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Research Article

Bycatch of Amboina Box Turtle (*Cuora amboinensis*) by Fishermen in Rawa Aopa, Southeast Sulawesi

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ABSTRACT
Rawa Aopa is a permanent swamp ecosystem that serves as one of the suitable habitats for amboina box turtles (*Cuora amboinensis*). Some of the area is part of a national park (Rawa Aopa Watumohai National Park) and is designated as a traditional zone for fishing activities, where local fishermen sometimes reported accidental catch *C. amboinensis* in their fishing gear. The aims of this study were to record the existence of *C. amboinensis* bycatch, size and age structure of bycatch, characteristic of fishing activity, and to discuss the conservation implication of bycatch. The number of bycatch was recorded by direct observation of 7 selected fishermen in 14 days. The *C. amboinensis* caught accidentally were measured and weighed. A total of 38 individuals of *C. amboinensis* were accidentally caught by fishermen during the study, having a size ranged of 7.4 to 18.5 cm (juveniles, young adults, and old adults; no hatchling), and weighed 248 to 996 g. Based on sex, there was no significant difference between morphological size of male and female, although bycatch for females (59%) tend to be slightly higher than males (41%). Most of fishermen lives in Pewutaa Village and used *bubu* traps to catch fishes. *C. amboinensis* are the most common bycatch compared to other species. In order to minimize the impact of bycatch of the *C. amboinensis* by fishermen, we need to ensure that the turtle that accidentally trapped in the fishermen's fishing gear would be released unharmedly to their habitat.

INTRODUCTION
Inland fisheries in freshwater in Indonesia are considered small compared to the coastal and marine fisheries. Yet, artisanal fisheries of inland waters, especially in lakes, are important for the livelihood of the local communities, for instance in Tondano Lake, Sulawesi and Sentarum Lake, Kalimantan (Makmur et al. 2021). In the swamp of Rawa Aopa in Southeast Sulawesi, part of the Rawa Aopa Watumohai National Park, fishes are diverse and abundant (Wulandari et al. 2018; Muliani et al. 2021) which attract fishermen. In addition to fishes, the swamp is also a home to diverse birds and other wildlife species (Putri 2016; Ridha et al. 2021).

As a permanent swamp ecosystem, Rawa Aopa is considered as suitable habitats for Amboina box turtle *Cuora amboinensis* (Aini et al. 2019), a freshwater turtle with a wide distribution in Indonesia and Southeast Asia. The turtle has been harvested for food in many part of its range (Schoppe

2009; Fauzi et al. 2020), which eventually raised the conservation status from Vulnerable to Endangered in IUCN Red List 2020 (Cota et al. 2020).

To conserve a certain species, basic information on biology and ecology should be made available, including threats. Information is usually obtained from the local communities living around its habitat. This traditional ecological knowledge can be used to obtain relevant data and increase understanding to conserve certain species (Howard et al. 2011; Butler et al. 2012). Fishermen are one of the potential informants to gather information of certain species or to obtain information regarding bycatch (Thornton & Scheer 2012; Zappes et al. 2016; Lucchetti et al 2017).

Previous research about *C. amboinensis* in the Rawa Aopa Watumohai National Park mostly was conducted in temporary pools in the savanna ecosystem, focusing on population estimation and habitat suitability models to analyze its distribution (Widagti 2007; Schoppe 2009; Aini et al. 2019). Unlike the previous research, this research was focused on permanent swamp ecosystem, the Rawa Aopa (±30,000 ha; '*rawa*' means swamp), located in a traditional zone where local community utilizes natural various resources, including fishing (KLHK 2018).

Fishing activities by fishermen in the study area will be used as the source of information for the existence of *C. amboinensis*, as well as the possible threat for this species due to bycatch. Anecdotal report indicated that *C. amboinensis* were accidentally trapped in fishermen's traditional fishing gear (called *bubu*) during fishing (Aini et al. 2019) and thus considered as bycatch. Bycatch is an important issue in fisheries as it creates a problem due to unused and discarded catch of unwanted species (Nugroho et al. 2015). The study of bycatch is needed to understand the size and area of bycatch (Wallace et al. 2010). In order to mitigate the population decline of *C. amboinensis* due to human activities, it is important to collect information regarding the characteristics of captured *C. amboinesis* as bycatch. The aims of this study were to record the existence of *C. amboinensis* bycatch, the size and age structure of this bycatch, characteristic of fishing activities and to discuss the conservation implications of this bycatch.

