Species composition and abundance of small fishes in seagrass beds of the Karang Congkak Island, Kepulauan Seribu National Park, Indonesia

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Abstract. It is extensively recognized that seagrass meadows have been defined as nursery ground for fish. In this study, we investigated species composition and abundance of small fishes in seagrass beds of Karang Congkak Island, Kepulauan Seribu National Park from November 2018 to March 2019. In total, about 10,000 individuals of 46 fish species belonging to 26 families were captured using a seine net at four fixed stations. The major families graded by species number were Labridae, Apogonidae, Gobiidae, Siganidae, and Atherinidae. More than 90% of fish was juvenile and mostly economically important species and reef-associated fish. Majority of fish juveniles inhabit seagrass beds were categorized as temporary resident and regular visitors. It was observed that the top five ranked fish species in abundance were Spratelloides gracilis (33.4%), Stenatherina panatela (19.5%), Siganus canaliculatus (13.2%), Gerres oyena (11.8%) and Siganus spinus (5.9%). There was a propensity that species richness and diversity were higher in areas with higher seagrass coverage. However, two-way ANOSIM revealed fish abundance was not significantly different spatially and temporally (p>0.05). Predominant trophic function of fish were zooplanktivores and crustacivores. The present study, therefore, identified seagrass beds of Karang Congkak Island as feeding habitats and shelter for fish juveniles.

Keywords: fish assemblages, fish juvenile, habitat connectivity, nursery ground, seagrass

1. Introduction
Seagrass meadows in Indonesian archipelago as one of the marine ecosystems, supply remarkably ecological services such as nursery and feeding habitats for marine faunal species (Vonk et al 2010, Unsworth and Cullen 2010, Unsworth et al 2008, Gillanders 2006). It supports high fish species richness and fish abundance (Ambo-Rappe et al 2013, Susilo et al 2018, Irawan et al 2018, Hidayati and Suparmoko 2018). Nevertheless, seagrass meadows in Indonesia are the most threatened coastal habitat due to anthropogenic such as land-originated sedimentation, coastal development, reclamation,
pollution, garbage dumping and boating activities (Ralph et al 2006, Nadiarti et al 2012, Unsworth et al 2018). Decreasing seagrass health condition and extensive loss of seagrass meadows are widely occurred around the Indonesian archipelago, as well as in Kepulauan Seribu National Park (KSNP) (Fajarwati et al 2015, Unsworth et al 2018). When seagrass beds are lost, it will disrupt fish assemblages, reducing fish diversity and abundance, and therefore lead to degrading fisheries resources status (Connolly 1994, Heck et al 2003, Hyndes et al 2018).

Seagrass beds are widely acknowledged as a harbor of a high number and diversity of fishes and invertebrates because it has hugely high primary and secondary productivities (Gillanders 2006). It provides varied food resources and microhabitats for assemblages of fish (Adams et al 2004, Unsworth et al 2007) and also protection for fish juveniles from predators (Nuraini et al 2007). Lots of studies have reported that at some point of their lives, fish and invertebrates were connected to seagrass (Adams et al 2006, Nakamura et al 2012), and a number of them are reef fishes which categorized as commercially important species (Kimirei et al 2011, Espino et al 2015). Moreover, various fish species of different age classes and at different trophic levels are utilizing seagrass beds as a place to looking for food and shelter (Unsworth et al 2007). In terms of residential status, therefore, fish assemblages in seagrass meadows may consist of permanent resident (PR), temporary resident (TR), regular visitor (RV) and occasional visitor (OV) (Gillanders 2006). All of these fishes get benefit from seagrass even though some of them do not inhabit seagrass for all of their life cycle. In this study, we suggest the hypothesis that species richness, diversity and abundance of fish juveniles are higher in the habitat with larger seagrass coverage.

Research on fish juveniles in seagrass beds around the globe are well established. Most studies were carried out in the Caribbean Sea (de la Moriniere et al 2002, Aguilar-Perera and Appeldoorn 2007, Nagelkerken and van der Velde 2004), temperate zones (Smith and Sinerchia 2004, Horinouchi 2005, Jaxion-Harm et al 2012), and Indo-Pacific region (Dorenbosch et al 2005, Unsworth et al 2009). Recent researchs have displayed that seagrass habitat has substantial role as nursery for small fishes in tropical region (Le et al 2018, Lee et al 2019). However, few works have been done regarding fish juvenile diversity and abundance in Indonesian archipelago (Nuraini et al 2007, Syahailatua and Nuraini 2011, Edrus and Hartati 2013). The objective of this study, therefore, was to examine species composition and abundance of fish juveniles in seagrass beds of Karang Congkak Island, Kepulauan Seribu. The information from this work can be use as baseline data for conservation and rehabilitation of seagrass ecosystem (Hyndes et al 2018) as well as a basic data for coastal fisheries management in KSNP Indonesia (Arkema et al 2019, Unsworth et al 2014).

