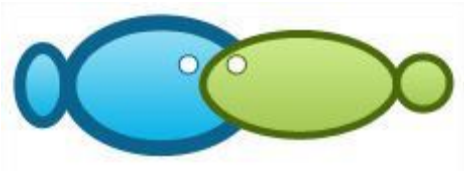

Characteristics of boat bagan for squid (*Loligo chinensis*) fishing at Kao Bay, North Maluku, Indonesia

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Abstract. Boat bagan is one of the fishing gear used for squid fishing. The purpose of this study was to describe characteristics of one boat bagan and two boats bagans in squid fishing at Bobaneigo village, Kao Bay, North Maluku. This research was conducted from July to September 2021. The data analysis of bagan characteristics and composition of squid catches was carried out descriptively, while the sex ratio was determined by the chi square test. The results showed that the one-boat and two-boats bagans used in squid fishing had the same characteristics but differed in size, as well as the support poles and bagan houses which were only found in one boat bagan. The results of the analysis of the sex ratio of the whole sample are 1:0.65 and the results of the chi square test show that the sex ratio is not balanced.
Key Words: boat bagan, Bobaneigo, cephalopod, light fishing, squid.

Introduction. Squid (*Loligo* sp.) is one of fishery resources of the Cephalopoda class that has important economic value. The Cephalopoda class consists of several groups that are widely consumed, namely squid, cuttlefish, and octopus. Squid is a commercially important fishery commodity that is commonly found in coastal areas of Asia (Sin et al 2009).

Squid can be found in all layers of water from the surface to a certain layer depth. The squid migration pattern is carried out in groups with a diurnal movement pattern, namely during the day it is at the bottom of the waters and will spread at night (de Araujo & Gasalla 2018). Squid consists of many species and has a very wide distribution throughout the world. Its distribution areas include the Adriatic Sea (Petric et al 2021), Prydz Bay, Antarctica (Sajikumar et al 2020), Vietnam (Cuong et al 2016), the bay of Zeus, the southwest Red Sea (Sabrah et al 2015), Mediterranean waters (Emam et al 2014), Indian waters (Anusha & Fleming 2014; Nitin et al 2015; Soomro et al 2015; Sasikumar et al 2018), South China Sea (Jin et al 2017), in Thai waters (Islam et al 2015), the South Atlantic Coast and Indian Ocean in South Africa (Wu et al 2019). Almost all parts of Indonesia have the potential for squid including in the coastal waters of Banyuasin, North Sumatra (Fauziyah et al 2021), in the coastal waters of Lamongan-East Java (Mulyono et al 2017), in the waters of Belitung Regency (Tejo et al 2020). North Maluku is one of potential areas for squid fishing. Different levels of utilization of this resource can affect the condition of its stock in nature.

At Bobaneigo village, *Loligo* squid are usually caught by boat lift nets. The use of boats in fishing operations serves to easier movement of fishing gears to targetted squid fishing grounds. Boat lift nets are operated at night so that the fishing operations need to use lights as a fishing tool. The lights also function to attract fish and other target animals to gather towards the catchable area. Higher light intensity can increase the numbers of squid and other non-target catches (Fauziyah et al 2021). The use of light in

catching squid is in accordance with positive phototaxis nature of squid species (Jereb & Roper 2010).

Boat lift nets are one type of fishing gear that is included in the classification of lift nets (Sudirman et al 2019). Bagan catch targets are fish with high economic value (Borges et al 2005; Broadhurst et al 2006) such as small pelagic fish, anchovies, and squid (Tejo et al 2020). In this study, one boat and two boats lift net were used as fishing gear which was operated at night during the full moon. The study was important since there was no study yet on characteristics of two boats and one boat lift net in squid fishing in North Maluku. The purpose of this study was to describe characteristics of one boat and two boats bagan in squid fishing in Bobaneigo village, North Maluku.

Material and Method

Research location. The research was carried out at Bobaneigo village, West Halmahera District, North Maluku Province as shown on map in Figure 1, from July to September 2021.

