Chinese Red Swimming Crab (*Monomia haanii*) Fishery Improvement Project (FIP) in Zhangzhou City, Fujian Province, China (January-December 2019)

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1. Introduction

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

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

Monomia haanii fishery has become to be important in Minnan-Taiwan Bank fishing grounds since the 1990s, and it can be caught year-round (Zhang 1997). The estimated annual capture volume of *M. haanii* in the 1990s was 30,000-35,000 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). *Monomia haanii* in Minnan-Taiwan Bank fishing grounds was reported to have two spawning seasons, in February-April and in October (Zhang 1997).

Monomia haanii is currently the most commercially important crab processed in Dongshan County (Zhangzhou City, Fujian Province, China) with the majority for export as crab meat products. Based on a previous study, the abundance and average size of *M. haanii* have shown a decline since first explored in the 1990s.

In an effort to ensure the fishery's sustainability, 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) launched a fisheries improvement project (FIP) in 2018. In the Phase I (August-December 2018), we conducted trawl and trap fisheries surveys in Dongshan County. Due to the low number of trap fishery landings in Dongshan County, we mainly focused on the trawl fishery.

In January-April 2019, Qingdao Marine Conservation Society (QMCS) launched the Phase II surveys for the FIP. We continued our focus on trawl and trap fisheries in Dongshan County with an extension to the trap fishery in Longhai County. The operation patterns of trap fisheries in Dongshan County and Longhai County are different; offshore in Minnan-Taiwan Bank fishing grounds and nearshore along coastline, respectively.

In August-December 2019, Ocean Outcomes (O2) and Qingdao Marine Conservation Society (QMCS) launched the phase III surveys for the FIP. We continued our focus on biology of four crabs (*Monomia haanii*, *Portunus sanguinolentus*, *Charybdis nataor* and *Calappa philargius*) and their fisheries in both trawl and trap fisheries in Dongshan County. Moreover, we started logbook surveys.

The initial fishery monitoring efforts of the Phase I-III were all contracted to Dr. Min Liu at Xiamen University. In order to better understand the patterns and trends of the crab fishery between trawl and trap fisheries, this report integrated the results from the Phases II and III, i.e. representing data as a 9-month period (January-April 2019, August-December 2019) when available. The objectives are defined as follows:

(1) to document the main species or species group composition and proportions in catches from trawl and trap gears, including those from "feed fishes"[1];

(2) to measure the size ranges of the main species (species groups) (including crustaceans, fishes and cephalopods) in catches;

(3) to determine the sex of crabs sampled and the status of females carrying eggs;

(4) to test logbook data collection approach; and

(5) to provide recommendations of steps needed to monitor, manage and ensure regulatory compliance to achieve improved sustainability in the respective Fujian crab fisheries.

[1] "Feed fishes" in this report are the mixtures of small-sized, low-valued, poorly preserved various fishes (also including crustaceans and cephalopods), whose common use is for aquaculture species feed. "Feed fishes" include some food fish, crustacean and cephalopod species in their small sizes.

2. Materials and Methods

2.1. Sampling sites and dates

This study was conducted in Dongshan County. Two major landing ports (Dawo and Gongqian) from Dongshan County were surveyed monthly from August to December, 2019 (Table 1; Fig. 2).

Table 1. Sampling dates in August-December 2019 in Dongshan County of Zhangzhou City, Fujian Province, China.

No.	Dongshan County
1	August 21-25th
2	September 7-10th
3	October 8-12th
4	November 16-20th
5	December 13-20th

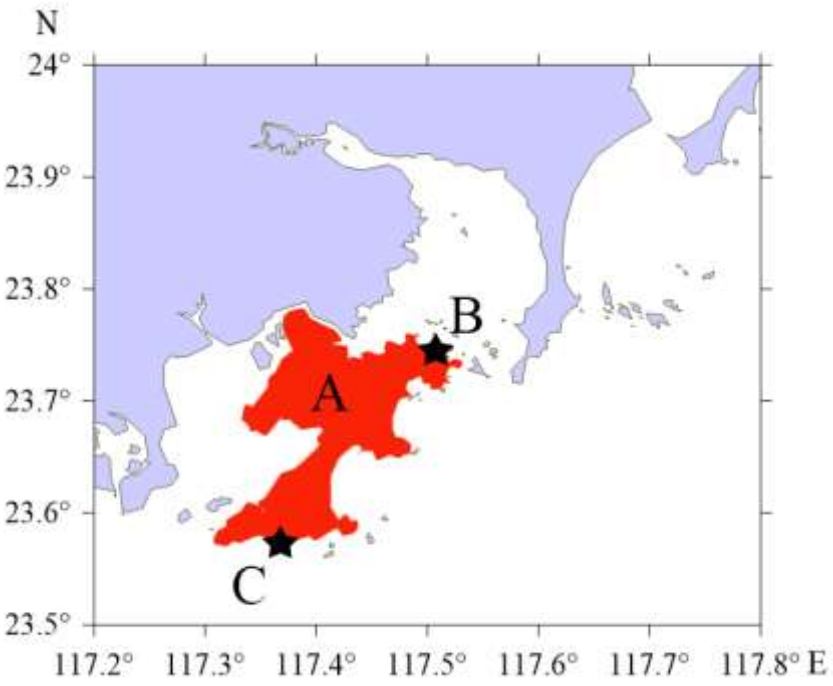

Fig. 2. Sampling sites (B: Dawo, C: Gongqian) in August-December 2019 in Dongshan County (A) of Zhangzhou City, Fujian Province, China

2.2. Types of fishing gears surveyed—trawl and trap

In Dongshan County, about 1,015 trawl vessels and 100 trap vessels are registered. For trap vessels, only 10-20% operate at sea in March and April (after Chinese Spring Festival), prior to the start of the national fishing moratorium in May due to the low catches of crabs (Mr. Fang & Mr. Xie, personal communications). In August-December 2019, two types of fishing gears were surveyed, trawl and trap (Fig. 3).

Fig. 3. Two types of fishing gears (left, trawl; right, trap) surveyed in August-December 2019 in Dongshan County.

2.3. Crab species sampled

In Dongshan County, four crab species - the Chinese red swimming crab *Monomia haanii*, the three-spot swimming crab *Portunus sanguinolentus*, the ridged swimming crab *Charybdis nataor* and the bread crab *Calappa philargius* - were dominant in crab catches and usually separated in catch landings in both trawl and trap fisheries.

Although the project focused on *M. haanii* fishery only, we extended our sample collection to *P. sanguinolentus*, *C. nataor* and *C. philargius* for better understanding the overall crab fishery in Dongshan County (Table 2).

In Dongshan County, at least 200 individuals of each of the four crab species (Table 2) were sampled randomly monthly for further measurement and examination in August-December 2019.

Table 2. Four crab species sampled.

No.	Photo	Species name
1		Red swimming carb *Monomia haanii*
2		Three-spot swimming crab *Portunus sanguinolentus*
3		Ridged swimming crab *Charybdis nataor*
4		Spotted box crab *Calappa philargius*

2.4. Feed fish sampled

At least 1 kg of feed fishes were randomly collected each month in August-December 2019 from trawl vessels in Dongshan County for further size measurement and species identification. This will explore our understanding on species diversity and size range in feed fishes in the trawl fishery of Dongshan County.

2.5. Fishing vessel information collection

For those trawl and trap vessels where crab and feed fish sampled, information on vessel registration number, fishing areas and number of days at sea were collected.

2.6. Capture volume data collection

For those trawl and trap vessels where crab and feed fish were sampled, total capture volume, crab capture volume, and 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.

2.7. Logbook information collection

We explained the importance of this crab project to the captains and crews, and identified 6 captains (3 trawl vessels and 3 trap vessels) who agreed to conduct logbook surveys. The logbooks were collected at the end of every month, and we also communicated directly with vessel crews through Wechat to solve the problems on data collection. Data collected included the total capture volume, crab capture volume, *M. haanii* capture volume, and fishing locations with detailed latitude and longitude.

2.8. 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 purchased for further identification in the laboratory.

For feed fish samples, species were identified to species or genus levels, as most specimens were of small size and usually in poor condition.

Fish identification was mainly 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).

2.9. Sample measurement

Sample measurements were conducted in the laboratory or at the landing ports.

2.9.1. Crabs

For the four target crabs sampled, the carapace size (cm) and body weight (g) of specimens were measured 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. 4). The sex was determined based on the morphology of abdomen (Fig. 5).

The spawning season of crabs is determined by the high proportions of the females bearing eggs (Fig. 6). 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; meanwhile the eggs are fertilized and then further develop until the larvae are released into the sea.

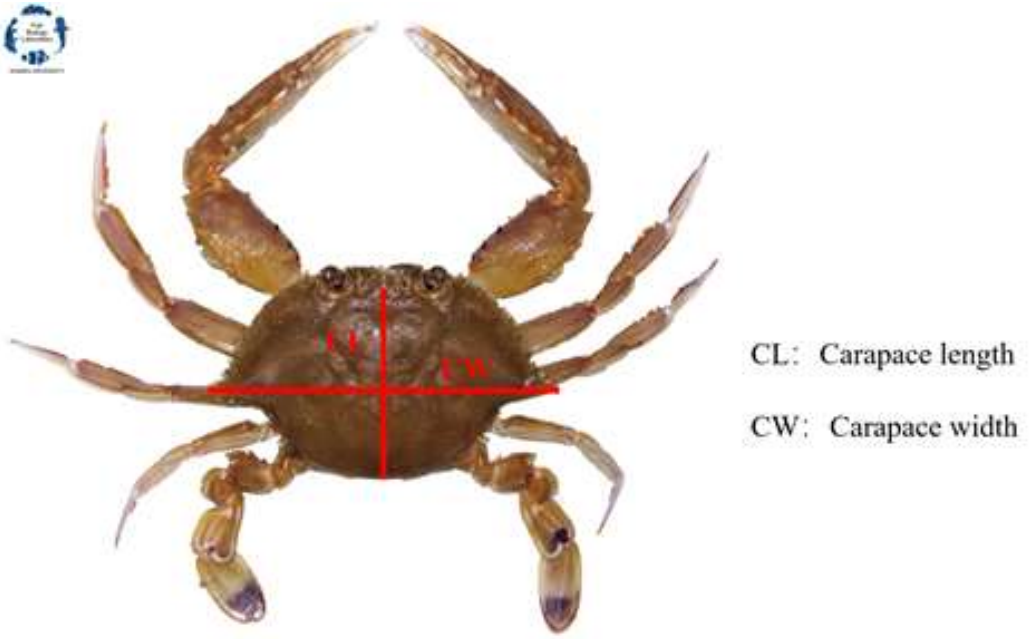

Fig. 4. Crab measurement for carapace size in the laboratory.

Fig. 5. Sex determination for crabs.

Fig. 6. A female crab bearing eggs.

2.9.2. Dominant species in catches

For dominant species in catches, sizes were estimated directly at the landing ports by deploying a ruler on the top of catches and subsequently by taking photos. Size estimation was conducted by displaying photos in the computer screen for measurement.

2.9.3. Feed fishes

For fishes, crustaceans and cephalopods in feed fish samples, measurements were also

conducted individually for length (in cm) and body weight (in g), with a maximum 30 individuals of each species per batch.

3. Results

3.1. Species diversity

3.1.1. Species composition

In Dongshan County, a total of 344 species was identified from trawl and trap fisheries between August 2018 and December 2019 (coving Phases I, II and III periods), including 269 fishes (78.2%), 57 crustaceans (16.6%) and 18 cephalopods (5.2%) (Table 3). Fishes come from two classes (Chondrichthyes and Actinopterygii), 21 orders and 88 families, with more than half of the fish species from the order Perciformes. Crustaceans come from two orders and 13 families, and cephalopods from two orders and four families.

Among 344 species, 320 species were found in trawl fishery including 247 fishes, 55 crustaceans and 18 cephalopods, while 95 species were found in trap fishery including 77 fish species, 12 crustaceans and 6 cephalopods (Table 3). There were 73 species, including 56 fishes, 11 crustaceans and 6 cephalopods, found in both trawl and trap fisheries (Table 3). There were 21 species, including 20 fish species and 1 crustacean species, only found in the trap fishery (Table 3).

Table 3. The complete species listing (N=344) from trawl and trap fisheries in August 2018-December 2019 (i.e. Phases I, II and III) in Dongshan County.

Order	Family	Species	Common Name	No.	Trawl	Trap
Fish						
Carcharhiniformes	Carcharhinidae	*Scoliodon macrorhynchos*	Pacific spadenose shark	1	+	
		Carcharhinus sorrah	Spot-tail shark	2	+	
		Galeocerdo cuvier	Tiger shark	3	+	
	Shpyrnidae	*Sphyrna lewini*	Scalloped hammerhead	4	+	
	Scyliorhinidae	*Cephaloscyllium umbratile*	Blotchy swell shark	5	+	
		Halaelurus buergeri	Blackspotted catshark	6	+	
	Triakidae	*Mustelus griseus*	Spotless smooth-hound	7	+	
Torpediniformes	Narcinidae	*Narcine lingula*	Chinese numbfish	8	+	
Rajiformes	Rhinidae	*Rhynchobatus immaculatus*	Taiwan wedgefish	9	+	
		Rhynchobatus australiae	Bottlenose wedgefish	10	+	
	Rhinobatidae	*Rhinobatos schlegelii*	Berown guitarfish	11	+	
		Rhinobatos microphthalmus	Smalleyed guitarfish	12	+	
		Rhinobatos hynnicephalus	Angel fish	13	+	
	Rajidae	*Okamejei boesemani*	Boeseman's skate	14	+	
Myliobattiformes	Platyrhinidae	*Platyrhina sinensis*	Chinese fanray	15	+	
		Urolophus aurantiacus	Sepia stingray	16	+	
	Dasyatidae	*Dasyatis akajei*	Red stingray	17	+	
		Dasyatis zugei	Pale-edged stingray	18	+	
		Neotrygon kuhlii	Blue-spotted stingray	19	+	
		Taeniura meyeni	Round ribbontail ray	20	+	

	Gymnuridae	*Gymnura japonica*	Japanese butterflyray	21	+	
	Myliobatidae	*Aetobatus flagellum*	Longheaded eagle ray	22	+	
		Aetobatus narinari	Spotted eagle ray	23	+	
Anguiliformes	Muraenidae	*Gymnothorax reticularis*	Netted moray	24	+	+
		Gymnothorax niphostigmus	Snowflake-patched moray	25		+
		Gymnothorax hepaticus	Liver-colored moray eel	26	+	+
		Gymnothorax flavimarginatus	Yellow-edged moray	27		+
		Gymnothorax cribroris	Sieve-patterned moray	28	+	+
		Gymnothorax albimarginatus	Whitemargin moray	29		+
		Gymnpthorax prionodon	Australian mottled moray	30		+
	Ophichthidea	*Xyrias chioui*	Snake eel	31	+	
		** Apterichtus hatookai*	Orange blotched eel	32	+	
		**Callechelys kuro*	Black ridge-fin eel	33	+	
		Pisodonophis cancrivorus	Longfin snake-eel	34	+	
		**Saurenchelys fierasfer*	Duck-billed eel	35	+	
		Caecula pterygera	Finny snake eel	36	+	
		Brachysomophis cirrocheilos	Stargazer snake eel	37	+	
	Congridae	*Conger japonicus*	Beach conger	38	+	+
		Gnathophis heterognathos	Shorttail pike conger	39	+	
		**Gnathophis nystromi*	Conger eel	40	+	
		Conger myriaster	Whitespotted conger	41		+
	Muraenesocidae	*Muraenesox cinereus*	Daggertooth pike conger	42	+	+
		Uroconger lepturus	Slender conger	43	+	
		Oxyconger leptognathus	Shorttail pike conger	44	+	
Clupeiformes	Clupeidae	*Nematalosa nasus*	Bloch's gizzard shad	45	+	

		Sardinella aurita	Round sardinella	46	+	+
		Sardinella zunasi	Japanese sardinella	47	+	
	Engraulidae	**Stolephorus commersonnii*	Commerson's anchovy	48	+	
		**Engraulis japonicus*	Japanese anchovy	49	+	
		**Thryssa kammalensis*	Kammal thryssa	50	+	
		Thryssa mystax	Moustached thryssa	51	+	
		Thryssa vitrirostris	Orangemouth anchovy	52	+	
		Thryssa hamiltonii	Hamilton's thryssa	53	+	
Gonorynchiformes	Gonorynchidae	*Gonorynchus abbreviatus*	beaked salmon	54	+	
Siluriformes	Ariidae	*Arius arius*	Threadfin sea catfish	55	+	
		Arius maculatus	Spotted catfish	56	+	
		Plotosus lineatus	Striped eel catfish	57	+	
Aulopiformes	Synodontidae	*Saurida elongata*	Slender lizardfish	58	+	+
		Saurida tumbil	Greater lizardfish	59	+	+
		**Synodus hoshinonis*	Blackear lizardfish	60	+	
		Trachinocephalus myops	Snakefish	61	+	+
Gadiformes	Bregmacerotidae	**Bregmaceros sp.*	Codlet	62	+	
Ophidiiformes	Ophidiiae	*Brotula multibarbata*	Goatsbeard brotula	63		+
Lophiiformes	Lophiidae	*Lophiomus setigerus*	Blackmouth angler	64	+	
		Antennarius striatus	Striated frogfish	65	+	
Mugiliformes	Mugilidae	*Mugil cephalus*	Flathead grey mullet	66	+	
		**Crenimugil crenilabis*	Fringelip mullet	67	+	
		Moolgarda cunnesius	Longarm mullet	68	+	
Beryciformes	Monocentridae	*Monocentris japonica*	Pineconefish	69	+	
Zeiformes	Zeidae	*Zeus faber*	John dory	70	+	

Gasterosteiformes	Pegasidae	*Pegasus laternarius*	Brick seamoth	71	+	
	Syngnathidae	*Halicampus grayi*	Gray's pipefish	72	+	
		Syngnathidae sp.	Pipefish	73	+	
		Trachyrhamphus serratus	Rough pipefish	74	+	
		Solegnathus hardwickii	Hardwicke's pipefish	75	+	
		Hippocampus histrix	Thorny seahorse	76		+
		Hippocampus kelloggi	Giant seahorse	77	+	
		Hippocampus kuda	Longnose seahorse	78	+	
		Hippocampus trimaculatus	Spotted seahorse	79	+	+
		Hippocampus kelloggi	Giant seahorse	80	+	
	Fistulariidae	*Fistularia commersonii*	Bluespotted cornetfish	81	+	
		Fistularia petimba	Red cornetfish	82	+	
Scorpaeniformes	Scorpaenidae	*Apistus carinatus*	Ocellated waspfish	83	+	
		Dendrochirus bellus	Bricked firefish	84	+	
		Pterois paucispinula	Turkeyfish	85	+	
		Pterois volitans	Lionfish	86	+	
		**Parapterois heterura*	Blackfoot Lionfish	87	+	
		Minous monodactylus	Grey stingfish	88	+	
		Sebastiscus marmoratus	False kelpfish	89	+	+
		Scorpaenopsis macrochir	Flasher scorpionfish	90	+	+
		Scorpaena miostoma	Scorpionfish	91		+
		Scorpaenopsis cirrosa	Weedy stingfish	92	+	+
	Aploactinidae	**Aploactis aspera*	Dusky velvetfish	93	+	
	Triglidae	*Dactyloptena orientalis*	Oriental flying gurnard	94	+	
		Chelidonichthys spinosus	Spiny red gurnard	95	+	

		**Lepidotrigla alata*	Forksnout searobin	96	+	
		Lepidotrigla microptera	Redwing searobin	97	+	
		**Lepidotrigla japonica*	Longwing searobin	98	+	
	Platycephalidae	*Grammoplites scaber*	Rough flathead	99	+	+
		** Rogadius asper*	Olive-tailed flathead	100	+	
		** Thysanophrys celebica*	Celebes flathead	101	+	
		** Suggrundus macracanthus*	Large-spined flathead	102	+	
		Platycephalus indicus	Bartail flathead	103	+	+
		Cociella crocodila	Crocodile flathead	104	+	
		Inegocia japonica	Japanese flathead	105	+	+
		**Inegocia guttata*	Crocodile flathead	106	+	
		**Sorsogona tuberculata*	Tuberculated flathead	107	+	
Perciformes	Mornidae	*Lateolabrax japonicus*	Japanese seabass	108	+	
	Serranidae	*Diploprion bifasciatum*	Barred soapfish	109	+	
	Epinephelidae	*Cephalopholis boenak*	Chocolate hind	110	+	+
		Cephalopholis sonnerati	Tomato grouper	111		+
		Epinephelus akaara	Hong Kong grouper	112	+	+
		Epinephelus areolatus	Areolate grouper	113	+	
		Epinephelus awoara	Yellow grouper	114	+	+
		Epinephelus bleekeri	Duskytail grouper	115	+	+
		Epinephelus bruneus	Longtooth grouper	116	+	
		Epinephelus coioides	Orange-spotted grouper	117	+	+
		Epinephelus latifasciatus	Striped grouper	118	+	+
		Epinephelus quoyanus	Longfin grouper	119	+	+
		Epinephelus tankahkeei	Grouper	120	+	+

		Triso dermopterus	Oval grouper	121	+	+
	Priacanthidae	*Priacanthus tayenus*	Purple-spotted bigeye	122	+	+
		Priacanthus macracanthus	Red bigeye	123	+	+
		Pristigenys niphonia	Japanese bigeye	124		+
	Apogonidae	*Apogon semilineatus*	Half-lined cardinal	125	+	
		* *Ostorhinchus kiensis*	Rifle cardinal	126	+	
		Apogon cathetogramma	Cardinalfish	127	+	+
		**Apogon lineatus*	Indian perch	128	+	
		**Apogon niger*	Cardinalfish	129	+	
		**Ostorhinchus fasciatus*	Broadbanded cardinalfish	130	+	
	Sillaginidae	*Sillago sihama*	Silver sillago	131	+	+
		Sillago japonica	Japanese sillago	132	+	+
	Coryphaenidae	*Coryphaena hippurus*	Common dolphinfish	133	+	
	Rachycentridae	*Rachycentron canadum*	Cobia	134	+	
	Echeneidae	*Remora remora*	Shark sucker	135	+	
	Carangoides	*Parastromateus niger*	Black pomfret	136	+	
		Selaroides leptolepis	Yellowstripe scad	137	+	
		**Alepes kleinii*	Razorbelly scad	138	+	
		Decapterus maruadsi	Japanese scad	139	+	
		Trachurus japonicus	Japanese jack mackerel	140	+	+
		Seriola aureovittata	Yellowtail amberjack	141	+	+
		Seriola nigrofasciata	Blackbanded trevally	142	+	
		Alectis ciliaris	African pompano	143	+	
	Menidae	*Mene maculata*	Moonfish	144	+	
	Leiognathidae	*Equulites rivulatus*	Ponyfish	145	+	

		**Secutor ruconius*	Deep pugnose ponyfish	146	+	
	Lutjanidae	*Lutjanus russellii*	Russell's snapper	147	+	
		Lutjanus vitta	Brownstripe red snapper	148		+
		Lutjanus erythopterus	Crimson snapper	149	+	
		Lutjanus ophuysenii	Spotstripe snapper	150		+
	Haemulidae	*Hapalogenys analis*	Broadbanded velvetchin	151	+	+
		Parapristipoma trilineatum	Chicken grunt	152	+	+
		Plectorhinchus pictus	Trout sweetlips	153	+	
		Plectorhinchus cinctus	Crescent sweetlips	154	+	
	Nemipteridae	*Nemipterus japonicus*	Japanese threadfin bream	155		+
		Scolopsis vosmeri	Whitecheek monocle bream	156		+
		Parascolopsis inermis	Unarmed dwarf monocle bream	157		+
	Lethrinidae	*Lethrinus atkinsoni*	Pacific yellowtail emperor	158	+	
		Lethrinus nebulosus	Spangled emperor	159		+
	Sparidae	*Acanthopagrus latus*	Yellowfin seabream	160	+	
		Evynnis cardinalis	Threadfin porgy	161	+	+
		Rhabdosargus sarba	Goldlined seabream	162	+	+
	Polynemidae	*Eleutheronema tetradactylum*	Fourfinger threadfin	163	+	
		Polydactylus sextarius	Sixfinger threadfin	164	+	
	Sciaenidae	*Megalonibea diacanthus*	Croaker	165	+	
		Argyrosomus japonicus	Japanese meagre	166	+	
		Johnius distinctus	Croaker	167	+	
		Johnius taiwanensis	Taiwanese croaker	168	+	