2. Materials and methods

2.1. Study area
The study was performed in the seagrass beds of the Karang Congkak Island, Kepulauan Seribu National Park (KSNP) (figure 1). This island is situated in the northern part of KSNP and its coastal waters is characterized with extensive seagrass meadows, reef flat and surrounded by barrier reef. The distance between seagrass habitats to coral reefs was from 15-30 m. Seagrass meadows and coral reefs surrounding of this island are the fishing grounds for local fishermen, especially to collect marine ornamental fishes.

2.2. Fish sampling
Sampling was undertaken monthly from November 2018 to March 2019 in four fixed sites, namely east, south, west and north part of the Karang Congkak Island (figure 1). Prior to fishing activities, environmental parameters such as temperature (°C), salinity (ppt), dissolved oxygen (mgL⁻¹), and pH were measured at each sampling station. Fishes were captured by beach seine net measured 10 m in length and 1 m in height, with 5 mm stretched mesh in the main net and 1 mm mesh in the cod end,
during ebb to low tides (daytime fishing). The highest water depth at which the gear was operated ranged from 0.5 to 1.2 m, and the sampled area was approximately 300 m$^2$ per tow. All specimens captured in the seine were immediately preserved in 10% formaldehyde–seawater solution for 2-3 hours, then specimens were rinsed with seawater and preserved in 80% ethanol. In laboratory, all fish samples were identified to species level according to Allen (1997), Allen and Erdmann (2012), Carpenter and Niem (1999a, b, 2001a, b), Kuiter and Tonozuka (2001). Fish specimens were counted, its body weight was measured to the nearest g and body length was estimated to the nearest mm.

![Figure 1](image-url) 

**Figure 1.** Map of research area at Karang Congkak Island, Kepulauan Seribu National Park, Indonesia.

### 2.3. Seagrass observation

In order to identify seagrass species and determine seagrass coverage, three line transects along 50 m were performed at each station. Each line transect consists of five quadrant plots of 1 m x 1 m. The distance between line transects was 10 m as well as the distance between quadrant plots. Percentage of seagrass cover measurement refers to McKenzie et al (2003), while seagrass species was identified according to Azkab (1999). This observation was performed once time in November 2018.

### 2.4. Data analysis

Species composition of fish assemblages was analyzed descriptively. Species richness is a measure of the number of species and is known as the Menhinick's index ($S$). Species diversity of fish was estimated by the Shannon-Wiener diversity index ($H'$), the Pielou's evenness index ($J'$), and the Simpson dominance index ($D$) were computed using the relative abundance of each species in each assemblage. Two-way crossed Analysis of Similarity test (ANOSIM; PAST Ver.3.26) (Hammer et al 2001) was used to assess whether biomass and number of fish differed or not spatially (among sampling sites) and temporally (months). The similarity matrix used in the ANOSIM test was calculated based on Bray-Curtis coefficients of pairs of individual samples.
3. Results and discussion

3.1. Environmental condition
The physico-chemical water parameters average (±SD) are presented in Table 1. Water temperature ranged from 29.45±0.56 to 29.73±0.52; salinity varied from 33.28±0.48 to 33.48±0.54; dissolved oxygen values aligned from 7.6±0 to 7.98±0.23. In terms of environmental conditions, Two-way ANOSIM revealed no major difference in all the three parameters between stations (p>0.05, R=0.123), but differed among months (p<0.05, R=0.895). The highest seagrass cover age ratio was observed at north station (33%), followed by south station (32%), east station (21%) and west station (20.7%). ANOSIM detected significant difference among all stations in terms of seagrass coverage (p<0.05, R=1.00).

Table 1. Mean (±SD) values of several physio-chemical and biological factors in various site of seagrass beds of Karang Congkak Island, Kepulauan Seribu.

| Site  | Water Temperature (°C) | Salinity (ppt) | Dissolved oxygen (mgL⁻¹) | Seagrass coverage ratio (%) |
|-------|------------------------|----------------|--------------------------|-----------------------------|
| East  | 29.73±0.52             | 32.8±0.96      | 7.85±0.13                | 21±0                        |
| South | 29.7±0.62              | 33.28±0.48     | 7.88±0.31                | 32±0                        |
| West  | 29.55±0.53             | 33.48±0.54     | 7.98±0.23                | 20.7±0                      |
| North | 29.45±0.56             | 32.98±0.70     | 7.6±0                    | 33±0                        |

