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Effectiveness of milkfish (*Chanos chanos*) live bait from aquaculture versus live bait from nature in pole and line fisheries

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Abstract. Pole and line fisheries are currently one of the most environmentally friendly fisheries. The target pole and line catches are skipjack (*Katsuwonus pelamis*), yellowfin tuna (*Thunnus albacares*), big eye tuna (*Thunnus obesus*) and albacora (*Thunnus alalunga*), which are in one group and only produce few bycatch. In pole and line fisheries, catch is largely determined by the availability of live bait from nature with chart-shape and lampara fishing gear. Natural live bait is very difficult to obtain and is vulnerable to overfishing. This condition causes the number of pole and line vessels to decrease. The aim of the study was to investigate the effectiveness of milkfish (*Chanos chanos*) live bait of aquaculture results and natural live bait and analyze the ratio of *C. chanos* live bait of aquaculture results and live bait from nature with catch. The study was conducted in Maumere, East Nusa Tenggara. The method used in this research was experimental fishing. In this study, 3 fleets of pole and line fishing vessels were used in each fishing trip, carrying different types of live bait. The area of fishing was located in the Flores Sea. From the research, it was found that the use of culture *C. chanos* sized of 3-8 cm as live bait was more effective, with a higher average catch, than the live bait from nature. The ratio of the used *C. chanos* live bait to the catch was 1:15, higher than the ratio of the used natural live bait to the catch, which was of 1:12 (signifying the catch quantity by kg of live bait).

Key Words: overfishing, fisheries production, catch result, skipjack.

Introduction. Tuna fisheries play an important role the development of Indonesia. Tuna is the second commodity, after shrimp, in terms of export value of fishery products. Tuna fishing in Indonesia is a labor-intensive industry involving all systems from pre-production to post-production. The main industrial products are fresh, frozen, loin and also canned fish. At the community and household levels, the main fish processing activities are scavenging and fumigation. Tuna fisheries are dominated by yellowfin tuna (*Thunnus albacares*), bigeye tuna (*Thunnus obesus*), skipjack tuna (*Katsuwonus pelamis*), mackerel tuna (*Euthynnus affinis*) and others. Indonesia occupies the fifth position in the world after Thailand, China, Spain and Ecuador, with an export value of approximately US $ 765 million (Galland 2016).

As the world's population grows, the availability of fish protein becomes essential, but the food quality also became a priority, especially for the European Union and North-American consumers. Food industries must meet several safety, traceability and sustainability requirements. Fresh, frozen and canned tuna fish, caught by using Pole and Line, is one of the seafood products with the fastest growing market demand.

Huhate (pole and line) fisheries are currently among the environmentally friendly production units, because the catches are more selective. For instance, statistics on catches composition show that, in the Maldives, the main catch at pole and line is skipjack tuna (*K. pelamis*) and only 0.64% by catch is in the form of rainbow runner (*Elagatis bipinnulata*) and common dolphin fish (*Coryphaena hippurus*) (Miller 2017).

Indonesia is the second largest tuna producer in the world using pole and line. The biggest producing countries are Japan with a total catch of 28%, followed by Indonesia

25%, Maldives 21% and other countries 26% (Gillet 2015). According to statistics from the Ministry of Marine Affairs and Fisheries, in 2012 there were 7338 units of pole and line fishing fleets spread in the Central to Eastern Indonesia. Based on data provided by the Western and Central Pacific Fisheries Commission (WCPFC 2020), the composition of the pole and line catch in Indonesia is dominated at 80% by *K. pelamis*, followed by *T. albacares* 17% and *T. obesus* 3%. In pole and line fisheries, live bait is a determining factor for successful fishing.

The catch is largely determined by the availability of adequate live bait. In 2014 there were around 104 pole and line vessels in Larantuka, but only 50 were actively catching because of limited live bait. Something similar happened in Maumere: out of 50 pole and line vessels registered to have Fishing Licenses (FL) in the marine and fisheries service in Nusa Tenggara Timur province in 2020, only about 25 ships were actively carrying out fishing operations. Japan, as the highest producer of *K. pelamis* from pole and line fishing gear, also experienced a decrease in the number of actively operating fleets; in 1961 there were 5,046 units of pole and line vessels, but in 1989 there were only 269 active units and in 2018 only 69 active units were remaining (WCPFC 2020).

