ranged from 1.7 to 12.7 cm CW, and monthly average sizes ranged from 6.8 cm CW in January to 8.4 cm CW in November (Table 3-7; Fig. 3-8). The sizes of *M. haanii* in Phases I-III (August 2018-December 2019) were larger than those in Phase V. In Phases I-III, the minimum sizes were larger than 2.0 cm CW, and in Phase V the minimum sizes were less than or equal to 2.0 cm CW in January 2022, April 2022 and October 2021.

Table 3-7. Number of samples and size (carapace width, CW, cm) of *Monomia haanii* from trawl fishery in Dongshan County in October 2021-April 2022

Month	Number	Range of CW (cm)	Average CW (cm)
Jan-2022	250	2.0-12.7	6.8
Mar-2022	261	2.9-11.3	6.9
Apr-2022	221	1.8-11.0	8.2
Oct-2021	152	1.7-10.8	7.6
Nov-2021	225	2.5-11.5	8.4
Dec-2021	120	2.6-11.5	8.2

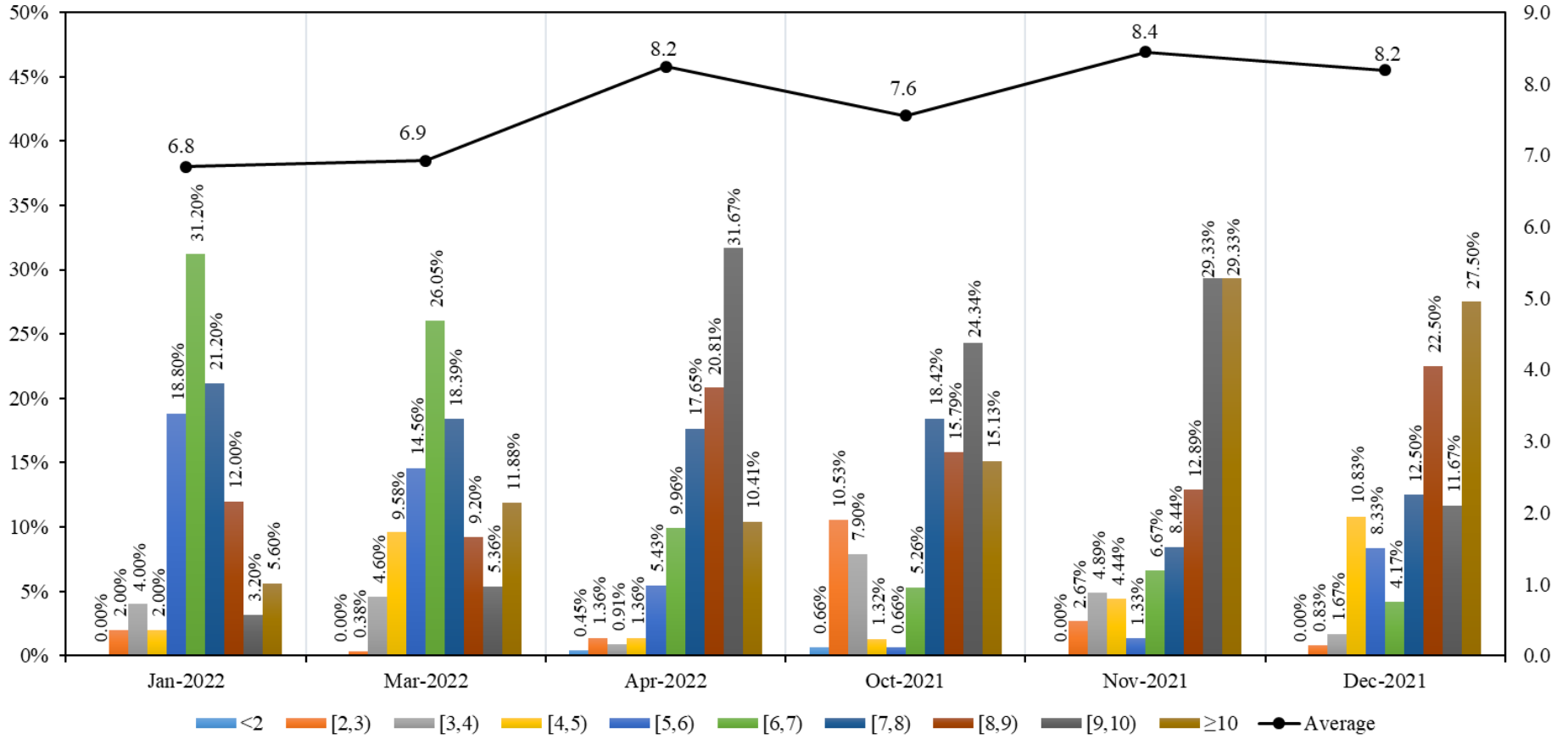

Fig. 3-8. Proportions of different size classes (cm in carapace width) of *Momonia haanii* (left Y-axis) and the trends of the monthly average sizes (right Y-axis) in trawl fishery in Dongshan County in October 2021-April 2022.

The dominant size classes of *M. haanii* in October 2021-April 2022 showed monthly variation (Fig. 3-8):

(1) Proportions of larger sizes (≥ 10.0 cm CW) were high in November and December at 29.33% and 27.50%, respectively, and were less than 20% in the rest of months.

(2) Sizes smaller than 8.0 cm CW (the minimum size for catch regulation in Fujian Province, 2018) were 79.20% in January 2022, 73.56% in March 2022, 37.12% in April 2022, 44.75% in October 2021, 28.44% in November 2021 and 38.33% in December 2021.

(3) Sizes smaller than 6.0 cm CW (around the size at 50% sexual maturity) were found in all months, and mainly in December 2021 (8.33%), January 2022 (18.80%) and March 2022 (14.56%).

3.6.2. Size variation by sex

The sizes ranged from 2.7 to 10.6 cm CW for females (mean = 6.8, SD = 1.4, N = 481), and from 1.7 to 12.7 cm CW for males (mean = 8.2, SD = 2.4, N = 798) (Fig. 3-9). Males were significantly larger than females in CW ($W = 98{,}732$, $p < 0.01$). Females dominated in size classes of 5.0-9.0 cm CW, and males in size classes of 8.0-11.0 cm CW.

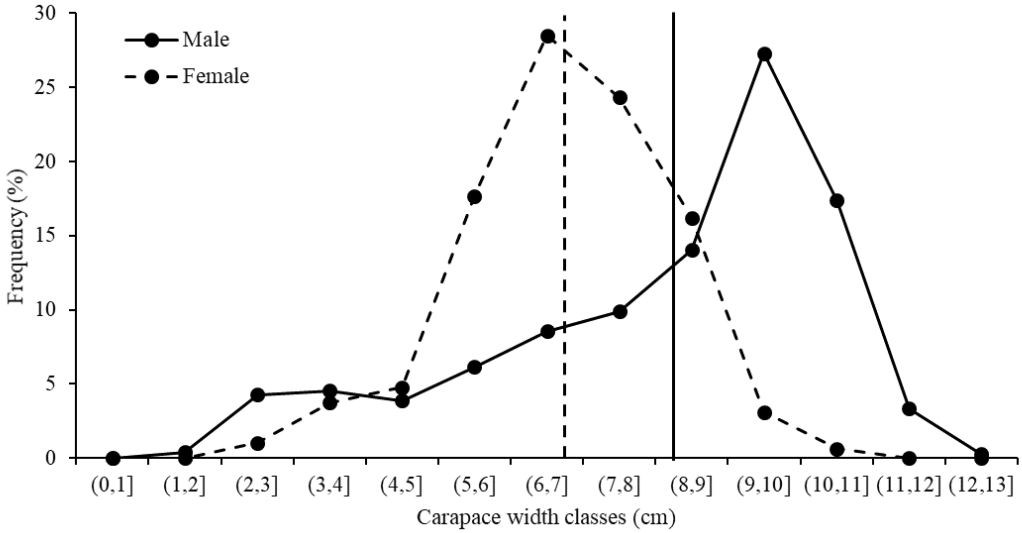

Fig. 3-9. Size (carapace width, CW) frequency (%) of *Monomia haanii* males (N = 748) and females (N = 481), collected from October 2021 to April 2022. Vertical lines indicate the average sizes of males and females.

3.6.3. Sex ratio

Sex ratios of *M. haanii* showed monthly variation. From the 1,229 individuals randomly sampled, the overall sex ratio of *M. haanii* was 1.56: 1 (male: female, N = 748 for males, N = 481 for females), showing an obvious male-bias in October-December 2021 and April 2022 (Fig. 3-10).