		Johnius trewavasae	Trewavas croaker	169	+	
		Nibea albiflora	Yellow drum	170	+	
		Pennahia macrocephalus	Big-head pennah croaker	171	+	
		Pennahia anea	Truncate-tail croaker	172	+	
		Chrysochir aureus	Reeve's croaker	173	+	
	Mullidae	*Upeneus japonicus*	Japanese goatfish	174	+	+
		Parupeneus spilurus	Blackspot goatfish	175	+	+
		Parupeneus chrysopleuron	Yellow striped goatfish	176		+
	Glaucosomatidae	*Glaucosoma buergeri*	Deepsea jewfish	177	+	
	Kyphosidae	*Microcanthus strigatus*	Stripey	178		+
	Terapontidae	*Terapon jarbua*	Jarbua terapon	179	+	
		Pelates quadrilineatus	Fourlined terapon	180		+
	Drepaneidae	*Drepane punctata*	Spotted sicklefish	181	+	
	Chaetodontidae	*Heniochus acuminatus*	Pennant coralfish	182	+	
	Pomacanthidae	*Chaetodontoplus septentrionalis*	Bluestriped angelfish	183	+	
	Oplegnathidae	*Oplegnathus fasciatus*	Barred knifejaw	184	+	
	Pomacentridae	**Teixeirichthys jordani*	Jordan's damsel	185	+	
		**Pomacentrus sp.*	Damselfish	186	+	
		**Pomacentrus sp.2*	Damselfish	187	+	
		* *Chromis ternatensis*	Striped-tail puller	188	+	
	Cepolidae	*Acanthocepola indica*	Bandfish	189	+	
	Labridae	*Bodianus masudai*	Pacific Redstriped Hogfish	190	+	+
		Choerodon azurio	Scarbreast tuskfin	191	+	+
		Coris musume	Black stripe wrasse	192		+

		Parajulis poecilepterus	Multicolorfin rainbowfish	193	+	+
		Pseudolabrus eoethinus	Wrasses	194		+
		Pseudolabrus eoethinus	Red naped wrasse	195		+
		Scarus ghobban	Blue-barred parrotfish	196	+	+
		**Suezichthys gracilis*	Slender wrasse	197	+	
		Xyrichtys dea	Blackspot razorfish	198	+	
		Xyrichtys twistii	Blue-barred parrotfish	199	+	
		Xyrichtys verrens	Rosed razorfish	200	+	+
	Pinguipedidae	**Parapercis ommatura*	Sandperch	201	+	
		**Parapercis puplchella*	Harlequin sandsmelt	202	+	
		Parapercis sexfasciata	Grub fish	203	+	+
	Callionymidae	**Bathycallionymus kaianus*	Kai Island deepwater dragonet	204	+	
		Callionymus curvispinis	Izu ruddertail dragonet	205	+	
		**Calliurichthys japonicus*	Dragonet	206	+	
		* *Callionymus doryssus*	Dragonet	207	+	
		* *Callionymus curvicornis*	Dragonet	208	+	
		* *Calliurichthys izuensis*	Dragonet	209	+	
	Trichonotidae	*Trichonotus setiger*	Spotted sand-diver	210	+	
		* *Trichonotus elegans*	Long-rayed sand-diver	211	+	
		**Trichonotus filamentosus*	Black-spot sand-diver	212	+	
	Percophidae	*Acanthaphritis barbata*	Duckbill	213	+	
	Ammodytidae	*Bleekeria mitsukurii*	Sand lance	214	+	
		Bleekeria viridianguilla	Sand lance	215	+	
	Uranoscopidae	*Uranoscopus bicinctus*	Marbled stargazer	216	+	

		**Uranoscopus chinensis*	Chinese stargazer	217	+	
		Ichthyscopus lebeck	Longnosed stargazer	218	+	
	Gobiidae	** Valenciennea wardii*	Ward's sleeper	219	+	
		**Amblychaeturichthys hexanema*	Pinkgray goby	220	+	
		Trypauchen vagina	Burrowing goby	221	+	
	Ephippidae	*Platax teira*	Longfin batfish	222	+	
	Siganidae	*Siganus fuscescens*	Mottled spinefoot	223	+	+
	Sphyraenidae	*Sphyraena flavicauda*	Yellowtail barracuda	224	+	
		Sphyraena japonica	Japanese barracuda	225	+	
	Trichiuridae	*Trichiurus japonicus*	Largehead hairtail	226	+	
		Trichiurus sp.	Hairtail fish	227	+	
	Scombridae	*Scomber japonicus*	Chub mackerel	228	+	+
		Scomberomorus commerson	Narrow-barred Spanish mackerel	229	+	
		Scomberomorus niphonius	Japanese Spanish mackerel	230	+	
		Sarda orientalis	Striped bonito	231	+	
	Centrolophidae	*Psenopsis anomala*	Pacific rudderfish	232	+	
	Stromateidae	*Pampus argenteus*	Butterflyfish	233	+	
Pleuronectiformes	Paralichthyidae	*Paralichthys olivaceus*	*Bastard halibut*	234	+	
		Pseudorchombus arsius	Largetooth flounder	235	+	
		Pseudorhombus cinnamoneus	Cinnamon flounder	236	+	
		Pseudorhombus oligodon	Roughscale flounder	237	+	
	Bothidae	**Bothus myriaster*	Indo-pacific oval flounder	238	+	
		**Engyprosopon grandisquama*	Largescale flounder	239	+	

		**Engyprosopon filipennis*	Lefteye flounder	240	+	
		** Engyprosopon macrolepis*	Largescale dwarf flounder	241	+	
		Crossorhombus azureus	Blue flounder	242	+	
		**Psettina tosana*	Lefteye flounder	243	+	
	Soleidae	**Liachirus melanospilus*	Blackspotted sole	244	+	
		Solea ovata	Ovate sole	245	+	
		**Zebrias crossolepis*	Sole	246	+	
		Zebrias zebra	Zebra sole	247	+	
	Pleuronectidae	*Pleuronichthys cornutus*	Ridged-eye flounder	248	+	
	Cynoglossidae	*Cynoglossus abbreviatus*	Three-lined tongue sole	249	+	
		Cynoglossus puncticeps	Speckled touguesole	250	+	
		**Cynoglossus oligolepis*	Touguesole	251	+	
		** Cynoglossus itinus*	Tonguefish	252	+	
		**Cynoglossus sp.*	Tonguefish	253	+	
		Paraplagusia japonica	Black cow-tongue	254	+	
Tetraodontiformes	Monacanthidae	*Aluterus monoceros*	Unicorn leatherjacket filefish	255	+	+
		Chaetodermis penicilligerus	Prickly leatherjacket	256	+	+
		Stephanolepis cirrhifer	Threadsail filefish	257	+	+
		Paramonacanthus pusillus	Japanese leatherjacket	258	+	+
	Tetraodontidae	*Lagocephalus wheeleri*	Blowfish	259	+	+
		Lagocephalus inermis	Smooth-backed blowfish	260	+	
		Lagocephalus suezensis	Blowfish	261	+	
		Takifugu oblogus	Lattice blaasop	262	+	+
		Takifugu xanthopterus	Yellowfin puffer	263	+	+

		Takifugu poecilonotus	Pufferfish	264	+	+
		Arothron stellatus	Stellate pufferfish	265	+	
		Torquigener pallimaculatus	Orange-spotted toadfish	266	+	
	Diodontidae	*Diodon holocanthus*	Longspined porcupinefish	267	+	
	Balistidae	*Abalistes stellaris*	Starry triggerfish	268	+	+
		Sufflamen fraenatum	Masked triggerfish	269	+	+
Crustaceans						
Stomatopoda	Squillidae	*Lysiosquilla sulcirostris*	Orange & White mantis shrimp	270	+	
		Oratosquilla oratoria	Japanese squillid mantis shrimp	271	+	
		**Oratosquilla kempi*	Mantis Shrimp	272	+	
		**Odontodactylus japonicus*	Mantis Shrimp	273	+	
		Harpiosquilla harpax	Robber harpiosquillid mantis shrimp	274	+	
		* Erugosquilla woodmasoni	Smooth squillid mantis shrimp	275	+	
		**Lophosquilla costata*	Mantis Shrimp	276	+	
		**Lophosquilla* sp.	Mantis Shrimp	277	+	
Decapoda	Sicyoniidae	**Sicyonia japonica*	Japanese Rock Shrimp	278	+	
		**Sicyonia cristata*	Mediterranean rock shrimp	279	+	
	Solenocerdae	*Solenocera carssicornis*	Udang merah	280	+	
	Penaeidae	*Atypopenaeus stenodactylus	Periscope shrimp	281	+	
		Penaeus canaliculatus	Witch prawn	282	+	

		Penaeus semisulcatus	Green tiger prawn	283	+	
		Penaeus latisulcatus	Western king prawn	284	+	
		Penaeus longistylus	Red Spot King Prawn	285	+	
		Penaeus japonicus	Kuruma shrimp	286	+	
		Panaeus monodon	Asian tiger shrimp	287	+	
		**Parapenaeopsis tenella*	Smoothshell shrimp	288	+	
		Parapenaeopsis cultrirostris	Shrimp	289	+	
		Parapenaeopsis hardwickii	Spear shrimp	290	+	
		Parapenaeopsis cornuta	Coral shrimp	291	+	
		Trachypenaeus curvirostris	Southern rough shrimp	292	+	
		Metapenaeopsis dalei	Kishi velvet shrimp	293		
		Metapenaeopsis barbata	Whiskered velvet shrimp	294	+	
		Metapenaeopsis palmensis	Southern velvet shrimp	295	+	
		Metapenaeopsis lamellata	Humpback Prawn	296	+	+
	Caridae	*Leptochela gracilis	lesser glass shrimp	297	+	
		**Birulia kishinouyei*	Glass shrimp	298	+	
	Palinura	*Panulirus stimpsoni*	Chinese spiny lobster	299	+	+
		Panulirus ornatus	Ornate lobster	300		+
	Porcellanidae	**Porcellana* sp.	Porcelain crab	301	+	
	Raninidae	*Ranina ranina*	Red frog crab	302	+	
	Leucosiidae	**Leucosia* sp.	Crab	303	+	
	Calappidae	*Calappa philargius*	Spotted box crab	304	+	+
		Calappa lophos	Box crab	305	+	+
		**Matuta lunaris*	Spotted moon crab	306	+	
		*Cycloes granulosa		307	+	

	Corystidae	* *Jonas distincta*	Crab	308	+	
	Portunidae	*Scylla paramamosain*	Mud crab	309	+	
		Charybdis miles	Soldier swimming crab	310	+	
		**Charybdis variegata*	Swimming crab	311	+	
		**Charybdis bimaculata*	Swimming crab	312	+	
		Charybdis sagamiensis	Swimming crab	313	+	
		Charybdis amboinensis	Swimming crab	314	+	
		Charybdis hellerii	Indo-Pacific swimming crab	315	+	
		Charybdis acuta	Swimming crab	316	+	
		Charybdis feriatus	Crucifix crab	317	+	+
		Charybdis granulata	Swimming crab	318	+	+
		Charybdis nataor	Rock crab	319	+	+
		**Lupocycloporus gracilimanus*	Swimming crab	320	+	
		**Xiphonectes hastatoides*	Swimming crab	321	+	
		**Monomia argentatus*	Swimming crab	322	+	
		Monomia haanii	Red swimming crab	323	+	+
		Portunus sanguinolentus	Three-spot swimming crab	324	+	+
		Portunus pelagicus	Flower crab	325	+	+
		Portunus trituberculatus	Japanese blue crab	326	+	+
Cepholopod						
Teuthoidea	Loliginidae	*Loligo chinensis*	Southern dumpling squid	327	+	
		Loligo oshimai	Squid	328	+	
		Loligo japonicus	Squid	329	+	

		Loligo duvaucelii	Squid	330	+	
		Loligo bleekeri	Indian squid	331	+	
		Loligo sp.	Loliginid squid	332	+	
		Sepioteuthis lessoniana	Bigfin reef squid	333	+	
Sepioidea	Sepiolidae	*Sepiola* sp.	Bobtail Squid	334	+	
		Euprymna berryi	Bobtail Squid	335	+	
	Sepiidae	*Sepiella maindroni*	Spineless cuttlefish	336	+	
		Sepia aculeata	Needle cuttlefish	337	+	+
		Sepia lycidas	Kisslip cuttlefish	338	+	
		Sepia pharaonic	Pharaoh cuttlefish	339	+	+
	Octopodinae	*Octopus variabilis*	Whiparm octopus	340	+	+
		Octopus ocellatus	Webfoot octopus	341	+	+
		Octopus aegina	Octopus	342	+	+
		**Octopus dolliusi*	Marbled octopus	343	+	+
		**Hapalochlaena lunulata*	Greater blue-ringed octopus	344	+	

3.1.2. ETP species

Between August 2018 and December 2019, seven ETP (endangered, threatened and protected) species were observed from both trap and trawl fishery in Dongshan County, including two Elasmobranch fishes (Scalloped hammerhead shark (*Sphyrna lewini*) and Bottlenose wedgefish *Rhynchobatus australiae*) and five Actinopterygii fishes (Thorny seahorse *Hippocampus histrix*, Longnose seahorse *Hippocampus trimaculatus*, Spotted seahorse *Hippocampus kuda*, Giant seahorse *Hippocampus kelloggi* and Hong Kong grouper *Epinephelus akaara*) (Table 3).

Sphyrna lewini was listed in CITES Appendix II in 2014, and as "Endangered" in the International Union for Conservation of Nature (IUCN) Red List in 2007. As a by-catch species, *S. lewini* had a low occurrence at the landing ports of Dongshan County (Fig. 7). Six individuals from two trawl vessels were found in October 2018 surveys and 5 individuals from three trawl vessels were found in September and October 2019; all were sold to the local markets for food.

Fig. 7. Scalloped hammerhead shark *Sphyrna lewini* found at the landing ports in Dongshan County trawl fishery.

Rhynchobatus australiae was listed in CITES Appendix II in 2019, and as "Critical Endangered" in the International Union for Conservation of Nature (IUCN) Red List in 2019. As a by-catch species, *R. australiae* had a low occurrence at the landing ports of Dongshan County (Fig. 8). Only two individuals were found in October and December 2019 surveys, and sold to the local markets for food.

Fig. 8. Bottlenose wedgefish *Rhynchobatus australiae* found at the landing port in October 2019 in Dongshan County trawl fishery

Four seahorses, *H. histrix*, *H. kelloggi*, *H. trimaculatus* and *H. kuda* were listed in CITES Appendix II in 2002, and as "Vulnerable" in IUCN Red List in 2012. In China, *H. kelloggi* was also listed in the National Protected Animals Class II in 1989. In Dongshan County, *H. trimaculatus* is the absolutely dominant species in seahorse landed from trawl fishery throughout the entire survey period in August 2018-December 2019 (Fig. 9). Up to nearly 48.5% of trawl vessels had *H. trimaculatus* catches during landing port surveys in January-April 2019. The average seahorse catch volumes were about 2.68 kg wet weight/vessel/trip in January-April 2019 (0-30 kg wet weight/vessel/trip, n=30). In August-December 2019, 100% of trawl vessels surveyed had seahorse catches and the average catch volumes increased to 17.99 kg wet weight/vessel/trip (1-54.2 kg wet weight/vessel/trip, n=47).

Hippocampus kuda was mixed with *H. trimaculatus* in seahorse catches and only found in April 2019 in the trawl fishery, while *H. kelloggi* was occasionally caught in the trawl fishery (Fig. 9). Only one *H. histrix* individual was caught in trap fishery in April 2019.

Seahorse wholesale prices (majority of *H. trimaculatus*) are approximately 1,600-2,000 RMB yuan/kg wet weight (220-280 USD/kg) at landing ports, revealing its unit price is the highest among all capture species. *Hippocampus kelloggi* is the most expensive seahorse known so far with 4000 RMB yuan/kg wet weight.

Epinephelus akaara was listed as "Endangered" in IUCN Red List in 2016. It had low occurrence in trawl fishery in Dongshan County.

Fig. 9. Giant seahorse *Hippocampus kelloggi* (left), Spotted seahorse *H. kuda* (middle) and Longnose seahorse *H. trimaculatus* (right) found in Dongshan County trawl fishery.

3.2. Number of fishing vessels surveyed at the landing ports

In August-December 2019, a total of 76 vessels were surveyed at the landing ports of Dongshan County, including 47 trawl vessels and 29 trap vessels.

3.3. Fishing areas

Based on captain and crew interviews in August-December 2019, trawl and trap vessels from Dongshan County mainly operated in offshore fishing grounds, including Minnan Fishing Ground, Taiwan Bank Fishing Ground and Yuedong Fishing Ground within 116 º-119 °E and 21 º-24 ºN or more extended (Fig. 10), similar to the results from the Phases I and II.

We also conducted on-board observation on a trawl vessel for 10 days, providing a better understanding on the operation pattern and fishing ground.

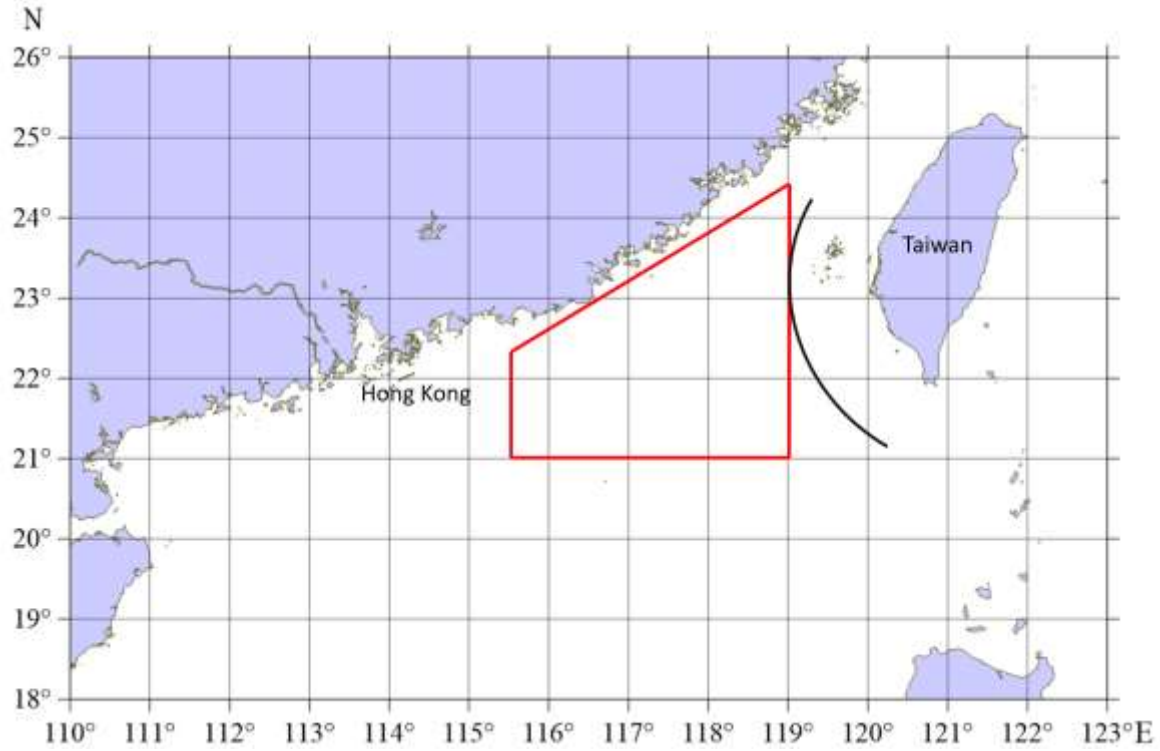

Fig. 10. Offshore trawl and trap fisheries in Dongshan County (red line). Black line shows the boundary between mainland China and Taiwan at sea, and no fishing vessels from mainland China are allowed to crossed it.

3.4. Operation patterns by gears

Based on trawl vessels surveyed at the landing ports in Dongshan County in January-December 2019, they spent 3-12 days/trip at sea (mean = 7.2, N = 79) (Table 4). The variation of fishing days at sea highly depends on weather condition; however, most trawl vessels surveyed spent 7-10 days/trip at sea when the weather is fine. The results are similar with the findings in the Phase I report (August-December 2018).

Based on trap vessels surveyed at the landing ports in Dongshan County in January-December 2019, the catches from trap vessels were usually delivered by transfer vessels every 1-11 days (mean = 5.1, N = 51), so that the trap vessels can operate at sea longer, to 20 days/trip and even up to 30 days/trip (Table 4).

Table 4. Operation patterns, capture volumes and proportions from trawl and trap vessels surveyed in January-December 2019 at the landing ports of Dongshan County.

	Dongshan County (Range, mean, N=sample size)		
	Trawl		**Trap**
Fishing days per trip	3~12 (mean=7.16, N=79)		1~11 (mean=5.12, N=51)
Average total capture volume per trip (kg/vessel/trip)	8153.79 (N=79)		2514.12 (N=51)
Average total crustacean capture volume per trip (kg/vessel/trip)	**Shrimps**	**Crabs**	**Crabs**
	271.49 (N=79)	920.33 (N=79)	1914.90 (N=51)
	1202.46 (N=79)		
Total crustacean volume/total capture volume (%)	**Shrimps**	**Crabs**	**Crabs**
	3.46% (N=79)	11.29% (N=79)	76.17% (N=51)
	14.75% (N=79)		
Average total fish capture volume per trip (kg/vessel/trip)	5805.80 (N=79)		493.26 (N=51)
Total fish volume/total capture volume (%)	71.20% (N=79)		19.62% (N=51)
Average total feed fish capture volume per trip (kg/vessel/trip)	1370.49 (N=79)		-
Total feed fish volume/total capture volume (%)	16.81% (N=79)		-
Average total cephalopod capture volume per trip (kg/vessel/trip)	1145.54 (N=79)		105.96 (N=51)
Total cephalopod volume/total capture volume (%)	14.05% (N=79)		4.21% (N=51)

3.5. Capture volumes and proportions by trawl and trap in Dongshan County

3.5.1. Overall capture volumes and proportions of different taxonomic groups

Based on the trawl vessels surveyed in Dongshan County in January-December 2019 (Table 4):

(1) The most dominant taxonomic group caught consisted of fishes, which contributed to 71.20% (average of 5805.80 kg fish/trawl vessel/trip) of the average total capture volume (8153.79 kg/trawl vessel/trip).

(2) About one fourth of the fish capture consisted of feed fishes (average of 1370.49 kg feed fish/trawl vessel/trip), which contributed to 16.81% of the average total capture volume.

(3) The average total crustacean capture volume (1202.46 kg crustacean/trawl vessel/trip) contributed to 14.75% of the average total capture volume, with the average of 920.33 kg crab/trawl vessel/trip (11.29%) and of 271.49 kg shrimp/trawl vessel/trip (3.46%).

(4) The average total cephalopod capture volume (1145.54 kg cephalopod/trawl vessel/trip) contributed to 14.05% of the average total capture volume.

Based on the trap vessels surveyed in Dongshan County in January-December 2019 (Table 4):

(1) The average total fish capture volume (493.26 kg fish/trap vessel/trip) contributed to 19.62% of the average total capture volume (2514.12 kg/trap vessel vessel/trip).

(2) The average total crustaceans (only crabs) capture volume (1914.90 kg/trap vessel/trip) contributed to 76.17% of the average total capture volume, the highest among different taxonomic groups.

(3) The average total cephalopod capture volume (105.96 kg/trap vessel/trip) contributed to 4.21% of the average total capture volume.

3.5.2. Crabs

3.5.2.1. Overall

The crab capture volume proportions in total capture volumes of trawl and trap fisheries in Dongshan County in January-December 2019 were analyzed and showed monthly variation (Fig. 11):

(1) Crab proportions in total capture volumes of trawl fishery in Dongshan County were

about 2.10-14.97% (mean = 11.29%) in January-December 2019 with the highest in November 2019 (14.97%). Crab proportions declined largely from January 2019 (14.57%) to April 2019 (2.10%) and increased from August (9.61%) to November (14.97%).

(2) The differences on crab capture proportions between trawl and trap fisheries in Dongshan County were significant. Trap provided significantly higher proportions on crab catches (46.55-92.75%, mean = 76.17%) than those of trawl fishery in January-December 2019.