3.2. Fish species composition, abundance and structure

In total, we counted approximately 10,000 individuals of 46 fish species belonging to 26 families across all sites (Table 2). The major families ranked by species number were Labridae (6 species), Apogonidae, Gobiidae, Siganidae (each with 4 species), and Atherinidae (3 species). The main families rated by numbers were Clupeidae, Atherinidae, Siganidae and Gerreidae; while families graded by biomass were Clupeidae, Siganidae, Atherinidae and Labridae (Figure 2). Regularly species, recorded for 81% of catches were silver-stripe round herring Spratelloides gracilis (43.4% of total abundances during the study period), followed by tropical silverside (Atherinomorus duodecimalis) (10.9%), Siganus canaliculatus (white-spotted spinefoot) (10.2%), Siganus virgatus (barhead spinefoot) (4.2%), Gerres oyena (common silver-biddy) (2.9%), Halichoeres argus (argus wrasse) (2.9%), Siganus spinus (little spinefoot) (2.4%), Stenatherina panatela (panatella silverside) (2.4%), Spratelloides delicatulus (delicate round herring) (1.5%) (Figure 3). Mostly of the individuals caught were of tiny body size or at the juvenile phase (> 90% of total number) (Table 2). It is likely these fishes to be reliant on seagrass meadows for refuge during their early life history. Some of the fish juveniles were economically important species and reef-associated fish such as Lutjanus fulviflamma, Lethrinus genivittatus, Epinephelus quoyanus, Siganus canaliculatus, S. punctatus, S. spinus, and S. virgatus (Table 2). This indicates that the seagrass beds of Karang Congkak Island may play role as nursery grounds for plenty of marine fish species. Other previous studies in tropical seagrass meadows are broadly in agreement with our results (Dorenbosch et al 2005, Kopp et al 2010, Kwak and Klumpp 2004, Nagelkerken et al 2002).
Figure 2. The uppermost abundant (weight and number) fish families collected in seagrass beds of Karang Congkak Island, Kepulauan Seribu National Park. (■ = weight), (udoku = number).

Figure 3. The most abundant fish species captured in seagrass beds of Karang Congkak Island, Kepulauan Seribu National Park. (■ = weight), (odu = number).
Table 2. Fish species collected from Karang Congkak Islands, Kepulauan Seribu National Park, Indonesia showing developmental stage, resident status, ranges of total length and body weight, and trophic guild.

| Fish Species | Common name                        | Stage | Resident Status | Total length (mm) | Body weight (g) | Trophic guild       |
|--------------|------------------------------------|-------|-----------------|-------------------|-----------------|---------------------|
| **Atherinidae** |                                    |       |                 |                   |                 |                     |
| Atherinomorus duodecimalis (Valenciennes. 1835) | Tropical silverside | J     | TR              | 14.0-67.0         | 0.02-5.32       | Crustasivore        |
| Hypoatherina temminckii (Bleeker. 1854) | Samoan silverside | J     | TR              | 13.0-22.5         | 0.01-0.14       | Zooplanktivore      |
| Stenatherina pandelea (Jordan & Richardson. 1908) | Panatella silverside | J     | TR              | 11.0-23.5         | 0.01-0.13       | Zooplanktivore      |
| **Belonidae** |                                    |       |                 |                   |                 |                     |
| Tylosurus crocodilus (Péron & Lesueur. 1821) | Crocodile needlefish | J     | OV              | 205.0-271.0       | 53.72-59.88     | Zooplanktivore      |
| **Blenniidae** |                                    |       |                 |                   |                 |                     |
| Meiacanthus grammistes (Valenciennes. 1836) | Striped poison-fang blenny | J     | OV              | 13.0-30.5         | 0.06-0.58       | Zooplanktivore      |
| **Clupeidae** |                                    |       |                 |                   |                 |                     |
| Spratelloides delicatulus (Bennett. 1832) | Delicate round herring | J     | RV              | 16.0-36.0         | 0.04-0.60       | Zooplanktivore      |
| Spratelloides gracilis (Temminck & Schlegel. 1846) | Silver-stripe round herring | J-A  | RV              | 14.0-58.0         | 0.03-1.10       | Zooplanktivore      |
| **Gobiidae** |                                    |       |                 |                   |                 |                     |
| Amblygobius phalaena (Valenciennes. 1837) | Whitebarred goby | J     | RV              | 16.5-22.0         | 0.08-0.22       | Zooplanktivore      |
| Amblygobius strophthalmus (Bleeker. 1851) | Freckled goby | J     | RV              | 23.0-42.0         | 0.88-1.72       | Zooplanktivore      |
| Istigobius ornatus (Rüppell. 1830) | Ornate goby | J     | RV              | 15.0-40.5         | 0.04-1.62       | Zooplanktivore      |
| Valenciennea longipinnis ( Hayward & Bennett. 1839) | Long-finned goby | J     | RV              | 32.5-89.0         | 0.64-14.03      | Zooplanktivore      |
| **Ambassidae** |                                    |       |                 |                   |                 |                     |
| Ambassis vachelli Richardson, 1846 | Vachelli's glass perchlet | J     | OV              | 19.5-21.0         | 0.16-0.20       | Zooplanktivore      |
| **Apo gonidae** |                                    |       |                 |                   |                 |                     |
| Chelodipterus quinquelineatus (Cuvier. 1828) | Five-lined cardinalfish | J     | TR              | 19.0-31.5         | 0.10-1.16       | Crustasivore        |
| Fibramia lateralis (Valenciennes. 1832) | Humpback cardinal | J     | TR              | 12.0-21.0         | 0.04-0.22       | Crustasivore        |
| Ostorhinchus marginotrophus (Bleeker. 1855) | Red-striped cardinalfish | J     | PR              | 14.0-41.0         | 0.06-1.72       | Zooplanktivore      |
| Sphaeramia orbicularis (Cuvier. 1828) | Orbiculate cardinalfish | J     | OV              | 16               | 0.14            | Zooplanktivore      |
| **Callionymidae** |                                   |       |                 |                   |                 |                     |
| Anaora tentaculata (Gray. 1835) | Tentacled dragonet | J     | RV              | 16.0-37.5         | 0.10-1.14       | Zooplanktivore      |
Table 2. (continued).