Many fleets of pole and line fishing vessels are reluctant to go to sea because of limited live bait, resulting in operational cost losses, the catches per ship and trip being under the break-even point. At present, the live bait demand satisfaction is very dependent on the natural catches of the chart-shape and lampara fishing gear. Live bait is very difficult to obtain, to depending on the phase of the bright moon. Fish species used as live bait are also increasingly demanded for the consumption of local communities. Lampara fishing gear and purse seine compete to obtain the same small pelagic fish resources to meet the needs of the home industry. More environmentally friendly pole and line fleets than chart fishing gear units are used capture the live bait, therefore the latter becomes more rare and expensive.

In order to prevent excessive exploitation, special management plan for natural live bait is needed (Gillet 2013). These conditions cause the number of pole and line vessels to decrease, in addition to the pressure from large pelagic purse seine fishing gear that has the same fish target, the *K. pelamis*.

This study aimed to analyze the effectiveness of milkfish (*Chanos chanos*) live bait from aquaculture against the live bait from nature and to analyze the respective ratios of live bait to catch, in order to overcome the scarcity of live bait on pole and line and to increase Indonesian fisheries production, especially in fish species caught using the pole and line fleet, such as *K. pelamis* and *T. albacares*. This research is also useful as a model of integrated fisheries management between catch fisheries and aquaculture fisheries in a sustainable manner.

Material and Method

Data collection. The study was conducted in Maumere Sikka district, East Nusa Tenggara, using 3 fleet units of pole and line vessels (Table 1). Fishing ground was in the Flores Sea (Figure 1).

Table 1

Pole and line catch unit data

Fleet name	*Gross tonnage*	*Size of live bait chamber*			*Number of live bait trip^{-1}*
		Length (m)	*Breath (m)*	*Depth (m)*	
FV. Tujuan Baru	30	6	2.5	1.50	6 buckets
FV. Nurdila	30	7.5	3	1.75	6-7 buckets
FV. Asti Sayang	30	6	3	1.75	6 buckets

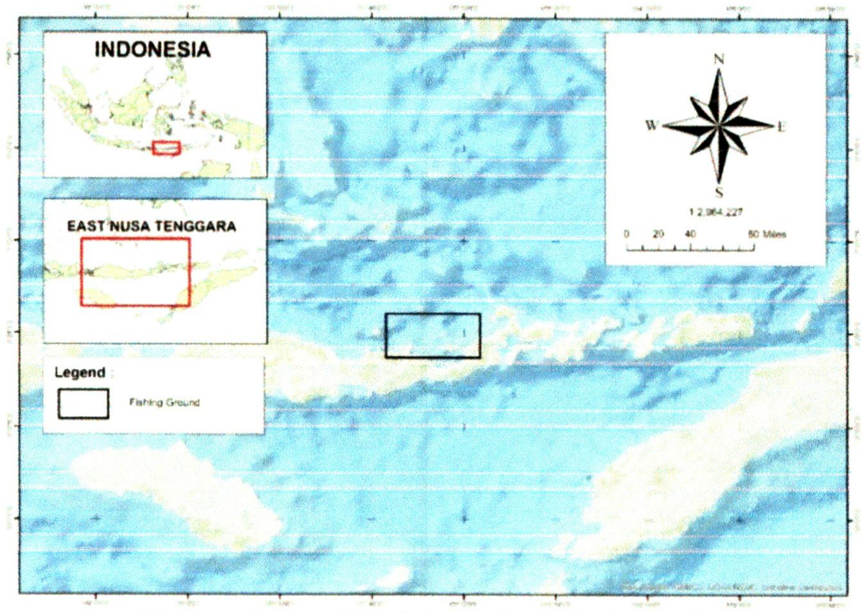

Figure 1. Pole and line fishing ground in Flores Sea.