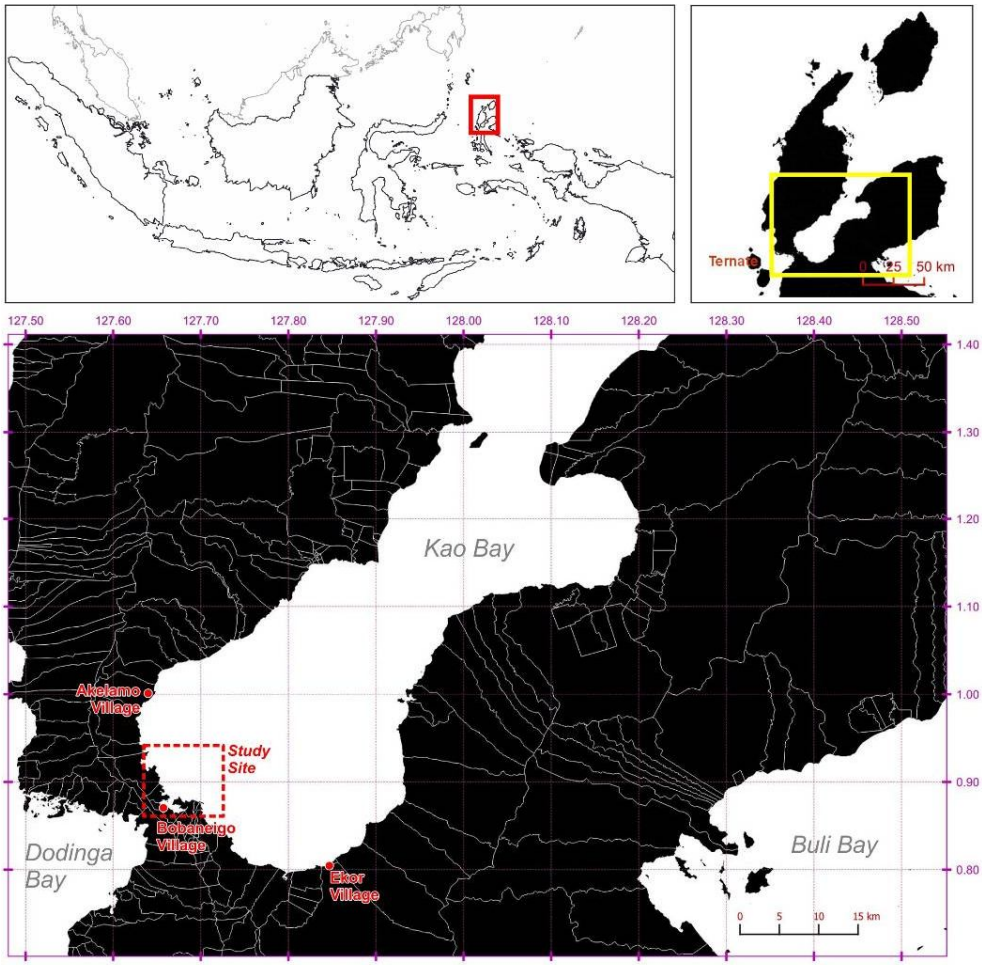

Figure 1. Map of research location.

Data collection. Squid fishing was done by using one-boat and two-boats bagans. Those fishing gears were operated by fishers at night during the full moon by using a boat as a tool to carry or tow a lift net (fishing gear) to a selected fishing area. Fishing operation used one unit of one-boat and two-boats bagans, respectively. Data collection was carried out with one capture trip per month. Both bagans used were measured for their technical characteristics that included main dimensions of their fishing gears, specific identification of their squid fishing aids, and their method of fishing operation (fishing/ operation time, fishing area, setting and hauling stages).

Squid samples were then taken randomly, 250 individuals per each boat bagan every month, so that the total sample was 500 individuals per month. Next three steps were measuring mantle length (ML) following method of Emam et al (2014) (Figure 2), weighing total wet weight, and observing the squid sex.