| Fish Species       | Common name                      | Stage | Resident Status | Total length (mm) | Body weight (g) | Trophic guild      |
|--------------------|----------------------------------|-------|-----------------|-------------------|-----------------|--------------------|
| **Centrogenyidae** | *Centrogenys vaigiensis* (Quoy & Gaimard. 1824) | False scorpionfish | J     | OV   | 99        | 25.58              | Crustasivore       |
| **Chaetodontidae** | *Parachetodon ocellatus* (Cuvier. 1831) | Sixspine butterflyfish | J     | OV   | 20.0-21.0  | 0.58-0.64          | Zoobenthivore      |
| **Gerreidae**      | *Gerres oyena* (Forsskål. 1775)  | Common silver-biddy   | J     | TR   | 8.5-42.5  | 0.01-2.02          | Zooplanktvore      |
| **Labridae**       | *Chlorodon anchorage* (Bloch. 1791) | Orange-dotted tuskfish | J     | RV   | 20.0-27.0  | 0.14-0.24          | Zooplanktvore      |
|                    | *Halichoeres argus* (Bloch & Schneider. 1801) | Argus wrasse           | J-A   | RV   | 19.0-62.0  | 0.20-5.26          | Zooplanktvore      |
|                    | *Halichoeres bicolor* (Bloch & Schneider. 1801) | Pearly-spotted wrasse  | J-A   | RV   | 22.0-86.5  | 0.20-16.25         | Zooplanktvore      |
|                    | *Halichoeres chloropterus* (Bloch. 1791) | Pastel-green wrasse    | J     | RV   | 89.5      | 21.26              | Zooplanktvore      |
|                    | *Halichoeres margaritaceus* (Valenciennes. 1839) | Pink-belly wrasse      | A     | RV   | 79        | 14.54              | Zooplanktvore      |
|                    | *Stethojulis strigiventer* (Bennett. 1833) | Three-ribbon wrasse    | J     | RV   | 18.5-60.0  | 0.14-4.82          | Zooplanktvore      |
| **Lethrinidae**    | *Lethrinus genivittatus* (Valenciennes. 1830) | Longspine emperor      | J     | TR   | 13.0-55.0  | 0.10-2.76          | Crustasivore       |
| **Lutjanidae**     | *Lutjanus fulviflamma* (Forsskål. 1775) | Dory snapper           | J     | OV   | 17.5      | 0.2                | Crustasivore       |
| **Mullidae**       | *Upeneus tragula* (Richardson. 1846) | Freckled goatfish      | J     | OV   | 30        | 0.52               | Crustasivore       |
| **Nemipteridae**   | *Pentapodus trivittatus* (Bloch. 1791) | Three-striped whiptail | J     | TR   | 29.0-101.5 | 0.8-27.7           | Crustasivore       |
|                    | *Scolopsis ciliata* (Lacepède. 1802) | Saw-jawed monocle bream | J     | OV   | 32        | 0.68               | Crustasivore       |
| **Pomacentridae**  | *Acanthochromis polyacanthus* (Bleeker. 1855) | Spiny chromis         | J     | OV   | 58        | 9.52               | Zooplanktvore      |
|                    | *Dischistodus perspicillatus* (Cuvier. 1830) | White damsel          | A     | OV   | 68        | 15.44              | Crustasivore       |
| **Pseudochromidae**| *Congrogadus subducens* (Richardson. 1843) | Green wolf eel        | A     | OV   | 217       | 43.44              | Crustacivore       |
| **Scaridae**       | *Scarus ghobban* (Forsskål. 1775) | Blue-barred parrotfish | J     | TR   | 18.0-22.0 | 0.16-0.30          | Zooplanktvore      |
Table 2. (continued).

| Fish Species | Common name                     | Stage | Resident Status | Total length (mm) | Body weight (g) | Trophic guild |
|--------------|---------------------------------|-------|-----------------|-------------------|-----------------|---------------|
| Scaridae     | Scarus ghobban (Forsskål. 1775) | Blue-barred parrotfish | J TR | 18.0-22.0 | 0.16-0.30 | Zooplanktivore |
| Serranidae   | Epinephelus quoyanus (Valenciennes. 1830) | Longfin grouper | J OV | 88.5 | 23.34 | Crustasivore |
| Siganidae    | Siganus canaliculatus (Park. 1797) | White-spotted spinefoot | J TR | 16.0-36.5 | 0.24-1.34 | Crustasivore |
|              | Siganus punctatus (Schneider & Forster. 1801) | Goldspotted spinefoot | J OV | 43 | 2.42 | Crustasivore |
|              | Siganus spinus (Linnaeus. 1758) | Little spinefoot | J TR | 15.5-24.5 | 0.08-0.38 | Crustasivore |
|              | Siganus virgatus (Valenciennes. 1835) | Barhead spinefoot | J TR | 15.5-38.0 | 0.22-1.68 | Crustasivore |
| Sphyraenidae | Sphyraena barracuda Edwards. 1771) | Great barracuda | J OV | 18.0-71.5 | 0.04-2.96 | Crustasivore |
| Terapontidae | Pelates quadrilineatus (Bloch. 1790) | Fourlined terapon | J TR | 16.0-32.0 | 0.10-0.64 | Zooplanktivore |
| Centriscidae | Aeoliscus strigatus (Günther. 1861) | Razorfish | J PR | 33.0-50.0 | 0.04-0.24 | Crustasivore |
| Soleidae     | Pardachirus pavoninus (Lacepède. 1802) | Peacock sole | J RV | 62.0-117.0 | 5.04-41.36 | Zooplanktivore |
| Monacanthidae| Acreichthys tomentosus (Linnaeus. 1758) | Bristle-tail file-fish | J RV | 20.0-72.0 | 1.02-15.66 | Zooplanktivore |
|              | Chaetodermis penicilligerus (Cuvier. 1816) | Prickly leather-jacket | J RV | 117 | 69.48 | Crustasivore |