METHODS

Study Area

The research was conducted in Rawa Aopa swamp, located in *Seksi Pengelolaan Taman Nasional (SPTN) I* of the Rawa Aopa Watumohai National Park, Southeast Sulawesi (Figure 1). Field data was collected from February to March 2020.

Rawa Aopa is a large peat swamp and the only major peat swamp in Sulawesi under administration of two regencies: South Konawe and Konawe. The water bodies of the swamp are covered with vegetation of more than 90% with substrates mostly peat. The topography is flat that gradually turns into hilly (Zwahlen 1992). Rawa Aopa has an important function as water regulator for the surrounding area. During rainy season, it serves as water

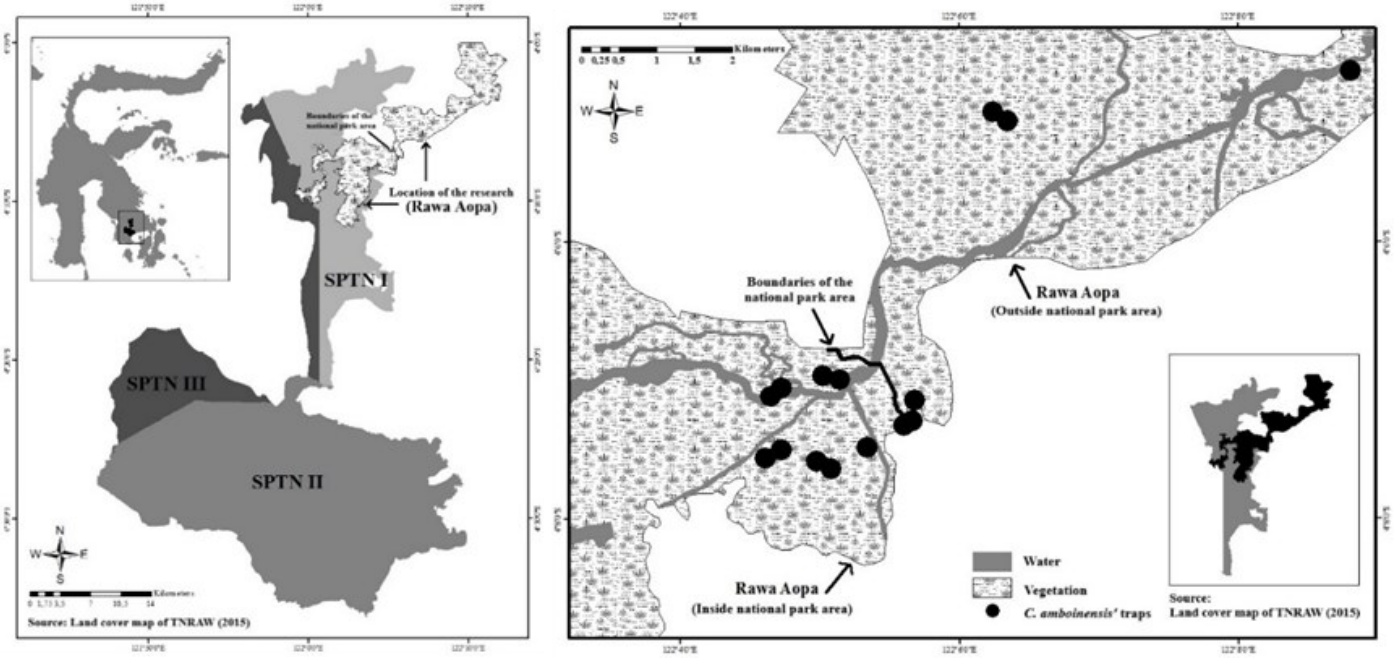

Figure 1. Map of Rawa Aopa, showing the placement of fish traps (right). Some of the swamp area is located inside the national park area (Management Section I), while some others is outside the national park.

catchment area and supplies the water to the local communities along the Sampara River Basin to Kendari during dry season. The water is also used by a regional drinking water company to fulfill water needs for the people of Kendari and its surrounding area (Sugiarto 2007).