Methodology. The method used in this research was the experimental fishing method, where observations are made under artificial conditions created and regulated by the researcher (Nazir 2017), using 3 poles and line fishing vessels in each fishing trip. Three fishing trips were carried out, each time using a different live bait composition: 100% live bait from nature, mix of 50% live bait of *C. chanos* aquaculture with 50% live bait from nature and 100% live bait *C. chanos* from aquaculture sized 3-8 cm.

Data analysis. Data analysis was done with SPSS 21.0 one way ANOVA analysis, for estimating the average difference of the observation data series. The data analysis test sequence included a normality test data using Shapiro-Wilk. A homogeneity test was applied to the normally distributed data. Hypothesis testing (one way ANOVA) was applied to the normal and homogeneous data. A Duncan Test followed, in order to find out if one variant that is significantly different from the other variants.

Analysis of live bait and catch ratio. Live bait per catch ratio in pole and line fleet measures the catch result per unit of live bait used. To find out the effectiveness of the *C. chanos* live bait, if the ratio of *C. chanos* live bait unit to the catch results > the ratio of natural live bait unit to the catch, it means that the use of *C. chanos* bait of aquaculture is more effective.

Results

Pole and line at Maumere. According to the Statistics of East Nusa Tenggara Province (2020), *T. albacares*, *E. affinis* and *K. pelamis* production in East Nusa Tenggara Province landed in East Flores Regency and Sikka Regency in 2018 were 4468.7 t, in 2017 were 3772.16 t, in 2016 were 3256.54 t and in 2015 were 5934.67 t. Pole and line ships and hand line vessels are the main contributors to the production in these two districts. The pole and line fishing area is located in the Flores Sea and the Savu Sea, which are included in the Republic of Indonesia Fisheries Management Area (FMA-RI) 713 and the Republic of Indonesia Fisheries Management Region (FMR-RI) 573. The Alok fishing landing port in Maumere is a port for 42 pole and line active vessels with a fishing license in the Flores sea area of the Republic of Indonesia Fisheries Management (FMA-RI) 713. According to Sai Global (2019), there are 25 pole and line vessels that have been registered in the Marine Stewardship Council (MSC) fisheries assessments. The size of pole and line ships in Maumere ranges from 25-30 gross tonnage. *K. pelamis* landed in Maumere, exceeding the local consumption in mainland Flores, are sent to Jakarta, Surabaya and Bitung for the needs of the fish canning industry. The condition of pole and line vessels in Maumere faces the same problem as the pole line vessels in Bitung, namely the limitations of live bait.

(a) (b)

Figure 2. Live bait bucket (a) and live bait chamber (b) (original).

Each pole and line fishing trip in Maumere is relatively shorter, 2-3 days, because the catching area of the Maumere harbor takes only 6-8 hours away. Natural live bait is caught by using bagan (boat lift nets) and lampara, but the quality of live bait caught with this fishing equipment is not good because it dies quickly (Figure 2a). Each boat needs about 5-7 live bait buckets, each bucket contains about 15 kg of live bait (Figure 2b). During the peak fishing season, all pole and line fleets try to go to sea but live bait requirements are not enough. Much time is wasted because of the bagan (boat lift nets) long waiting time until live bait is available. It is not uncommon for a ship to search first for live bait into the eastern Flores region, which is about 80 nm (nautical miles) from Maumere, then to head to the fishing area. This results in increased operational costs for diesel. The fish types of live bait from nature, caught using a bagan, include: commerson's anchovy (*Stolephorus commersonii*), shorthead anchovy (*Encrasicholina heteroloba*), slender fusilier (*Gymnocaesio gymnoptera*), shortfin scad (*Decapterus macrosoma*) and fringescale sardinella (*Sardinella fimbriata*). Commonly used live bait sizes are 4-10 cm, weighing about 6-15 g. The live bait used should not be too large so as not to lure large tuna to the surface which can cause the horde of tuna to disperse. Living bait conditions that need to be considered are: nimble, bright colors, scales do not fall out, are not deformed, fish specimens are not dead or prone to death and can survive in a live bait hold, with water circulation, for 2-4 days. During fishing, the fishers keep throwing live bait to the surface of the water about 10-30 tails at a time, in order to maintain the target fish at the surface.