(3) The dominant crab species in trawl fishery was *M. haanii*, while the dominant species in trap fishery was *P. sanguinolentus*.

3.5.2.2. *Monomia haanii*

Monomia haanii capture volumes and proportions in total capture volumes were further analyzed, and showed monthly variation between trawl and trap fisheries in Dongshan County (Table 4; Table 5; Fig. 11; Fig. 12):

(1) The *M. haanii* proportions in total capture volumes in the trawl fishery were about 1.63-12.31% in January-December 2019 with the highest in January 2019 (12.31%). The *M. haanii* proportions in total capture volumes in the trap fishery remained high (13.06-44.01%) in January-December 2019, except in March (4.76%).

(2) *Monomia haanii* was the dominant species in crab catches of trawl and the second dominant species in crab catches of trap fisheries. Among the estimated average total crab capture volume of 920.33 kg/trawl vessel/trip in trawl fishery, *M. haanii* was 651.47 kg/trawl vessel/trip, *P. sanguinolentus* was 173.69 kg/trawl vessel/trip, *C. nataor* was 53.36 kg/trawl vessel/trip and *C. philargius* was 41.80 kg/trawl vessel/trip, contributed to 7.99%, 2.13%, 0.65% and 0.51% of the total capture volume, respectively. Among the estimated average total crab capture volume of 1914.90 kg/trap vessel/trip in trap fishery, *M. haanii* was 611.85 kg/trap vessel/trip, *P. sanguinolentus* was 842.71 kg/trap vessel/trip, *C. nataor* was 375.34 kg/trap vessel/trip and *C. philargius* was 174.05 kg/trap vessel/trip, which contributed to 24.34%, 33.52%, 14.93% and 6.92% of the total capture volume, respectively.

(3) The capture volumes of *M. haanii* showed monthly variation in in trawl fishery in January-December 2019, ranged from 109.50 to 1127.21 kg/vessel/trip (mean 640.40 kg/vessel/trip), declined gradually from the January 2019 to the lowest in April 2019

and remained high in August-December 2019 with the highest in December 2019. Based on the average fishing days that the vessels surveyed through interviews at the landing ports, the average CPUE of *Monomia haanii* ranged from 15.21 to 134.00 kg/vessel/day (mean 90.29 kg/vessel/day), with the highest in August 2019 and the lowest in April 2019, and with a decline from January to April 2019 and August to December 2019.

(4) The capture volumes of *M. haanii* also showed monthly variation in trap fishery in January-December 2019, ranged from 17.00 to 1050.93 kg/vessel/trip (mean 601.70 kg/vessel/trip), the highest in September and the lowest in March. The CPUE of *M. haanii* ranged from 5.67 to 192.65 kg/vessel/day (mean 117.29 kg/vessel/day), the highest in January and the lowest in March.

(5) The trap fishery provided higher CPUE for *M. haanii* than that of trawl fishery.

(6) The trawl fishery provided much higher capture volume than the trap fishery.

Table 5. Four crab species average capture volumes (kg) and proportions (%) in average total capture volumes from trawl and trap vessels surveyed in January-December 2019 at the landing ports of Dongshan County
(red bold: the dominant species).

Crab species	Trawl (N=79)		Trap (N=51)	
	Volume (kg)	Proportion (%)	Volume (kg)	Proportion (%)
Monomia haanii	651.47	**7.99%**	611.85	24.34%
Portunus sanguinolentus	173.68	2.13%	842.71	**33.52%**
Charybdis nataor	53.36	0.51%	375.34	14.93%
Calappa philargius	41.80	0.51%	174.05	6.92%
Other crabs	0.00	0.0%	19.57	0.78%
Total	920.33	11.29%	1914.90	76.17%

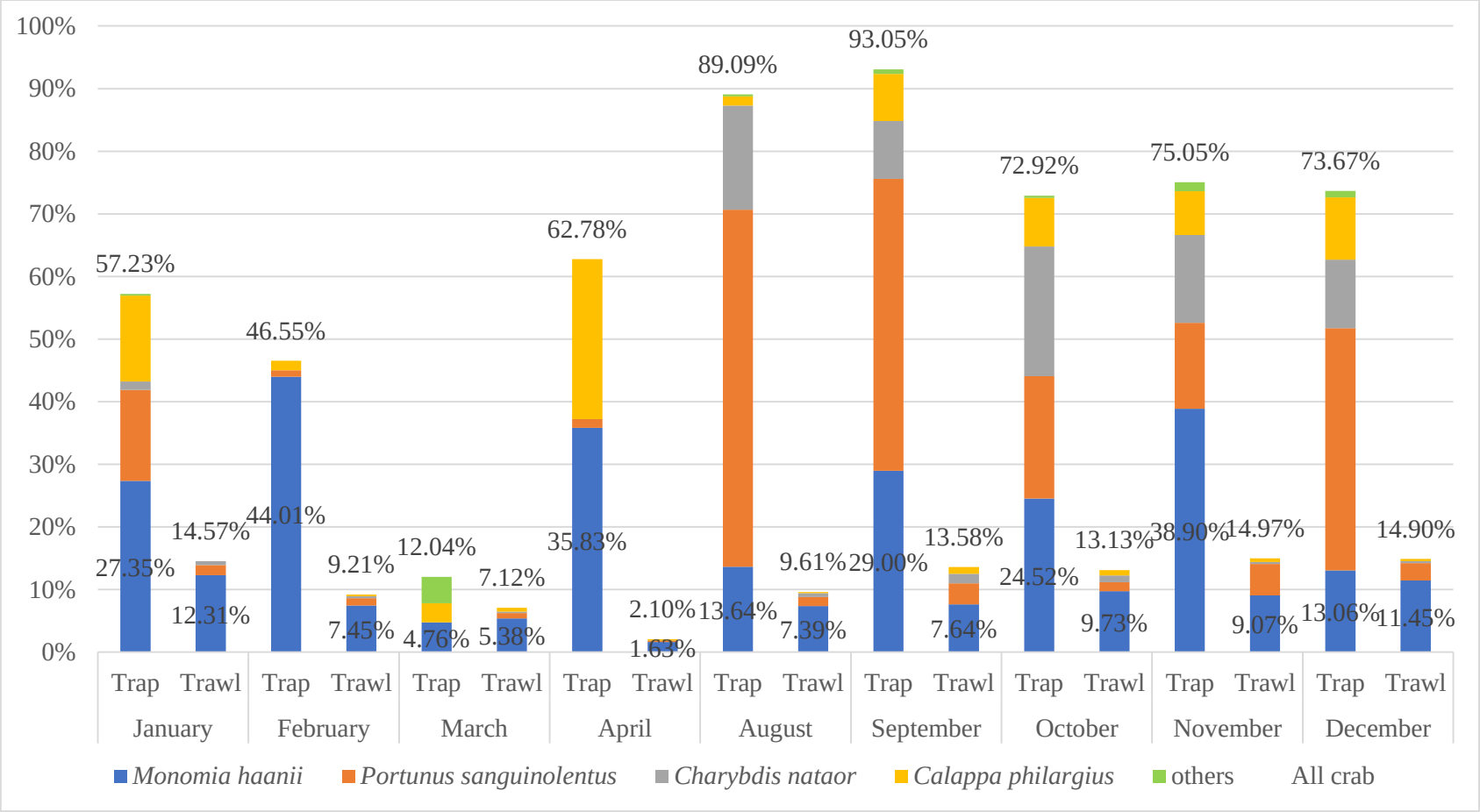

Fig. 11. Crab capture proportions (% shown at the tops of bars) in total capture volume from trawl and trap fisheries surveyed at the landing ports of Dongshan County in January-December 2019. *Monomia haanii* capture proportions shown at the bottoms of blue bars.

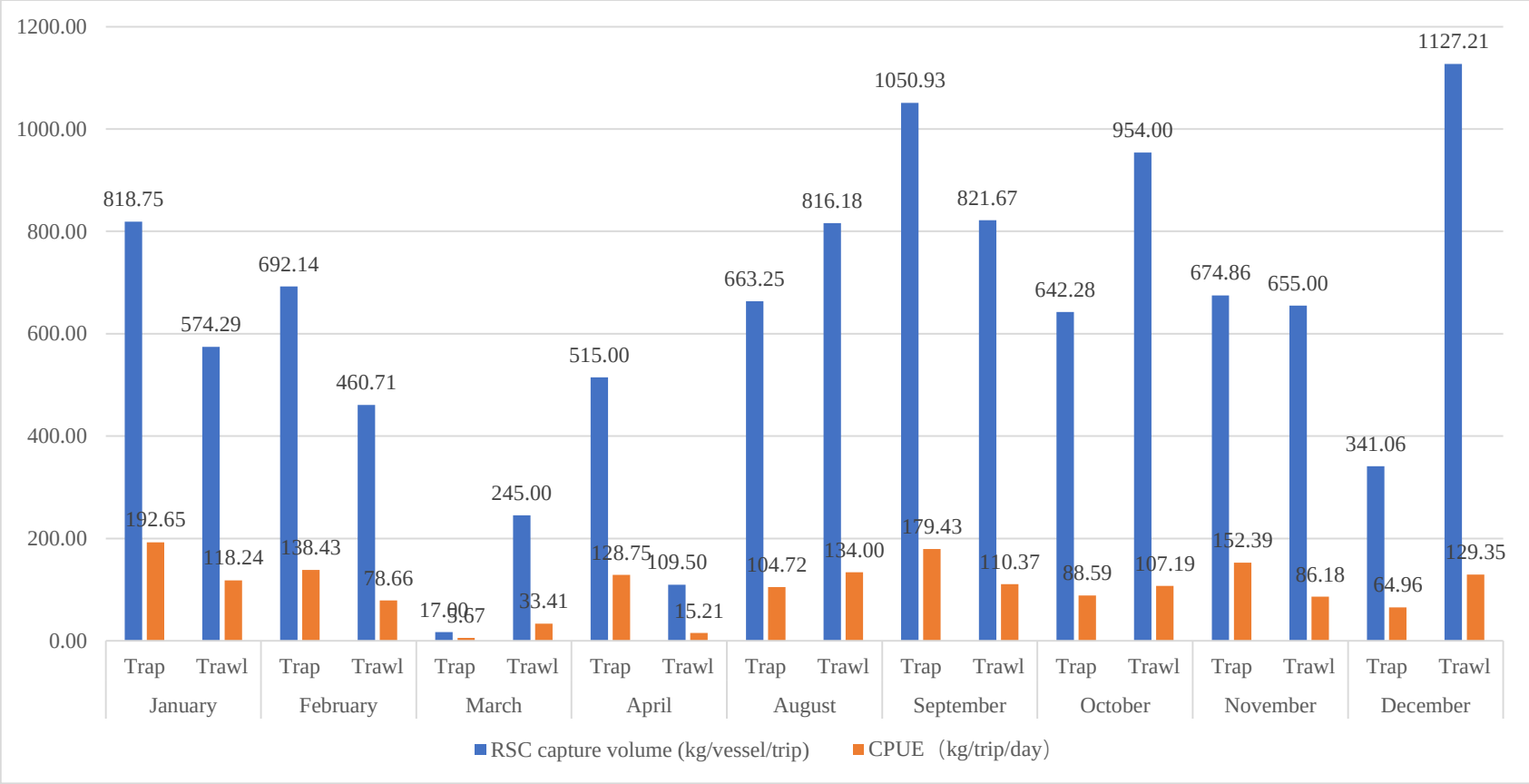

Fig. 12. Monthly CPUE of *Monomia haanii* (kg/vessel/trip) surveyed at the landing ports of Dongshan County in January-December 2019 from trawl and trap fisheries (values shown at the tops of the bars).

3.5.3. Food fishes[2]

Dominant food fish species, capture proportions in the total capture volumes and their size ranges (SL in cm) showed monthly variation by different fishing gears (trawl and trap) in Dongshan County in January-December 2019 (Table 6).

The dominant food fish species or species groups in the trawl fishery in Dongshan County were *Trachinocephalus myops*, *Saurida* species, *Decapterus maruadsi*, *Trachurus japonicus*, *Sillago sihama*, *Sillago japonica*, *Upeneus japonicus*, *Evynnis cardinalis*, *Trichonotus setiger*, Monacanthidae species, *Trichiurus* species, *Acanthaphritis barbata* and *Bleekeria mitsukurii*. Among these fish species, *Trachinocephalus myops* and *Saurida* species, *Sillago sihama* and *Sillago japonica*, *Trichonotus setiger*, *Acanthaphritis barbata* and *Bleekeria mitsukurii*, *Trichiurus* species. and four species in Monacanthidae were usually mixed in catches.

The dominant species or species groups in trap fishery in Dongshan County were *Gymnothorax* spp., *Trachinocephalus myops*, *Saurida* species, *Epinephelus awoara*, *Sillago japonica*, *Upeneus japonicus*, *Parupeneus chrysopleuron*, *Choerodon azurio*, *Evynnis cardinalis*, Monacanthidae species and *Trichiurus* species. Species from *Gymnohorax*, Monacanthidae and *Trichiurus*, *Trachinocephalus myops* and *Saurida* spp. were usually mixed in catches.

[2] "Food fishes" in this report refers to fish species consumed by humans, either directly or indirectly, with the latter including products such as fish balls.

Table 6. Dominant food fish species or species groups in capture proportions of total capture volumes and their size ranges (SL, standard length in cm) in trawl and trap fisheries in Dongshan County in January-April 2019.

(Red: the dominant species or species group)

	January		February		March		April		August		September		October		November		December	
Fish species	Trawl (%, cm)	Trap (%, cm)	Trawl (%, cm)	Trap (%, cm)	Trawl (%, cm)	Trap (%, cm)	Trawl (%, cm)	Trap (%, cm)	Trawl (%, cm)	Trap (%, cm)	Trawl (%, cm)	Trap (%, cm)	Trawl (%, cm)	Trap (%, cm)	Trawl (%, cm)	Trap (%, cm)	Trawl (%, cm)	Trap (%, cm)
Total fish%	58.44%	40.57%	79.49%	48.12%	59.21%	78.72%	75.92%	30.64%	77.05%	7.15%	70.83%	4.09%	67.43%	19.69%	58.81%	18.34%	66.09%	23.76%
Gymnothorax spp.						7.84% (30.6-80.9)												0.90%
Trachinocephalus myops & *Saurida* spp.	5.10% (13.3-25.2)		4.16% (8.3-26.8)		8.79% (12.2-34.2)		2.11%		13.81% (10.9-29.4)		12.12% (11.7-29.9)	2.46%	14% (12.8-28.6)	5.15% (20-32)	14.5% (10-30)		17.46% (12.3-52)	
Epinephelus awoara						10.75% (16.1-28.3)				1.50%		0.51%		9.95% (10-42)		7.90%		6.11%
Sillago spp.	12.44% (8.0-14.2)		1.57%		4.03% (8.5-12.4)		2.56% (12.3-15.2)		0.26% (9.6-16.1)		0.52%		1.54% (8.5-15.6)		1.13% (8.5-14.5)		7.57% (9.6-13.2)	
Decapterus maruadsi & *Trachurus japonicus*			0.18%		0.15%				8.75% (14.0-15.8)		20.44% (11.2-18.3)		8.37% (11.2-16.3)		6.29% (12.5-19.5)		3.41% (13.1-25.1)	
Scolopsis vosmeri				6.36% (10.5-15.5)		3.36%												

Upeneus japonicus	1.99%	1.17% (6.7-13.5)	1.94% (6.8-11.2)	1.27%	3.02%		2.29% (8.6-12.8)	4.17% (7.3-14.8)	2.74% (7.9-12.5)	0.33%	3.36% (10.1-15.3)	0.20%	2.47% (8.6-17.2)	1.49%	2.89% (8.0-14.5)	2.26%	3.32% (8.6-15.3)	
Parupeneus chrysopleuron																2.45%		
Evynnis cardinalis	1.82% (7.5-12.5)	35.15% (7.3-15.7)	1.39%	14.90% (10.5-15.5)	0.81%		0.33%	11.48% (10.2-16.3)	40.65% (7.0-12)		22.37% (7.8-11.8)	0.52%	8.98% (9.6-12.3)	2.15%	1.10% (9.4-13.5)	2.31%	2.32% (8.9-13.1)	13.87%
Choerodon azurio		0.67%		3.63%		3.36% (10.9-19.4)		1.39%										
Trichonotus setiger, *Acanthaphritis barbata*, *Bleekeria mitsukurii*			28.31% (7.5-9.7)		21.43% (7.8-11.4)		52.01% (6.2-11.4)				0.11% (8.8-16)		0.82%		0.07%		0.79%	
Trichiurus spp.									2.03% (8.5-24.3)		1.76%		2.01% (66-84)		2.98%		4.54%	
Monacanthidae spp.			0.69%		1.61%		0.49%		6.52%		7.70% (7.3-10.6)		4.03%		0.83%			
Takifugu spp.		1.92% (11.4-25.4)		6.18% (17.0-21.0)	0.07%		0.15%	9.04% (16.8-22.4)	1.51%	1.77%	2.12% (12-21.6)	1.45%	1.16% (9.6-20.5)	0.95% (11.6-26.3)	2.03% (9.1-27.5)	0.63%	2.34% (8.3-22.3)	0.42%

3.5.4. Feed fishes

3.5.4.1. Proportions and species diversity of feed fishes

The “feed fishes” in this report means those small-sized, low-valued, and often poorly preserved fishes (also including crustaceans and cephalopods), whose common use is for aquaculture fish (also including other carnivourous animals) feed, mentioned by the captains of the trawl vessels surveyed. Based on the 79 trawl vessels surveyed at the landing ports of Dongshan County in January-December 2019, feed fishes contributed to 0.28%~41.02% of the total catches (Fig. 13). In January and February, more than 50% of the fish catches were feed fishes, while August and September (right after the fishing moratorium) had very low feed fish catches (< 2% of total catches).

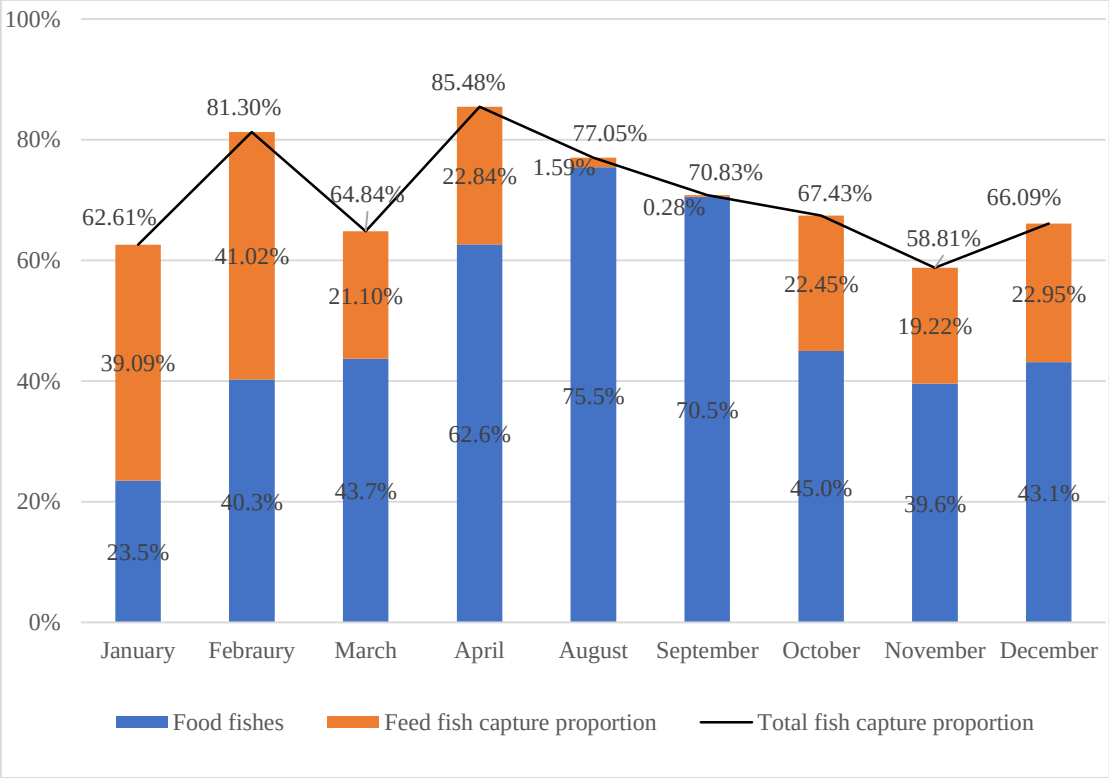

Fig.13. Food fish and feed fish capture proportions in total capture volumes in trawl fishery in Dongshan County in January-December 2019.

Based on the random samples (mean 2.07 kg/month, range of 0.87-4.68 kg) of feed fishes at the landing ports of Dongshan County in January-December 2019, 148 species were identified, comprised of 108 fishes, 32 crustaceans and 8 cephalopods (Table 7):

(1) Among these, 74 species (51 fishes, 21 crustaceans and 2 cephalopods) were only found in feed fish samples;
(2) *Hippocampus trimaculatus*, a ETP species, was found;
(3) More than 50% of species in feed fishes were also food species;
(4) More than 10 food species were also common in feed fishes, defining as the occurrence in at least 5 months during 9 month sampling;
(5) *Monomia haanii* was one of the common food species in feed fishes (see below).

3.5.4.2. *Monomia haanii* in feed fishes

Based on the size for 50% female maturity of *M. haanii* (7.3 CW cm) (see Section 3.6.3), almost all *M. haanii* individuals in feed fish samples were small juveniles < 5 cm CW (Table 7).

Monomia haanii was one of the few common species found in feed fishes in trawl fishery in Dongshan County, contributed to up to 21.87% of total feed fish volumes (Table 8).

Table 7. Body sizes/size ranges (cm) of species (standard length for fishes, shrimps and cephalopods, carapace width for crabs) in feed fishes in trawl fishery in Dongshan County in January-April 2019.

