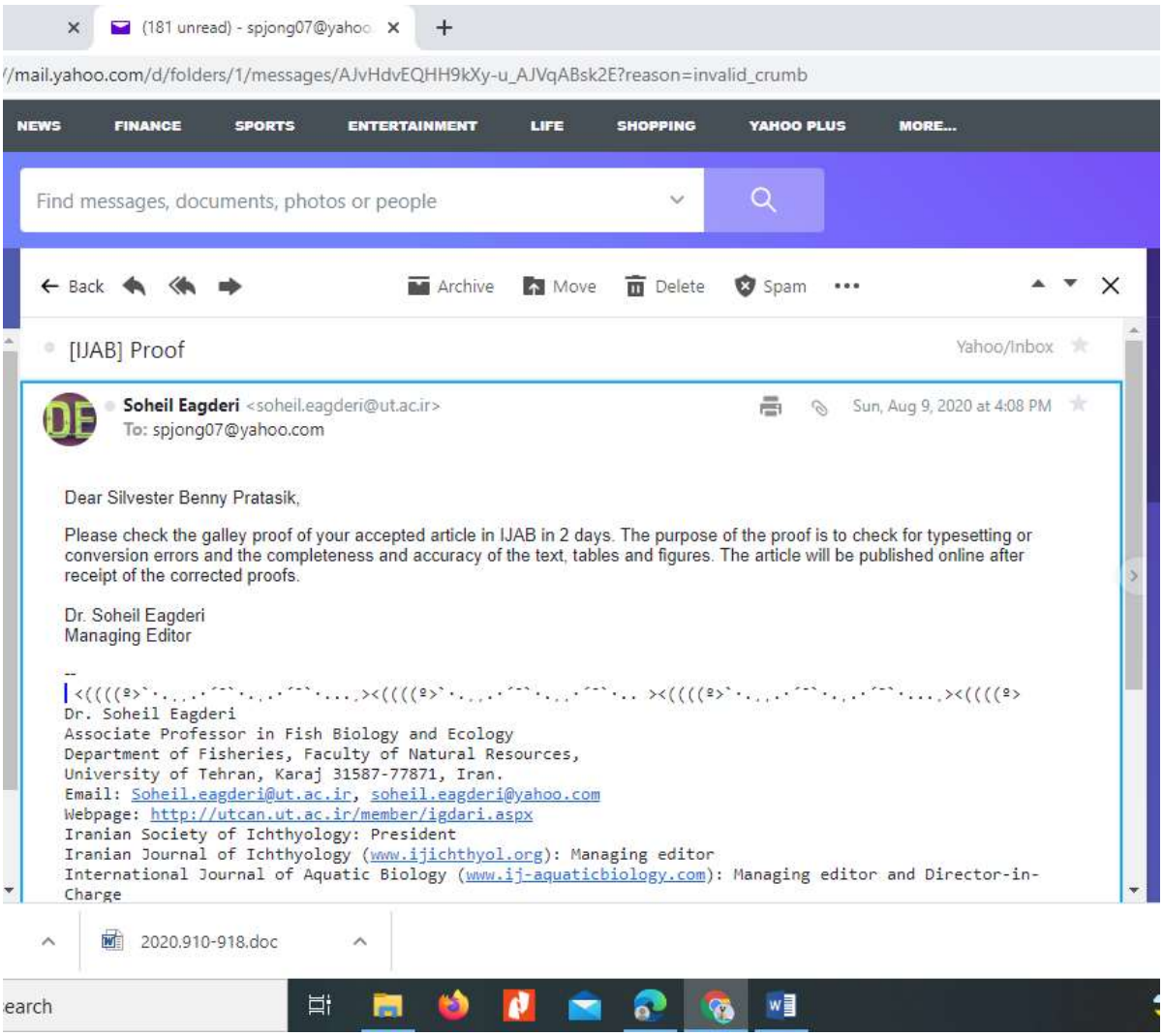

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Short Communication

Small pelagic fisheries condition in North Sulawesi: A case study on traditional purse seine practice in Likupang Village, Indonesia

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Abstract: This study was conducted to know the impact of traditional purse seine fisheries in Likupang village, North Minahasa Regency, North Sulawesi, on pelagic fish stocks of scad *Decapterus* spp. by size at first maturity estimation. Samples were collected from the purse seine catch of Likupang fishermen. They were individually measured and dissected for maturity level examinations. The results showed a wide size range in *D. macarellus* catch and high catch of small individuals of *D. macrosoma* reflecting that traditional purse seiners in Likupang could become potential fishing gear to deplete the stocks of scad. This situation makes the purse seine fishermen have to adjust the mesh size to the fishing target.