Discussion

Live bait. *K. pelamis* can be found throughout the year in eastern Indonesian waters, such as the Banda Sea, Flores, Arafura, Halmahera, Maluku, Sulawesi, Aru and Northern Papua (Monintja 1993). According to Surur (2007), tuna is a fast swimmer and likes to fight for food in a very large group. These fish often invade smaller fish clusters at the surface of the water, very fastly, having a greedy or frenzy behavior. With these characteristics, *K. pelamis* are easily caught using the pole and line system. The favorite food of is *S. commersonii*, *S. fimbriata*, the yellowstripe scads (*Selaroides leptolepis*), short mackerel (*Rastrelliger brachysoma*) and the mottled fusilier (*Dipterygonotus balteatus*) (Subani & Barus 1989).

The factor that significantly affected the CPUE of *K. pelamis* with pole and Line vessels was the type of bait used, namely the shortfin scad (*Decapterus* spp.) mixed with *D. balteatus* (Setiyawan 2016). Live bait is used to attract the *K. pelamis* at the surface of the water. In pole and line ship operations, the technical factors that most influence the catch are the number of fishing trips and the amount of live bait used (Sutrisno 2017). The best type of live bait is anchovy (*Stelophorus* spp.) (Simbolon 2003). When the fish appears at the surface, the water starts to be sprayed through a pipe that is installed along the bow to the side of the boat, so that the fish keep swimming at the surface of the water. When the *K. pelamis* group is sufficiently large, fishing activities start immediately. Throughout the process fishers will continue throwing live bait, preventing the fish hordes dispersal. *K. pelamis* are attracted by the striking color of the fish, therefore alternative bait should resemble the characteristics of the fish bait. *S. commersonii* has the best catch performances among the live bait, followed by the shortfin scad, *Decapterus macrosoma* (Susanto 2012).

Milkfish from aquaculture for live bait. Scarcity of live bait results in an increase in fuel consumption by as much as 20% due to the long distance to the area of acquisition of live bait, following the replacement of anchovies (*Engraulis laponica*) with *C. chanos* (Yamashita et al 2011). *C. chanos* live bait pole and line should be silver colored, which increases the catch (Gondo 2010), and shiny bottom. *C. chanos* is one of the species of fish that is quite easy to maintain because of its capacity of adaptation to the environment. They are euryhalin fish classified as omnivorous and its harvesting time can be adjusted according to the needs. The choice of the size of *C. chanos* used as live bait uses as reference the size of live bait from nature, the most often used is 4-10 cm. In tuna (*K. pelamis*) fishing activities with pole and line in Larantuka, the live bait used is *C. chanos* at a log-size of about 6-9 cm (Padiyar & Budhiman 2014).

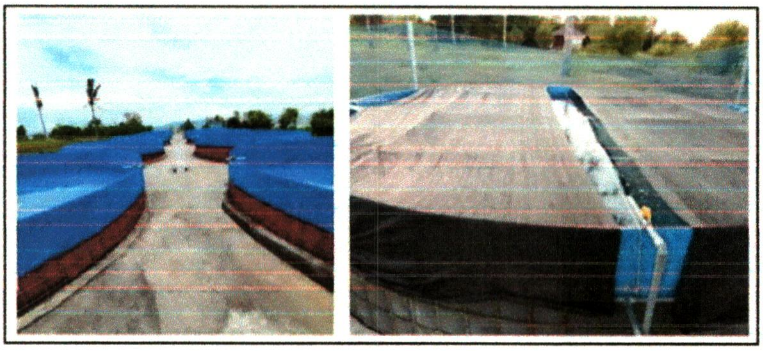

Figure 3. *Chanos chanos* aquaculture in tarpaulin ponds for live bait in Maumere (original).

The *C. chanos* used as live bait was aquacultured by PT. Fajar Flores Flamboyan Fishindo company in Maumere, Sikka Regency using sea water. The facilities owned are 10 tarpaulin ponds with a diameter of 5 m, equipped with air pumps (aerators) and sea water pumps (Figure 3). To start the nursery, a young milkfish supply from Gondol, Bali was carried out. *C. chanos* used as live bait was harvested at a size 7-8 cm and weight about 6-7 g (Figure 4).