Note: Developmental stage (J: juvenile, A: adult, based on the first length maturity (Lm)) (Fishbase 2019), resident status (PR: permanent resident, TR: temporary resident, RV: regular visitor, OV: occasional visitor, after Gillanders 2006), trophic guild data from gut contents analysis (Fishbase 2019, Simanjuntak. unpublished).
Two-way ANOSIM noticed no significant difference between stations in the mean number of fish (p>0.05, R = 0.34) and months (p>0.05, R = 0.11). In addition, ANOSIM also revealed similarity in fish biomass among stations (p>0.05, R = 0.03) and months (p>0.05, R = 0.17). Two-way ANOSIM indicated no considerable difference in the mean of species richness, diversity, evenness and dominance of fish assemblages among stations (p>0.05, R = 0.13) and months (p>0.05, R = 0.31). However, species richness and diversity index were higher in east and north part of Karang Congkak Island (figure 4). Since the Karang Congkak Island is a small island with a few different in seagrass coverage ratio, surrounded by fringing reef and its water physico-chemical conditions was relatively similar among stations, therefore, it can be accepted that number and biomass of fish assemblage were not significantly different among stations. Some studies reported that fish diversity and abundance were considerably greater in seagrass beds than in unvegetated areas (Espino et al 2015, Park and Kwak 2018).

![Figure 4](image-url)

Figure 4. Mean (± SE) of species richness (S), diversity index (H'), evenness index (J) and dominance index of fish assemblages in Karang Congkak Island, Kepulauan Seribu National Park.

Regarding inhabitant status in seagrass beds, about 51% of fish was categorized temporary resident (TR), while 39.7% as regular visitor (RV), 1% as permanent resident (PR) and 0.3% as occasionally visitor (OR) (figure 5, table 2). Temporary resident means that fish only utilize seagrass for a little part of their life cycle (i.e. postflexion larva or juvenile settle in the seagrass beds from pelagic state and then move to other habitat at bigger sizes) or use seagrass as a shelter or refugia from predator or as feeding habitat (Gillanders 2006). Four of five predominant species in seagrass beds of Karang Congkak Island namely *Stenatherina panatela*, *Siganus canaliculatus*, *Gerres oyena*, and *Siganus spinus* were grouped as temporary resident. In this study, we found juveniles of longspine emperor (*Lethrinus genivittatus*) in seagrass beds. The subadults and adults of emperor fishes inhabit coral habitats and utilizing the seagrass meadows as potential nursery habitats (Nakamura et al 2009). Therefore, this species shows an ontogeny habitat shift. Silver-stripe round herring (*Spratelloides gracilis*) as the most plentiful fish species is classified as regular visitor (RV). They regularly visit seagrass beds as inshore schooling for feeding purposes, especially foraging zooplankton from Calanoid copepods as their main diet (Milton et al 1990). Fishes that are large in number on coastal area and might also present in few amounts on seagrass meadows are recognized as occasionally visitor (OR) in seagrass beds. Some juveniles of carnivorous fishes that known as occasionally visitor were recorded in this present study, e.g. crocodile
needlefish (*Tylosurus crocodilus*), dory snapper (*Lutjanus fulviflamma*), longfin grouper (*Epinephelus quoyanus*), saw-jawed monocle bream (*Scolopsis ciliata*) and great barracuda (*Sphyraena barracuda*). They take advantage from tidal cycle to visit seagrass habitats for feeding intention (Lee *et al* 2014). Permanent residents (PR) are normally tiny in size and cryptic. Fishes inhabit seagrass beds throughout their entire life cycle are called permanent residents (PR). Probably some cryptic species inhabit seagrass of Karang Congkak Island could not collected due to the limitles s of our gear. However, in this study we identified resident species such as red-striped cardinalfish (*Ostorhinchus margaritophorus*) and razorfish (*Aeoliscus strigatus*). Gillanders (2006) stated that some of syngnathids and atherinids are resident species and they spawn in nearshore seagrass areas.

![Figure 5](image)

**Figure 5.** Residential status of fishes collected in in Karang Congkak Island.

PR = permanent resident, RV = regular visitor, TR = temporary resident, OV = occasionally visitor.