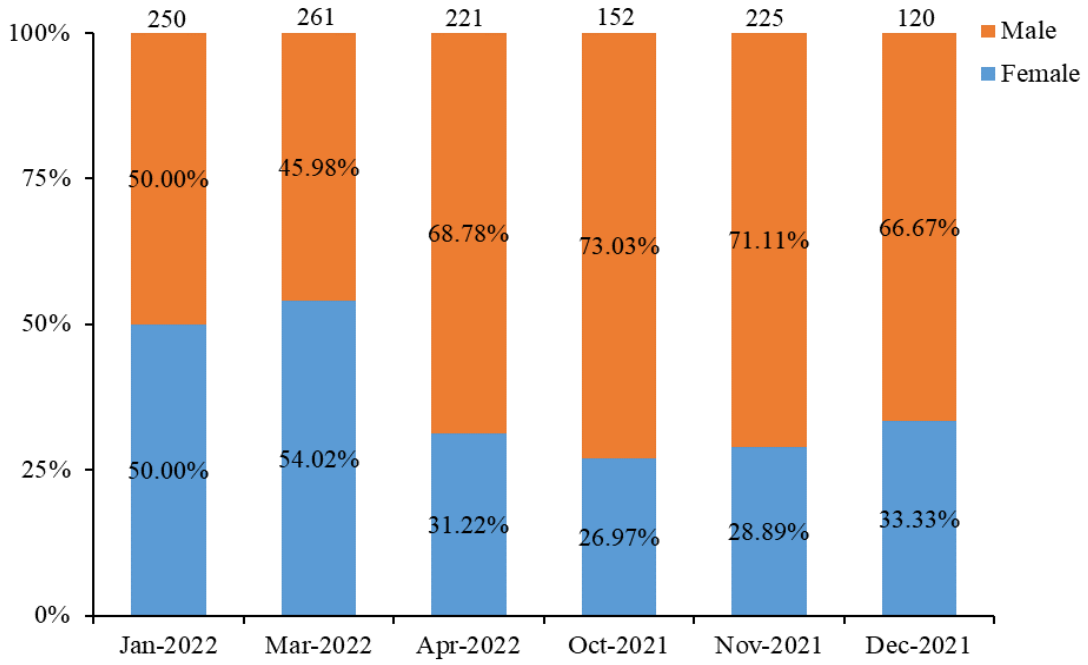

Fig. 3-10. Proportions of males and females of *Monomia haanii* (N = 1,229) in trawl fishery in Dongshan County in October 2021-April 2022.
(Number of samples at the top of the bars)

3.6.4. Spawning season

M. haanii females carrying eggs were found in most of sampling months except November 2021 (Fig. 3-11). The spawning peak was in March 2022, determining by the proportions (%) of number of females carrying eggs/number of females. No samples were collected in February 2022. There was a small peak in December 2021-January 2022.

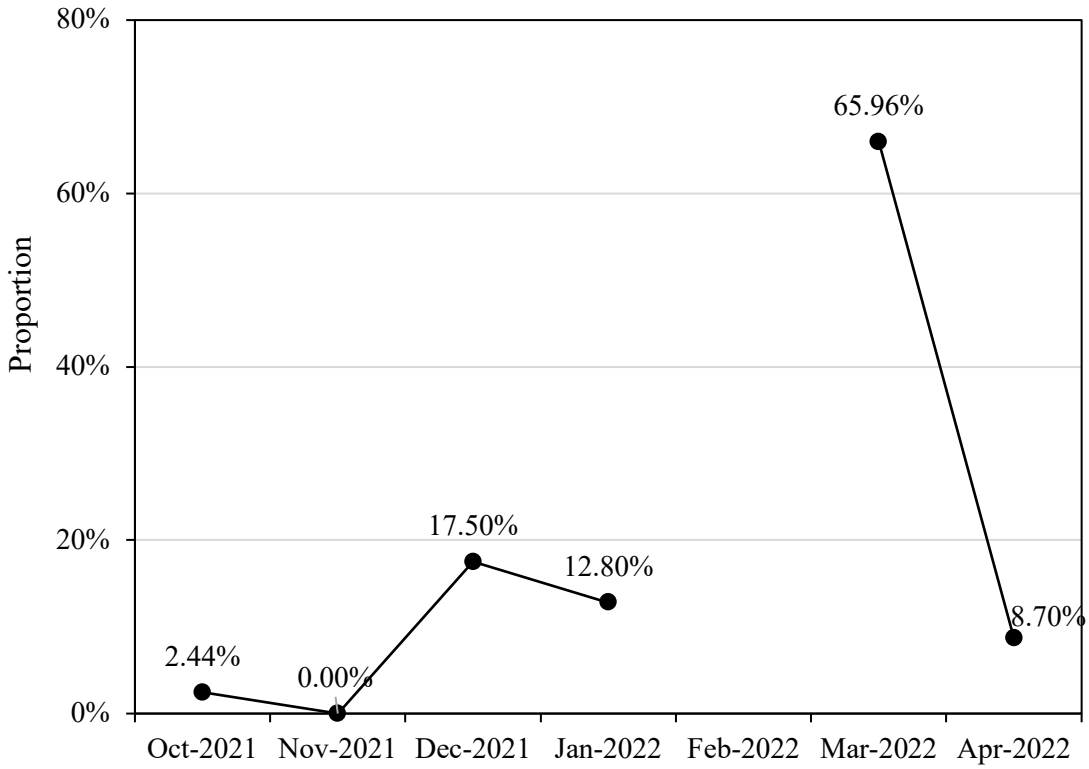

Fig. 3-11. Proportions of *Monomia haanii* females carrying eggs in trawl fishery in Dongshan County in October 2021-April 2022.

3.6.5. Sizes for female maturity

The minimum size for females carrying eggs was 4.0 cm CW, caught in March 2022, smaller than 4.6 cm CW in April 2019 and 5.5 cm CW in August 2018.

Females sampled in March 2022 (the spawning peak) were used to calculate the size at 50% female maturity (CW_{50}), and the estimated CW_{50} was 5.3 cm CW (Fig. 3-12), which was smaller than 6.3 cm CW estimated from 2019 samples (Lin et al., 2021).

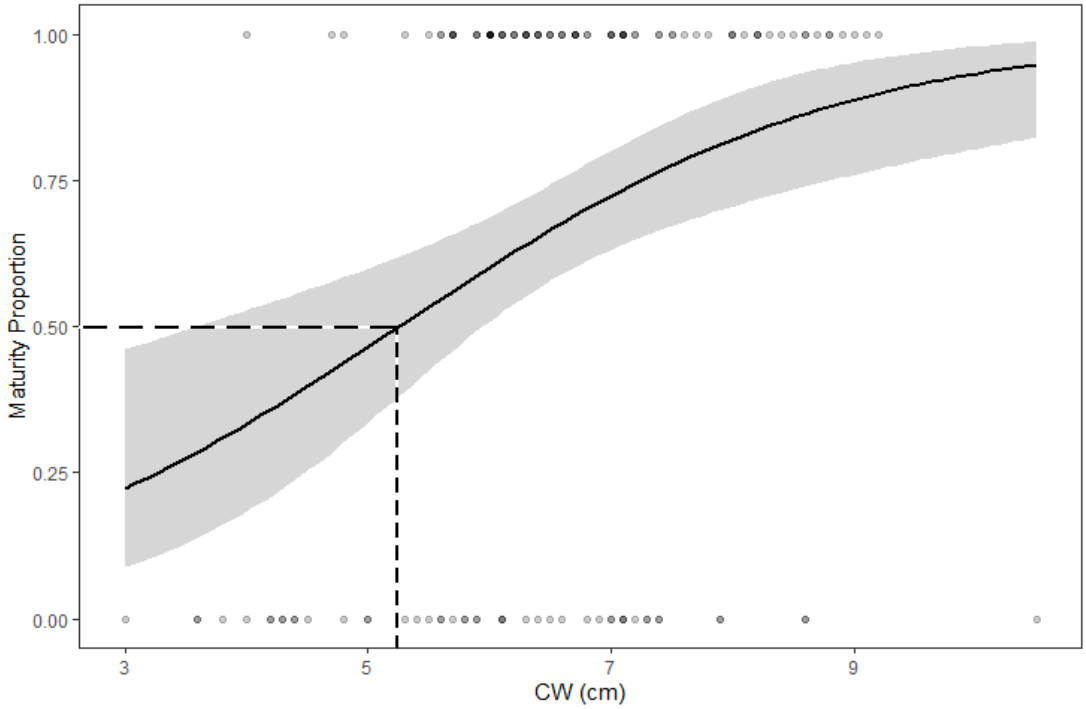

Fig. 3-12. Size (carapace width, CW) at 50% female maturity of *Monomia haanii* based on all females sampled in spawning peak determined, i.e. March 2022 (N = 144). The fitting curve was suggested by the black solid line with 95% CI. The circle represented the individuals that were mature (proportion = 1) or not (proportion = 0).