Of the total ±30,000 ha of Rawa Aopa swamp, ±11,488 ha is managed by the national park authority (Sugiarto 2007; BTNRAW 2018). The boundary of the national park is marked by a bridge. The northeast area is outside the national park and the southwest area is inside the national park. Rawa Aopa within the national park is part of the traditional zone, where the local communities are allowed to utilize the natural resources, such as fishing and harvesting swamp plants (swamp pandanus or in the local languange called *totole*) for producing a mat (KLHK 2018). The community of Pewutaa Village located in the east of the Rawa Aopa has carried out traditional fishing from generations. The communities divided the year into three seasons: the rainy season (February to July), the dry season (August to January), and the transitional season (May to June).

Data collection

Information regarding *C. amboinensis* was obtained through a 7-day face-to-face interview to 32 fishermen. Prior to the study, we obtained prior informed consent (PIC) by informing interviewees the purpose of the study commencing the survey. Interviews were only carried out after verbal consent were issued by the fishermen. We ensured that data collected were confidential and anonymity of fishermen was protected. After PIC were obtained, we began with showing a photo of *C. amboinensis* and its egg to ensure respondents recognized the turtle. We develop a set of open questions consisted of three categories: identity of respondent, frequency of *C. amboinensis*

captured (including number of captured, turtle size, condition of the turtle caught), and equipment (i.e., type of fishing gear, location of installation, species of harvested fish, treatment of caught turtle).

Based on the interview, we followed activities of 7 selected fishermen to gather more detailed information of *C. amboinensis* bycatch. Data were collected for 14 days in the morning (6-9 am) or evening (4-6 pm) by canoeing the swamp to find *C. amboinensis* trapped in fishermen's fishing gear or moving around the swamp.

We recorded sex and morphological characteristics of each individual of *C. amboinensis* obtained from the fishermen's trap. The morphological characteristic recorded included carapace length and width, plastron length and width, tail length, and body mass (Figure 2). To identify a possible of recapture, *C. amboinensis* then were marked on the marginal carapace using a marker with a unique code following Karraker et al. (2020). Individuals that have been measured were released to their original location of capture.

The fishing area as the turtle habitat (presence of plants, water depth) was recorded and described. In addition, the abiotic components were also measured, including air temperature, humidity, and water acidity.

Figure 2. Measurements of morphological characteristics of *C. amboinensis* (a) straight carapace length, (b) straight plastron length, (c) straight carapace width, (d) straight plastron width, (e) height, (f) curved carapace length, (g) curved carapace width, (h) curved plastron length, (i) curved plastron width, (j) tail length, (k) weight.

Data analysis

Average and standard deviation were calculated to determine the range for each morphological variable of captured turtles, and presented in a box plot. An independent t-test was performed to obtain differences between sex, with a normality test carried out to ensure that the data distributed normally. The results of the calculations were displayed in tabular form for descriptive analysis. The age structure of *C. amboinenesis* was distinguished by the size of the straight carapace length and classified into four categories (Table 1) (Widagti 2007). Results of this study were compared to similar study in Southeast Asia.

Table 1. Age structure of *C. amboinensis* based on straight carapace length (SCL).

Age Class	Straight Carapace Length (cm)	Age Structure
I	≤ 5.0	Hatchling
II	5.1-11.5	Juvenile
III	11.6 -15.9	Young adult
IV	≥ 16.0	Old adult

RESULTS AND DISCUSSION

Morphological characteristic and age structure of *C. amboinensis*

During the research, 38 individuals of alive *C. amboinensis* were caught in fish traps, of which 4 individuals were recaptured. The *C. amboinensis* turtles were found in fish traps located inside (n = 21, 55%) and outside (n = 17; 45%) the national park. Most of turtles (n = 24; 63%) are normal, and unfortunately 14 turtles (37%; 4 juveniles and 10 adults) were found with certain abnormalities. The abnormality found in this research includes damage to the carapace and plastron, differences in number of marginal carapace, and defect in the legs and tail. There might be several factors that caused the abnormality, including fishermen handling when releasing turtle, predatory attack, and genetic disorders. As for nest finding, only one fisherman informed a finding of a nest near a dry grassy area underneath a *longgida* tree (*Nauclea orientalis*).