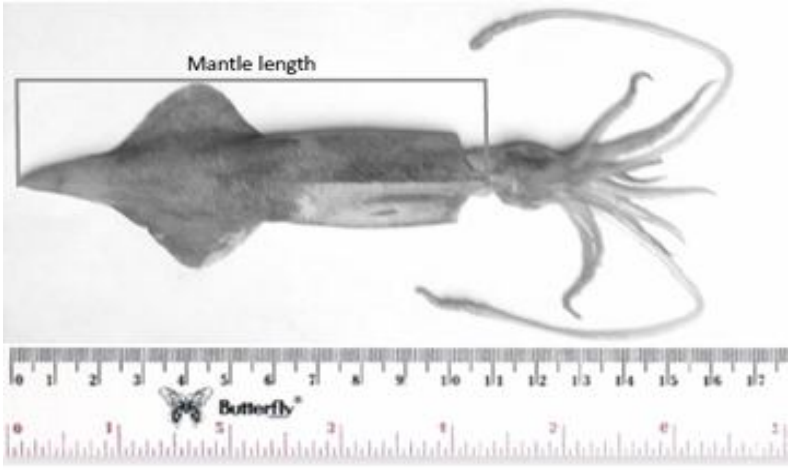

Figure 2. Measurement of squid mantle length.

Data analisys

Characteristics of bagan. Analysis of characteristics of each boat bagan included its technical specifications, technical operation, and fishing area descriptively.

Characteristics of squid. Squid sample data that included mantle length (ML) and body wet weight were described descriptively. Analysis was also carried out on sex ratio data to compare male and female squids number and to define sample sex ratio. Sex ratio test used Chi-square test (Siregar 2004) with following statistical equation:

$$\chi^{2}{}_{hit} = \sum_{i=1}^{n} \frac{(oi - ei)^2}{ei}$$

Where χ^2_{hit} = Chi-Square value, oi = observed frequency, ei = expected frequency.

Results and Discussion

Characteristics of boat bagan

Technical specifications of one-boat and two-boats bagans. The fishing gear boat bagan is one of the most widely used gear for squid fishing at Bobaneigo (Figure 3). A boat bagan has rectangular shape consisting of a boat and a series of liftnet frames. In the center of the bagan, a fishing net is installed which functions to catch fish under the boat bagan. Boat bagan is usually operated at night by using a lighting device to attract and to lead schools of fish or squid to a catchable area.

The boat bagans studied were rectangular in shape that had the same length and width. The construction of those boat bagans consisted of nets, bamboo, iron pipes, rigging, lights and motorized boats. The net part of those bagans were made of waring material which was formed into a pocket or a bag. The pocket section consisted of waring sheets that were assembled or sewn in such a way that they formed a square-shaped pocket due to its framework made of bamboo and iron pipes (Sudirman & Nessa 2011; Sudirman et al 2019).

There were two types of boat bagans at Bobaneigo village, they were two-boats bagan and one-boat bagan that functioned as floating facilities. Number of boats bagan at the village was 62 units, consisting of 35 units one-boat bagan and 27 units two-boats bagan. All of them were actively operating during the study period. Specifically, the two types of boat bagans had different technical specifications and constructions, but they

shared similar operation principles (Table 1). Number of fishers who operated these fishing gears is 4-5 people per bagan.

Figure 3. View of boat bagans of Bobaneigo, Kao Bay, North Maluku.

Table 1
Technical specification of two-boat and one-boat bagans at Bobaneigo, Kao Bay, North Maluku

Two-boats bagan				*One-boat bagan*			
Unit	*Specifications*		*Material*	*Unit*	*Specifications*		*Material*
Boat	LOA	9.35 m	Wood	Boat	LOA	19.56	Wood
	LWL	8.20 m			LWL	17.80	
	B	0.80 m			B	1.80	
	D	0.60 m			D	2.50	
Bagan frame	P	9 m	Wood	Bagan frame	P	19.70m	Wood
	L	7 m			L	19.70m	
Waring frame	P	9 m	Wood	Main/ central pole	T	8.5 cm	Wood
	L	7 m			Ø base	17 cm	
					Ø end	10 m	
Waring	P	9 m	Polypro-pylene	Bagan house	P	2.5 m	Wood
	L	7 m			L	2 m	
	D	15 m			D	1.9 m	
	Mesh size	5 mm					
Ballast	Frame	8 kg	Stone	Waring frame	P	19.50 m	Wood
	Bagan-anchor	50 kg	Iron		L	19.50 m	
	Waring	10 kg	Stone				
Rigging	Waring	12 mm	Poly-ethilene	Waring	P	19.70 m	Poly-propylene
	Weighing	12 mm			L	19.70 m	
	Anchor	20 mm			D	17 m	
					Mesh size	5 mm	
Electricity power source	Generator	2,5 KW	LED	Ballast	Frame	10 kg	Stone
					Bagan-anchor	75 kg	Iron
					Waring	15 kg	Stone
Lighting	Lamp 20W	50 unit	LED	Rigging	Waring	12 m	Polyethilene
	Lamp 40W	6 unit			Weighing	12 m	
					Anchor	24 m	
				Electricity power source	Generator	3.5 KW	LED
				Lighting	Lamp 20W	80 unit	LED
					Lamp 40W	10 unit	