### 3.3. Fish trophic structure

The trophic functions of all fish species are presented in table 2. Data and information were obtained from examines of gut contents (Simanjuntak, unpublished) and generated from FishBase (2019). Three of the five most abundance fish in the captures viz. silver-stripe round herring, panatella silverside, common silver-biddy were zooplanktivores, mainly consumed on copepods; while little spinefoot and white-spotted spinefoot were algivore (herbivore), primarily feed on seagrass and epiphytic materials. A huge number of planktonic-animal feeders in seagrass beds indicates that planktonic animals were considerable as one main prey for the present seagrass fishes. Our result broadly consistent with previous research on feeding ecology of fishes in temperate seagrass (Horinouchi and Sano 2000). There was a small fraction of predators in the fish caught. Even though the number of individuals was not large, but diversity of predatory fish was high. At least 15 predator fish juveniles inhabited seagrass beds of Karang Congkak Island, namely videlicet tropical silverside, five-lined cardinalfish, humpback cardinal, false scorpionfish, longspine emperor, dory snapper, freckled goatfish, three-striped whiptail, saw-jawed monocle bream, white damsel, green wolf eel, longfin grouper, great barracuda, razorfish and prickly leather-jacket. Most of them were invertebrate feeders, particularly feeds on crustaceans (crustacivores). Seagrass beds supply essential feeding areas for fish due to the great number of invertebrate fauna that they support (Horinouchi *et al* 2012, Nakamura and Sano 2005). Moreover, most of fishes inhabit seagrass beds utilize small crustaceans as their main diet (Nakamura *et al* 2003). In short, from view point of feeding habits, it can be determined that seagrass beds of Karang Congkak Island, KSNP are important feeding habitats for fish juveniles.
4. Conclusion

In summation, our study suggests that the seagrass beds of Karang Congkak Island are harbor for lots of small fishes or fish juveniles. Fish juveniles use seagrass beds as feeding habitats and shelter or refugia from predators. Most of juveniles inhabit present seagrass habitats as temporary resident and regular visitor. Accordingly, the current study identifies seagrass beds of Karang Congkak Island as nursery habitat for fish juveniles. To the best of our knowledge, this research was the first comprehensive research exploring fish juveniles in seagrass beds of Kepulauan Seribu, National Park (KSNP), Indonesia. The results of this research are useful for rehabilitation of seagrass ecosystem as well as coastal fisheries management efforts in KSNP.