All *C. amboinensis* turtles were found inside traps (totalling 15 traps), except for one turtle which was found swimming near traps. All traps containing turtles were mostly traps located in areas with dense aquatic plants (Figure 3). Aquatic plants in Rawa Aopa consisted of lotus (*Nymphaea* sp.), *taboru-boru*, *doida* or swamp grass, *wolungatuleleo/apu-apu* or water lettuce (*Pistia stratiotes*), swamp pandanus (*Pandanus* sp.), water hyacinth (*Eichhornia crassipes*), *tolueda/lemidi* (*Stenochlaena palustris*), swamp fern, and *kurangkasoro* or water-moss (*Salvinia* sp.) (Figure 4).

Measurements of the abiotic components showed that the air temperature was between 25-33°C and the humidity was 94-99%. Meanwhile, the water color was blackish with acidity level (pH) 6. Water depth was between 2-10 m with peat substrate originated from rotting aquatic plants above it.

Based on the age structure (AS), the composition of bycatch *C. amboinensis* consisted of juveniles (AS II) and adults (AS III and AS IV) (Figure

5). No hatchling (AS I) was found. As for the sex ratio, of the 27 adult individuals that were able to be clearly distinguished the sex difference, the composition was 11 males (41%) and 16 females (59%).

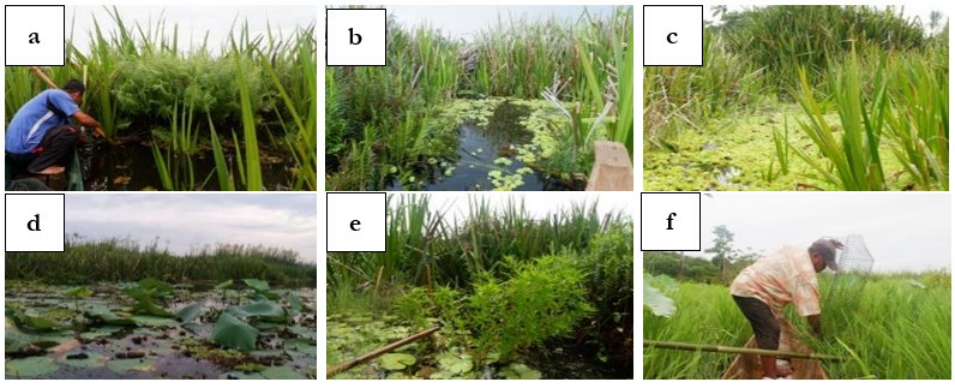

Figure 3. Habitat where *C. amboinensis* were mostly found in traps in Rawa Aopa (a and b), aquatic plants in trapping sites covered most of water level (c, d, e, and f).

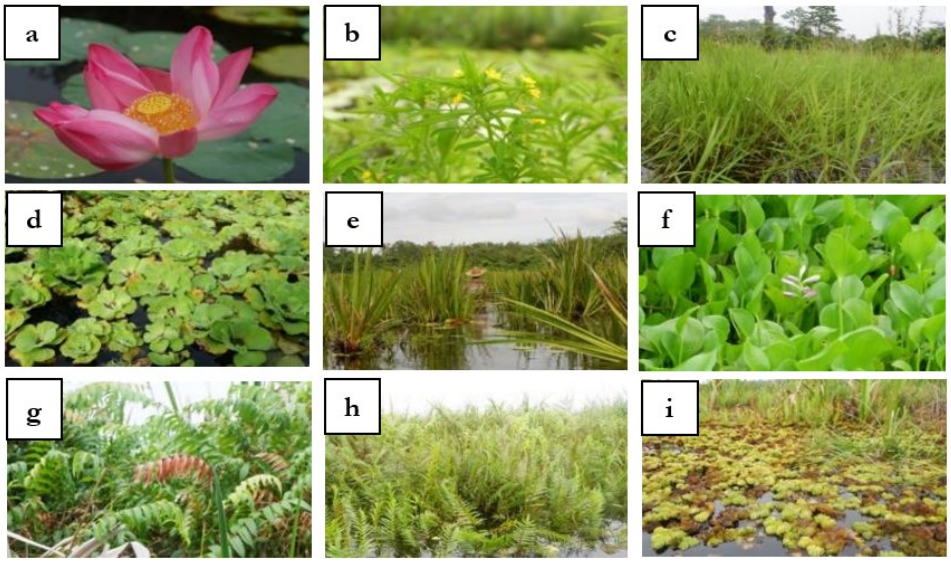

Figure 4. Several plants found in the habitat of *C. amboinensis* in Rawa Aopa: (a) lotus (*Nymphaea* sp.), (b) taboru-boru, (c) doida, (d) wolungatoleleo or water lettuce (*Pistia stratiotes*), (e) swamp pandanus (*Pandanus* sp.), (f) water hyacinth (*Eichhornia crassipes*), (g) tolueda (*Stenochlaena palustris*), (h) swamp fern, (i) kurangkasoro or watermoss (*Salvinia* sp.).