(*: species only found in feed fishes)

(Red: food species; red bold: food species which common in feed fish samples)

No.	Species name	January	February	March	April	August	September	October	November	December
1	*Platyrhina sinensis*			8.2		13	20.2			19.3
2	*Okamejei boesemani*					13.2				
3	*Gymnothorax reticularis*									38.3
4	**Apterichtus hatookai*				25.5					
5	*Oxyconger leptognathus*		24.6				23.7	23.3-29.7	20.2	
6	*Gnathophis heterognathos*		23.8		11.2	15.8				
7	**Gnathophis nystromi*								20	
8	*Pisodonophis cancrivorus*				30.5		51.3	44.3		
9	**Callechelys kuro*	23.2	31.8		21.2-30.4	26.6				24.2
10	*Caecula pterygera*					42	40.2-46.1	41.1-51.1		
11	**Saurenchelys fierasfer*						33.7			38.1
12	*Mugil cephalus*			12.0-15.8						
13	**Crenimugil crenilabis*									15
14	**Synodus hoshinonis*							12.3		
15	***Trachinocephalus myops***		7.8-11.8		5.9-10.1		4.1-12.6	7.4-12.8	5-10.5	5.6-12.7
16	*Saurida tumbil*	4.2-11.0	12.2							
17	***Saurida elongata***					7.1	5.4-7.8	6.2-9.3	8.7-13.1	5.3-9.2

18	*Thryssa kammalensis							9.2-9.6		
19	Thryssa vitrirostris							7.9-10.6		
20	*Engraulis japonicus			4.4-8.9						
21	*Stolephorus commersonnii								5.4-7	
22	Plotosus lineatus					11	7.2			
23	*Bregmaceros sp.	5.6-6.6	5.6-5.8		4.5-6.5	4.8			5.0-5.1	4.0-5.9
24	Pegasus laternarius				6.8				5.8	
25	Syngnathidae sp.								18.5	
26	Trachyrhamphus serratus					22.4		22.8-26.1		
27	Hippocampus trimaculatus							9		9.6
28	Antennarius striatus							11		
29	Apistus carinatus	6.3	4.8	2.1	3.4-7.2		10.7	5.8	3.2-3.4	3.6-7.7
30	*Parapterois heterura					9.3				
31	Minous monodactylus		5.4-6.2	3.3-5.8		6				
32	*Aploactis aspera		6.9							6.3
33	Sebastiscus marmoratus	5.3-7.1			3.7					
34	Scorpaena miostoma									7
35	*Lepidotrigla alata		10.2	11.5						
36	Lepidotrigla microptera					13.3				
37	*Lepidotrigla japonica					11.2				
38	*Rogadius asper					9-11.6				
39	*Thysanophrys celebica								15.2	16.1

40	*Inegocia japonica						7.9			
41	Cociella crocodila	5.2-9.6	6.1-11.3	15.8						
42	*Suggrundus macracanthus						5.5-14.2	4.6-16	4.6-12	6.9-12.5
43	Inegocia guttata				6.6					
44	*Sorsogona tuberculata				5.4-6.9					
45	Epinephelus areolatus		11.5							
46	Epinephelus awoara		12.4							
47	Priacanthus macracanthus								8.8-9	10.8
48	**Sillago sihama**	5.1-10.3				9.4	5.7-9.8	5.7-10.9	3.8-10.3	5.3-9.9
49	Polydactylus sextarius							9.3		
51	**Upeneus japonicus**	5.3-10.4	8.2-8.9		3.0-4.9	9.0-9.7	4.0-8.9	7.5-8.6	4.5-8.5	7.3-8.3
52	Apogon semilineatus								4.6	4.7-6.3
53	*Ostorhinchus kiensis						3.9	3.7		4.9
54	Apogon cathetogramma	5.8				6.6				
55	*Apogon lineatus		6.1							
56	*Apogon niger		4.7-5.9		5.6-6.5			4.2	4.0-6.3	5.6
57	*Ostorhinchus fasciatus			6.5						
58	Equulites rivulatus	3.5-4.5			3.1-4.9	3.2-5.2		5.8	4.0-5.8	3.9-5.2
59	*Secutor ruconius							3.3-4.7		
60	Selaroides leptolepis					9.3			5.8-8	9.5-9.9
61	Decapterus maruadsi	3.1-4.9		3.9-8.3						
62	*Alepes kleinii					3.2				

63	*Trachurus japonicus*	3.3-4.8		5.0-9.4						
64	*Scolopsis vosmeri*									9.6
65	*Evynnis cardinalis*	2.9-11.2		2.8-4.3						
66	**Teixeirichthys jordani*				2.6-9.0	6.5		6.5-8.6	6.5-9	7.0-7.8
67	**Pomacentrus* sp.	4.2-4.7								
68	**Pomacentrus* sp.2		9.0							
69	**Chromis ternatensis*									4.0-5.6
70	*Xyrichtys verrens*		11.3							
71	**Suezichthys gracilis*	6.4	10.5					6.8	6.8-9.1	10
72	*Parapercis ommatura*									
73	**Bathycallionymus kaianus*				4.1-6.6					
74	**Calliurichthys japonicus*									
75	**Callionymus doryssus*						8.1	9.3	4.9-9.7	8.1-9.1
76	**Callionymus curvicornis*	4.0-12.0	4.1-9.7	5.8-7.6	6.1-7.1				2.1-6.6	4.0-6.6
77	*Trichonotus setiger*	6.7-16.6	5.3-12.2	5.1-9.8	5.3-11.8		8.8-17.5	6.1-9.5	5.3-16.2	4.6-14
78	**Trichonotus elegans*					6.2-10.7				
79	**Trichonotus filamentosus*				5.1-7.6		9.7		8.7-9.6	
80	***Bleekeria viridianguilla***	1.2-12.3	8.7-11.8	8.8-11.8	6.6-10.6	6.1-12.3	7.1-13.8	8.3	9.0-13.6	6.1-12.5
81	***Bleekeria mitsukurii***	10.1-10.2	7.0-11.1		9.1-10.6			7.1-14	8.8-11.6	6.8-12.1
82	**Parapercis ommatura*	5.7-5.9								
83	**Parapercis puplchella*						8.3	7.3		8.1
84	*Chaetodontoplus septentrionalis*									18.5

85	*Trichiurus* sp.			1.2-2.6				30.7-39.5		
86	*Siganus fuscescens*									10.5
87	*Scomber japonicus*		3.9-10.0	4.4-13.3						
88	**Uranoscopus chinensis*			7.4	3.6-7.2		11.6		4.0-12.3	
89	*Ichthyscopus lebeck*					8.5			2.5	
90	**Valenciennea wardii*							7.7		7.6
91	**Amblychaeturichthys hexanema*			8.4						
92	*Pseudorhombus oligodon*	5.1-8.2								
93	*Pseudorchombus arsius*		5.4-10.1	2.8-5.9						
94	*Crossorhombus azureus*				5.9					
95	**Bothus myriaster*				6.9					
96	**Engyprosopon grandisquama*				4.3-8.5		10.6	5.8-10.8	5.1-8.1	4.6-9
97	**Engyprosopon macrolepis*		6.1-9.8							
98	**Engyprosopon filipennis*				3.7-8.8					
99	**Psettina tosana*					3.9-5.2	4.1-5.6	4.4-5		5
100	**Liachirus melanospilus*	6.1-8.2			6.3-10.4				10.1	
101	**Zebrias crossolepis*			9.3	3.8			12.5		
102	*Pleuronichthys cornutus*									
103	*Cynoglossus puncticeps*		6.0-12.6	9.1						
104	**Cynoglossus oligolepis*		6.5-8.6	2.4-4.6					4.6	6.9-14.4
105	**Cynoglossus itinus*					6.3		8.5-10.4	12.9	6.8
106	**Cynoglossus* sp.				6.0-10.8					

107	***Stephanolepis cirrhifer***	7.3-7.8				5.5-7.5	5.6-8.5	5.6-6.1	4.8-6.2	
108	*Lagocephalus wheeleri*							9.0-9.9		
109	**Odontodactylus japonicus*		10.8		13.3					
110	**Erugosquilla woodmasoni*					11.8		12.2		2.4
111	**Oratosquilla kempi*	1.2								
112	**Lophosquilla costata*				7.7				6.6	5.6
113	**Lophosquilla* sp.	1.0-1.5		1.2-1.5						
114	**Sicyonia cristata*						3.6			
115	**Sicyonia japonica*						3.8	4.5		
116	**Atypopenaeus stenodactylus*									3.9
117	**Parapenaeopsis tenella*									3.7
118	*Parapenaeopsis cornuta*	1.3-2.0	1.4-2.6						4.8-8.2	
119	*Parapenaeopsis cultrirostris*							6.7		
120	*Metapenaeopsis lamellata*				6.5			8.5		
121	*Metapenaeopsis dalei*						3	4.2-4.8	4.4-5.4	3.8-4
122	*Metapenaeopsis palmensis*	1.1-2.7			2.2-6.1					
123	***Metapenaeopsis barbata***	0.9-1.4	1.1-3.2	1.0-3.3		8.9	6.5	6.2-8.5	4.7-8.1	4.3-7.6
125	*Trachypenaeus curvirostris*		2.8			4.6-5.2				
126	**Leptochela gracilis*			0.3-0.4		2.4-2.6				
127	**Birulia kishinouyei*				2.2-2.5					
128	**Porcellana* sp.	0.6								
129	**Leucosia* sp.			0.8						

130	**Matuta lunaris*	1.8-3.0	2.6-2.9	2.6-2.8					1.3	
131	*Calappa lophos*					0.9		3.2-4.5		1.8
132	**Cycloes granulosa*				1.1-2.0					
133	**Jonas distincta*					2.5				
134	**Charybdis variegata*	1.7-2.0	2.0-3.3	1.7-1.8	0.8-1.2			1.5-2.5	0.9	
135	**Charybdis bimaculata*		3.0-3.9							
136	*Charybdis nataor*							2.4-3.2		
137	*Portunus sanguinolentus*							4.0-5.3		2.2
138	**Xiphonectes hastatoides*			3.7				3.2-3.5		
139	**Lupocycloporus gracilimanus*	2.4						2.7-3		1.7-4.4
140	***Monomia haanii***	2.1-5.8	1.3-3.2	3.1-3.8	1.2-3.8		8.4	2.5-5.8	1.5-3.6	2.1-5.8
141	*Octopus ocellatus*	4.4	5.0		15.7-18.4				3.3	
142	*Octopus variabilis*							2.9		
143	**Octopus dolliusi*		5.0						2.5	
144	**Hapalochlaena lunulata*				3.1					
145	*Loligo duvaucelii*								4.1	
146	*Loligo* sp.	2.3-5.1	3.6-6.2				-	-		
147	***Sepiola* sp.**	2.6	5.0		1.2-1.6			2.3	2.5	1.9
148	***Euprymna berryi***	2.2-3.8	2.0-2.8			3.4		1.2		1.5-3.3

Table 8. Proportions (%) of feed fish species (weight of feed fish species/total weight of feed fishes sampled × 100) in trawl fishery in Dongshan County in January-April 2019.

(*: species only found in feed fishes)

(Red: food species; red bold: food species which common in feed fish samples)

No.	Species name	January	February	March	April	August	September	October	November	December
1	*Platyrhina sinensis*			1.21%		13.70%	18.62%			13.32%
2	*Okamejei boesemani*					8.70%				
3	*Gymnothorax reticularis*									2.95%
4	**Apterichtus hatookai*				3.63%					
5	*Oxyconger leptognathus*		0.89%				0.69%	2.43%	0.43%	
6	*Gnathophis heterognathos*		1.27%		0.24%	0.86%				
7	**Gnathophis nystromi*								0.75%	
8	*Pisodonophis cancrivorus*				1.63%		5.10%	3.57%		
9	**Callechelys kuro*	0.30%	0.70%		1.66%	0.61%				0.26%
10	*Caecula pterygera*					1.83%	1.42%	2.11%		
11	**Saurenchelys fierasfer*						0.36%			0.74%
12	*Mugil cephalus*			4.39%						
13	**Crenimugil crenilabis*									0.03%
14	**Synodus hoshinonis*							1.11%		
15	***Trachinocephalus myops***		1.48%		2.16%		4.85%	2.85%	8.18%	6.41%
16	*Saurida tumbil*	0.86%	0.73%							

17	***Saurida elongata***					0.36%	0.70%	2.58%	10.82%	0.41%
18	**Thryssa kammalensis*							1.75%		
19	*Thryssa vitrirostris*							9.24%		
20	**Engraulis japonicus*									
21	**Stolephorus commersonnii*			2.11%					0.33%	
22	*Plotosus lineatus*					1.09%	0.11%			
23	**Bregmaceros* sp.	0.32%	0.11%		0.77%	0.11%			0.10%	0.20%
24	*Pegasus laternarius*				0.59%				0.16%	
25	*Syngnathidae* sp.								0.11%	
26	*Trachyrhamphus serratus*					0.45%		1.23%		
27	*Hippocampus trimaculatus*							0.12%		0.12%
28	*Antennarius striatus*							4.19%		
29	*Apistus carinatus*	0.33%	0.12%	0.02%	0.21%		1.69%	0.55%	0.08%	0.63%
30	**Parapterois heterura*					2.72%				
31	*Minous monodactylus*		0.56%	0.65%		1.04%				
32	**Aploactis aspera*		0.27%							0.18%
33	*Sebastiscus marmoratus*	0.95%			4.83%					
34	*Scorpaena miostoma*									0.60%
35	**Lepidotrigla alata*		1.28%	1.79%						
36	*Lepidotrigla microptera*					5.33%				
37	**Lepidotrigla japonica*					3.86%				
38	**Rogadius asper*					3.74%				

39	*Thysanophrys celebica								2.83%	3.33%
40	*Inegocia japonica						0.31%			
41	Cociella crocodila	2.20%	2.13%	2.68%						
42	*Suggrundus macracanthus						2.89%	5.27%	5.06%	4.43%
43	Inegocia guttata				0.70%					
44	*Sorsogona tuberculata				0.15%					
45	Epinephelus areolatus		1.55%							
46	Epinephelus awoara		2.72%							
47	Priacanthus macracanthus								1.94%	1.70%
48	***Sillago sihama***	2.70%				1.17%	3.14%	2.46%	7.24%	2.31%
49	Polydactylus sextarius							1.22%		
51	***Upeneus japonicus***	2.12%	2.38%		0.56%	3.91%	9.51%	1.83%	1.71%	2.11%
52	Apogon semilineatus								0.11%	0.67%
53	*Ostorhinchus kiensis						0.06%	0.05%		0.13%
54	Apogon cathetogramma	0.44%				1.29%				
55	*Apogon lineatus		0.40%							
56	*Apogon niger		0.84%		2.18%			0.15%	2.58%	0.34%
57	*Ostorhinchus fasciatus			0.48%						
58	Equulites rivulatus	0.21%			0.71%	0.64%		0.48%	1.01%	2.19%
59	*Secutor ruconius							0.92%		
60	Selaroides leptolepis					1.81%			0.77%	1.82%
61	Decapterus maruadsi	3.04%		3.16%						

62	*Alepes kleinii					0.07%				
63	Trachurus japonicus	2.26%		12.63%						
64	Scolopsis vosmeri									1.66%
65	Evynnis cardinalis	22.04%		16.97%						
66	*Teixeirichthys jordani				11.46%	1.21%		2.47%	5.91%	2.10%
67	*Pomacentrus sp.	0.41%								
68	*Pomacentrus sp.2		1.15%							
69	*Chromis ternatensis									0.67%
70	Xyrichtys verrens		1.44%							
71	*Suezichthys gracilis	0.22%	0.75%					0.27%	0.82%	0.81%
72	Parapercis ommatura									
73	*Bathycallionymus kaianus				0.93%					
74	*Calliurichthys japonicus									
75	*Callionymus doryssus						0.76%	0.46%	1.94%	1.55%
76	*Callionymus curvicornis	9.75%	5.01%	0.81%	1.07%				0.75%	0.41%
77	Trichonotus setiger	32.87%	5.63%	0.98%	1.35%		1.49%	0.43%	4.15%	6.25%
78	*Trichonotus elegans					0.01%				
79	*Trichonotus filamentosus				5.89%		0.13%		0.30%	
80	**Bleekeria viridianguilla**	26.78%	4.68%	1.74%	2.11%	6.22%	10.87%	0.20%	4.70%	10.98%
81	**Bleekeria mitsukurii**	1.62%	7.91%		5.83%			11.27%	1.14%	7.17%
82	*Parapercis ommatura	0.38%								
83	*Parapercis puplchella						0.57%	0.41%		0.44%

84	*Chaetodontoplus septentrionalis*									0.11%
85	*Trichiurus* sp.			0.33%				7.60%		
86	*Siganus fuscescens*									1.16%
87	*Scomber japonicus*		8.28%	42.83%						
88	**Uranoscopus chinensis*			0.77%	3.56%		3.18%		3.97%	
89	*Ichthyscopus lebeck*					2.70%			0.14%	
90	**Valenciennea wardii*							0.37%		0.31%
91	**Amblychaeturichthys hexanema*			0.38%						
92	*Pseudorhombus oligodon*	1.94%								
93	*Pseudorchombus arsius*		1.53%	0.25%						
94	*Crossorhombus azureus*				0.20%					
95	**Bothus myriaster*				0.07%					
96	**Engyprosopon grandisquama*				3.75%		1.09%	2.42%	2.84%	3.92%
97	**Engyprosopon macrolepis*		1.77%							
98	**Engyprosopon filipennis*				5.99%					
99	**Psettina tosana*					9.98%	20.84%	0.43%		0.12%
100	**Liachirus melanospilus*	0.81%			3.40%				1.24%	
101	**Zebrias crossolepis*			0.81%	0.56%			1.90%		
102	*Pleuronichthys cornutus*									
103	*Cynoglossus puncticeps*		2.12%	0.29%						
104	**Cynoglossus oligolepis*		0.46%	0.38%					0.04%	2.73%
105	**Cynoglossus itinus*					0.28%		1.05%	1.02%	0.11%

106	*Cynoglossus sp.				15.15%					
107	***Stephanolepis cirrhifer***	1.89%				17.58%	1.30%	1.31%	0.66%	
108	*Lagocephalus wheeleri*							4.70%		
109	**Odontodactylus japonicus*		0.96%		0.41%					
110	**Erugosquilla woodmasoni*					0.03%		0.01%		0.01%
111	**Oratosquilla kempi*	0.25%								
112	**Lophosquilla costata*				0.39%				0.20%	0.10%
113	**Lophosquilla* sp.	1.10%		0.31%						
114	**Sicyonia cristata*						0.06%			
115	**Sicyonia japonica*						0.07%	0.15%		
116	**Atypopenaeus stenodactylus*									0.04%
117	**Parapenaeopsis tenella*									0.23%
118	*Parapenaeopsis cornuta*	0.45%	0.36%						1.69%	
119	*Parapenaeopsis cultrirostris*							0.21%		
120	*Metapenaeopsis lamellata*				0.13%			0.58%		
121	*Metapenaeopsis dalei*						0.00%	0.17%	0.00%	0.00%
122	*Metapenaeopsis palmensis*	1.61%			3.35%					
123	***Metapenaeopsis barbata***	1.55%	1.40%	2.78%		0.94%	0.14%	0.85%	0.73%	0.80%
125	*Trachypenaeus curvirostris*		0.23%			0.42%				
126	**Leptochela gracilis*			0.06%		0.05%				
127	**Birulia kishinouyei*				1.15%					
128	**Porcellana* sp.	0.02%								

129	*Leucosia* sp.			0.02%						
130	*Matuta lunaris*	0.77%	0.80%	0.69%					0.04%	
131	*Calappa lophos*					0.08%		1.43%		0.05%
132	*Cycloes granulosa*				1.09%					
133	*Jonas distincta*					0.79%				
134	*Charybdis variegata*	0.07%	0.56%	0.15%	0.27%			0.63%	0.02%	
135	*Charybdis bimaculata*		0.64%							
136	*Charybdis nataor*							0.52%		
137	*Portunus sanguinolentus*							0.70%		0.26%
138	*Xiphonectes hastatoides*			0.14%				0.24%		
139	*Lupocycloporus gracilimanus*	0.07%						0.37%		1.31%
140	***Monomia haanii***	4.42%	3.45%	0.52%	8.77%		3.22%	11.23%	21.87%	6.22%
141	*Octopus ocellatus*	0.64%	1.85%		1.83%				0.87%	
142	*Octopus variabilis*							0.57%		
143	*Octopus dolliusi*		1.03%						0.19%	
144	*Hapalochlaena lunulata*				0.37%					
145	*Loligo duvaucelii*								0.40%	
146	*Loligo* sp.	1.02%	1.04%	0.29%			6.55%	0.44%		
147	***Sepiola* sp.**	0.14%	1.03%		0.90%			0.23%	0.23%	0.14%
148	***Euprymna berryi***	0.79%	2.17%	1.48%		1.32%		0.07%		1.24%

3.6. Biological variation of *Monomia haanii* between trawl and trap fisheries in Dongshan County

The Chinese national fishing moratorium periods are from the 1st May to the 1st August for trap fishery and from the 1st May to the 15th August for trawl fishery. Surveys were conducted in January-April 2019 and August-December 2019 (covered all official fishing months) in Dongshan County, focusing on two fishing gears (trawl and trap) fishing in the same grounds offshore (see Section 3.3). In total 6,143 individuals of *M. haanii* were collected and measured; 1,568 from trawl fishery and 833 from trap fishery in January-April 2019, and 2,624 from trawl fishery and 1,118 from trap fishery in August-December 2019.

3.6.1. Size variation

Irrespective of fishing gears, sizes (carapace width, CW in cm) of *M. haanii* ranged from 2.7 to 12.6 cm CW, and monthly average sizes ranged from 6.3 to 9.5 cm CW, showing a monthly fluctuation in January-December 2019 (Table 9; Fig. 14):

(1) The average sizes (carapace width, CW in cm) of *M. haanii* caught by trap were larger than those caught by trawl in the same period.

(2) The largest average size was found in March in trap fishery, and in December in trawl fishery.

(3) The smallest average size was found in September in trap fishery, and in November in trawl fishery.

(4) The size ranges of *M. haanii* caught by trawl and trap overlapped largely during the same fishing season, both operating in the same fishing grounds; however, trawl fishery caught smaller juveniles < 5 cm CW.

Table 9. Size range and average size (carapace width, cm) of *Monomia haanii* between trawl and trap fisheries in Dongshan County in January-December 2019

	Trawl		Trap	
	Range	Average	Range	Average
January	2.9-11.4	6.5	5.3-11.3	8.2
February	4.4-12.1	7.3	5.8-11.5	8.4
March	4.9-11.9	7.4	5.1-12.0	9.5

April	4.2-12.2	7.0	5.5-10.1	8.0
August	4.9-11.8	7.5	6.5-11.7	8.5
September	2.7-11.4	8.0	4.9-11.5	8.1
October	2.8-11.0	7.5	6.5-11.3	9.0
November	3.7-12.1	6.3	6.2-11.0	9.2
December	4.7-11.9	9.0	5.8-12.6	9.1

The dominant size classes (defined as the proportion >20%) of *M. haanii* caught by trawl and trap in January-December 2019 showed monthly variation (Fig. 14):

(1) In trawl fishery, more than 90% of individuals were larger than 6.0 cm CW in March and August-October and December 2019, and in January, February, April and November, around 42.41%, 10.84%, 24.82% and 51.87% individuals smaller than 6.0 cm. In trap fishery, more than 90% of individuals were larger than 7.0 cm CW, expect February (89.23%), April (85.23%) and August (81.90%).

(2) In trawl fishery, the dominant size classes were 5.0-6.9 cm (60.54%) in January, 6.0-7.9 cm (65.08%) in February, 6.0-7.9 cm (68.50%) in March 2019, 5.0-7.9 (75.93%) in April, 6.0-8.9 (83.41%) in August, >6.0-9.9 (93.19%) in September, 6.0-8.9 (84.21%) in October, 5.0-6.9 (72.11%) in November and > 8.0 (80.12%) in December. In trap fishery, the dominant size classes were 7.0-8.9 (70.51%) in January, 7.0-8.9 and >10.0 cm (79.23%) in February 2019, >9.0 cm (72.22%) in March 2019, 7.0-8.9 (70.45%) in April 2019, 8.0-9.9 (46.15%) in August, 7.0-8.9 (80.69%) in September, >8.0 (80.69%) in October, >8.0 (80.39%) in November and > 8.0 (81.47%) in December.

(3) In trawl fishery, proportions of larger sizes (>10.0 cm CW) were high in December at around 45.59%, and were low in the rest of months, mainly less than 10%. In trap fishery, proportions of larger sizes (>10.0 cm CW) were high in February-March, August and October-December.

(4) In trawl fishery, sizes smaller than 6.0 cm CW were found in all months, and mainly in January, April and December. In trap fishery, sizes smaller than 6 cm CW were found in January-April, August and December with the proportion less than 5%.