Notes: LOA = length over all; LWL = length water line; B = breadth; D = depth; P = length; L = wide; Ø = diameter.

Below are specifications of boat bagans for squid fishing found at Bobaneigo village.

Boat. Boat for bagan fishing gear was a floating means that supported the fishing gear operation. In one-boat bagan, the boat was placed in the middle of bagan; while in two-boats bagan, the boats were placed on the left and the right sides of bagan. The size of the boat for the one-boat bagan was 19.56 m long, 1.80 m wide, and 2.50 m high. For two-boats bagan, boats size were averagely 9.35 m long, 0.80 m wide, and 0.60 m high.

Bagan frame. The frame or the structure of the bagan was a series of wood strung together in the form of a frame on a boat bagan, with a length and width of 19.70 m on a one-boat bagan, while on a two-boats bagan it measured 9 m long and 7 m wide. The function of the bagan frame was as a place to put lights and media for setting and hauling activities.

Support pole. The stanchion serves as a fastener of the steel rope to the bagan frame, so that the bagan frame is more sturdy and maintains the stability of the boat bagan. The support poles are only used on the bagan of one boat with a diameter of 15 cm at the base, the number of supporting poles for each bagan of one boat is 1 unit with a pole height of 8 meters.

Bagan house. Bagan house functioned as place to store equipment and electrical installations for lighting, and as a resting place for fishers during fishing operations. The size of the bagan house on the bagan of one boat tends to vary according to the needs of fishers. Based on the identification results, the average size of the bagan house is 2.5 m long, 2 meters wide and 1.9 m high. The bagan house is only found on the bagan of one boat. Bagan two boats are not equipped with a bagan housing, but are made of temporary shields that can be used during fishing operations.

Waring. The waring on the boat bagans at Bobaneigo were rectangular in shape with the same length and width. The color of the waring used by fishermen on the fishing gear of the boat bagan was generally black. The length and width of the fishing line on the one-boat bagan was 19.50 m and the deep-net was 17 m, while the two-boats bagan was 9 meters long and 7 meters wide and 15 meters deep. The waring material used by both types of bagans was polypropylene with a mesh size of 5 mm.

Waring frame. The waring frame was in the form of a square that serves as a place to tie the waring, weights, and hanging ropes that are connected to the waring roller. At each corner and center of the waring frame were attached stones weighing 5-10 kg. The frame on the netting net or waring was made of wood with a length of 19.50 m, a cross-section size of 5 x 15 cm which was connected to each other in the form of a square.

Waring ballast. The ballast served to sink the fishing line and fishing line at a certain water depth according to the fishing gear operating area. The weights consisted of frame weights and net weights or main weights. The number of ballast and the weight of each ballast on the fishing gear was adjusted to the size of the frame and netting of each fishing gear. Fishers in Bobaneigo who use two-boat lift nets used 8 weights on the fishing line with a weight of 1 kg each, while for one boat, on average, they used 10 ballast with a weight of 2 kg each. The weights of the warings in each bagan were 1 piece with the weight of the one-boat bagan being 15 kg and the two-boats baganing weighing 10 kg. The difference in weight in each bagan was caused by the different sizes of the nets between the two types of boat bagans.

Rigging. The use of rigging on a boat bagan consisted of two types, namely:

- anchor rope was a rope that served to hold the fishing bagan in order to remain in fishing area position desired by fishers. Type of rope used was polyethelene with a size of 24 mm on a one-boat bagan and 20 mm on two-boats bagan. The length of the anchor rope used was approximately 80 m;
- net pulling rope was a rope that functioned to lower and pull the net up the bagan. Towing ropes were tied to anet frame on the sides of bagan frame for easy pulling.