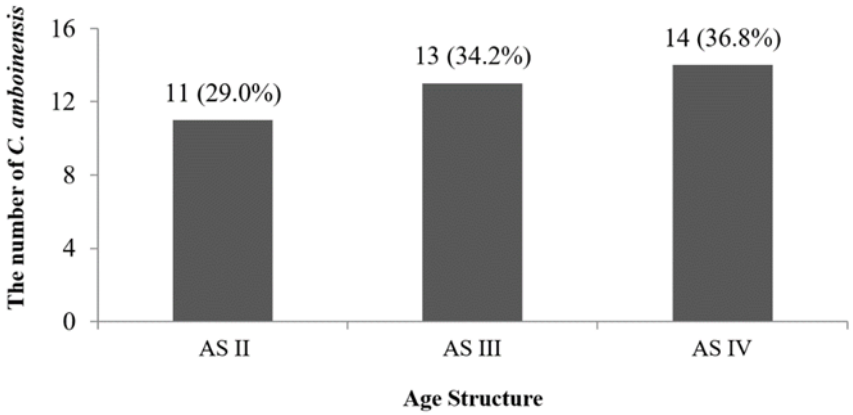

Figure 5. The age structure of *C. amboinensis* that were found from the bycatch in Rawa Aopa.

The size of *C. amboinensis* found from bycatches in Rawa Aopa varied highly, ranging from 7.4 cm to 18.5 cm (based on the SCL measurements; Figure 6). The largest size of female captured has SCL of 18.5 cm and for male with SCL 18.3 cm (Table 2).

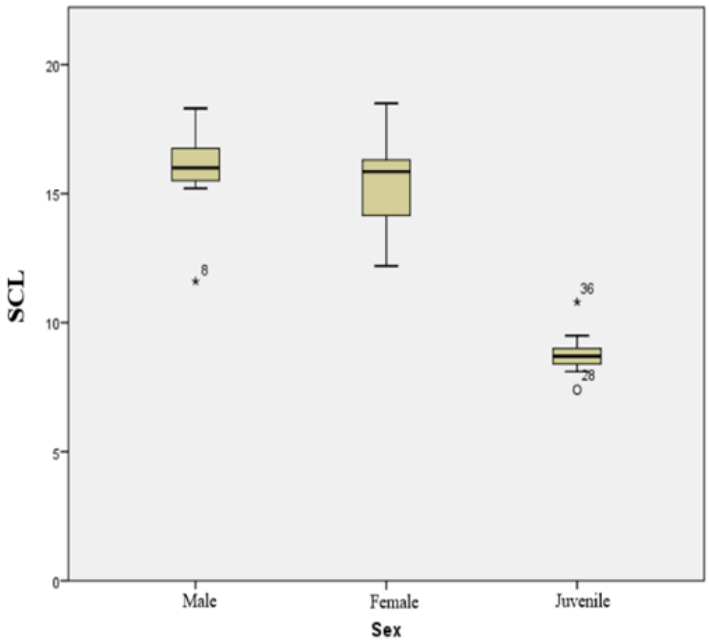

Figure 6. The boxplot of straight carapace length (SCL) from male (n = 11), female (n = 16), and juvenile (n = 11) of the *C. amboinensis* bycatch in Rawa Aopa.

The mean size (SCL) of the *C. amboinensis* in this study was smaller than the turtle found in Malaysia (SCL 21.5 cm) (Schoppe 2008), in temporary pools savanna in the national park from previous study (SCL 22 cm) (Widagti 2007), and in Myanmar (SCL 23 cm) (McCord & Philippen 1998). The difference might be caused by the equipment used in trapping the turtle. Fishing traps usually has a small opening gap (5-7 cm), thus bigger size turtles were not able to be trapped. Another study on four species of freshwater turtles (*Chrysemys picta, Graptemys geographica*, *Sternotherus odoratus*, dan *Chelydra serpentina*) in Canada also showed that the opening gap of the fishing gear was known to be affected on the size of the turtles caught (Cairns 2013). Turtles

Table 2. Morphological characteristics of adult *C. amboinensis* bycatch in Rawa Aopa.