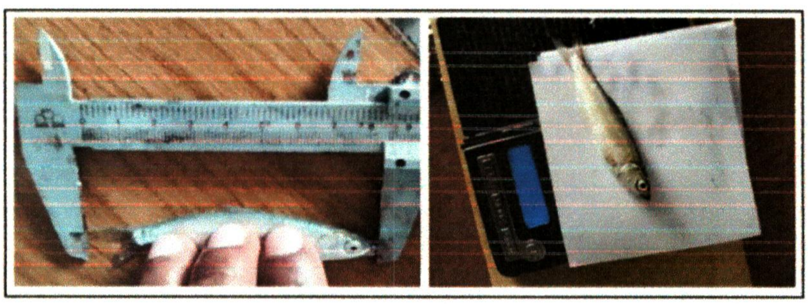

Figure 4. *Chanos chanos* for live bait in Maumere (original).

Data on the use of live bait and catches during 3 fishing trips is shown in Table 2. In Figure 5, the usage of bait by type is shown for each fishing session per trip.

Table 2

Live bait and catch usage data

Trip	*Live bait type*	*Total live bait (kg)*	*Total catch (kg)*
1	Nature	90	1,025
1	Nature and *Chanos chanos*	90	1,244
1	*Chanos chanos*	90	1,391
2	Nature	90	1,156
2	Nature and *Chanos chanos*	90	1,153
2	*Chanos chanos*	90	1,299
3	Nature	90	1,108
3	Nature and *Chanos chanos*	90	1,215
3	*Chanos chanos*	90	1,290