Lighting. Light was used as fish attractor in bagan fisihing at Bobaneigo village. Fishers used a generator with a power capacity of 3000-5000 Watt as source of electric power. Types of lamps used were incandescent bulbs and LED bulbs of 20 W, 42 W and 100 W with number of bulbs per bagan was between 70-100 units. The placement of the lights on the boat bagan was at the front, back and left and right sides of the bagan, while the focus lights were placed on the center of the bagan.

Bagans operated at Bobaneigo village had almost the same characteristics as 'rambo' bagans used to catch fish and other resources in Makassar Strait (Sudirman et al 2019). In principle, the operated bagans from different places had different constructions and sizes but their fishing operation techniques were the same.

The use of light in fishing operations with boat lifts is also carried out by fishermen in Belitung district (Tejo et al 2020) with the objective of collecting fishes and other catch targets into a light source. Using light has been experimented by Fauziyah et al (2021) using a stationary lift net in Banyuasin and found that the use of 315 lux LED light obtained the highest catch of 94.20 kg and could be used as a substitute for kerosene lamps. The increase of light intensity can increase the relative abundance of squid (predators) and non-target catches (Fuad et al 2019; Fauziyah et al 2021). The choice of LED light by boat lift fishermen in Bobaneigo was because these lights are easy to obtain, easy to use, durable and affordable. The similar finding was also reported by Susanto et al (2017) in Banten Bay and Mgana et al (2019) in South Africa.

Technical operation. The bagan operation at Bobaneigo village started from a fishing base to a fishing ground at 17.00 (5.00 PM) local time with a travel time of approximately 10-20 minutes depending on the distance traveled by fishing ground selected by fishers. Before heading to the fishing ground, fishers team needed to prepare all materials for fishing activities. Materials prepared included: fuel, ice blocks, crew supplies, and other equipment. Once arriving at the fishing ground, the stages of the fishing operation were carried out, as follows:

Setting (lowering waring). The reduction of the waring was carried out at 18.00 (06.00 PM) local time, then continued by turning on the light attractor, both the main light and the focus light which were placed in the center of the catchable area. The process of lowering the waring lasts for approximately 20 minutes, until the waring was at the right depth and position.

Soaking (soaking waring). After lowering the net and turning on the light attractor, fishers observed the presence of biota (types of fish and squid) that began to associate with light. Soaking can last for 2-4 hours, depending on the response of the biota to light. Observations on the response of the biota were carried out to ensure that the fish or squid flocks were concentrated on the light attractor, and then the netting could be withdrawn.

Hauling (withdrawal/lifting of waring). Prior to the withdrawal of the fishing net, it was necessary to treat the light so that the flock of fish or squid can be concentrated in the light in the catchable area. This treatment was in the form of reducing light on the left and right sides as well as the front and back. This treatment was carried out in stages so that schools of fish and squid are not disturbed and can be brought to catchable areas. The process of herding a herd of fish or squid in a catchable area can take 10-20 minutes. After the fish are completely concentrated in the light of the focus lamp, then the fishing can be done. Towing the nets was done slowly so that schools of fish and squid are not disturbed or surprised by the speed with which the nets are pulled to the surface. After the waring was on the surface of the water, the catch can be herded to one side of the boat bagan and then raised to the top of the bagan.

Fishing grounds or fishing areas. Fishing areas of the lift net of Bobaneigo fishers consisted of two fishing areas according to fishing target, namely fishing areas for small pelagic fish (anchovies, mackerel, and other types of fish) and fishing areas for squid. The squid fishing area was less than 1 mile from Bobaneigo coast. Catching squid during

the full moon phase was in accordance with the behavior of squid which was phototaxis positive. Squid fishing areas from Bobaneigo to the surrounding areas were around Ekor village (East Halmahera), and Akelamo village (North Halmara) (Figure 4).