Measurement (cm)	Female (n=11)		Male (n=16)	
	Average ± SD	Min-Max	Average ± SD	Min-Max
Straight carapace length (SCL)	15.38 ± 1.81	12.2-18.5	15.95 ± 1.76	11.6-18.3
Curved carapace length (CCL)	17.63 ± 2.17	13.6-21.7	18.65 ± 2.76	11.2-22.0
Straight carapace width (SCW)	12.01 ± 1.71	10.1-17.7	11.59 ± 0.89	9.4-13.1
Curved carapace width (CCW)	17.10 ± 3.24	13.5-27.6	16.24 ± 1.59	12.4-17.8
Straight plastron length (SPL)	13.93 ± 1.69	11.4-17.3	13.45 ± 1.31	10.1-15.1
Curved plastron length (CPL)	15.06 ± 3.32	11.6-25.8	15.52 ± 4.55	10.5-24.6
Straight plastron width (SPW)	7.56 ± 0.80	6.3-9.0	7.16 ± 0.56	5.7-7.9
Curved plastron width (CPW)	7.66 ± 0.79	6.3-9.0	7.35 ± 0.62	5.8-8.1
Height#	6.53 ± 0.83	5.2-7.8	5.96 ± 0.59	5.1-7.2
Tail length**	4.05 ± 0.61	3.0-5.0	5.08 ± 1.05	3.3-6.9
Weight (in g)	556.19 ± 199.79	269-996	548.82 ± 127.59	248-785

**highly significant different at α=0.01, #slightly different at α=0.1

which had entered the trap need to have shorter carapace height than opening gap of the trap.

Except for the tail length (i.e., males had longer tail), other morphological characteristics showed no significant difference between males and females. Females slightly had higher body, although the differences was not quite apparent. The limited number of samples on large-sized *C. amboinensis* might hamper a firm conclusion on the body characteristics between males and females.

Fishing gear used by fishermen in Rawa Aopa was selective to the size of the *C. amboinensis* bycatch. There were three types of the fishing gear used by fishermen in Rawa Aopa: fishing line, seine, and *bubu* trap (Figure 7). *Bubu* traps of different size and shape were the most common fishing gear used by the fishermen. Almost all the turtles were trapped in the *bubu* (juveniles to adults), although no hatchling was found. The lack of hatchling might be caused by smaller carapace height of the hatchling compared to the opening gap of the *bubu* (5-7 cm), which enabled trapped hatchling to get out easily.

Fishermen characteristics and activities

Most of the people in Pewutaa Village are fishermen. This might be influenced by the location of the village which is surrounded by Rawa Aopa swamp, thus harvesting fish was the main source of income of the people in the village. According to the fishermen, the use of *bubu* trap as the main fishing gear was due to the fact that most water level was covered by the aquatic plants. Time for checking *bubu* trap is relatively longer than other type of fishing gear, which is more effective and efficient because it does not need to be checked every day. In addition, fishes caught by *bubu* trap is still alive

Figure 7. Fishing gear used by fishermen of Rawa Aopa (a) fishing hook, (b) fishing line, (c) seine, (d) *bubu* trap size 20 × 130 cm, (e) *bubu* trap size 40 × 40 × 50 cm, (f) *bubu* trap size 40 × 40 × 100 cm, (g) *bubu* trap size 20 × 100 cm.

compared to other gears i.e. fishing rods or seine, where the fish caught will be mostly dead and rotting when harvested. This is considered to reduce the quality and the quantity of the catch.