3.6.6. Size-weight and size-size relationships

The relationship of size (carapace width, CW) and weight (whole body weight, BW) for *M. haanii* was: $BW = 0.4542 \times CW^{3.1487}$ ($R^2 = 0.9684$; N = 1,229) (Fig. 3-13). The carapace length (CL)-carapace width (CW) relationship for *M. haanii* was: $CL = 0.553 \times CW + 0.1206$ ($R^2 = 0.9624$; N = 1,229) (Fig. 3-14).

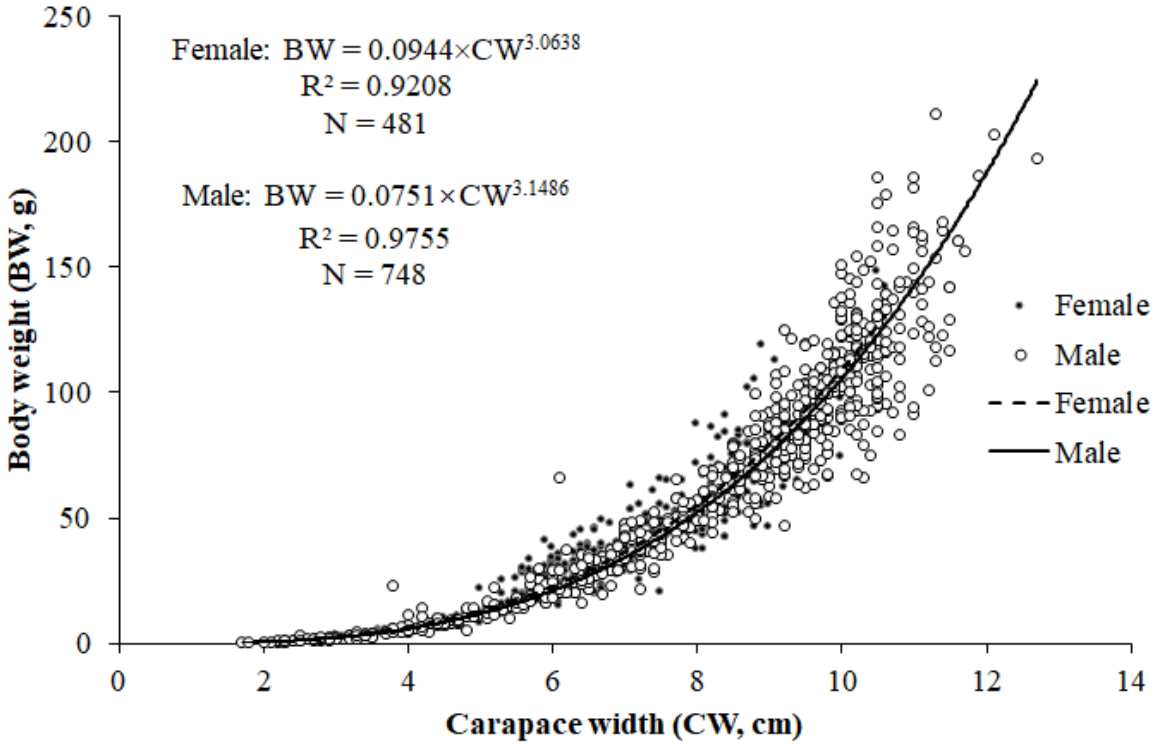

Fig. 3-13. Size (carapace width, CW)-weight (whole body weight, BW) relationship of *Monomia haanii* in Dongshan County in October 2021-April 2022.

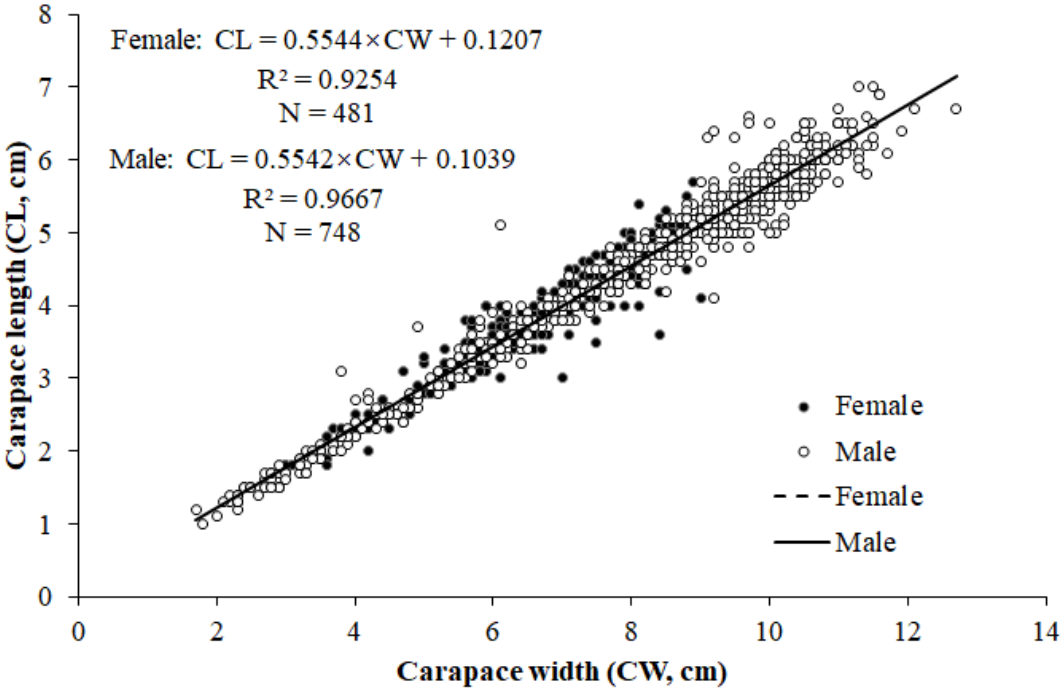

Fig. 3-14. Carapace length (CL)-carapace width (CW) relationship of *Monomia haanii* in Dongshan County in October 2021-April 2022.

3.7 Biology of *Portunus sanguinolentus*

Portunus sanguinolentus samplings were conducted in October 2021-April 2022 (except February). A total of 578 individuals were collected and measured from trawl fishery.

3.7.1. Size variation by month

Sizes (carapace width, CW in cm) of *P. sanguinolentus* ranged from 2.1 to 18.9 cm CW, and monthly average sizes ranged from 10.1 cm CW in March 2022 to 15.2 cm CW in December 2021 (Table 3-8, Fig. 3-15). The minimum sizes smaller than 3 cm CW were found in January and March 2022.

The dominant size classes of *P. sanguinolentus* in October 2021-April 2022 showed monthly variation:

(1) Proportions of larger sizes (≥ 15.0 cm CW) were high in October, November and December, accounting for 31.43%, 44.44% and 46.00%, respectively, and were less than 15% in January, March and April.

(2) Sizes smaller than 12.0 cm CW (the minimum size for catch regulation in Fujian Province) were 32.62% in January, 77.59% in March, 45.04% in April, 10.01% in October, 15.88% in November, and 8.00% in December; high before national fishing moratorium and low after national fishing moratorium.

Table 3-8. Number of samples and sizes (carapace width, CW, cm) of *Portunus sanguinolentus* from trawl fishery in Dongshan County in October 2021-April 2022.