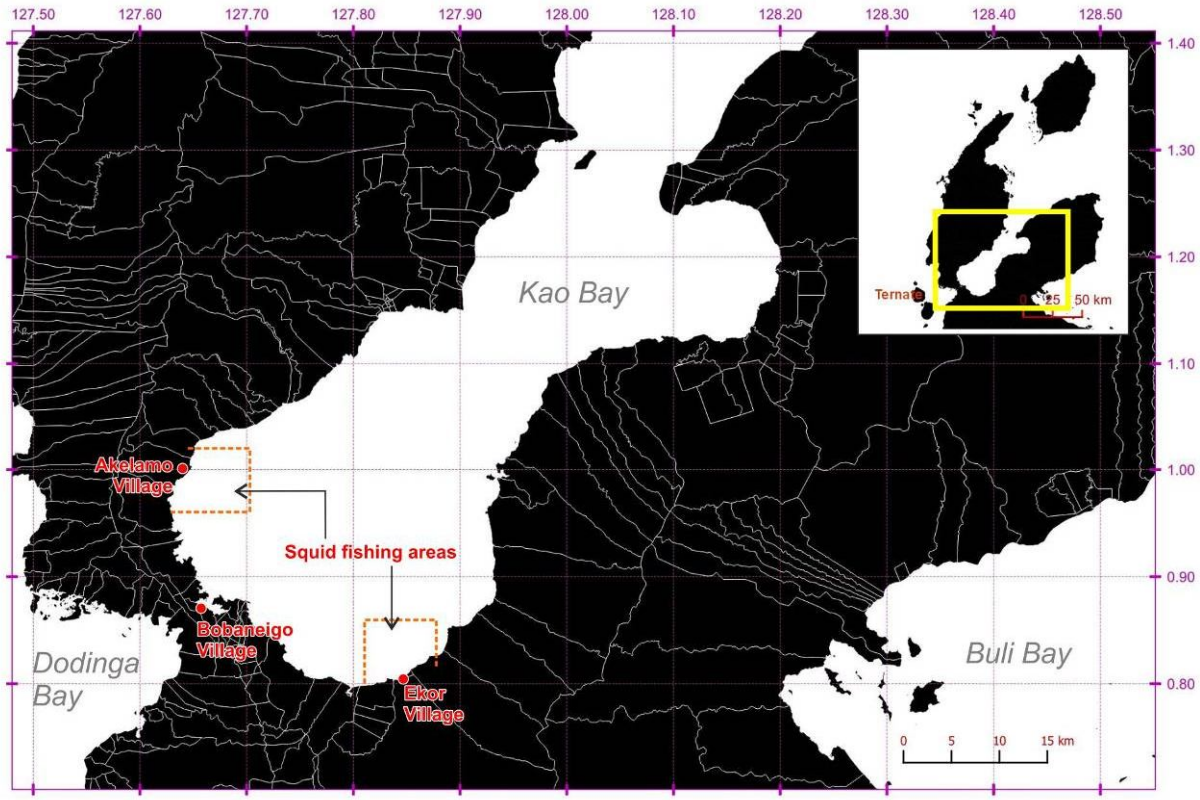

Figure 4. Map of squid fishing grounds of Bobaneigo boat bagans.

Characteristics of caught squid

Catch composition. The main catch of boat bagan fishing at Bobaneigo was squid of the *Loligo chinensis*. Apart from squid, other types of fish were also caught in the operation of bagan fishing, both the one-boat bagan and the two-boats bagan. Other types of fish caught were anchovy (*Stolephorus* spp.), yellow snakehead fish (*Selaroides* spp.), kite (*Decapterus* spp.), and layur fish (*Trichiurus lepturus*). In one fishing trip using a one-boat bagan, the catch was 40-250 kg of squid, while using a two-boats bagan it was 40-275 kg. These results indicate that the productivity of the one-boat bagan was higher than that of the two-boats bagan because the number of catches obtained was relatively the same with less fishing effort (one boat).

The highest catch on the one-boat bagan was found in September (830 kg), followed by August (455 kg), and the lowest in July (482 kg). For the two boats bagan, the highest catch was also found in September (134 kg), then August (545 kg), and the lowest in July (85 kg). Prasetyo et al (2014) found the highest catch of squid occured during the east-west transitional season while the lowest catch occured during the west-east season transition to the east monsoon. Changes in seasons and differences in geographical location also affected the diet of squid in a waters (Oktariza et al 2015). Puspito et al (2015) found 34 kg or 11.72% *Loligo* sp. in lift net fisheries. The number of squid catch in a fishing operation was determined by the type of fishing gear.