Fish commodity from Rawa Aopa consisted of tilapia fish (*Oreochromis mossambicus*), climbing perch (*Anabas testudineus*), kissing gourami (*Helostoma temminckii*), snakeskin gourami (*Trichogaster pectoralis*), snakehead murrel (*Channa striata*), Java barb (*Barbonimus gonionotus*), and catfish (*Clarias batrachus*). Bycatch is the accidently capture of all other aquatic animals outside the main target catch including all other aquatic animals by fishing gear (Novrizal et al. 2018). Bycatch consisted of snails, crayfish (Cherax sp.), birds, snakes, water monitor (*Varanus salvator*), juvenile crocodile (*Crocodylus porosus*), armored catfish (*Glyptoperichthys gibbiceps*), and amboina box turtle (*C. amboinensis*). Some of the bycatch was consumed (i.e., armored catfish, crayfish, and snail), used as fishing bait (snails), or released by the fishermen (birds, snakes, water monitors, crocodile, and amboina box turtles). *C. amboinensis* are the most common bycatch compared to other species. The number of turtles found in one trap ranged from 1 to 10 individuals with varying sizes. The use of *bubu* traps might be one of the reasons for bycatch of *C. amboinensis* and there is a possibility that turtles were "attracted" by the content of the *bubu* trap. All respondents remarked that when they found the turtle they will immediately threw the turtle away and considered them as pests. This is because often fish catch decreased when turtle is found in the fishing gear (especially *bubu*). Although most fishermen said that they released all turtles alive, no fishermen stated that he specifically killed turtles found inside the *bubu* trap.

Conservation implication of bycatch

Discard catch is part of bycatch that can be destructive, because the organism being discarded is almost never reported, resulting in distortion of the data used in stock assessments (Ardill et al. 2011). Reports on bycatch has focused more on marine fisheries i.e. marine turtles (Aucoin & Leon 2007, Moore et al. 2010; Lucchetti et al. 2018) marine snakes (Fry et al 2001), and marine mammals (Read et al. 2006; Moore et al. 2010; Mackay & Knuckey 2013). Meanwhile, reports of bycatch in freshwater fisheries are very few (Larocque 2011). Freshwater turtle bycatch reports are also very few and so far only been reported in Canada (McCord & Philippen 1998; Larocque 2011; Nguyen et al. 2013). Bycatch occurs as a result of overlaps in the spatial distribution between target (fish) and non-target (turtle) species, putting these turtles at risk of being caught accidentally (Larocque 2011). This research reveals the existence of freshwater turtle bycatch in Indonesia, even in Asia for the first time.

The impact of the bycatch is the mortality in non-target species. The mortality of non-target species bycatch can cause demographic shifts that lead to population decline and community change (Midwood et al. 2015). Bycatch is even major problem affecting turtle populations worldwide (Moore et al 2010).

This study revealed that bycatch of the *C. amboinensis* affected almost all class age, except hathcling. The population of *C. amboinensis* in Rawa Aopa might be threatened if the fishing gear used by fishermen is not selective (i.e., having a small opening) and if fishermen killed the turtle when the turtle trapped in their fishing gear. Therefore, the attitude of the fishermen toward the conservation of the *C. amboinensis* is crusial in maintaining the age structure and population in general.

On a large scale, the decreased population of this species can disrupt the balance of the ecosystem. *Cuora amboinensis* plays a central role in the ecosystem's food chain either as a predator of various invertebrates or as distributor of plants' seed (Karraker et al. 2020). The significant ecological impact of the loss of this species includes changes in energy flow, nutrient cycling, and food web structure (Schoppe 2008).

Most of the fishermen in Rawa Aopa have indirectly protected the existence of *C. amboinensis*. The fishing gear used was quite selective and most fishermen released the bycatch of *C. amboinensis* alive. This attitude needs to be maintained to protect the population of this species in Rawa Aopa. Ashanika people in Central Peru can serve as a good example on the conservation of turtle by using their traditional knowledge (Ferronato & Cruzado 2013).

CONCLUSION

This research showed that the bycatch of *C. amboinensis* in Rawa Aopa occurred at all age class for both sexes. As fishing has been one of the major economic activities for the local people, the balance between the utilization of natural resources (i.e., fishing) and conservation (i.e., maintaining *C. amboinensis*) need to be achieved and maintained. Positive attitude of the fishermen to release the turtles unharmed is definitely needed to maintain the population of the *C. amboinensis* in Rawa Aopa.

AUTHORS CONTRIBUTION

H.N. collected and analysed the data and wrote the manuscript. M.D.K. designed the research and supervised all the process including translating report into English. A.M. supervised all the process and assisted in manuscript revision.

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CONFLICT OF INTEREST

No conflict of interest regarding the research or the research funding.

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