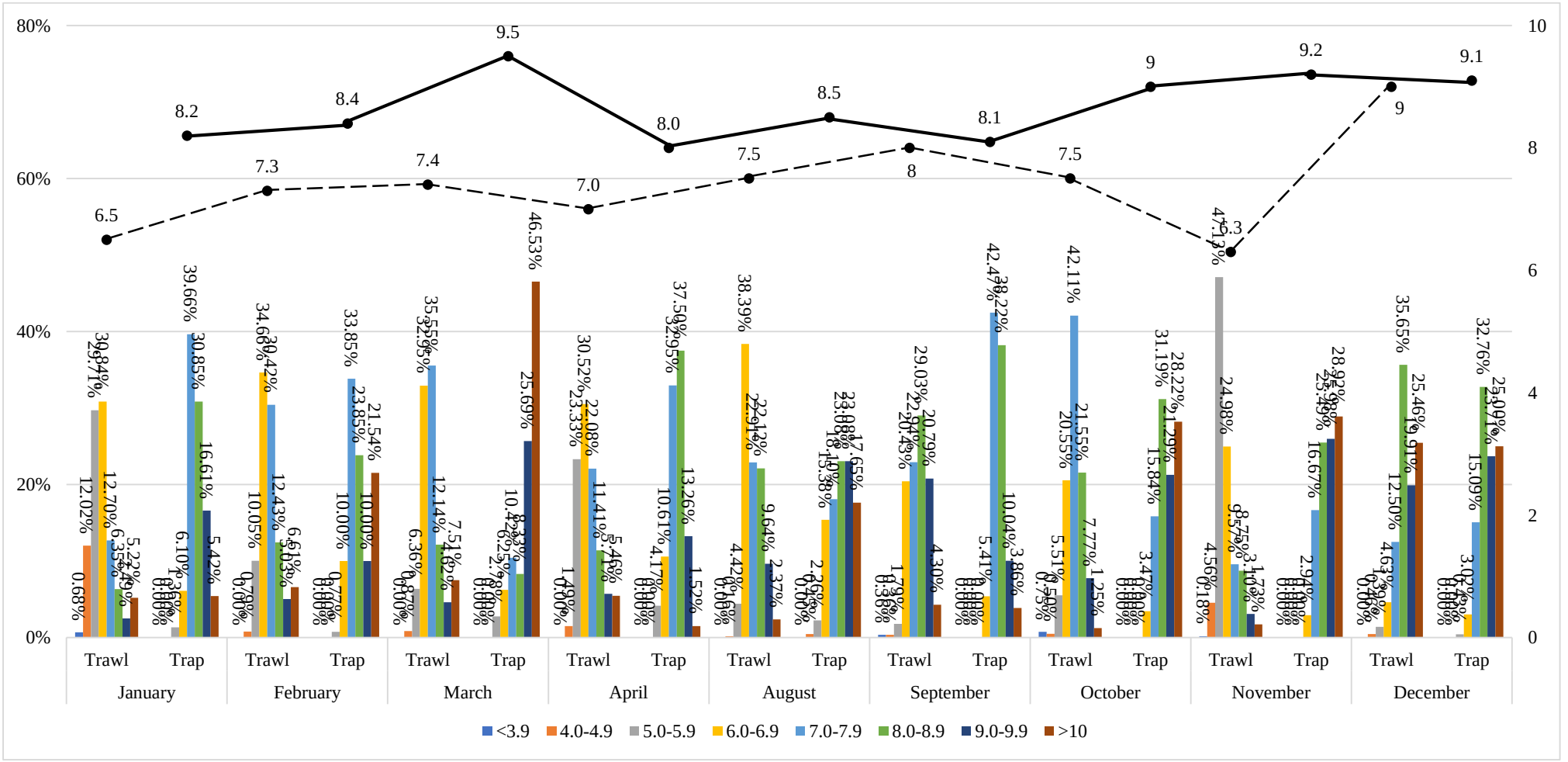

Fig. 14. Proportions of different size classes (cm in carapace width) of *Momonia haanii* (left Y-axis) and the trends of the monthly average sizes (right Y-axis) in trawl and trap fisheries in Dongshan County in January-December 2019.

3.6.2. Sex ratio variation

Sex ratios of *M. haanii* showed monthly variation in Dongshan County in January-December 2019 between trawl and trap fisheries (Fig. 15; Fig. 16):

(1) In the trawl fishery, the overall sex ratio was 1:1.04 (male: female) (N = 4,192), showing the change from a strong male-bias in August and September to a strong female-bias in February and March.

(2) In the trap fishery, the overall sex ratio in trap fishery was 1.36:1 (male: female) (N = 1,951), showing a strong male-bias in March-April, August and September, and a strong female-bias in January.

(3) Irrespective of different fishing gears, the overall sex ratio of *M. haanii* was 1.07:1 (male: female) (N = 6,143), showing a male-bias in April, August and September, and a female-bias in January-March.

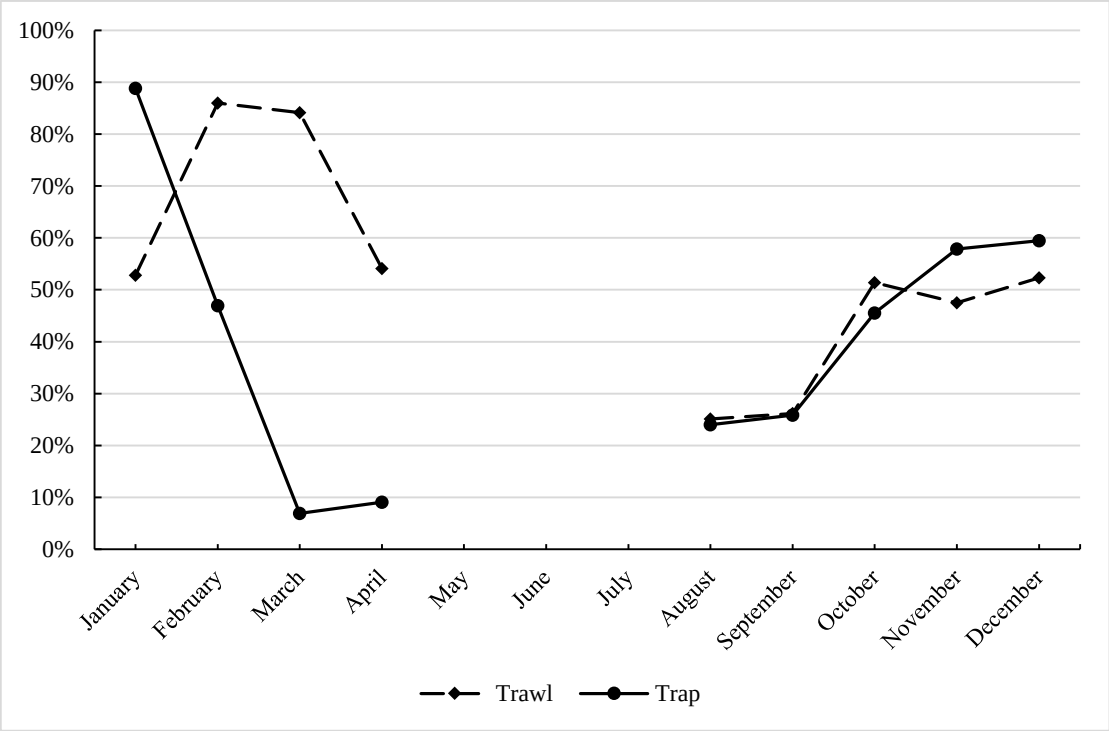

Fig. 15. Proportions of females of *Monomia haanii* in trawl (N = 4,192) and trap (N = 1,951) fisheries in Dongshan County in January-December 2019.

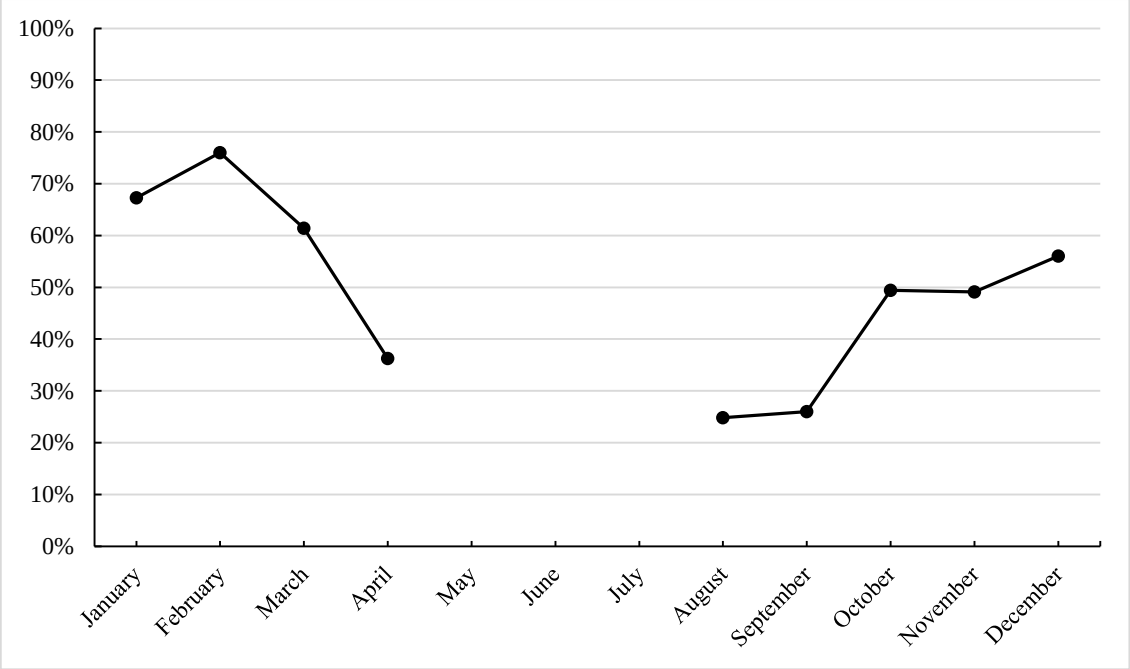

Fig. 16. Proportions of females of *Monomia haanii* in irrespective of different fishing gears in Dongshan County in January-December 2019.

3.6.3. Spawning season and size at 50% female maturity

Proportions of *M. haanii* females bearing eggs (number of females bearing eggs/number of females) were different between trawl and trap fishery in Dongshan County in January-December 2019 (Fig. 17; Fig. 18):

(1) In trawl fishery, the proportions of *M. haanii* females bearing eggs showed three peaks, in February-April, in September and in December.

(2) In trap fishery, the proportions of *M. haanii* females bearing eggs also showed three peaks, in December-March, in August and in October.

(3) Irrespective of fishing gears, one important spawning season of *M. haanii* was from December to April of the coming year, with another one in August and September.

The minimum size for females bearing eggs was 4.6 cm CW for *M. haanii*, caught in April 2019.

The size at 50% female maturity (CW_{50}) was estimated to be 7.3 cm CW, based on females sampled only in February-April, in September and in December (the peak spawning season determined in this study) from the trawl fishery (Fig. 19).

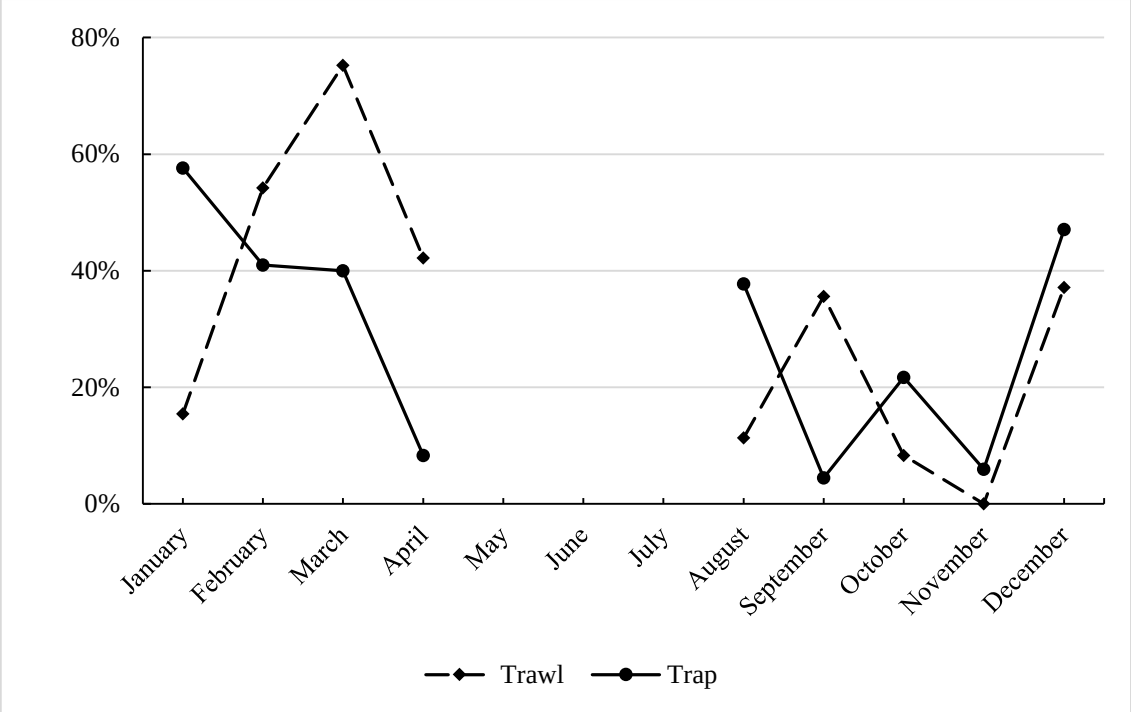

Fig. 17. Proportions of *Monomia haanii* females bearing eggs between trawl and trap fisheries in Dongshan County in January-December 2019.

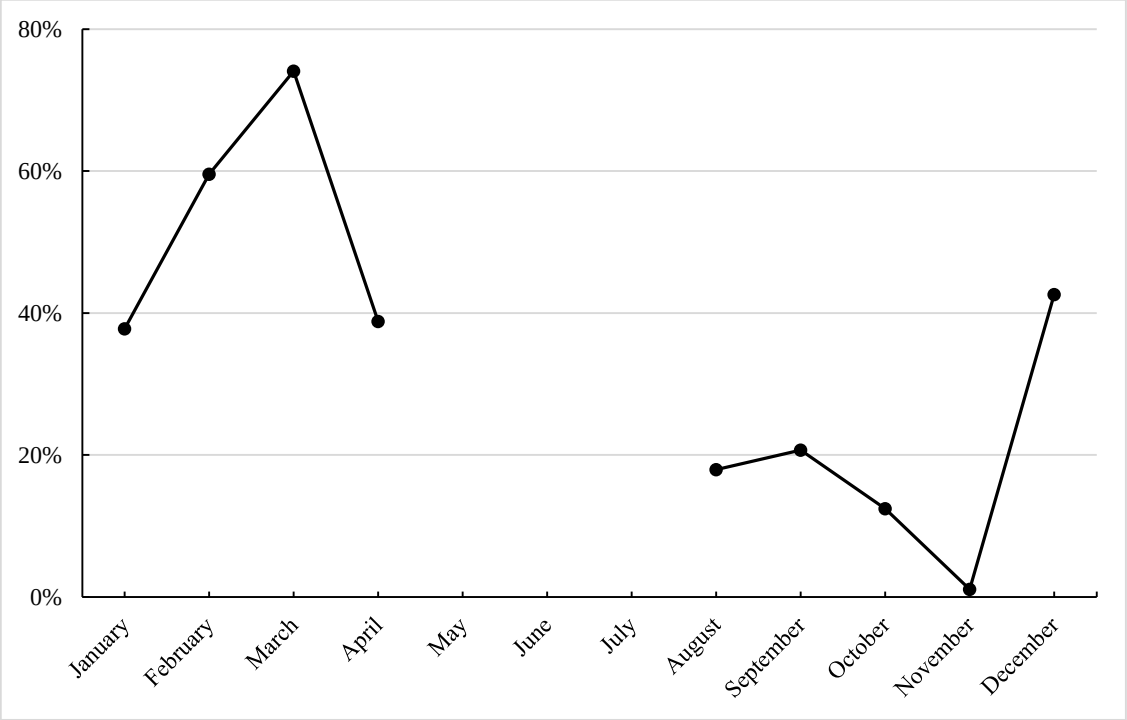

Fig. 18. Proportions of *Monomia haanii* females bearing eggs in irrespective of different fishing gears in Dongshan County in January-December 2019.

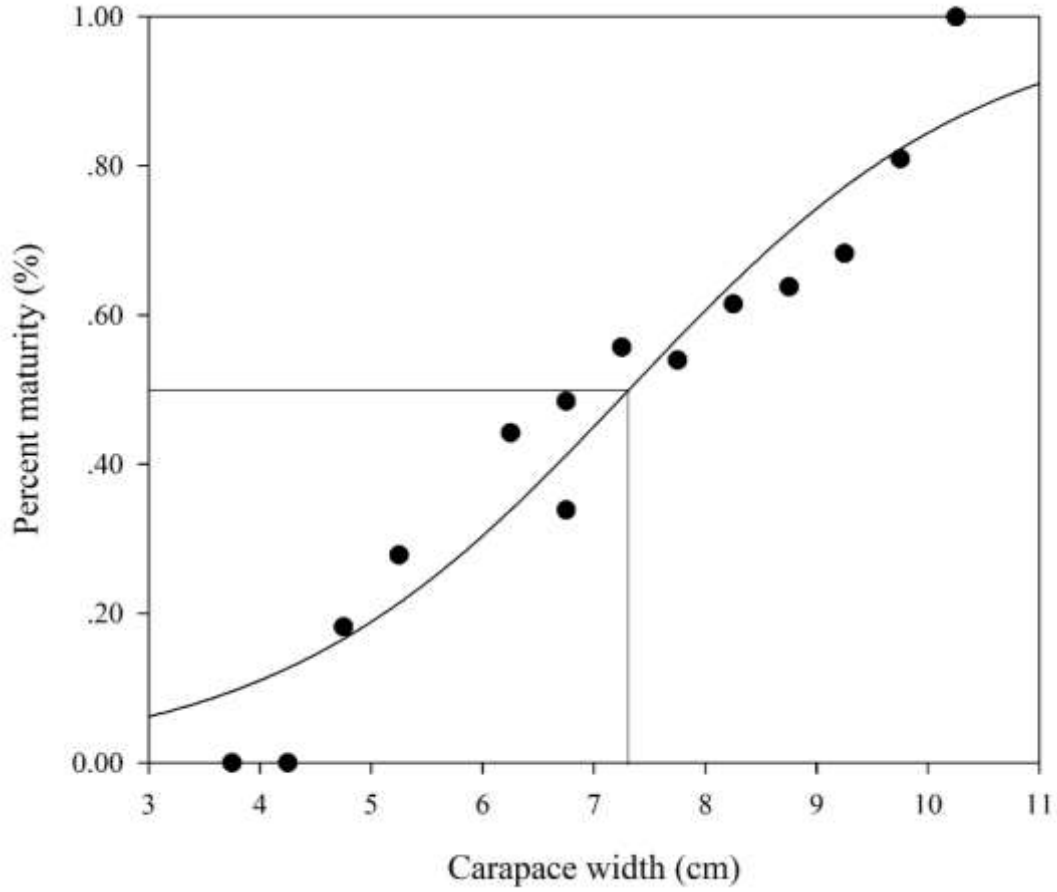

Fig. 19. Size (carapace width, CW) at 50% female maturity based on all females sampled from trawl fishery in spawning seasons determined, i.e., February-April, September and December 2019 (n = 1,605).

3.6.4. Size-weight and size-size relationships

The relationships of size (carapace width, CW) and weight (whole body weight, BW) for *M. haanii* were: $BW = 0.1224*CW^{2.9415}$ ($R^2 = 0.913$; N = 4,192) from the trawl fishery, and $BW = 0.075*CW^{3.1467}$ ($R^2 = 0.9172$; N = 1,951) from the trap fishery (Fig. 20).

The carapace length (CL)-carapace width (CW) relationships for *M. haanii* were: $CL = 0.5833*CW - 0.1327$ ($R^2 = 0.9425$; N = 4,192) from the trawl fishery, and $CL = 0.5483*CW + 0.1809$ ($R^2 = 0.9169$; N = 1,951) from the trap fishery (Fig. 21).

The relationships of size (CW)-weight (BW) and size (CW)-size (CL) between trawl fishery and trap fishery did not differ.

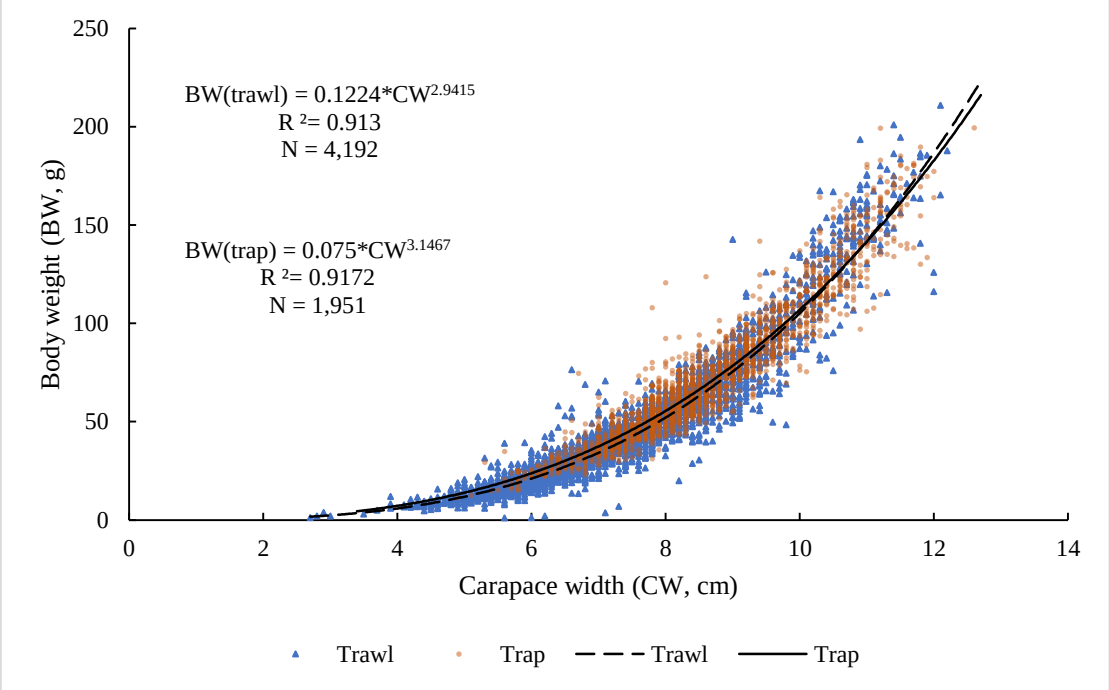

Fig. 20. Size (carapace width, CW)-weight (whole body weight, BW) relationship of *Monomia haanii* in trap and trawl fisheries in Dongshan County in January-December 2019.

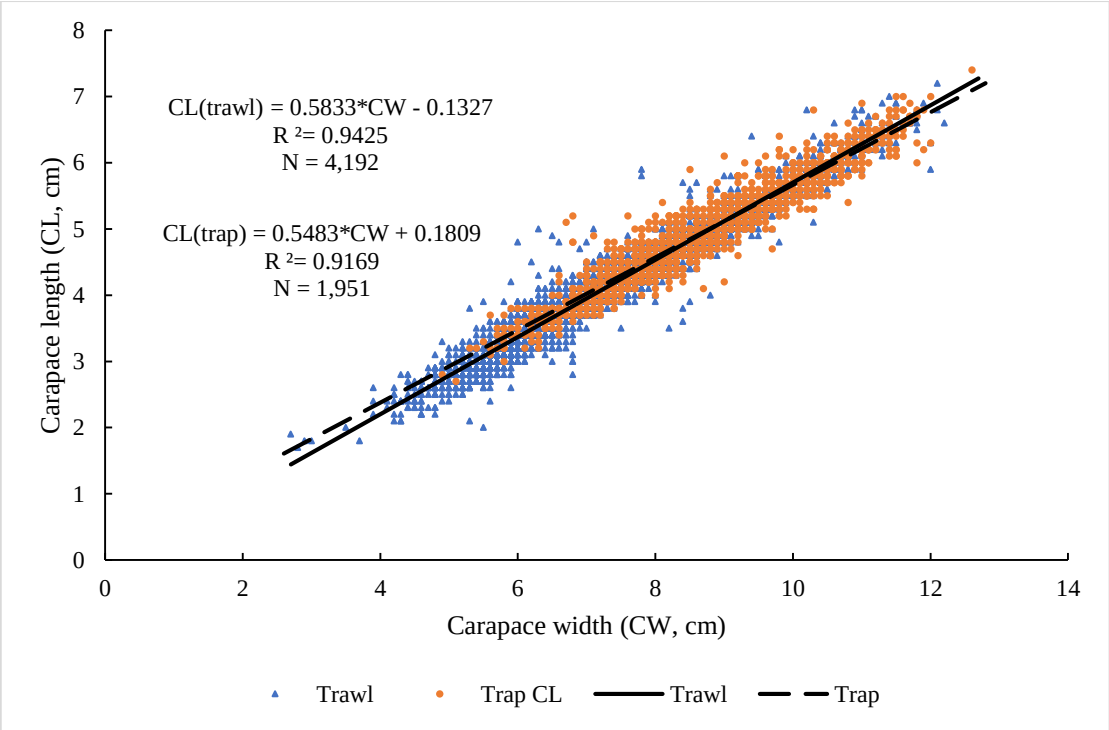

Fig. 21. Carapace length (CL)-carapace width (CW) relationship of *Monomia haanii* in trap and trawl fisheries in Dongshan County in January-December 2019.

3.7. Biological variation of other crabs in Dongshan County in January-December 2019

In Dongshan County, the trawl and trap vessels operated in different habitats or sometimes in the same habitats of the same fishing grounds (see Section 3.3, and more details in Phase I-II report). For *M. haanii*, the size, sex ratio and proportion of females bearing eggs were different between trawl and trap fisheries (see Section 3.7). For the other three targeted species, only *Portunus sanguinolentus* were collected from both fishing gears, while *Charybdis nataor and Calappa philargius* samples were only collected from trawl fishery. In this section, we analyzed their biological data, irrespective of different fishing gears.