The samples used in this study were 1500 individuals from three sampling periods (July, August, September). The size of the squid caught in the one boat bagan and the two boats bagan has the same size variation. Range of squid sizes catch by one-boat bagan was 6.4 to 22.4cm, while for two-boats bagan it was 6.4 to 22.7 cm. These results indicate that the use of a one-boat or two-boats bagan does not provide a difference in the size of the catch. The variation in the size of the catch in Bobaneigo is due to

differences in sex (male and female) where the male squid has a larger maximum size than the female squid. This difference was also found by Sabrah et al (2015) by trawling along the northwestern part of the Red Sea.

The range of mantle length of squid in this study was 6.4-21.6 cm (female) and 6.7-22.7 cm (male) with an average mantle length of 10.9 mm (female) and 11.5 mm (male). The wet weight of squid caught in Bobaneigo was 8.0-412 g (female) and 11.0-460 g (male) with an average wet weight of 53.2 g (female) and 59.4 g (male). Fauziyah et al (2021) found squid (*L. chinensis*) in the coastal waters of Banyuasin with a mantle length range of 40-210 mm (average 105.5 mm) and a weight of 2-42 grams (average 13.5 grams). Another study by Oktariza et al (2015) in Bangka Reqency showed that average lenght size of *L. chinensis* caught in that area was of 144-176 mm (20.11%) for male squid and 144-176 mm (43.50%) for female.

Squid was the main catch for boat bagan at Bobaneigo village during the full moon phase. In other moon phases, squid catches number was less and could even be classified as by-catch. However, at Bobaneigo areas in Kao Bay, squid can be harvested by boat bagan on a monthly basis.

Sex ratio. The squid collected during the sampling period were dominated by male squid, namely 910 individuals (63.7%), while female squid number was 590 individuals (39.3%). The sex ratio of the whole sample was 1:0.65, which meant that male squid dominated the catch. The sex ratio of squid caught using one boat and two boats bagan during the observation period (July, August, September) also showed that male squid were more dominantly caught (Table 2). The same result was also found by Sabrah et al (2015) with male squid was more dominant (N = 442) than female (287). However, several studies have found female squid dominate the catch. Mulyono et al (2017) found the ratio of females was greater than males (1:1.04) in Lamongan, East Java.

Table 2

Sex ratio of squid caught by one-boat bagan and two-boats bagans

Bagan type	*Month*	*Sex ratio*
One-boat bagan	July	1:0.77
	Agust	1:0.52
	September	1:0.84
Two-boats bagan	July	1:0.46
	Agust	1:0.53
	September	1:0.85

Based on the "chi square" test at a significance level of 0.05, it was found that the sex ratio of squid males and females at Bobaneigo as a whole was not balanced. Squid caught at Bobaneigo based on size class intervals showed a balanced sex ratio (1:1) only for class range of 20.0-21.6 mm, while the other classes had an unbalanced sex ratio (Table 3).

Table 3

Squid sex ratio based on mantle length interval

Class intervals (mm)	*Median (mm)*	*Sex ratio*
6.4-8.0	10.4	0.76:1.32
8.1-9.7	13.0	1:0.77
9.8-11.4	15.5	1:0.46
11.5-13.1	18.1	1:0.47
13.2-14.8	20.6	1:0.41
14.9-16.5	23.2	1:0.24
16.6-18.2	25.7	1:0.40
18.3-19.9	28.3	0.91:1.10
20.0-21.6	30.8	1:1
21.7-23.3	33.4	1:0.24

Sex ratio of male and female squids in nature always changes or varies in spaces and times. These differences can be caused by environmental factors, behavior and spawning time. The difference in sex ratio of squid found in this study was expected to be influenced by the size of fishing areas of Bobaneigo fishers so that the squid caught were not from same spawning area.

Conclusions. The one-boat and two-boats bagans operated at Bobaneigo village for squid fishing had the same material characteristics for most of their component. Their difference is in sizes of components (boat, bagan frame, waring, waring frame, ballast, rigging, and light source) as well as support poles and bagan houses which is only used on one-boat bagan. Both bagans applied similar operating techniques. The squid caught by fishers of Bobaneigo Village is *Loligo chinensis*, and have the same size variation both bagan types.

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Conflict of interest. The authors declare that there is no conflict of interest.

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