Month	Number	Range of CW (cm)	Average CW (cm)
Jan-2022	92	2.1-15.8	11.6
Mar-2022	192	2.9-15.1	10.1
Apr-2022	111	8.2-15.8	12.3
Oct-2021	70	8.7-18.9	14.5
Nov-2021	63	4.2-18.6	14.8
Dec-2021	50	8.1-18.5	15.2

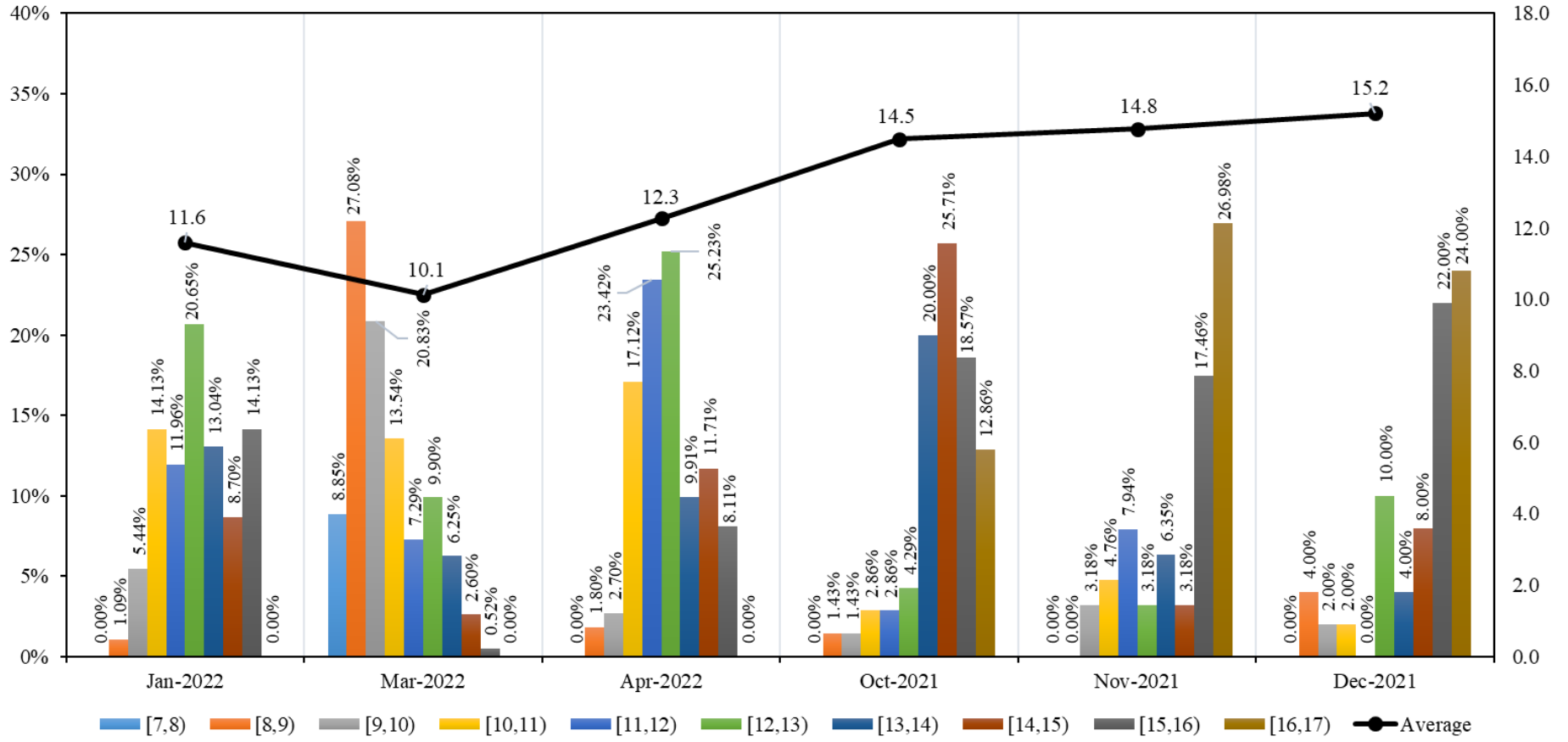

Fig. 3-15. Proportions of different size classes (cm in carapace width) of *Portunus sanguinolentus* (left Y-axis) and the trends of the monthly average sizes (right Y-axis) in trawl fishery in Dongshan County in October 2021-April 2022.

3.7.2. Size variation by sex

The sizes ranged from 5.1 to 17.6 cm CW for females (mean = 12.1, SD = 2.7, N = 341), and from 2.1 to 18.9 cm CW for males (mean = 12.2, SD = 3.6, N = 237) (Fig. 3-16). There was no significant difference between males and females in CW (W = 39,206, $p > 0.05$).

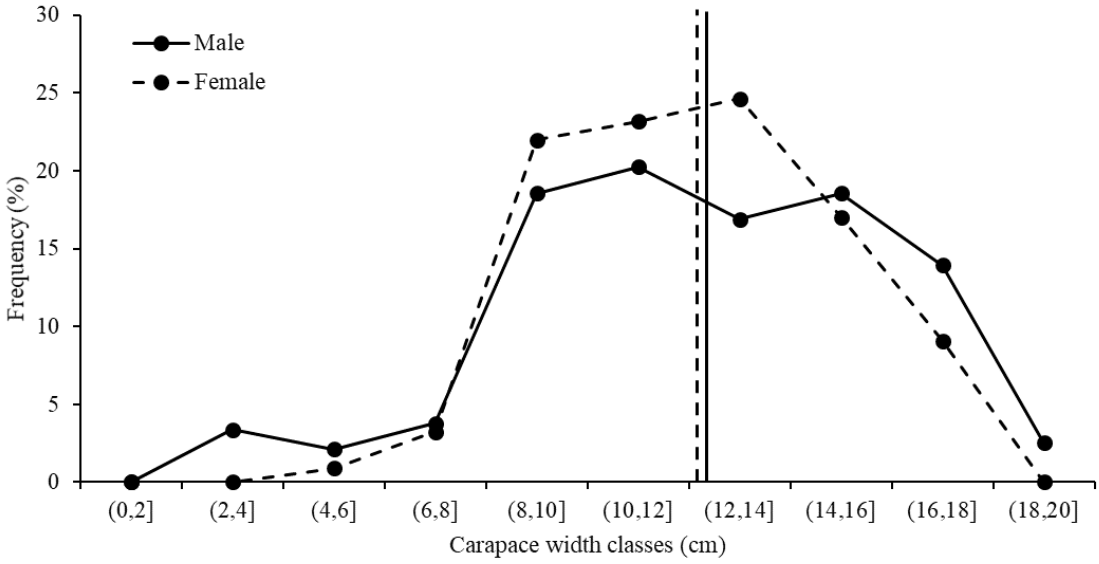

Fig. 3-16. Size (carapace width, CW) frequency (%) of *Portunus sanguinolentus* males (N = 237) and females (N = 341), collected from October 2021 to April 2022. Vertical lines indicate the average sizes of males and females.

3.7.3. Sex ratio

Sex rations of *P. sanguinolentus* showed monthly variation. From the 578 individuals randomly sampled, the overall sex ration of *P. sanguinolentus* was 1: 1.44 (male: female, N = 578), showing a female-bias in all surveyed months (Fig. 3-17).

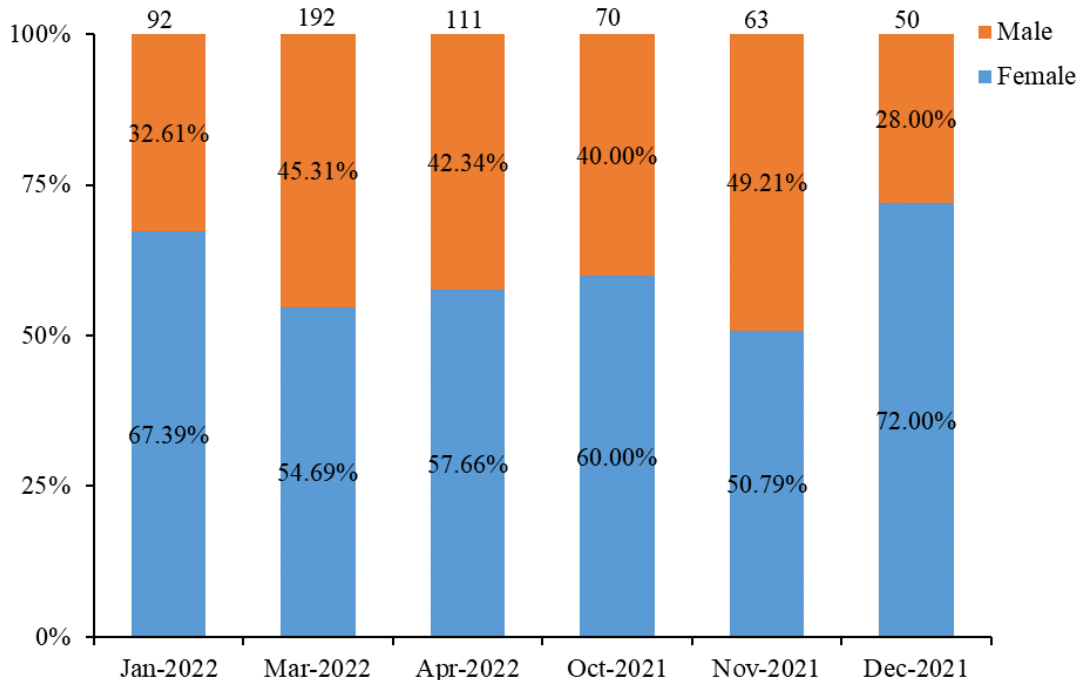

Fig. 3-17. Proportions of males and females of *Portunus sanguinolentus* (N = 578) in trawl fishery in Dongshan County in October 2021-April 2022.
(Number of samples at the top of the bars)

3.7.4. Spawning season

P. sanguinolentus females carrying eggs were found in most of sampling months except November 2021 (Fig. 3-18). The spawning peak was in April 2022, determining by the proportions (%) of number of females carrying eggs/number of females. No samples were collected in February 2022.