3.7.1. *Portunus sanguinolentus*

3.7.1.1. Size variation

In total 2,228 individuals of *P. sanguinolentus* were collected; 1,257 from trawl vessels and 971 from trap vessels in January-December 2019 in Dongshan County (Fig. 22):

(1) Sizes ranged from 3.9 to 19.1 cm CW.

(2) Monthly average sizes ranged from 12.3 to 14.3 cm CW, showing monthly variation, with the highest average in April 2019.

(3) In January-April, and August-September, the dominant sizes were larger than 11.0 cm CW.

(4) In October-December, the proportions of small size classes (<10.0 cm CW) were high.

(5) In April, November and December, the proportions of large size classes (> 16.0 cm CW) were high.

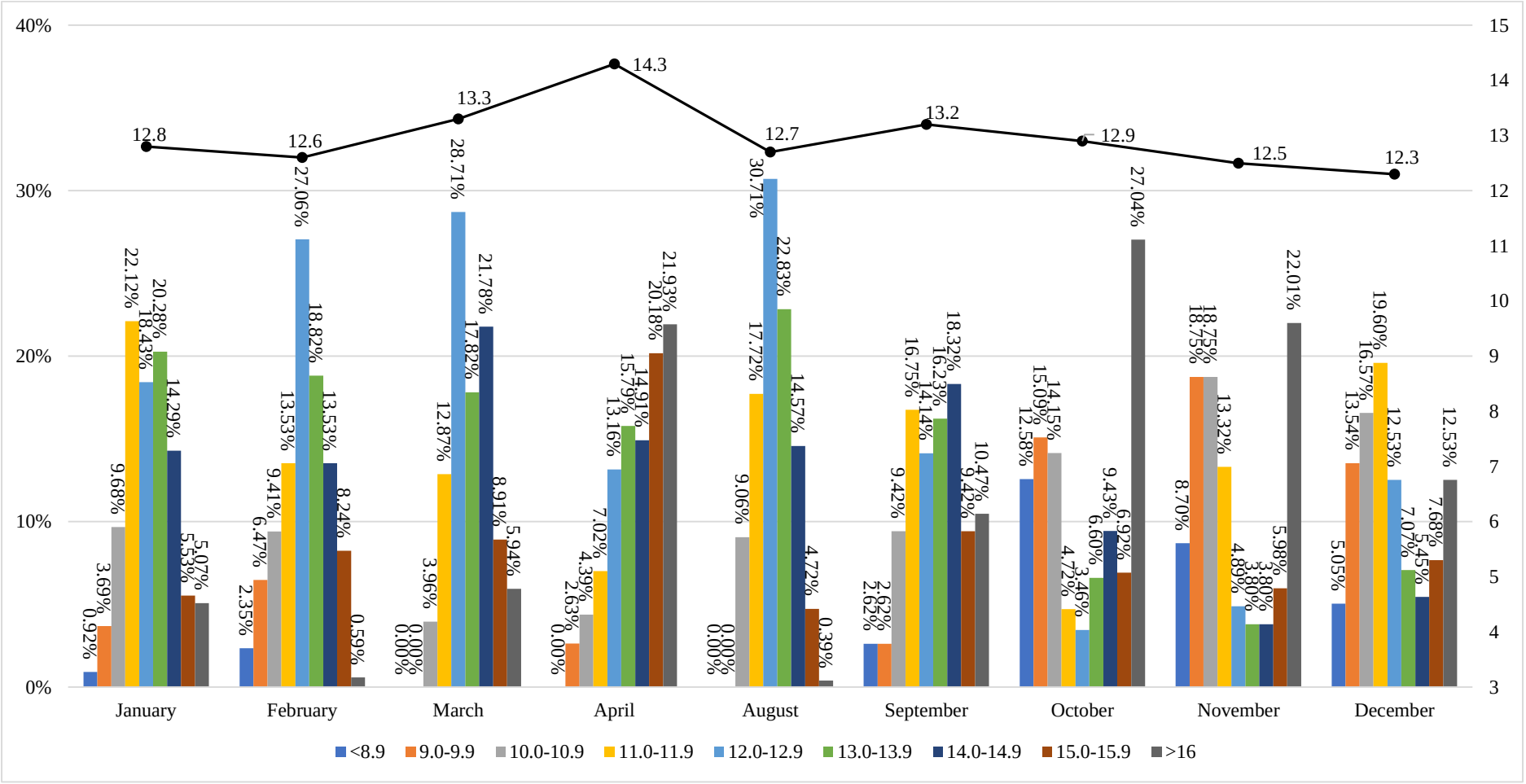

Fig. 22. Proportions of different size classes (cm in carapace width) of all *Portunus sanguinolentus* individuals (left Y-axis) and the trend of the monthly average sizes (right Y-axis) in both trawl and trap fisheries in Dongshan County in January-December 2019.

3.7.1.2. Sex ratio variation

Overall sex ratio of *P. sanguinolentus* was 1: 1.28 (male: female) in January-December 2019, showing a female-bias in January-April and August-September (Fig. 23).

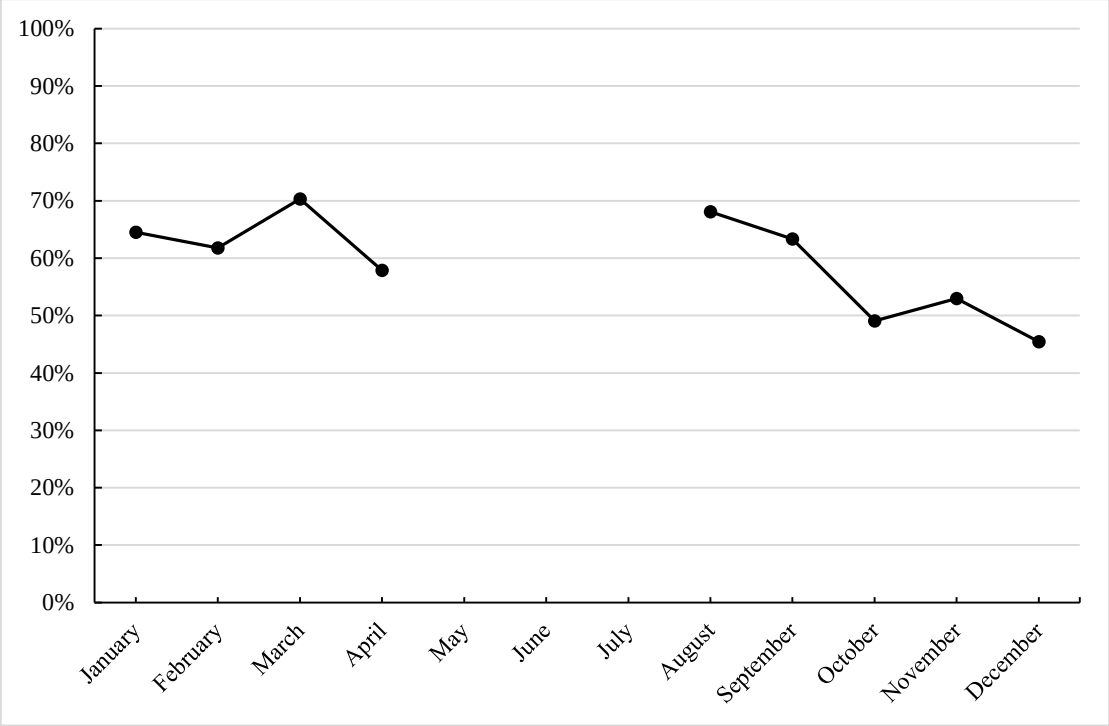

Fig. 23. Proportions of *Portunus sanguinolentus* females in both trawl and trap fisheries in Dongshan County in January-December 2019.

3.7.1.3. Size-weight and size-size relationships

The relationship of size (carapace width, CW) and weight (whole body weight, BW) for *P. sanguinolentus* was: $BW = 0.0466*CW^{3.0924}$ ($R^2 = 0.9316$; N = 2,288) (Fig. 24).

The carapace length (CL)-carapace width (CW) relationship for *P. sanguinolentus* was: $CL = 0.4378*CW + 0.1913$ ($R^2 = 0.951$; N = 2,288) (Fig. 25).

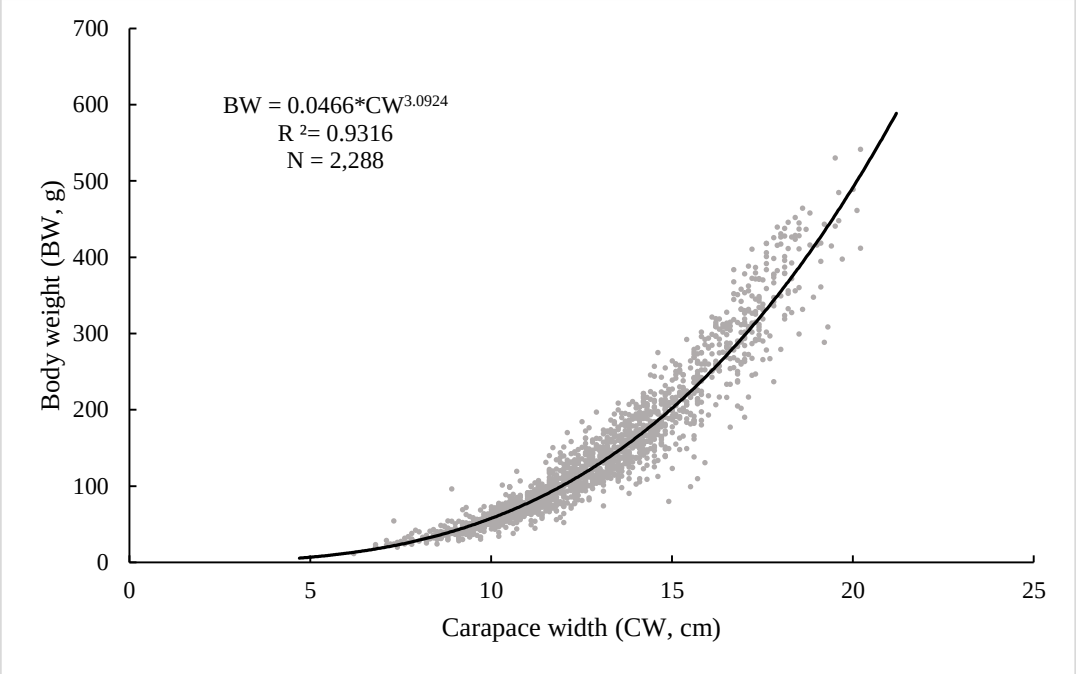

Fig. 24. Size (carapace width, CW)-weight (whole body weight, BW) relationship of *Portunus sanguinolentus* from both trap and trawl fisheries in Dongshan County in January-December 2019.

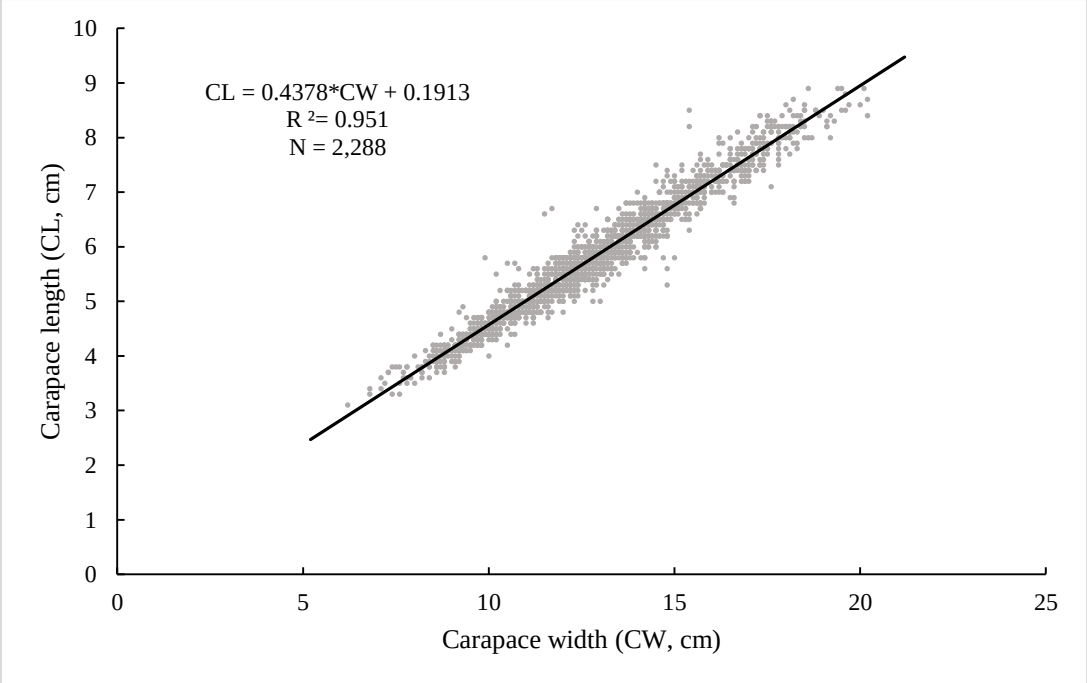

Fig. 25. Carapace length (CL)-carapace width (CW) relationship of *Portunus sanguinolentus* from both trap and trawl fisheries in Dongshan County in January-December 2019.

3.7.1.4. Spawning season and the minimum size for female bearing eggs

The proportions of females bearing eggs remained high (>20%) in February-April, and during August and September, indicating two spawning seasons (Fig. 26).

The minimum size for female bearing eggs was 9.6 cm CW for *P. sanguinolentus*, caught in September 2019.

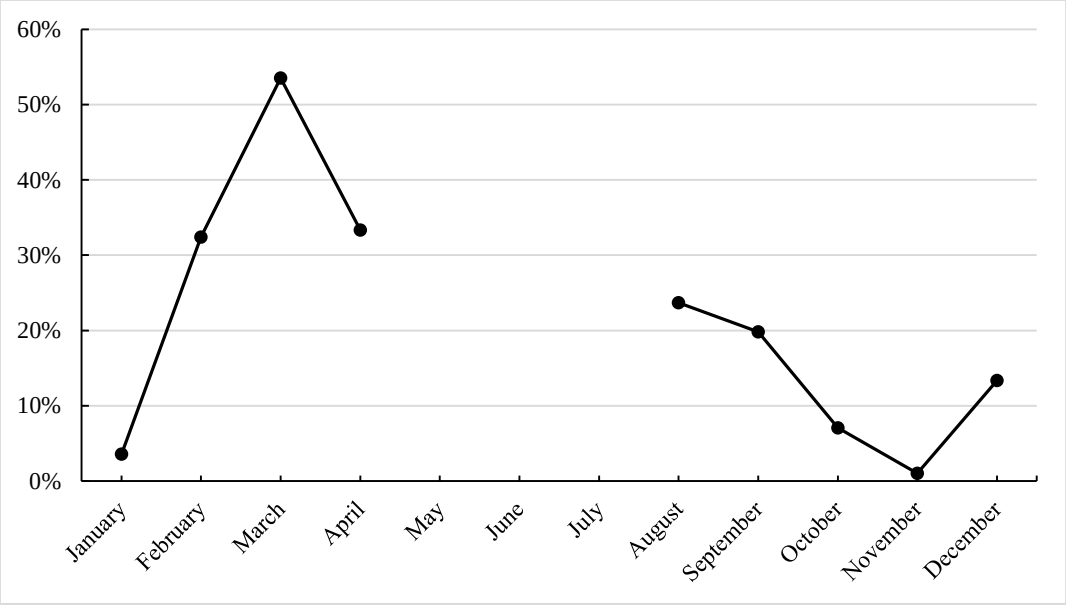

Fig. 26. Proportions of *Portunus sanguinolentus* females bearing eggs in Dongshan County in January-December 2019.

3.7.2. *Charybdis nataor*

3.7.2.1. Size variation

Totally 1,557 individuals of *C. nataor* were collected from trawl vessels in January-December 2019 in Dongshan County (Fig. 27):

(1) Sizes ranged from 4.0 to 13.4 cm CW.

(2) Monthly average sizes ranged from 6.5 to 9.0 cm CW, high in February, and low in November.

(3) The dominant size classes were generally in the following size classes: 5.0-7.9 cm CW in November (87.5%), 6.0-8.9 cm CW in January, March, October and December 2019 (proportions >75%), larger than 7.0 cm CW (proportions >88%) in February, April, August and September 2019, and larger than 8.0 cm in February 2019.

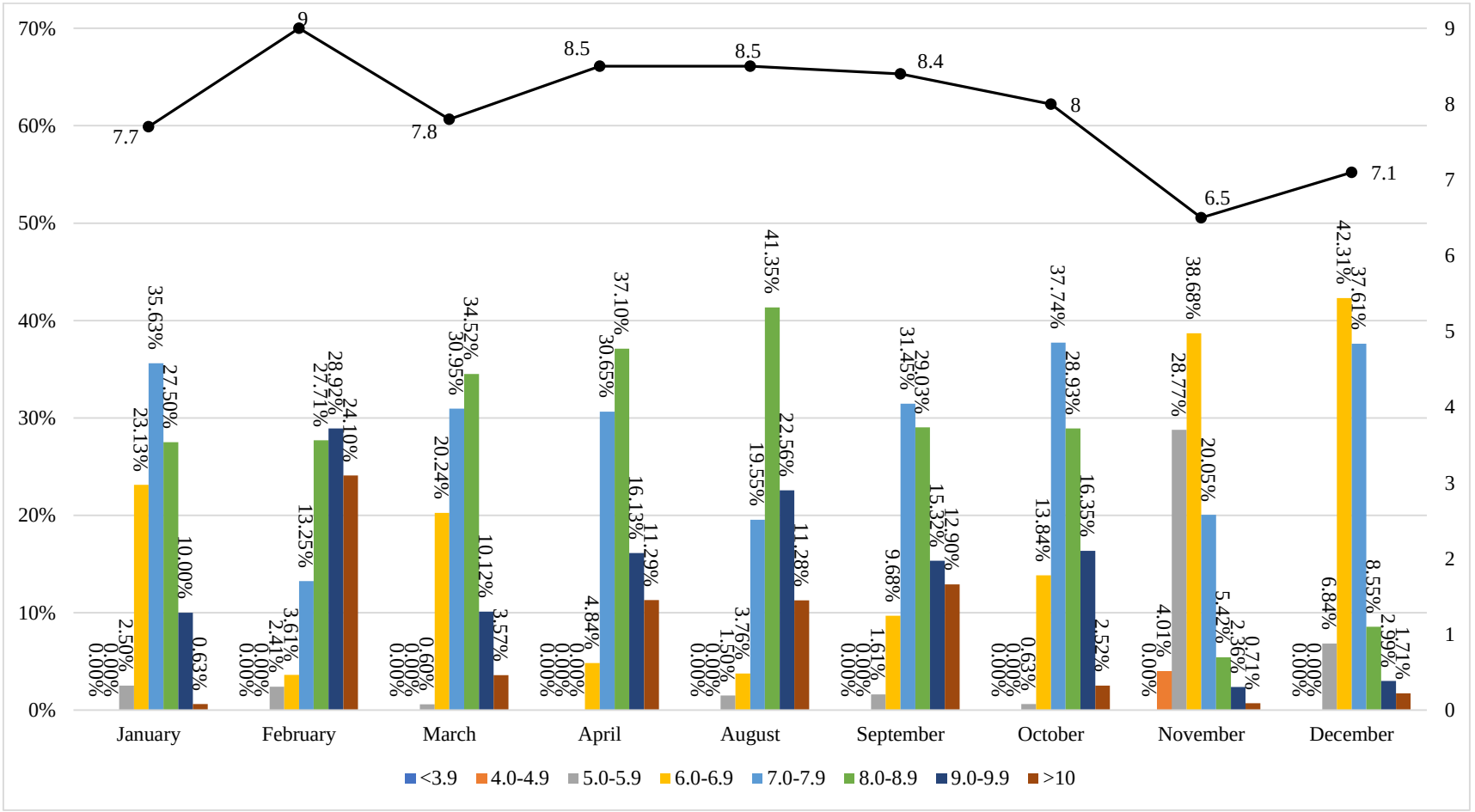

Fig. 27. Proportions of different size classes (cm in carapace width) of all *Charybdis nataor* individuals (left Y-axis) and the trend of the monthly average sizes (right Y-axis) in trawl fishery in Dongshan County in January-December 2019.

3.7.2.2. Sex ratio variation

Overall sex ratio of *C. nataor* was 1: 1.29 (male: female), showing a strong female-bias in February and March 2019 (Fig. 28).

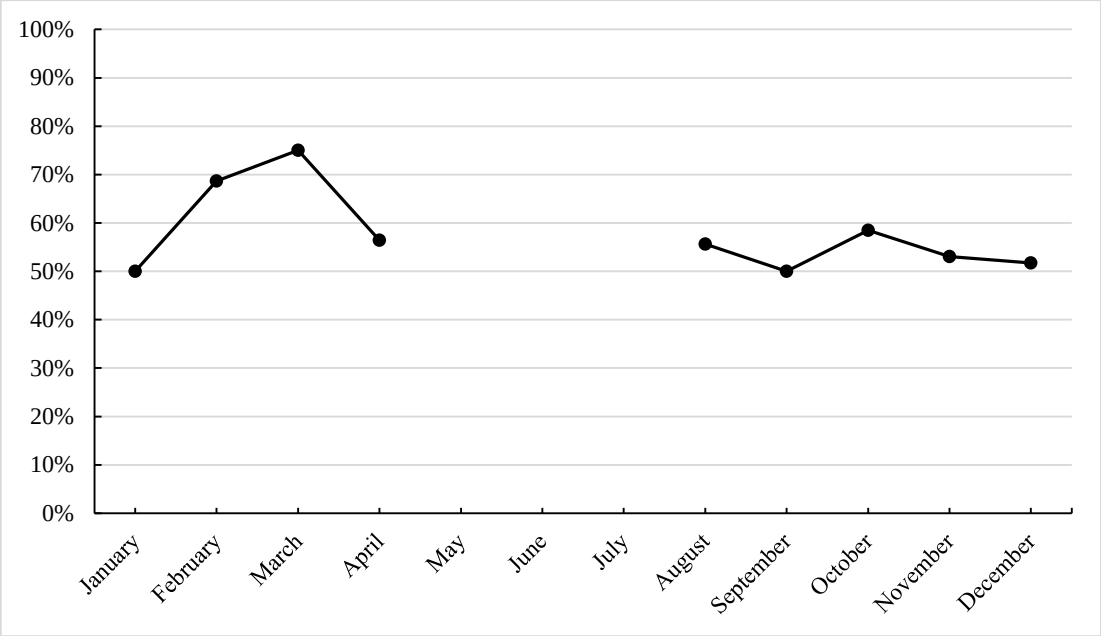

Fig. 28. Proportions of females of *Charybdis nataor* in Dongshan County in January-December 2019.

3.7.2.3. Size-weight and size-size relationships

The relationship of size (carapace width, CW) and weight (whole body weight, BW) for *C. nataor* was: $BW = 0.1508*CW^{3.1108}$ ($R^2 = 0.881$; N = 1,557) (Fig. 29).

The carapace length (CL)carapace width (CW) relationship for *C. nataor* was $CL = 0.653*CW + 0.2777$ ($R^2 = 0.9587$; N = 1,557) (Fig. 30).