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References

Adams A J, Locascio J V, Robbins B D 2004 Microhabitat use by a post-settlement stage estuarine fish: evidence from relative abundance and predation among habitats J. Exp. Mar. Biol. Ecol. 299 17-33
Adams A J, Dahlgren C P, Kellison GT, Kendall M S, Layman C A, Ley J A, Nagelkerken I and Serafy J E 2006 Nursery function of tropical back-reef systems Mar. Ecol. Prog. Ser. 318 287-301
Aguilar-Perera A and Appeldoorn RS 2007 Variation in juvenile fish density along the mangrove–seagrass–coral reef continuum in SW Puerto Rico Mar. Ecol. Prog. Ser. 348 139-148
Allen G 1997 Marine Fishes of Tropical Australia and South-East Asia (Perth:Western Australian Museum) p 292
Allen G R and Erdmann M V 2012 Reef Fishes of the East Indies Vol I–III (Perth:Tropical Reef Research) p 1, 292
Ambo-Rappe R, Nessa M N, Latuconsina H and Lajus D L 2013 Relationship between the tropical seagrass bed characteristics and the structure of the associated fish community Open Journal of Ecology 3 331-342
Arkema K K, Rogers L A, Toft J, Mesher A, Wyatt K H, Albury-Smith S, Moultrie S, Ruckelshaus M H and Samhouri J 2019 Integrating fisheries management into sustainable development planning Ecol. Soc. 24 p 1
Azkab H M 1999 Pedoman inventarisasi lamun J. Oseana 24 1-6
Carpenter K E and Niem V H (eds) 1999a FAO species identification guide for fishery purposes. The living marine resources of the Western Central Pacific Vol 3 Batoid fishes, chimaeras and bony fishes part 1 (Elopidae to Linophrynidae) (FAO: Rome) pp 1397-2068
Carpenter K E and Niem V H (eds) 1999b FAO species identification guide for fishery purposes. The living marine resources of the Western Central Pacific Vol 4 Bony fishes part 2 (Mugilidae to Carangidae) (FAO: Rome) pp 2069-2790
Carpenter K E and Niem V H (eds) 2001a FAO species identification guide for fishery purposes. The living marine resources of the Western Central Pacific Vol 5 Bony fishes part 3 (Menidae to Pomacentridae) (FAO: Rome) pp 2791-3380
Carpenter K E and Niem V H (eds) 2001b FAO species identification guide for fishery purposes. The living marine resources of the Western Central Pacific Vol 6 Bony fishes part 4 (Labridae to Latimeriidae), estuarine crocodiles, sea turtles, sea snakes and marine mammals. (FAO: Rome) pp 3381-4218
Connolly R M 1994 Removal of seagrass canopy: effects on small fish and their prey J. Exp. Mar. Biol. Ecol. 184 99-110
Dorenbosch M, Grol M G G, Christianen M J A, Nagelkerken I, and van der Velde G 2005 Indo-Pacific seagrass beds and mangroves contribute to fish density and diversity on adjacent coral reefs Mar. Ecol. Prog. Ser. 302 63-76
Edrus I N and Hartati S T 2013 Komposisi jenis, kepadatan dan keanekaragaman juvenile ikan pada padang lamun gugus Pulau Pari Bawal 5 9-22
Espino F, González J A, Haroun R and Tuya F 2015 Abundance and biomass of the parrotfish Sparisoma cretense in seagrass meadows: temporal and spatial differences between seagrass interiors and seagrass adjacent to reefs Environ. Biol. Fish. 98 21-133
Fajarwati S D, Setianingsih A I and Muzani 2015 Analisis kondisi lamun (seagrass) di perairan Pulau Pramuka, Kepulauan Seribu Jurnal SPATIAL: Wahana Komunikasi dan Informasi Geografi 13 (1) 22-32
Gillanders B M 2006 Seagrasses, Fish, and Fisheries Seagrasses: Biology, Ecology and Conservation eds A W D Larkum et al (Dordrecht: Springer) pp 503-536
Hammer Ø, Harper D A T and Ryan P D 2001 PAST: Paleontological Statistics Software Package for Education and Data Analysis Palaeontologia Electronica 4 (1) 9
Heck K L, Hays G and Orth R J 2003 Critical evaluation of the nursery role hypothesis for seagrass meadows Mar. Ecol. Prog. Ser. 253 123-136
Hidayati N and Suparmoko M 2018 Fish assemblage structure in relation to seagrass bed in Tidung Kecil Island, Kepulauan Seribu E3S Web of Conferences 74, 02005
Horinouchi M 2005 A comparison of fish assemblages from seagrass beds and the adjacent bare substrata in Lake Hamana, central Japan Laguna 12 69-72
Horinouchi M and Sano M 2000 Food habits of fishes in a Zostera marina bed at Aburatsubo, central Japan Ichthyol Res 47 163-173
Horinouchi M, Tongnumui P, Furumitsu K, Nakamura Y, Kanou K, Yamaguchi A, Okamoto K and Sano M 2012 Food habits of small fishes in seagrass habitats in Trang, southern Thailand Fish Sci 78 577-587
Hyndes G A, Francour P, Guidetti P, Heck Jr K L and Jenkins G 2018 The roles of seagrasses in structuring associated fish assemblages and fisheries Seagrasses of Australia eds AWD Larkum et al (Cham Switzerland: Springer International Publishing) pp 589-627
Irawan A, Supriharyono, Hutabarat J, Ambariyanto 2018 Seagrass beds as the buffer zone for fish biodiversity in coastal water of Bontang City, East Kalimantan, Indonesia Biodiversitas 19 (3) 1044-1053
Jaxion-Harm J, Saunders J and Speight M R 2012 Distribution of fish in seagrass, mangroves and coral reefs: life-stage dependent habitat use in Honduras Rev. Biol. Trop. 60 (2) 683-698
Kimirei I A, Nagelkerken I, Griffioen B, Wagner C, Mgaya Y D 2011 Ontogenetic habitat use by mangrove/seagrass-associated coral reef fishes shows flexibility in time and space Estuar. Coast. Shelf Sci. 92 47-58
Kopp D, e Bouchon-Navaro Y, Louis M, Mouillot D, and Bouchon C 2010 Juvenile fish assemblages in Caribbean seagrass beds: does nearby habitat matter? J Coast Res 26 (6):1133-1141
Kuiter R H and Tonozuka T 2001 Pictorial Guide to Indonesian Reef Fishes (Melbourne: Zoonetics) p 895
Kwak S N and Klumpp D W 2004 Temporal variation in species composition and abundance of fish and decapods of a tropical seagrass bed in Cockle Bay, North Queensland, Australia Aquatic Botany 78 119-134
Lee Chen-Lu, Huang Yen-Hsun, Chung Chia-Yun and Lin Hsing-Juh 2014 Tidal variation in fish assemblages and trophic structures in tropical Indo-Pacific seagrass beds Zoological Studies 53 56
Lee Chen-Lu, Wen C K C, Huang Yen-Hsun, Chung Chia-Yun and Lin Hsing-Juh 2019 Ontogenetic habitat usage of juvenile carnivorous fish among seagrass-coral mosaic habitats Diversity 11 25 doi:10.3390/d11020025
Lee D Q, Tanaka T, Hii Y S, Sano Y, Nanjo K, Shirai K 2018 Importance of seagrass-mangrove continuum as feeding grounds for juvenile pink ear emperor Lethrinus lentjan in Setiu Lagoon, Malaysia: Stable isotope approach J. Sea Res. 135 1–10

McKenzie L J, Campbell S J and Roder C A 2003 Seagrass-Watch: Manual for Mapping and Monitoring Seagrass Resources by Community (Citizen) Volunteers 2nd Edition (Marine Plant Ecology Group: Cairns)