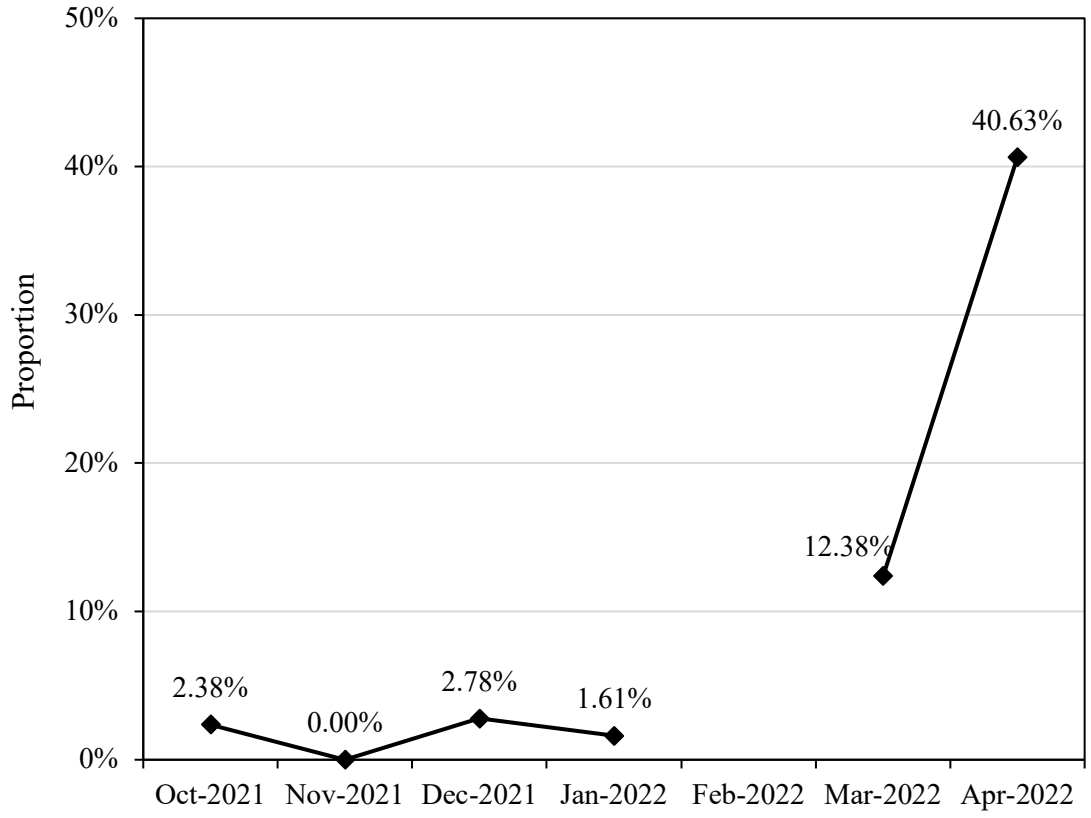

Fig. 3-18. Proportions of *Portunus sanguinolentus* females carrying eggs in trawl fishery in Dongshan County in October 2021-April 2022.

3.7.5. Sizes for female maturity

The minimum size for female carrying eggs was 5.6 cm CW for *P. sanguinolentus*, caught in the feed fish samples of January 2022, much smaller than 11.6 cm CW in August 2018, 9.6 cm CW in September 2019 and 8.0 cm CW in 1998 (Ye, 1998).

Females sampled in April 2022 (the spawning peak) were used to calculate the size at 50% female maturity (CW_{50}), and the estimated CW_{50} was 12.8 cm CW (Fig. 3-19).

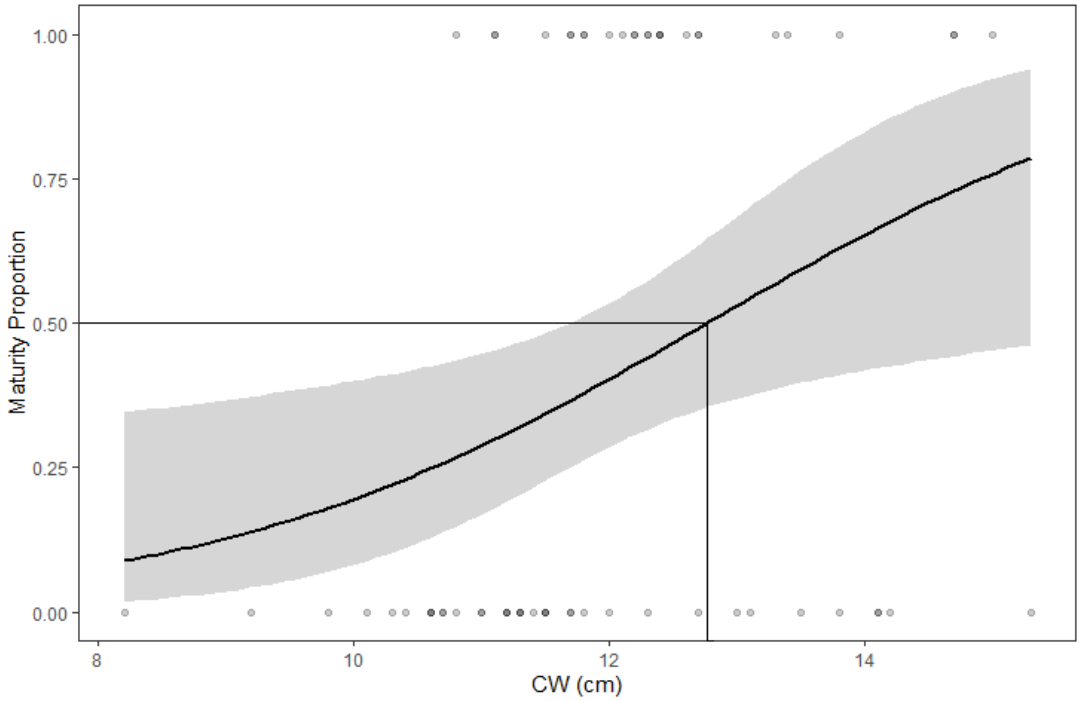

Fig. 3-19. Size (carapace width, CW) at 50% female maturity of *Portunus sanguinolentus* based on all females sampled in spawning peak determined, i.e. April 2022 (N = 64). The fitting curve was suggested by the black solid line with 95% CI. The circle represented the individuals that were mature (proportion = 1) or not (proportion = 0).

3.7.6. Size-weight and size-size relationships

The relationship of size (carapace width, CW) and weight (whole body weight, BW) for *P. sanguinolentus* was: $BW = 0.0683 \times CW^{2.9673}$ ($R^2 = 0.9413$; N = 578) (Fig. 3-20).

The carapace length (CL)-carapace width (CW) relationship for *P. sanguinolentus* was: $CL = 0.4294 \times CW + 0.3542$ ($R^2 = 0.9469$; N = 578) (Fig. 3-21).