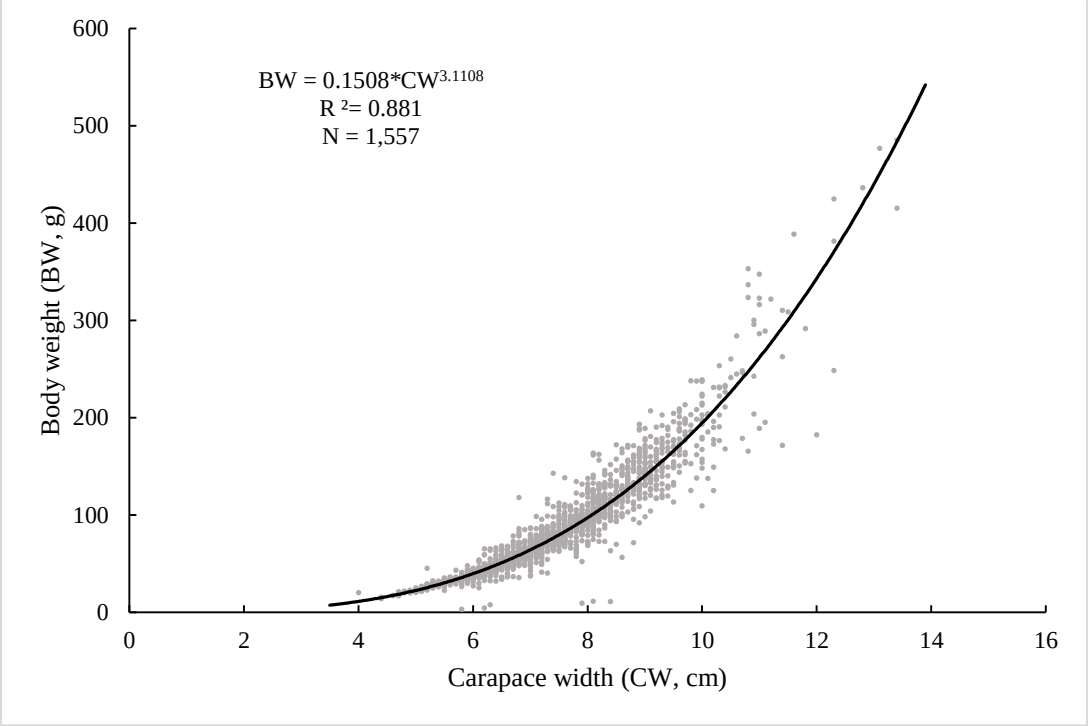

Fig. 29. Size (carapace width, CW)-weight (whole body weight, BW) relationship of *Charybdis nataor* from trawl fishery in Dongshan County in January-December 2019.

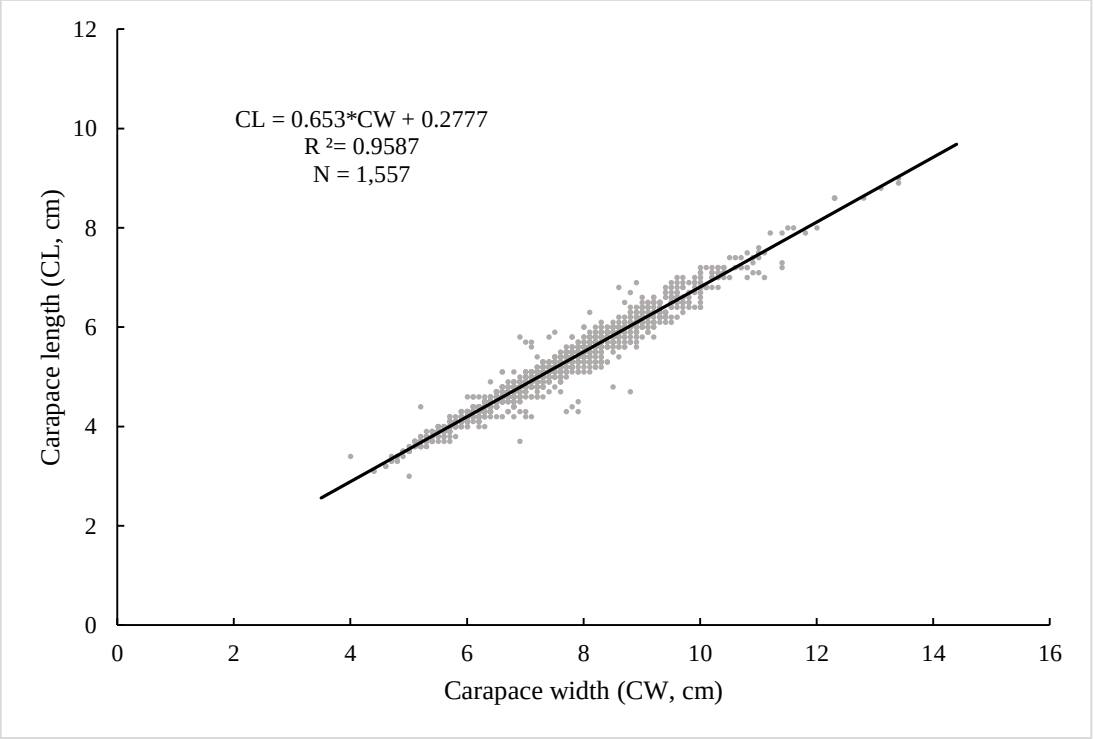

Fig. 30. Carapace length (CL)-carapace width (CW) relationship of *Charybdis nataor* from trawl fishery in Dongshan County in January-December 2019.

3.7.2.4. Spawning season and the minimum size for female bearing eggs

A clear spawning season was determined in February-April with the proportions of females bearing eggs (>55% (Fig. 31).

The minimum size for females bearing eggs was 6.1 cm CW for *C. nataor*, caught in March 2019.

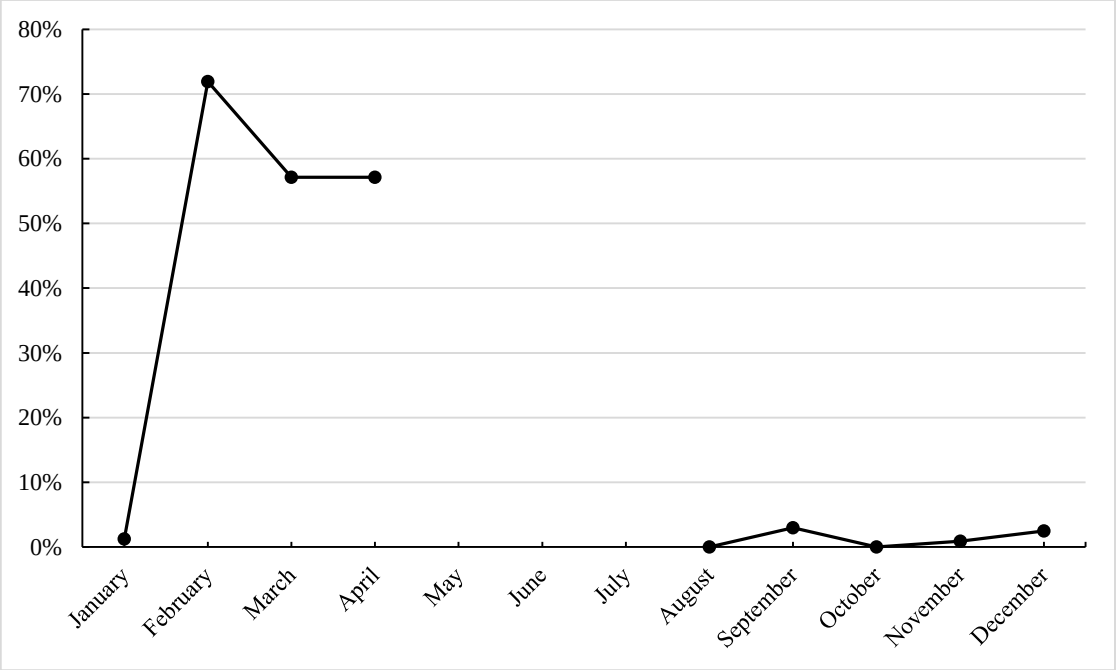

Fig. 31. Proportions of *Charybdis nataor* females bearing eggs in Dongshan County in January-December 2019.

3.7.3. *Calappa philargius*

3.7.3.1. Size variation

In total 1,004 individuals of *C. philargius* were collected from trawl vessels in January-December 2019 in Dongshan County (Fig. 32):

(1) Sizes ranged from 6.3 to 16.0 cm CW.

(2) Monthly average sizes ranged from 11.1 to 12.6 cm CW, showing a monthly variation.

(3) The dominant size classes were generally larger than 10.0 cm CW in all months. Smaller size classes <10.0 cm CW were dominant in March (28.21%) and November (33.34%).

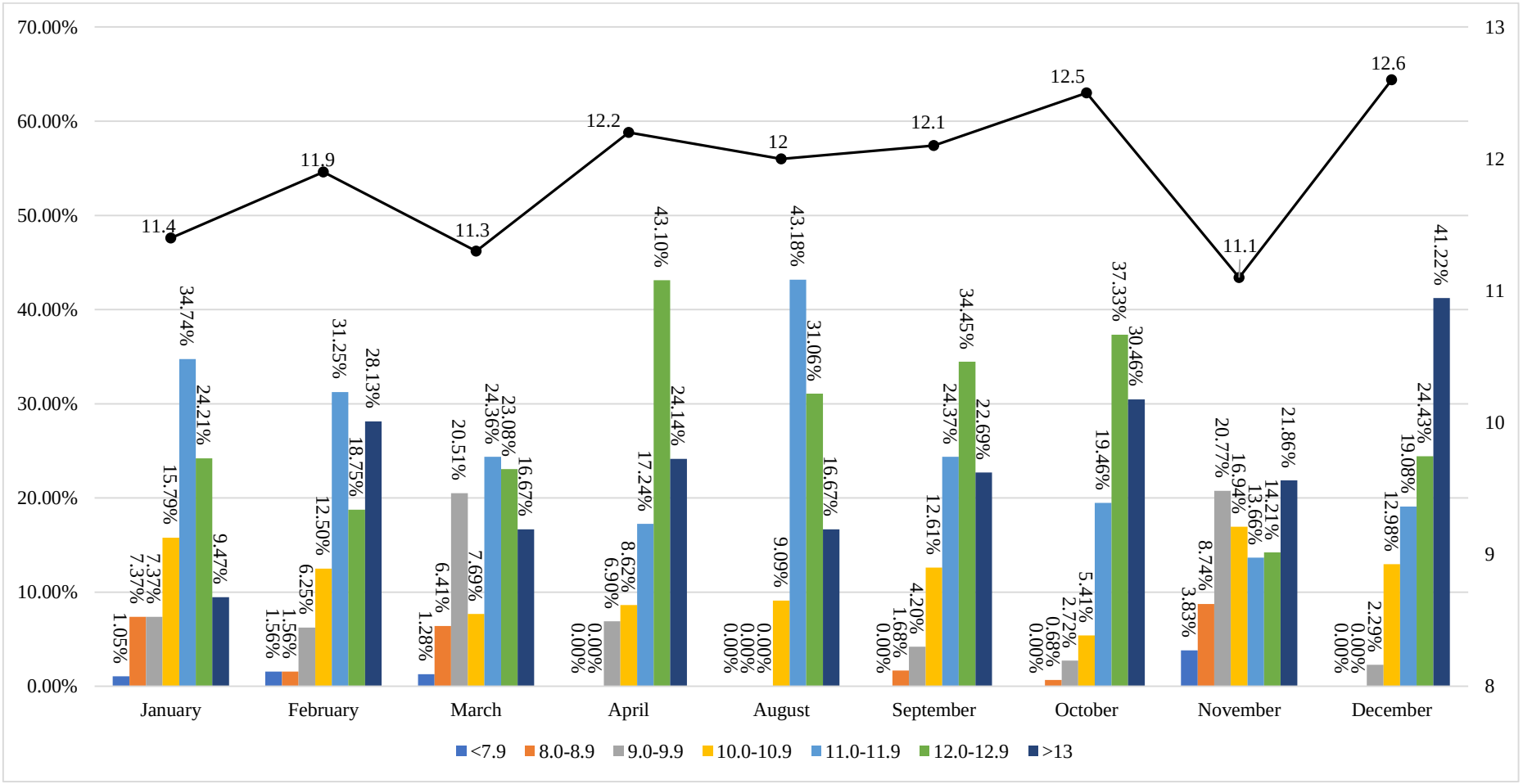

Fig. 32. Proportions of different size classes (cm in carapace width) of all *Calappa philargius* individuals (left Y-axis) and the trend of the monthly average sizes (right Y-axis) in trawl fishery in Dongshan County in January-December 2019.

3.7.3.2. Sex ratio variation

Overall sex ratio of *C. philargius* was 1: 1.46 (male: female) in January-December 2019, showing a strong male-bias in August, and a strong female-bias in January, February, and October-December (Fig. 33).

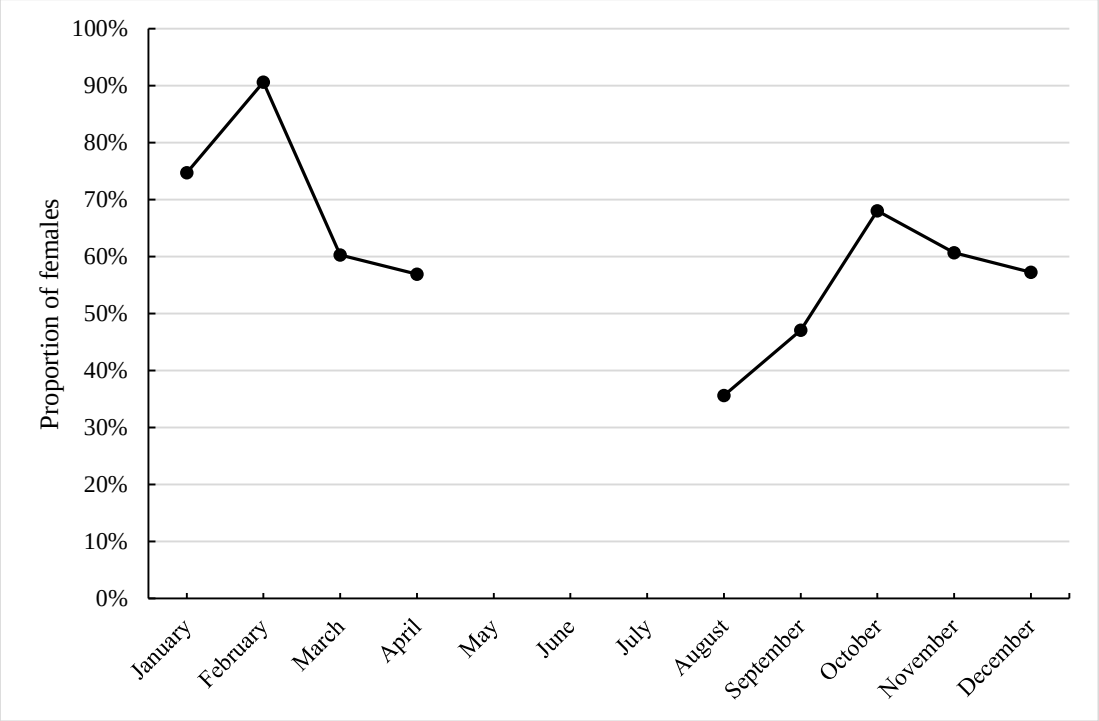

Fig. 33. Percentages of *C. philargius* females monthly from January-December 2019.

3.7.3.3. Size-weight and size-size relationships

The relationship of size (carapace width, CW) and weight (whole body weight, BW) for *C. philargius* was: $BW = 0.2296*CW^{2.7538}$ ($R^2 = 0.7645$; N = 1,004) (Fig. 34).

The carapace length (CL)-carapace width (CW) relationship for *C. philargius* was $CL = 0.6507*CW + 1.1922$ ($R^2 = 0.7129$; N = 1,004) (Fig. 35).

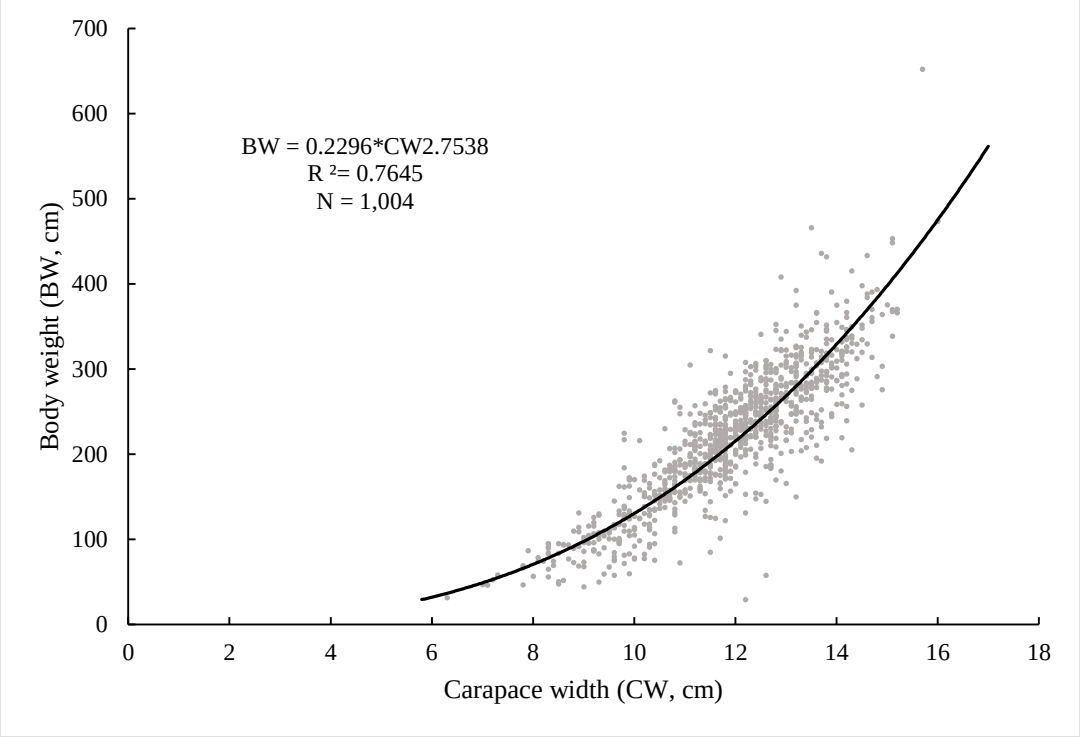

Fig. 34. Size (carapace width, CW)-weight (whole body weight, BW) relationship of *Calappa philargius* from trawl fishery in Dongshan County in January-December 2019.

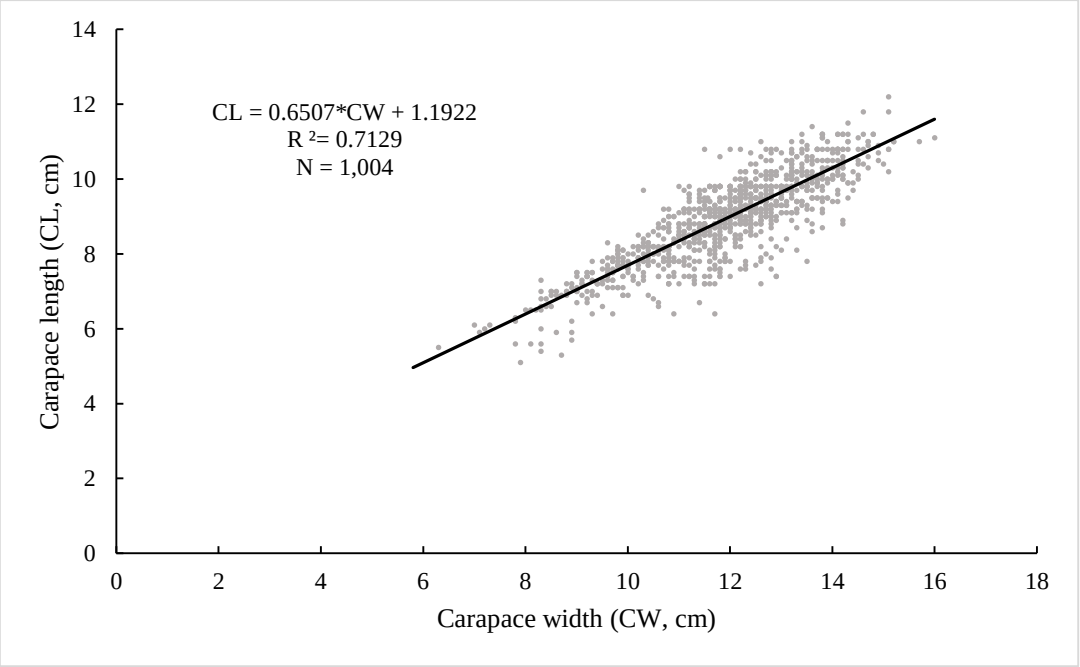

Fig. 35. Carapace length (CL)-carapace width (CW) relationship of *Calappa philargius* from trawl fishery in Dongshan County in January-December 2019.

3.7.3.4. Spawning season and the minimum size for female bearing eggs

The proportions of females bearing eggs showed significantly fluctuation with one peak from February to April 2019, indicating one spawning season in February-April, and a smaller peak in September (Fig. 36).

The minimum size recorded was 9.0 cm CW for *C. philargius*, caught in September 2019.

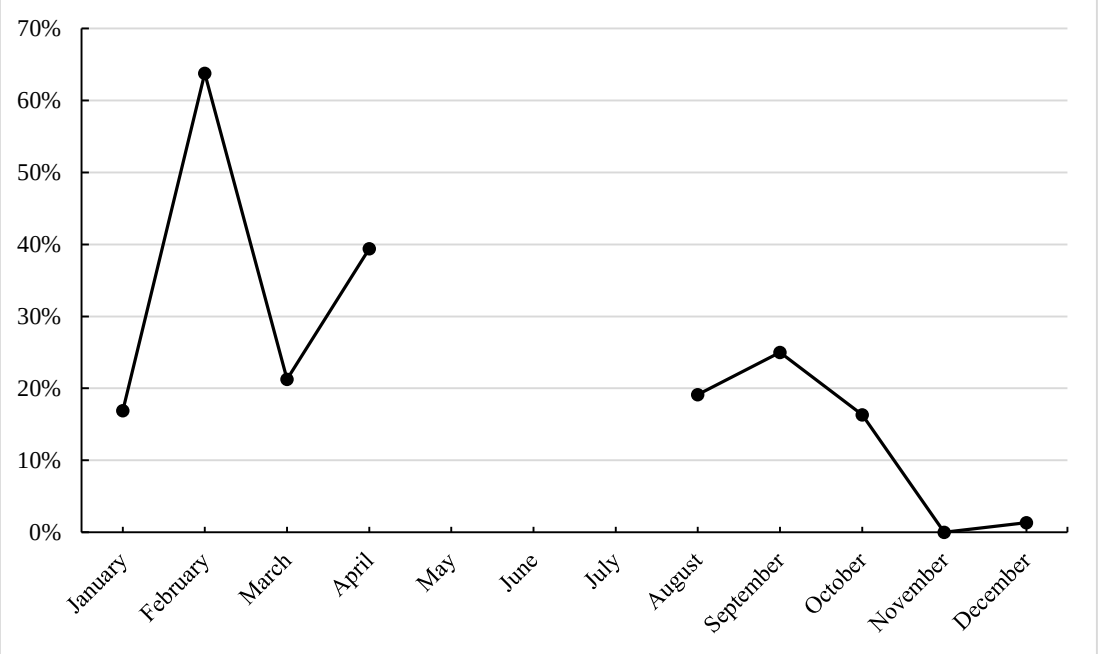

Fig. 36. Proportions of *Calappa philargius* females bearing eggs in Dongshan County in January-December 2019.

3.8. Ecological impacts of trawl and trap fishing gears

In the Minnan Fishing Ground, Taiwan Bank Fishing Ground and Yuedong Fishing Ground, a number of vessel based activities occur that have potential ecological impacts, including trawl, trap and gillnet fisheries and illegal sand pumping. In an effort to begin evaluating some of these impacts, interviews were conducted with trawl and trap vessels to assess the potential magnitude of lost and/or discarded fishing gear related to these sectors.

Based on the interviews of captains and crews of trawl vessels (10 vessels) at the landing ports in Dongshan County, trawl net loss was not identified as a significant issue, however, torn or damaged nets were common. Approximate 8 nets were carried

out for a fishing trip per vessel. A trawl net costs about 7,000 RMB. Net damage was mainly due to encountering rocky bottom, lost traps or large trash (e.g. woods, oil tanks and others); around 0-5 nets damages per trip. The broken nets were carried back to port for repair. The repair cost ranged from 600-1,500 RMB/net, and price variation was mainly due to the degree of net damage. Some lost traps were caught by trawl vessels and then discarded back into the sea in non-trawl fishing areas.