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Introduction

Overfishing can occur when many small individuals are caught, young individuals enter the fishing ground, and efforts are maximized for fishing (Pauly, 1988). Thus, knowledge on growth, length at maturity and spawning season is crucial to detect when and at which length the fish should be protected (Hunter et al., 1992) or to explain the variation of the level of population, such as estimation of fishing mortality, population of cohorts, and population of spawning stock (Karna and Panda, 2011) as well as to make efforts to increase the amount of fish harvest (Das et al., 1989).

Size composition of catches should represent mature individuals, the highest catch of a cohort, and reflects the conservation of big-sized mature individuals (Froese, 2004). Size at first maturity is important information for the proper management and conservation of fish stocks, and the information is very helpful to researchers and policymakers for the preparation of very effective sustainable management plans of fishery resources (Jennings et al., 1998; Waddy and Aiken, 2005; Karna and Panda, 2011; Nandikeswari, 2016; Peixoto et al., 2018). Size at first maturity (Lm) is the length at which 50% of the fish have reached maturity and has been taken as a reference point of minimum size and a useful index for determining the size of the exploitable stock (Siegel and Loeb, 1994; Jirapunpipat, 2008; Nadikeswari, 2016). It is related to the reproductive cycle of fishes that can be seen through the seasonal development changes in their gonads (Karlou-Riga and Economidis, 1996; Gomiero et al., 2008) and affected by the environmental changes particularly temperature, photoperiod and food supply (Bagenal, 1978). Estimation of size at first maturity has been used to let adult individuals spawn at least once or to protect young individuals (Fontoura et al., 2009), and can be employed as stock availability indicator and applied for the determination of mesh size used in fishing operation (Carlucci et al., 2006; Omar et al., 2015).

Information on fish gonad maturity is required to know the mature and immature fish ratio of a stock, size or age at the first spawning, spawning time, duration, and pattern etc. Change in fish gonad size is expressed with gonad maturity level (Kordi, 2010). Each fish species can reach first gonad maturity at

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Table 1. Fish gonad maturity level (Effendie, 2002).

Maturity stage	Note	Female	Male
I	**Immature**	Small ovary up to ½ the length of the body cavity. It is translucent. Oocyte does not appear.	The testis is small up to ½ the length of the body cavity. It is whitish.
II	**Maturing**	The ovary is about half the length of the body cavity. It is orange, translucent, and oocyte cannot be seen by the naked eye.	The testis is about ½ the length of the body cavity. It is white and about symmetrical.
III	**Ripening**	The ovary is about 2/3 the length of the body cavity. Ovary yellow-orange, oocyte appears. Ovary with blood vessels on the surface. No transparent eggs or translucent, eggs are still dark.	The testis is about 2/3 the length of the body cavity.
IV	**Ripe**	The ovary is about 2/3 up to full of the body cavity. The ovary is orange-pink with blood vessels on the surface, eggs are apparent.	The testis is about 2/3 up to fulfilling the body cavity. It is white-soft cream.
V	**Spent**	Ovary shrinks down to ½ the body cavity. Wall is thick. There may be dark and mature eggs in the ovary that disintegrate from absorption, dark or translucent.	Testis shrinks down to ½ the body cavity. Wall is thick. The testis is soft.

different body size, and same species that are distributed in the different latitude more than 5 degrees, can have different size and age at first gonad maturity due to different environmental conditions of their habitats. Therefore, knowledge on size at first maturity is crucial, since it allows us to examine mature and spawning stocks for management of their exploitation (Jennings et al., 1998) and developing a successful management program (Gupta and Triphati, 2017; Tesfahun, 2018).

Scads, *Decapterus* spp. are small pelagic fishes that have good economic value consumed in Indonesia. They belong to five different species, including *D. kuroides*, *D. ruselli, D. macarellus, D. macrosoma*, and *D. maruadsi*, with a maximum individual size range of 40-50 cm and common size of 25-30 cm (www.fishbase.org). Scads are target fish in light fishing in multiple hook-hand lines and purse seine fisheries. Fishermen in Likupang village, North Minahasa, Indonesia, have run mini purse seine as income source. This fishing gear is operated by encircling the fish school with net. This study is intended to describe the impact of traditional purse seine fisheries in Likupang village on pelagic fish stocks, especially *Decapterus* spp. by observations on size maturity of the fish catches and size composition.