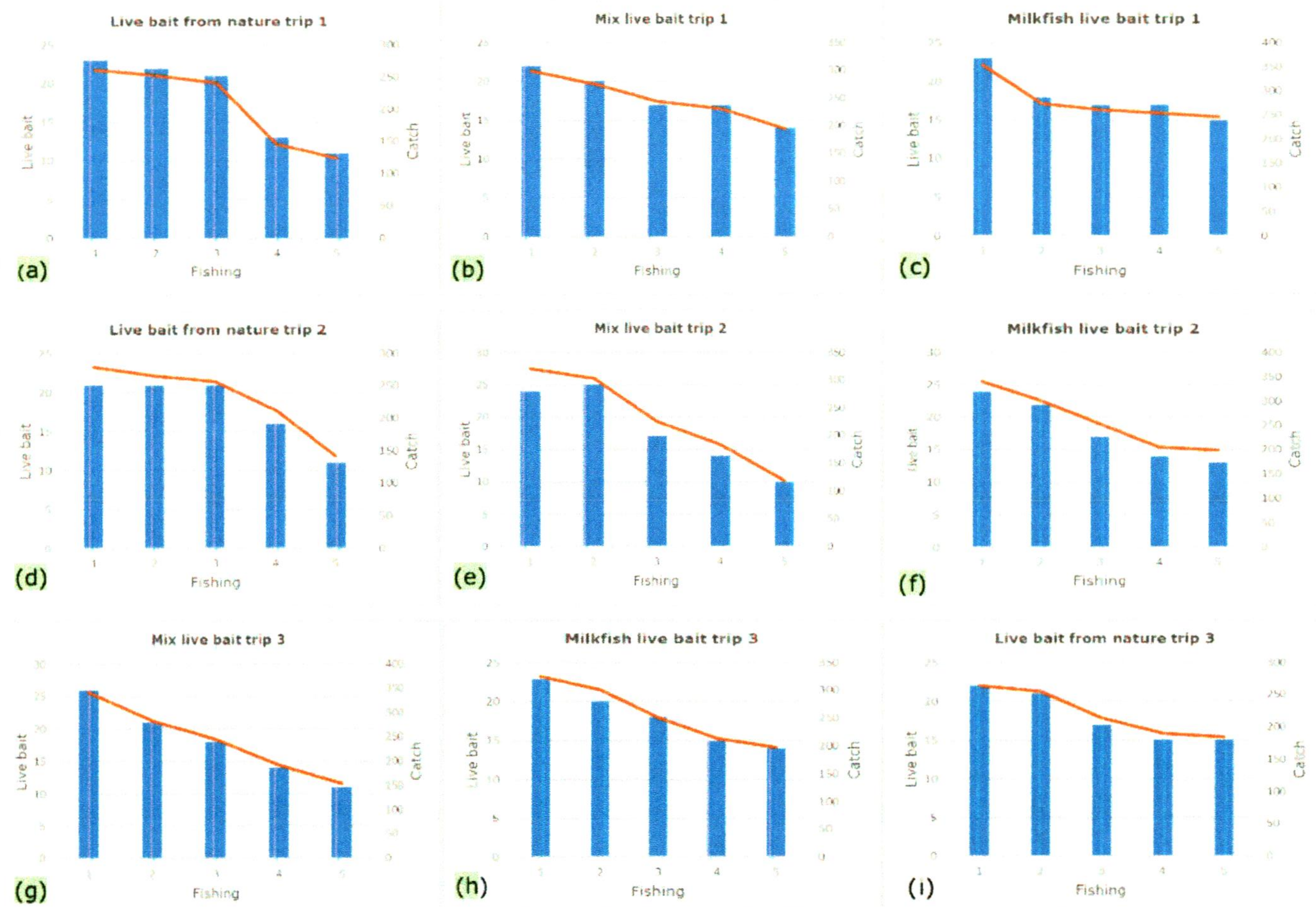

Figure 5. Live bait from nature trip 1 (a); ratio of mix live bait trip 1 (b); ratio of milkfish live bait trip 1 (c); ratio of live bait from nature trip 2 (d); ratio of mix live bait trip 2 (e); ratio of live bait milkfish trip 2 (f); ratio of live bait from nature trip 3 (g); ratio of mix live bait trip 3 (h); the ratio of milkfish live bait trip 3 (i).

Table 3

Shapiro-Wilk normality test

	Live bait	*Shapiro-Wilk*		
		Statistic	*Degree of freedom (df)*	*Significance*
Catch result	Natural	0.883	15	0.052
	Mix	0.977	15	0.944
	Milkfish	0.937	15	0.351

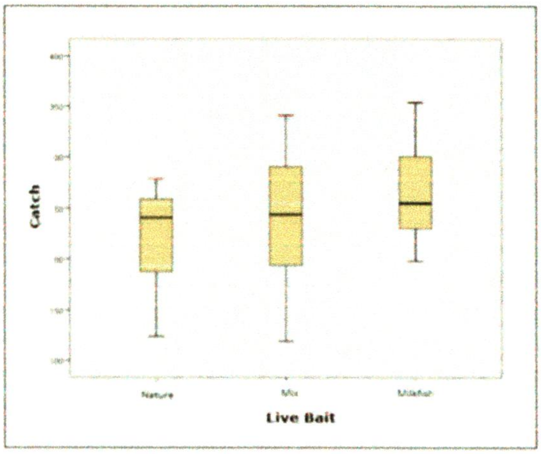

Figure 6. Data distribution.

For the variation test, the normality test of the data was performed first using Shapiro – Wilk (Table 3), which shows that Ho>0.05, meaning that the data meets the normal assumptions. Normal data distribution can be seen in Figure 6. Afterwards a homogeneity test was performed.

Table 4

Homogeneity test

Levene statistic	*Degree of freedom (df) 1*	*Degree of freedom (df) 2*	*Significance*
0.540	2	42	0.587

From the homogeneity test in Table 4 the results show a significance of 0.587>0.05, the catch data variance is the same, data are homogeneous. Afterwards, the data was analyzed by using one way ANOVA.

Table 5

The ANOVA test

	Sum of squares	*Degree of freedom (df)*	*Mean square*	*F*	*Significance*
Between groups	15938.533	2	7969.267	2.583	0.088
Within groups	129582.667	42	3085.302		
Total	145521.200	44			

From the ANOVA test results shown in Table 5, the obtained significance of 0.88>0.05 means that the average treatment was not significantly different. To find out the most influential treatment the Duncan test was applied.