Interviews were conducted of captains and crews from 10 trap vessels at landing ports in Dongshan County. About 3,000-4,000 traps were carried per trap vessel for each fishing trip. Trap vessels usually fish for crustaceans in muddy, sandy and rocky bottoms. The traps were divided into three ropes with each consisting of at least 1,000 traps connected in a 10 km long rope with a 7-8 meters distance between each trap. There were two white floating buoys at the start and the end of each rope. Traps were mainly produced in Dongshan and Longhai counties and those sold in Dongshan County cost approximately 20-25 RMB per trap (based on the weight and size of traps). The total cost of traps was significant, at an estimated 63,000-78,000 thousand RMB for one rope. As a result of trap vessels sharing of the same fishing grounds with trawlers and the related interaction of gear, an estimated 600-1,000 traps/vessel/trip are lost at sea in Dongshan County during an average trip length of about 20-30 days in August-December 2019. This equates to about 4,000-10,000 traps lost per vessel annually. Besides the loss of traps at sea, another 200-1,200 traps/vessel/trip (or about 2,000-8,000 traps/vessel/year) were broken during operation; more than 50% of them were discarded at sea, with no more than 50% taken back to landing ports for sale (0-1.0 RMB/trap as recycled metal and recycled plastic net). In comparison, when recycling programs were encouraged and available for crab traps 5-7 years ago, fishermen could recycle pots for 5 RMB/trap and decreased to 2-3 RMB/trap 2-3 years ago, which created an incentive not to discard pots at sea and encouraged trawlers to bring lost traps back to the landing ports. So currently, the lost and discarded traps at sea is estimated to be around 5,000-14,000 traps/vessel/year.

Regarding other ecological impacts of the trap fishery, sardines (*Sardinella* spp.) and Pacific saury (*Cololabis saira*) were commonly used as baits. About 200 g of bait was reportedly used for each trap. Sardines and Pacific saury were purchased from purse-seine fishery companies that use light attraction. An average of 1,000-1200 kg baits were carried per vessel, and subsequently supplied by transfer vessels.

3.9. Fishing logbook data in Dongshan County

Six vessels (three trawl vessels and three trap vessels) from Dongshan County were selected to conduct logbook surveys in August and September 2019. Information collected included fishing locations (longitude and latitude), operation time (hours), total capture volume (kg) per net in trawl fishery and per rope (with 1000 traps) in trap fishery, and the *M. haanii* capture volume (kg) were documented at sea. Two months of logbook data were analyzed.

3.9.1. *Monomia haanii* catch in trawl and trap fisheries

In the trawl fishery, the average total catch volume was 427.28 kg/day in August and 356.08 kg/day in September. The average of *M. haanii* catch volume was 104.70 kg/day in August and 109.74 kg/day in September. The CPUE (kg/h) of *M. haanii* was 16.04 kg/h (8.78-27.63 kg/h) in August and 26.00 kg/h (4.20-40.00 kg/h) in September.

In the trap fishery, an average of total catch volume was 284.85 kg/rope in August and 237.39 kg/rope in September. The average of *M. haanii* catch volume was 104.70 kg/rope in August and 109.74 kg/rope in September. The CPUE (kg/h) of *M. haanii* was 32.07 kg/h (17.65-55.26 kg/h) in August and 52 kg/h (8.39-80 kg/h) in September.

3.9.2. *Monomia haanii* spatial dynamics

Fishing locations of trap and trawl vessels from Dongshan County overlapped, particularly in August, with logbook information being similar to the interview results at the landing ports. Based on the CPUE (kg/h) data of *M. haanii* calculated from logbooks, the results are summarized below.

In the trawl fishery, there were two high capture areas in August: 118 °30-60 E and 23 °50-70 N, and 118-118 °10 E and 23 °20-40 N. While in September, only one high capture area was found: 118 °10 E and 23 °60 N (Fig. 37).

In the trap fishery, there were two high capture areas in August:117 °90-118 °10 E and 23 °30-40 N, and 118 °30-50 E and 22 °90-23 °20, While in September, five high capture areas for *M. haanii* were found: 118 °60-80 E and 23 °20-40N, 118-118 °10 E and 23 °70 N, 118-118 °10 E and 23 °30-40N, 118 °25-37 E and 23 °40 N and 118 °20-30 E and 23 °N (Fig. 38).

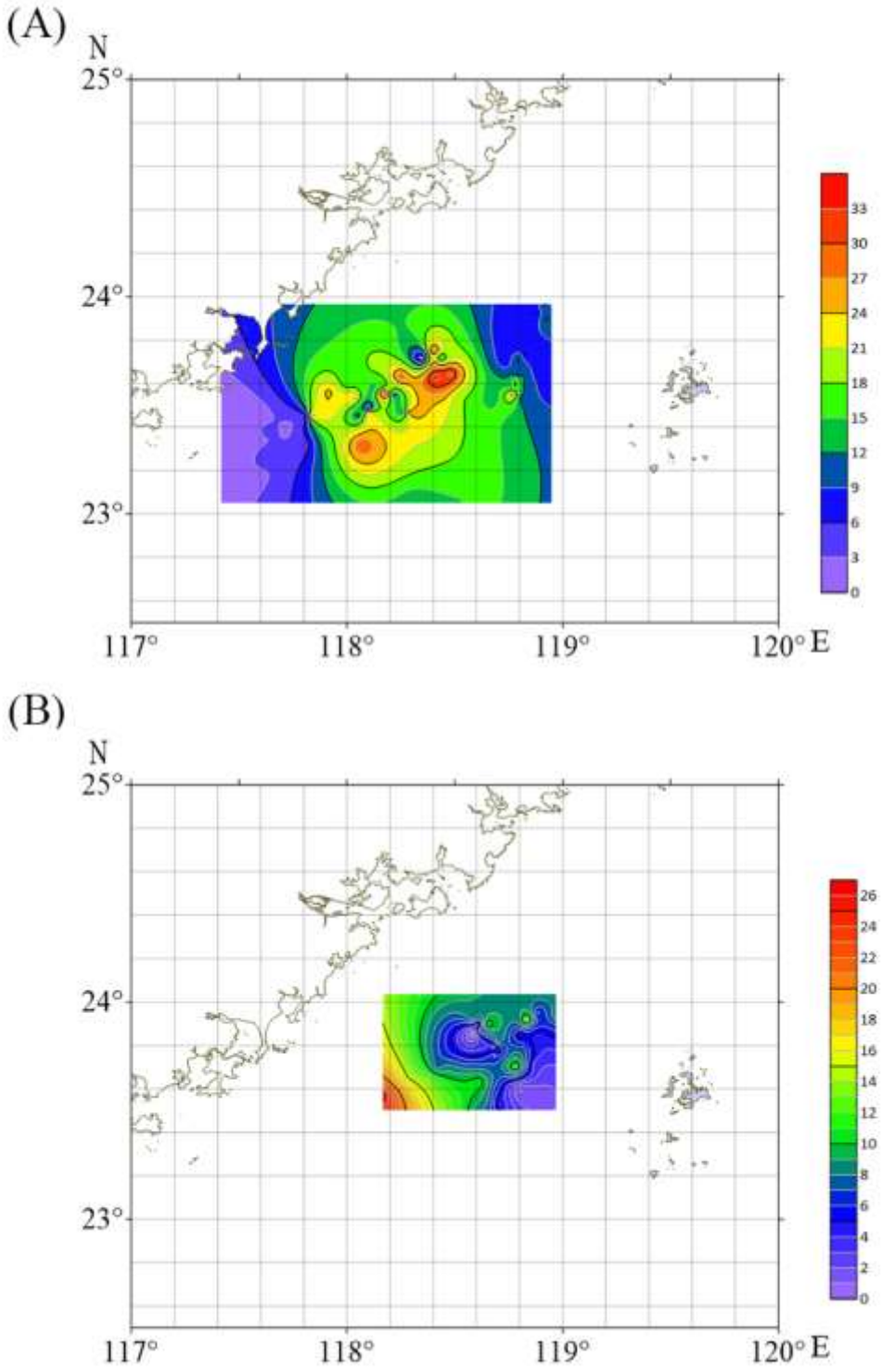

Fig. 37. The CPUE (kg/h) of *M. haanii* in trawl fishery. (A) in August 2019; (B) in September 2019.

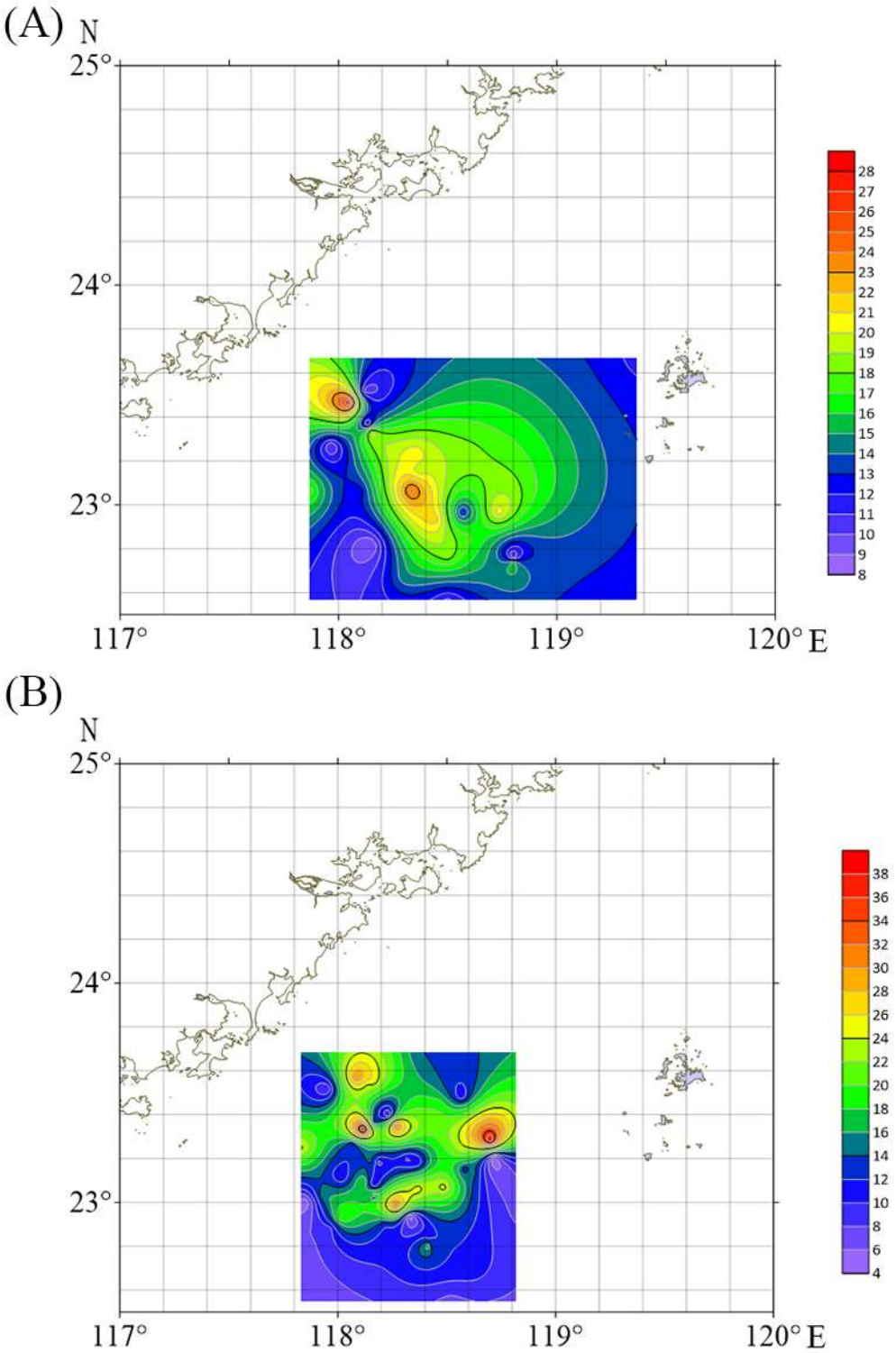

Fig. 38. The CPUE (kg/h) of *M. haanii* in trap fishery. (A) in August 2019; (B) in September 2019.

4. Significant findings

(1) In total 344 species were identified in August 2018-December 2019 landings, including 269 fishes (78.2%), 57 crustaceans (16.6%) and 18 cephalopods (5.2%). The trawl fishery had higher species diversity than the trap fishery. There were 73 species, including 56 fishes, 11 crustaceans and 6 cephalopods, found in both trawl and trap fisheries.

(2) There is a significant catch proportions of juveniles (< 7.3 cm CW, which is the size at 50% female maturity) of *M. haanii* in the trawl fishery.

(3) In total 148 species (108 fishes, 32 crustaceans and 8 cephalopods) were identified in feed fish landings. Among these, 74 species (51 fishes, 21 crustaceans and 2 cephalopods) were only found in feed fish landings. There was a high proportion of *M. haanii* juveniles < 5 cm CW found in feed fishes.

(4) Seahorse bycatch by trawl fishery is significant and common in Dongshan County. The species included *H. histrix*, *H. kelloggi*, *H. trimaculatus* and *H. kuda*.

(5) Based on the size range information collected for the main food species (including crustaceans, fishes and cephalopods) in trawl fishery in Dongshan County, the majority of landed food fish were less than 30 cm in length.

(6) The main species or species groups in catches were different among different fishing gears. In the trawl fishery, the main species groups were food fishes, feed fishes, crabs and shrimps. In the trap fishery, the main species groups were crabs and fishes.

(7) Based on the monthly sampling in January-December 2019, the spawning seasons for the four targeted species (*M. haanii*, *P. sanguinolentus*, *C. nataor* and *C. philargius*) were determined. All four species share a spawning season in February-April. Another spawning season also occurred in August-September.

(8) The project contributed significantly to understanding of crab biology in Chinese waters (Table 10).

Table 10. Sizes for female maturation (-: no data)

Crab species	Size (cm, CW)		
	Minimum size for female maturation		Size at 50% female maturity
	From reference	Present study	Present study
Monomia haanii	-	4.6 (in April 2019)	7.3

Portunus sanguinolentus	8.0	9.6 (in September 2019)	12.6 (data not shown)
Charybdis nataor	6.9	6.1 (in March 2019)	7.7 (data not shown)
Calappa philargius	-	9.0 (in September 2018)	12.7 (data not shown)

(9) The trap fishery has significant impact on the ecosystem. First, there is a significant volume of bait used. Based on the information on the weight of bait per trap (200 g), the number of traps per vessel (3000 traps) and the number of collection per day (3 collections) in the Dongshan trap fishery, the estimated amount of bait used was 1,800 kg bait/vessel/day (= 200*3000*3/1000). Second, the loss of traps at sea is significant, about 5,000-14,000 traps/vessel/year.

(10) The CPUE for *M. haanii* in the trawl fishery in Dongshan County showed a significant decline over 20 years except December (Fig. 39).

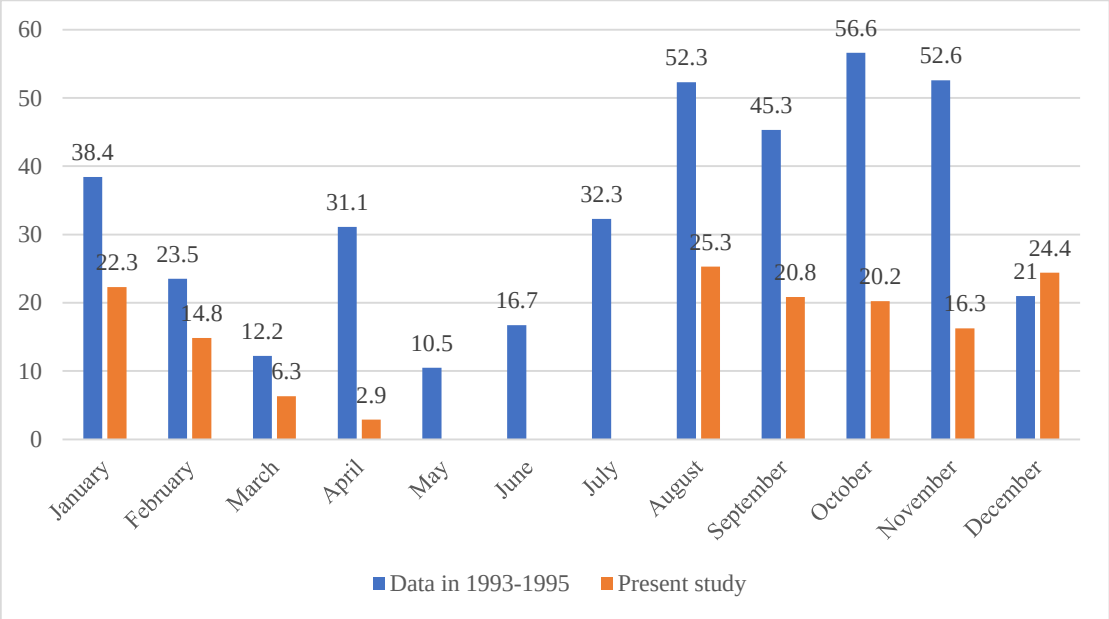

Fig. 39. *Monomia haanii* capture volumes (kg/net) (value on the tops of the bars) in 1993-1995 (Zhang 1997) and 2019 (the present study)

(11) The logbook approach was provided reliable data collection compared to the data collected at the landing ports (Fig. 40; Fig. 41).

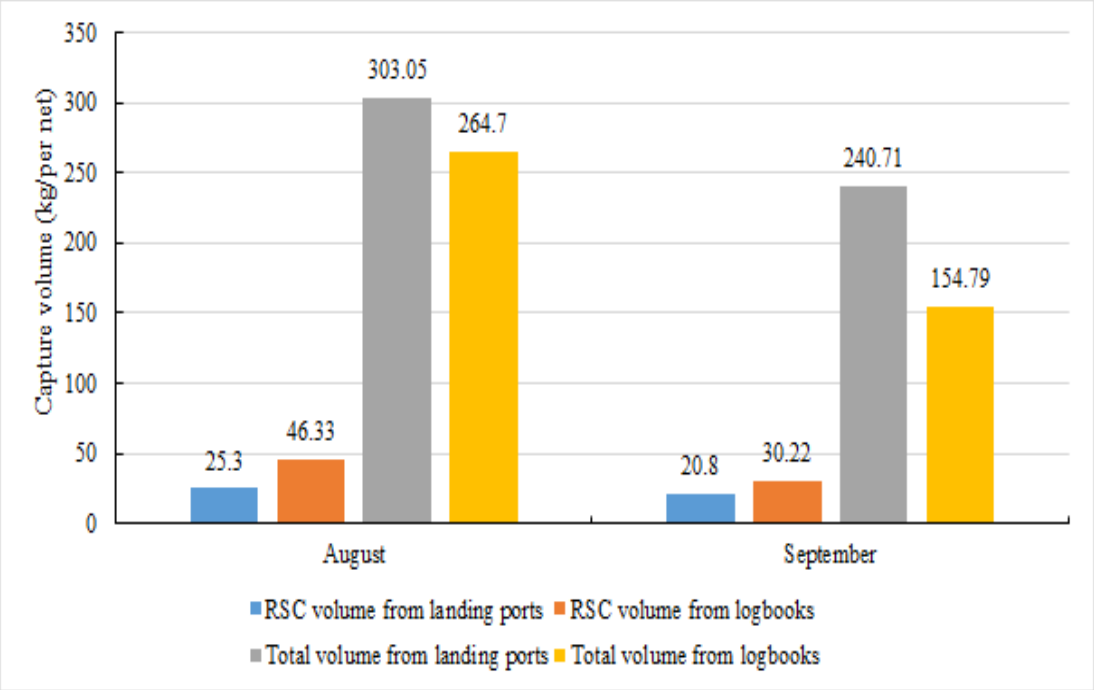

Fig. 40. Comparisons of capture volumes (kg/net) (for total and for *Monomia haanii*) obtained from landing port surveys and from logbooks in the trawl fishery.

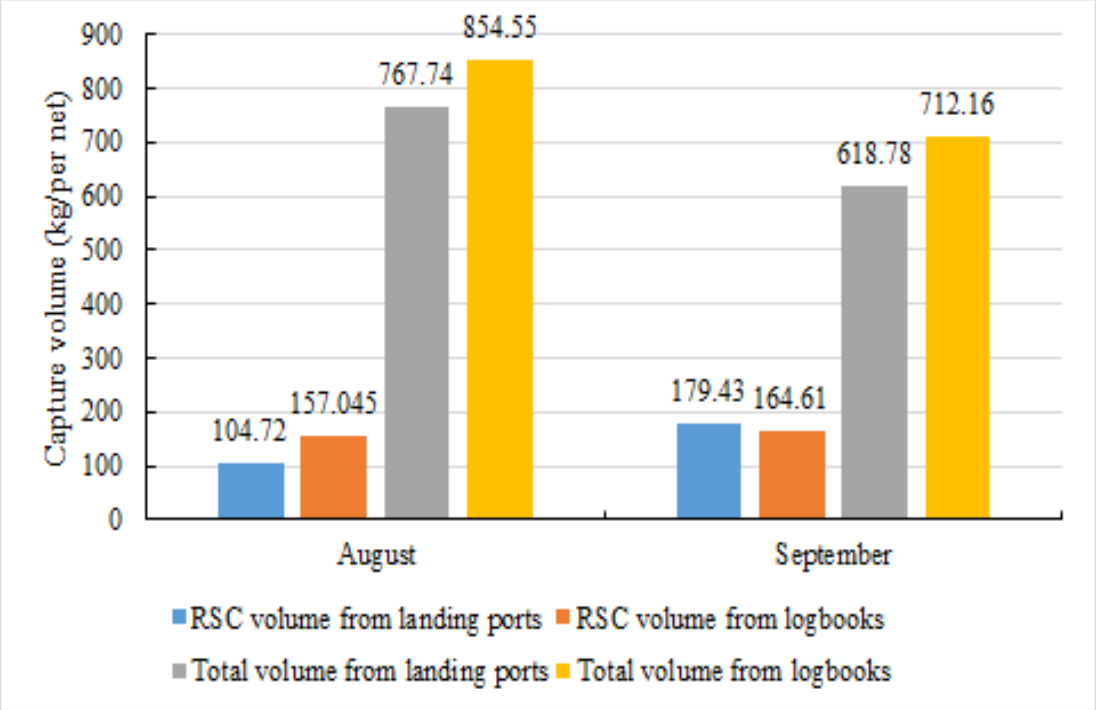

Fig. 41.Comparisons of capture volumes (kg/net) (for total and for *Monomia haanii*) obtained from landing port surveys and from logbooks by the trap fishery.

5. Recommendations

Based on our work in August 2018-December 2019, several recommendations are provided for sustainable development of Fujian marine capture fishery and crab fishery:

(1) **Initiating monitoring programs on seahorses in Taiwan Bank fishing ground and its adjacent waters.** Currently, *Hippocampus trimaculatus* is the most common seahorse found in landed catches in Dongshan County. The Minnan-Taiwan Bank fishing grounds are suitable habitats for seahorses. Monitoring on fishing site, habitat, stock density and capture volume should be conducted.

(2) **Spawning season management for *Monomia haanii*.** February-April is determined to be one of the spawning seasons for all four crabs studied in this project. For sustainable crab fisheries, management during the crab spawning season is necessarily.

(3) **Reduction of *Monomia haanii* juvenile catches in trawl fishery.** *M. haanii* is one of the most common species in feed fish landings, with high proportion and small sizes (< 4 cm CW) particularly found in February-April, and in October, consistent with its spawning seasons determined in this study. Management to reduce juvenile catches is essential.

(4) **Minimum catch size regulation.** A regulation on the minimum catch size of 35 commercial important specie was released in Fujian Province in 2018, including *M. haanii*. In the regulation, the minimum catch size for *M. haanii* is set at 8.0 cm CW. The regulation size is larger than the size at 50% female maturity (7.3 cm CW). The details of the regulation for *M. haanii* require the proportions of juveniles in the all species total catches per vessel per trip to be <30% juveniles in 2019, and <20% in 2020 and afterward. Based on this study, the proportions of *M. haanii* <8 cm CW were 43.70% in August-December 2018 in trawl and trap vessels, 72.78% in trawl vessels in January-December 2019, and 34.70% in trap vessels in Dongshan County in January-December 2019. Without revision of management measures, fishing practices, and enforcement, it will be impossible for trawl vessels to meet the juvenile proportion requirement in 2020 (i.e. <20%). The practices, such as the increase of mesh size in the trawl vessels and the closure of juvenile feeding grounds of *M. haanii* in certain months, could potentially be considered.

(4) **Reducing the ecological impact of the trap fishery at sea.** There is a significant loss of traps at sea mainly due to the trawl fishery operating in the same

fishing grounds. Effective communication mechanism between trawl and trap vessels is needed. Meanwhile, government and trap makers should work together to encourage captains to take damaged traps back to port as much as possible for recycling.

6. Acknowledgments

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