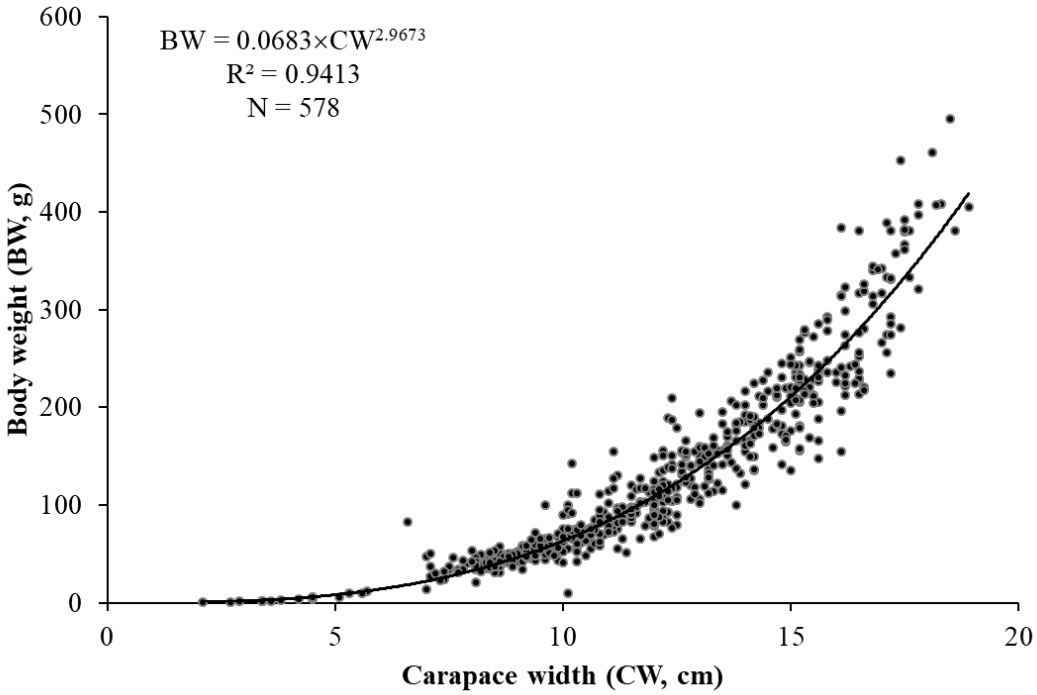

Fig. 3-20. Size (carapace width, CW)-weight (whole body weight, BW) relationship of *Portunus sanguinolentus* in Dongshan County in October 2021-April 2022.

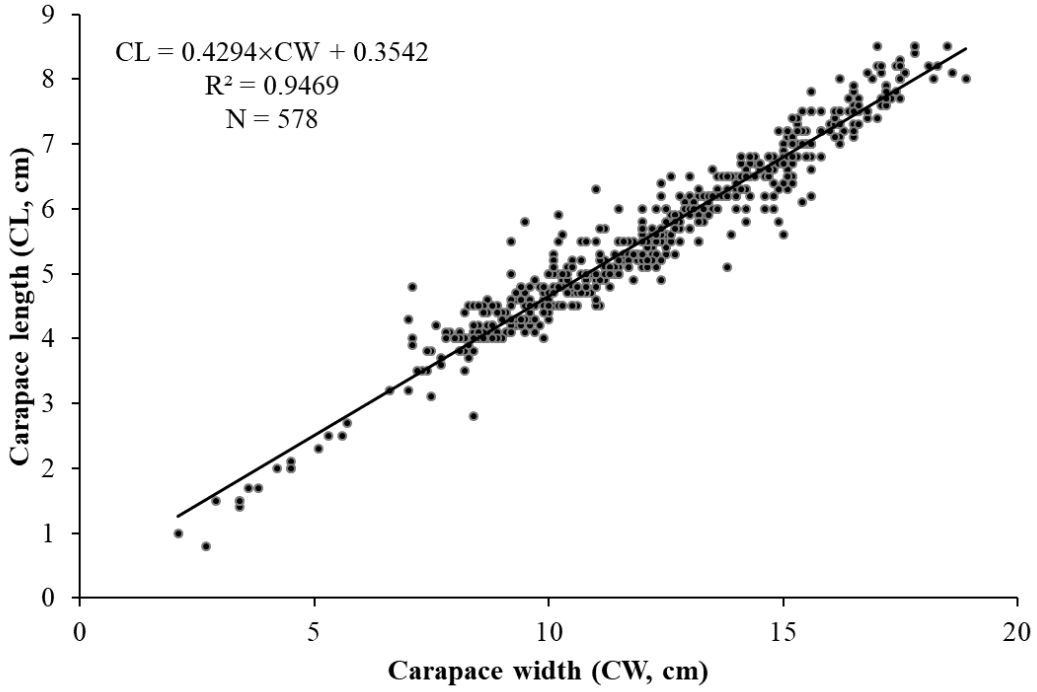

Fig. 3-21. Carapace length (CL)-carapace width (CW) relationship of *Portunus sanguinolentus* in Dongshan County in October 2021-April 2022.

3.8 Seahorse fishery and biology

3.8.1. Capture volume

The monthly average CPUE (kg/vessel/trip) and proportion (%, capture volume of seahorses in the total capture volume) of *H. trimaculatus* in January-April 2021 and October 2021-April 2022 (except February) at the landing ports of Dongshan County were estimated to be 0.00-1.06 kg/vessel/trip and 0.00%-0.01%, respectively (Fig. 3-22). The seahorse capture volumes declined dramatically; the highest CPUE (1.06 kg/vessel/trip in January 2021) was lower than the lowest CPUE of 1.82 kg/vessel/trip in August-December 2020.

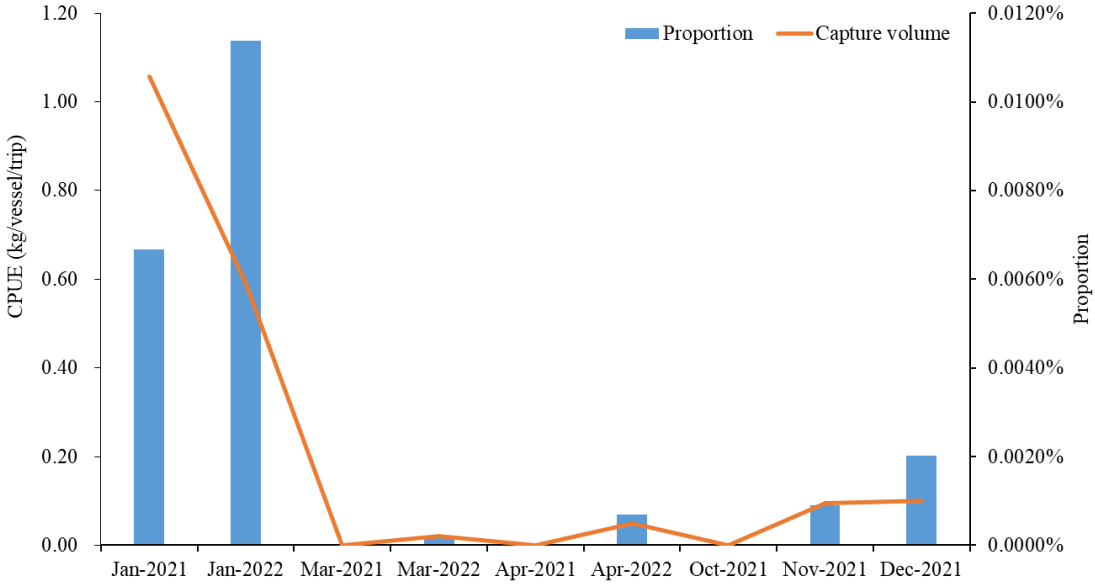

Fig. 3-22. Monthly average CPUE (kg/vessel/trip) and proportion (%) of *Hippocampus trimaculatus*, surveyed in January-April 2021 and October-December 2022 (except February) at the landing ports of Dongshan County (N = 79).

3.8.2. Capture area

Based on three logbook surveys from three trawl vessels in October 2021-April 2022 in Dongshan County, the main fishing grounds for seahorses were in Minnan Fishing Ground and Taiwan Bank Fishing Ground of the Taiwan Strait (Fig. 3-23). The depth data showed that the seahorses mainly live less than 70 m (Fig. 3-24).

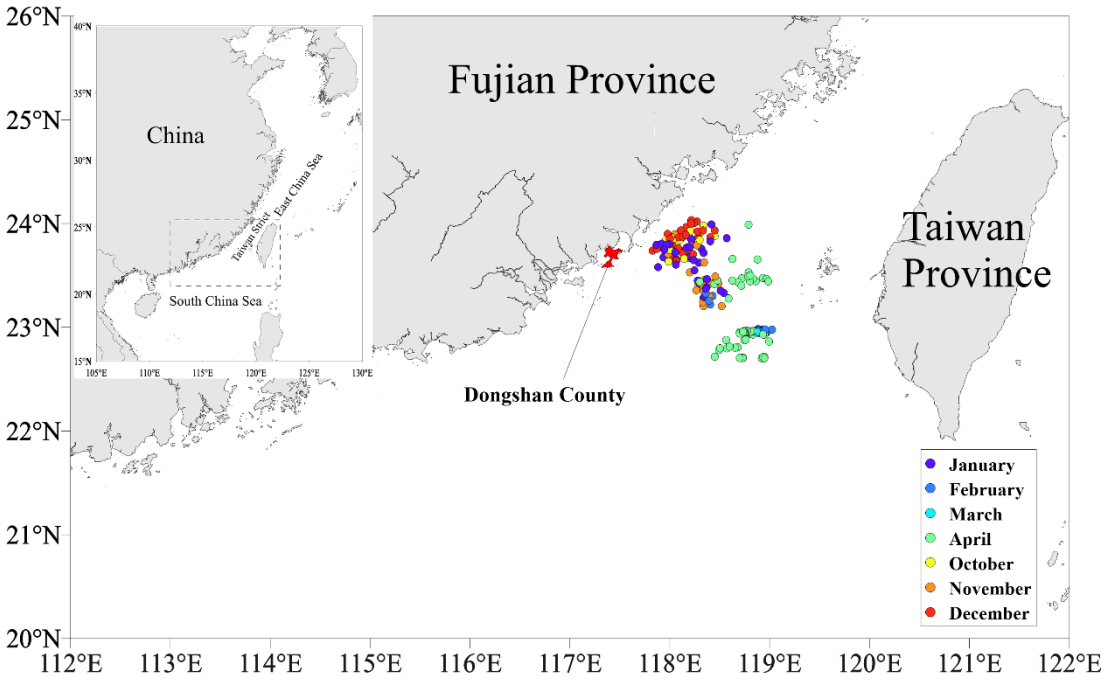

Fig. 3-23. Main fishing areas for seahorses.