Table 6

The Duncan test

Live bait	*N*	*Subset for alpha = 0.05*	
		1	2
Natural	15	219.27	-
Mix	15	240.80	240.80
Milkfish	15	-	265.33
Significance		0.294	0.233

From the Duncan's test in Table 6 it can be concluded that the use of live *C. chanos* from aquaculture is more effective, with an average catch of 265.33, higher than the average catch resulted from the mixed live bait and the one resulted from the natural live bait.

The use of *C. chanos* from aquaculture is more effective due to the fact that the fish endurance is longer in the live bait chamber so that the condition of the fish is better when used as live bait for the same size. Also, due to a smaller average size, the number of fish tales from aquaculture bait is larger than the number of live bait from nature, for the same bucket capacity. This affects the fishing duration, which is longer, in the range of 15-30 minutes. Another advantage of using *C. chanos* from aquaculture live bait is that the harvesting time can be performed in accordance with the planned catching timesaving operational costs, especially fuel, the live bait being loaded since leaving the fishing port towards the fishing ground.

Table 7

Ratio of live bait to the catch

	Trip	*Live bait (Kg)*	*Catch (Kg)*	*Live bait average*	*Catch average*	*Ratio*	*Ratio average*
100% natural live bait	1	90	1,025			1:11	
	2	90	1,156	90	1,096.333	1:13	1:12
	3	90	1,108			1:12	
50% natural live bait & 50% *C. chanos* live bait	1	90	1,244			1:14	
	2	90	1,153	90	1,204	1:13	1:13
	3	90	1,215			1:14	
100% *C. chanos* live bait	1	90	1,391			1:15	
	2	90	1,299	90	1,326.667	1:14	1:15
	3	90	1,290			1:14	

The ratio of live bait to catch for 3 trips can be seen in Table 7. *K. pelamis* fishing operations using pole and line vessels in Tuvalu and in the Gilbert Islands, using shortfin molly (*Poecilia mexicana*) live bait, obtained a ratio of 1:17 (Bryan1980).

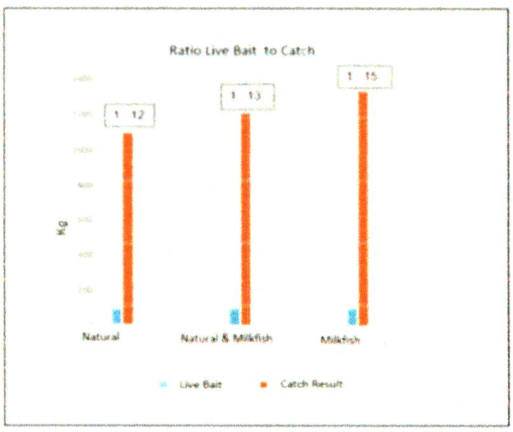

Figure 7. The ratio of the average live bait to the catch.

From the graph ratio of live bait to catch the catch, in Figure 7, it results that the ratio of the *C. chanos* live bait to the catch was 1:15 (1 kg of live bait gives 15 kg of catch), higher than the ratio of natural live bait to catch (1:12). The ratio of live bait for *C. chanos* to the catch was the same as Gillet's study in 2014, where the ratio of live bait to *K. pelamis* catches obtained from pole and line fishing operations in Larantuka was 1:15. This result is better than the *K. pelamis* fishing ratio in the 715 Indonesian Fisheries Management Area (FMA-RI) using natural live bait 1:11 (Nainggolan et al 2017).

The ratio of live bait from *C. chanos* to the catch in Maumere was also better than the value of 1:11.3 for the ratio of live bait from nature to catch in Maldives (Miller et al 2017) and better than the value of 1:8 for the same ratio for 25-29 gross tonnage wooden ships and 1:9 for 16 gross tonnage fiberglass ships in Larantuka (Padiyar & Budhiman 2014). In pole and line *K. pelamis* fishing in the Republic of Indonesia Fisheries Management Area (FMA-RI) 713-717, the ratio of live bait to catch was 1:4.41 (Widodo et al 2016), very low compared to other ratios.

Conclusions. The use of *C. chanos* of aquaculture, at a size of 3-8 cm, as live bait for the pole and line fleet is more effective, with higher average catches than live bait from nature caught with bagan (boat lift nets) or lampara. The ratio of live bait of *C. chanos* to the catch was higher than the ratio of live bait from nature.

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