Materials and Methods

Fish samples were obtained from small purse seiner's fishing operations in Likupang Village. The fishing grounds locate 1°41'05.54"N and 124°13'50.61E - 1°59'30.42"N and 125°22'32.86"E. All dimensions of the purse seine were measured. The fish were randomly taken from the boat and separated by species type. Body length was recorded in the standard length, the distance from the tip of the snout to the posterior end of the last vertebra. The scads were separated into several different size classes. Then, they were dissected for gonad maturity examination. The maturity level was determined following Effendie (2002) (Table 1). Data grouping into size classes was done using Struges (1926) as follows:

$$k = 1 + 3.3 \log n$$

Where k = number of classes and n = number of data. For class interval determination, the following formula was used:

$$C = \frac{Xn - X_1}{k}$$

Where C = class interval, Xn = the largest data value, X_1= the smallest data value, and k = number of classes. The data were then arranged from the smallest to the largest and grouped in the class interval. All data were plotted in a graph to present the size distribution. Size at first maturity was estimated based on gonad maturity level and size class following Spearman-Karber equation (Udupa, 1986) as follows:

$$m = x_{k+}\frac{x}{2} - (x\Sigma p_i)$$

Where Xk = log of last size in which 100% of the fish are fully mature, x = log of size increment = x_{i+1} - x_i, i = 1, 2,…k-1, and xo = log of last size in which

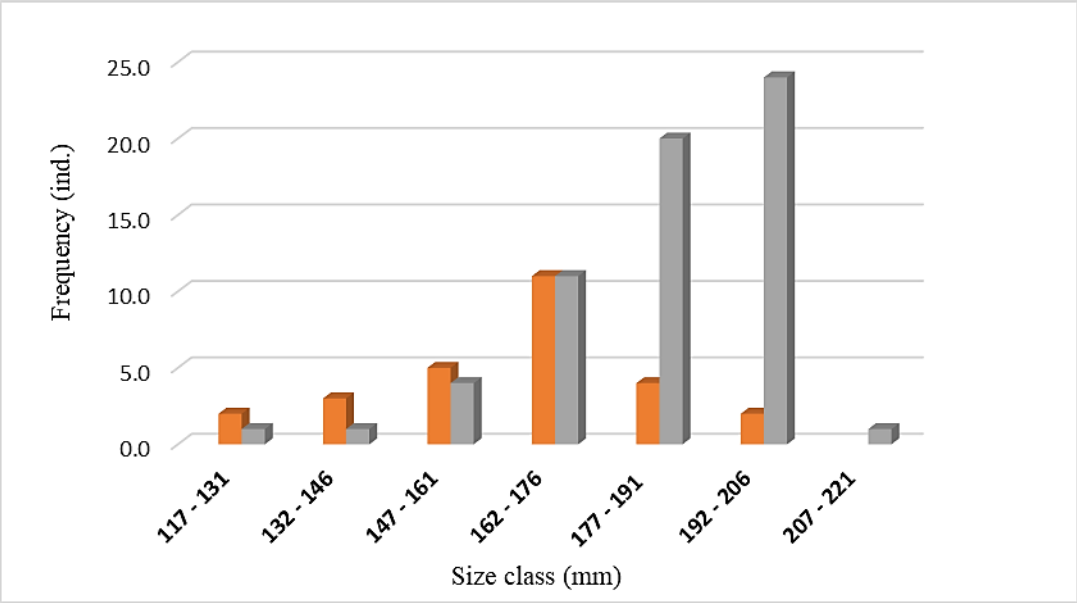

Figure 1. The size distribution of *Decapterus macarellus* catch: orange – male; grey – female.