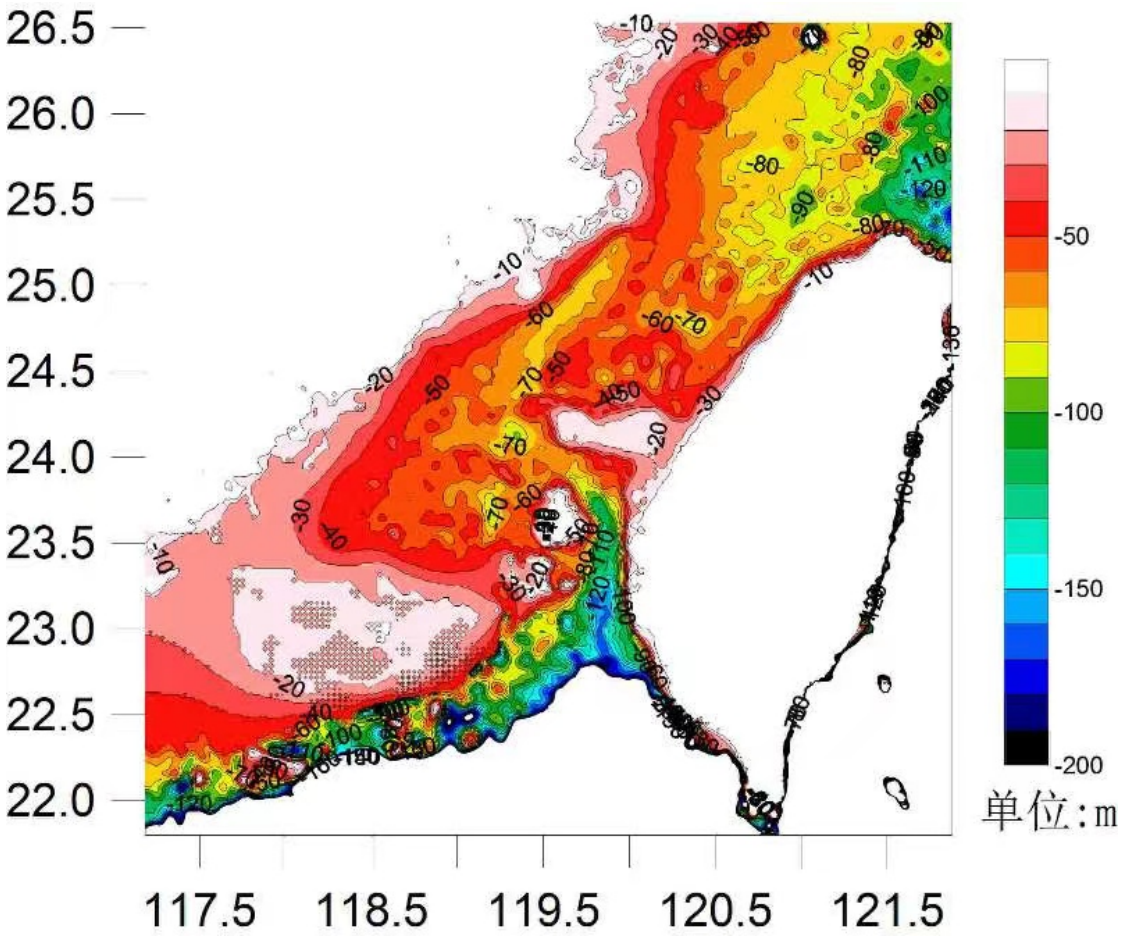

Fig. 3-24. Depth information in the Taiwan Strait. (From Zhao-zhang Chen)

3.8.3. Sex ratio

The overall sex ratio of *H. trimaculatus* was 1: 1.23 (male: female, N = 808) and there were significantly female-biases in April, September and October (Table 3-9).

Table 3-9. Number of samples, sex ratio, height and weight of *Hippocampus trimaculatus* in January-December 2019 (except May-July).

Month	Number	Sex Ratio (male: female)	Average height (range, cm)	Average weight (range, g)
January	93	1: 0.86	10.3 (8.1-13.0)	4.47 (1.59-9.47)
February	46	1: 1.09	12.3 (9.3-16.4)	7.85 (1.73-20.98)
March	56	1: 0.81	12.0 (9.5-14.8)	7.44 (3.04-15.28)
April	160	1: 2.48	9.1 (7.4-13.3)	2.91 (1.28-10.81)
May	-	-	-	-
June	-	-	-	-
July	-	-	-	-
August	55	1: 1.03	11.9 (9.8-13.2)	7.12 (3.12-12.91)
September	74	1:1.74	11.2 (9.1-13.0)	6.03 (2.11-9.87)
October	117	1: 1.85	9.6 (7.6-12.9)	3.31 (1.43-9.84)
November	114	1: 0.86	10.1 (7.7-14.0)	4.47 (1.45-12.46)
December	93	1: 0.63	9.6 (7.7-13.8)	3.40 (1.25-10.52)
Total	808	1: 1.23	10.3 (7.4-16.4)	4.59 (1.25-20.98)

3.8.4. Size variation

Sizes (height, H, cm) of *H. trimaculatus* ranged from 7.4 cm to 16.4 cm H, and monthly average sizes ranged from 9.1 cm H in April to 12.3 cm H in April (Table 3-9). The average H were large in February and March and small in April, October and December.

The dominant size classes of *H. trimaculatus* were 8-10 cm H for females, and 9-10 cm H for males (Fig. 3-25). Larger individuals (>13 cm H) were rare.

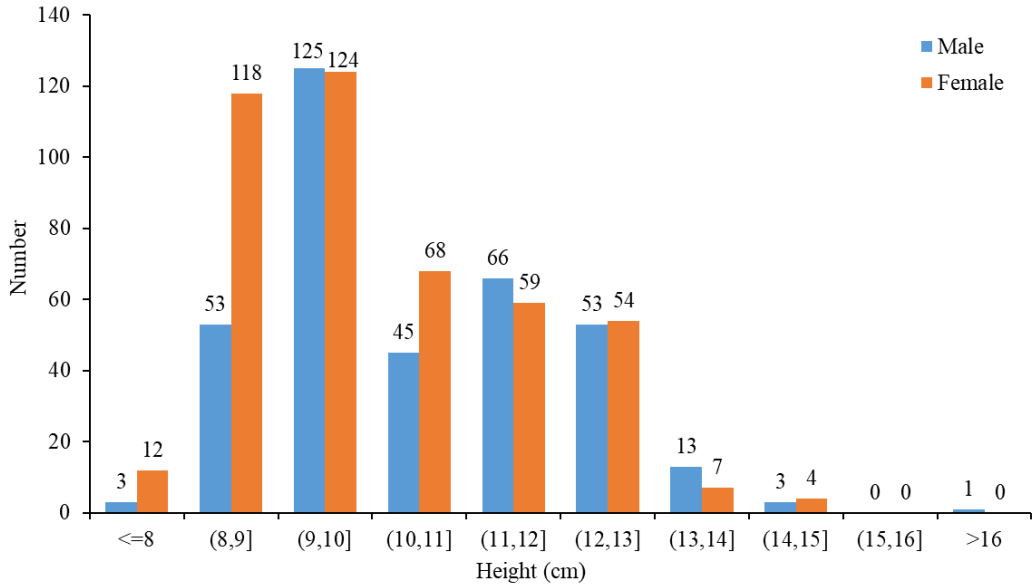

Fig. 3-25. Height distribution of *Hippocampus trimaculatus* males and females.