Milton D A, Blaber S J M and Rawlinson N J F 1990 Age and growth of major baitfish species in Solomon Islands and Maldives In: Blaber S J M, Copland JW (eds) Tuna baitfish in the Indo-Pacific region ACIAR Proc 30 134-140

Nadiarti, Riani E, Djuwita I, Budiharsono S, Purbayanto A and Asmus H 2012 Challenging for seagrass management in Indonesia J. Coast. Dev. 15 234-242

Nagelkerken I and van der Velde G 2004 A comparison of fish communities of subtidal seagrass beds and sandy seaboards in 13 marine embayments of a Caribbean Island, based on species, family, size distribution and functional groups J. Sea Res. 52 127-147

Nagelkerken I, Roberts CM, van der Velde G, Dorenbosch M, van Riel MC, de la Morinière E C, Nienhuis P H 2002 How important are mangroves and seagrass beds for coral-reef fish? The nursery hypothesis tested on an island scale Mar Ecol Prog Ser 244: 299-305

Nakamura Y, Horinouchi M, Nakai T, and Sano M 2003 Food habits of fishes in a seagrass bed on a fringing coral reef at Iriomote Island, southern Japan Ichthyol Res 50 15-22

Nakamura Y and Sano M 2004 Comparison between community structures of fishes in Enhalus acoroides- and Thalassia hemprichii-dominated seagrass beds on fringing coral reefs in the Ryukyu Islands, Japan Ichthyol. Res. 51 38-45

Nakamura Y and Sano M 2005 Comparison of invertebrate abundance in a Seagrass bed and adjacent coral and sand areas at Amitoru Bay, Iriomote Island, Japan. Fish Sci 71 543-550

Nakamura Y, Horinouchi M, Sano M, and Shibuno T 2009 The effects of distance from coral reefs on seagrass nursery use by 5 emperor fishes at the southern Ryukyu Islands, Japan Fish Sci 75 1401-1408

Nakamura Y, Hirota K, Shibuno T, Watanabe Y 2012 Variability in nursery function of tropical seagrass beds during fish ontogeny: timing of ontogenetic habitat shift Mar. Biol. 159 1305-1315

Nuraini S, Carballo E C, van Densen W L T, Machiels M A M, Lindeboom H J, Nagelkerke L A J 2007 Utilization of seagrass habitats by juvenile groupers and snappers in Banten Bay, Banten Province, Indonesia Hydrobiologia 591 85-98

Park J M and Kwak S N 2018 Seagrass fish assemblages in the Namhae Island, Korea: the influences of seagrass vegetation and biomass J. Sea Res 139 41-49

Ralph P J, Tomasko D, Moore K, Seddon S, and Macinnis-Ng C M O 2006 Human impacts on seagrasses: eutrophication, sedimentation, and contamination Seagrasses: Biology, Ecology and Conservation eds A W D Larkum et al (Dordrecht: Springer) pp 567-593

Smith K A and Sinerchia M 2004 Timing of recruitment events, residence periods and post-settlement growth of juvenile fish in a seagrass meadow, south-eastern Australia Environ. Biol. Fish. 71: 73-84

Susilo E S, Sugianto D N, Munasik, Nirwani, Suryono C A 2018 Seagrass Parameter Affect the Fish Assemblages in Karimunjawa Archipelago IOP Conf. Series: Earth and Environmental Science 116 012058

Syahailatua A and Nuraini S 2011 Fish species composition in seagrass beds of Tanjung Merah (North Sulawesi), Indonesia Mar. Res. Indonesia 36 1-10

Unsworth R K F, Wylie E, Smith D J and Bell J J 2007 Diel trophic structuring of seagrass bed fish assemblages in the Wakatobi Marine National Park, Indonesia Estuar. Coast. Shelf Sci. 72 81-88Unsworth R K F, De León P S, Garrard S L, Jompa J, Smith D J and Bell J J 2008 High connectivity of Indo-Pacific seagrass fish assemblages with mangrove and coral reef habitats Mar. Ecol. Prog. Ser. 353 213-224
Unsworth R K F, Garrard S L, De León P S, Cullen L C, Smith D J, Sloman K A and Bell J J 2009 Structuring of Indo-Pacific fish assemblages along the mangrove–seagrass continuum *Aquat. Biol.* 5 85-95

Unsworth R K F and Cullen L C 2010 Recognising the necessity for Indo-Pacific seagrass conservation *Conserv. Lett.* 3 63-73

Unsworth R K F, Hinder S L, Bodger OG and Cullen-Unsworth LC 2014 Food supply depends on seagrass meadows in the coral triangle *Environ. Res. Lett.* 9 094005

Unsworth R K F, Ambo-Rappe R, Jones B L, La Nafie Y A, Irawan A, Hernawan U E, Moore A M, Cullen-Unsworth L C 2018 Indonesia's globally significant seagrass meadows are under widespread threat *Sci. Total Environ.* 634 279-286

Vonk J A, Christianen M J A and Stapel J 2010 Abundance, edge effect, and seasonality of fauna in mixed-species seagrass meadows in southwest Sulawesi, Indonesia *Mar. Biol. Res.* 6 282-291