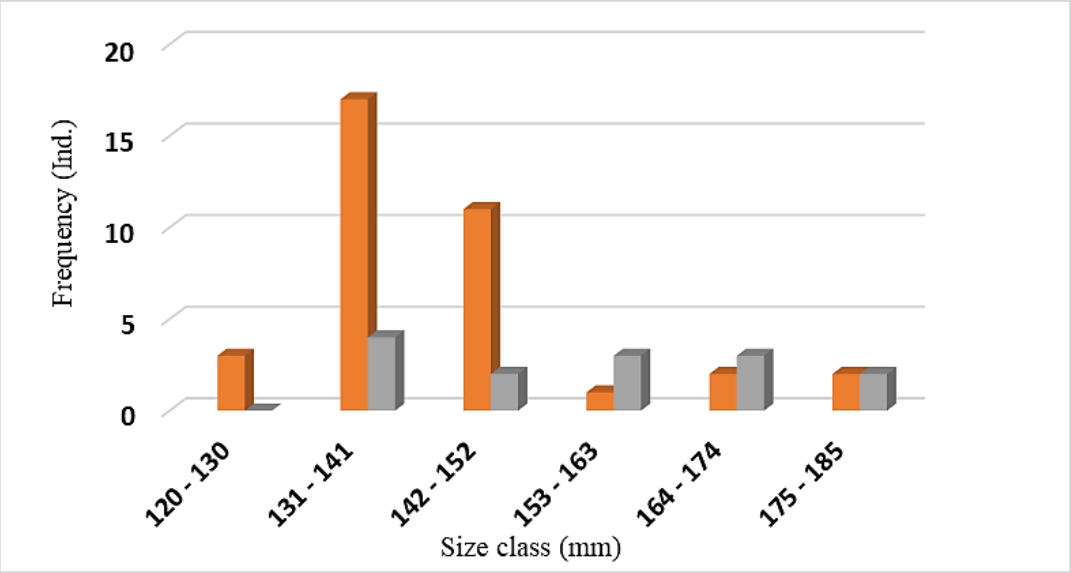

Figure 2. The size distribution of *Decapterus macrosoma* catch: orange - male; grey - female

there is no fully mature fish, r_i = number of fully mature fish at size group *i*, p*i* = proportion of fully mature fish at size group *i*, p*i* = ri/n*i*, if n*i* ≠ n*i*+1 for = 1, 2, …k-1 and p*i* = r*i*/n, if n = n*i* = n*i*+1 for *i* =*i* 1, 2…..k-1. Mean size at first maturity was obtained by antilog (m) = M.

Results and Discussion

Decapterus macarellus (n = 89) and *D. macrosoma*, (n = 50) caught by traditional purse seiners in Likupang, randomly collected from one of the fishing vessels. Sex composition consisted of 24 males and 65 females for the former and 36 males and 14 females for the latter.

Gonad maturity *D. macarellus* catches revealed that male size ranged from 117-166 mm dominated by gonad maturity I and II, and one individual with maturity III. Females had a size range of 117-131 mm belonging to gonad maturity of I, while in the size range of 132-161 mm gonad maturity of I and II dominated, but there were individuals with gonad maturity of IV. At the size range of 162-176 mm, a small number of females has reached gonad maturity of IV and V, but the larger size was dominated by

individuals of gonad maturity, and then no fish were found in gonad maturity level. Therefore, *D. macarellus* reaches the first gonad maturity at the size larger than 176 mm. Estimation of size at first maturity calculation found that *D. macarellus* reached the first maturity at 177 mm long in the size range of 177-191 mm (Fig. 1). In west Sulawesi waters, Nur et al. (2017) found that *D. macarellus* reached the first maturity at a larger size, 224 mm long for male and 188 mm long for female.

Size composition of *D. macrosoma* catch ranged 120-185 mm (Fig. 2) with the highest catch at the class interval of 131-141 mm (n = 21) and the lowest catch at the class interval of 175-185 mm {n = 4). *Decapterus macrosoma* reaches the first maturity at 163 mm in a range of 153-163 mm. Other previous studies have found different size at first maturity for the same species, 143-149 mm (Prihartini et al., 2006) with first spawning at 145-151 mm in Jawa Sea, and 195 mm for male and 210 cm for female in Bone Bay waters (Dahlan et al., 2015), in which males reach gonad maturity earlier than females. These differences could be as a result of different geographic localities influencing the ecological conditions (Blaxter, 1989). Since the size at maturity may vary between populations in different geographic locations, detailed information of the reproductive biology of widely distributed species is critical for developing effective management approaches (Herrera et al., 2016).

The size composition of the catch reflects that traditional purse seiners in Likupang catch also immature fish so that it could degrade the scad populations in North Sulawesi waters. Fingerling-sized scads are taken as well since they have a market value at both local and national levels. Fisheries companies purchase the small sized-individuals for cheaper price to meet the national market demand. This condition shows that scad populations in this area get sufficiently high fishing pressures, even though fish maturity in earlier stage could occur as an adaptation to the fishing pressure because size at maturity could respond very quickly both to natural selection and to additional selective pressures such as those caused by fisheries.

High fishing pressures could make mean length at sexual maturity of a population in a high fishing pressure area decrease in response to the removal of large individuals (Motta et al., 2005), and recovery rate is related with mortality rate in which the closer the length at first maturity to the maximum length is, the lower the mortality rate or the population pressure (ECTF, 2004). The present data show a wide size range in *D. macarellus* catch and high catch of small individuals of *D. macrosoma* reflect that traditional purse seiners in Likupang could become potential fishing gear to deplete the *Decapterus* spp. and other small pelagic fish groups, such as *Euthynnus* spp., and large pelagic fish groups, such as tuna, that have similar schooling behavior. This situation makes the purse seine fishermen have to adjust the mesh size to the fishing target. Therefore, the use of larger mesh-size at the pocket part of the traditional purse seine should be established to let the fish spawn at least once before caught and save the small individuals from exploitation for the small pelagic fish target.

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