3.8.5. Height-weight relationship

The relationships of height (H) and weight (W) for males and females were: $W = 0.0008 \times H^{3.6813}$ ($R^2 = 0.9287$, N = 362) and $W = 0.0017 \times H^{3.3403}$ ($R^2 = 0.9360$, N = 446), respectively (Fig. 3-26).

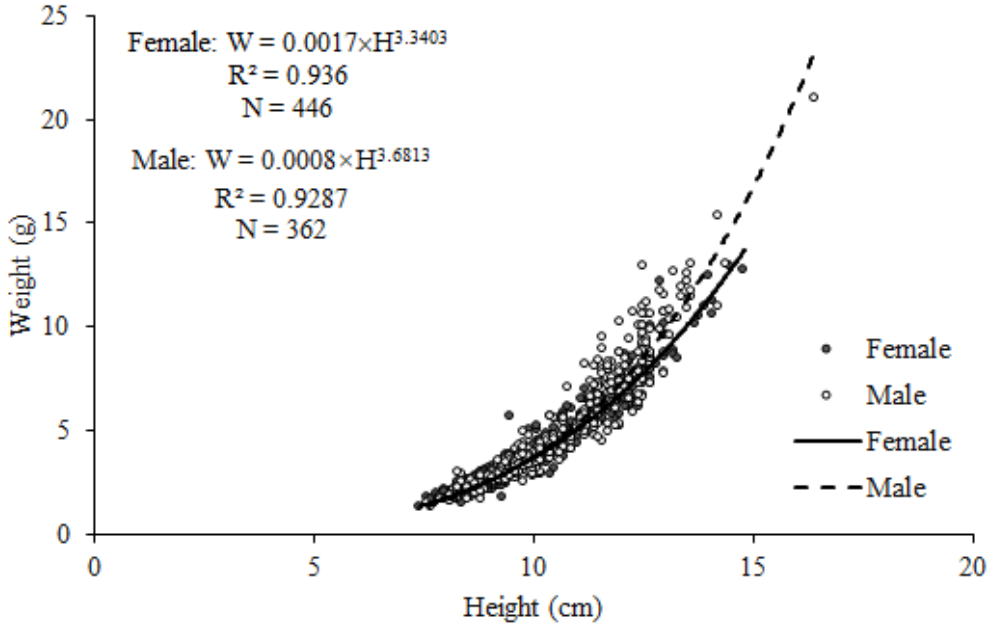

Fig. 3-26. Height (H)-Weight (W) relationships of *Hippocampus trimaculatus* males and females.

4. Significant findings

(1) A total of 253 species were identified in January-April 2021 and October 2021-April 2022 (except February), including 180 fishes (71.15%), 55 crustaceans (21.74%) and 18 cephalopods (7.11%).

(2) Totally 167 species with 108 fishes, 44 crustaceans and 15 cephalopods were identified in feed fishes in January-April 2021 and October 2021-April 2022 (except February). Among these species, 120 species were only found in feed fishes including 75 fishes, 36 crustaceans and 9 cephalopods.

(3) Seahorse bycatch by trawl fishery is common in Dongshan County. The dominant species was *H. trimaculatus*.

(4) Seahorse catches declined, dropping from about 0-50 kg/vessels/trip in 2018, 0-54.2 kg/vessel/trip in 2019 and 1.82-17.62 kg/vessel/trip in 2020 to 0-1.06 kg/vessel/trip in 2021-2022.

(5) In trawl fishery in Dongshan County, the main species groups were food fishes (46.16%), feed fishes (30.76%) and crustaceans (12.94%).

(6) 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 2022 (Figs. 4-1 & 4-2).

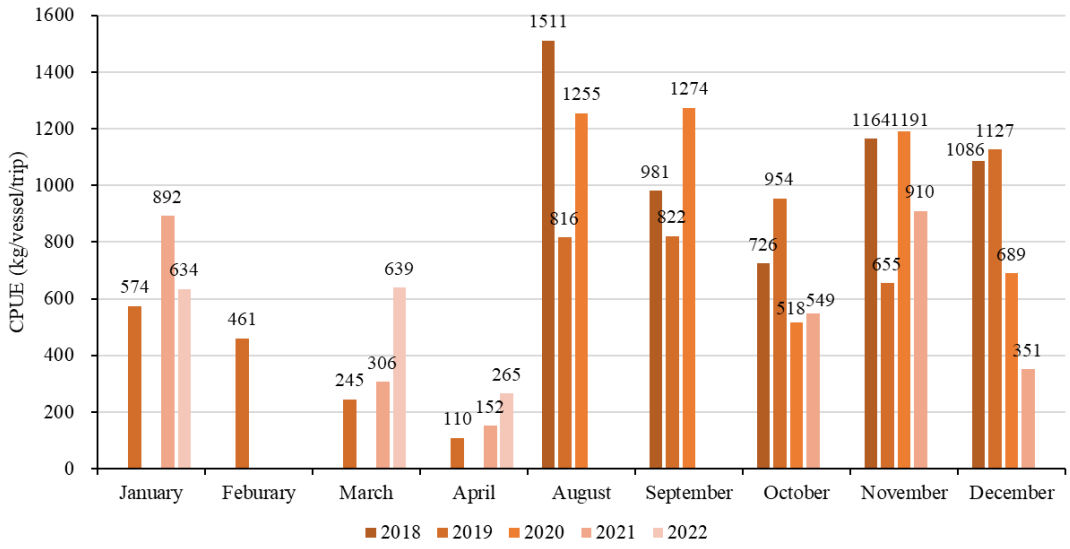

Fig. 4-1. Monthly average CPUE of *Monomia haanii* by kg/vessel/trip (values shown at the tops of the bars), surveyed at the landing ports of Dongshan County in 2018-2022.

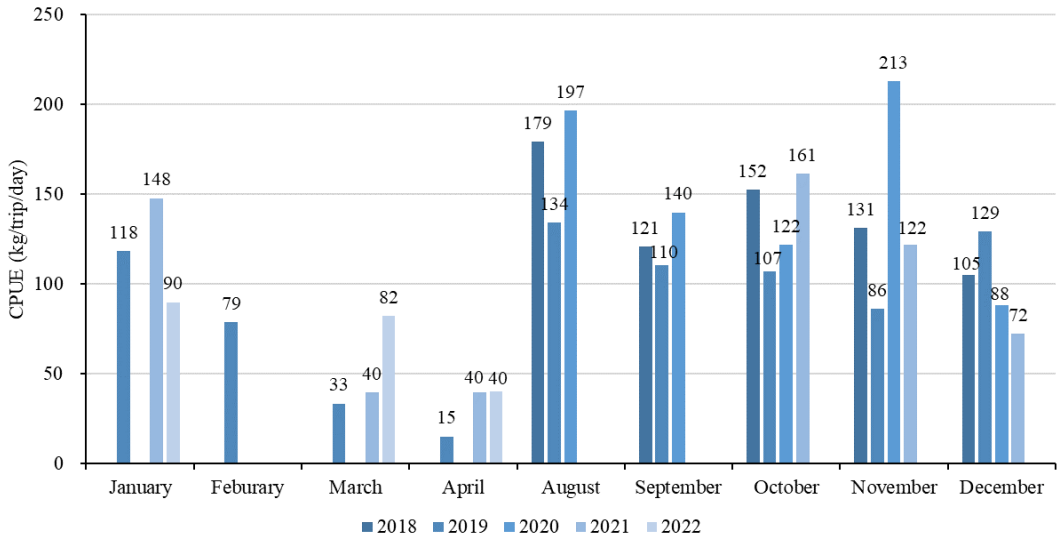

Fig. 4-2. Monthly average CPUE of *Monomia haanii* by kg/vessel/day (values shown at the tops of the bars), surveyed at the landing ports of Dongshan County in 2018-2022.

(7) There is a decline of size at 50% female maturity *M. haanii* in less than 5 years (Table 4-1).

(8) There are high proportion of *M. haanii* < 8 cm CW and *P. sanguinolentus* < 12 cm CW in catches, the minimum sizes for catch limitation.

(9) Based on the monthly sampling in October 2021-April 2022 (except February), the spawning peaks for *M. haanii* and *P. sanguinolentus* were in April and March, respectively.

Table 4-1. Sizes (carapace width, CW, cm) for female maturity.

Year	*Monomia haanii*		*Portunus sanguinolentus*	
	CWmin	CW50	CWmin	CW50
2018	5.5	-	11.6	-
2019	4.6	6.3	9.6	12.6
2021/2022	4.0	5.3	5.6	12.8

-: no data

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

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

5. Acknowledgements

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