

Commercial marine fish species from Weh Island, Indonesia: Checklist, distribution pattern and conservation status

ILHAM ZULFAHMI^{1,*}, MAURIZA APRIANSYAH², AGUNG SETIA BATUBARA³, NERI KAUTSARI⁴,
KIZAR AHMED SUMON⁵, MOHAMMAD MAHMUDUR RAHMAN⁶, FIRMAN M. NUR⁷

¹Department of Fisheries Resources Utilization, Faculty of Marine and Fisheries, Universitas Syiah Kuala. Jl. Syech Abdurrauf No. 3, Kopelma Darussalam, Syiah Kuala, Banda Aceh 23111, Aceh, Indonesia. Tel.: +62-651-7410248, Fax.: +62-651-755138, *email: ilham.zulfahmi@unsyiah.ac.id

²Center for Aquatic Research and Conservation, Universitas Islam Negeri Ar-Raniry. Jl. Kota Pelajar dan Mahasiswa, Darussalam, Banda Aceh 23111, Aceh, Indonesia

³Department of Biology, Faculty of Mathematics and Natural Sciences, Universitas Negeri Medan. Jl. Willem Iskandar/Pasar V, Medan 20221, North Sumatra, Indonesia

⁴Department of Aquatic Resources Management, Faculty of Animal Science and Fisheries, Universitas Samawa. Jl. Bypass Sering, Kerato, Unter Iwes, Sumbawa 84316, West Nusa Tenggara, Indonesia

⁵Department of Fisheries Management, Faculty of Fisheries, Bangladesh Agricultural University. BAU Main Rd, Mymensingh 2202, Bangladesh

⁶Global Centre for Environmental Remediation, College of Engineering, Science and Environment, University of Newcastle. Callaghan, NSW 2308, Australia

⁷Graduate School of Mathematics and Applied Science, Universitas Syiah Kuala. Jl. Syech Abdurrauf No. 3, Kopelma Darussalam, Syiah Kuala, Banda Aceh 23111, Aceh, Indonesia

Manuscript received: 15 February 2022. Revision accepted: 23 March 2022.

Abstract. Zulfahmi I, Apriansyah M, Batubara AS, Kautsari N, Sumon KA, Rahman MM, Nur FM. 2022. Commercial marine fish species from Weh Island, Indonesia: Checklist, distribution pattern and conservation status. *Biodiversitas* 23: 1977-1989. In this study, we first report a systematic checklist of commercial marine fish species from Weh Island, Indonesia, including notes on their distribution pattern, conservation status, and commercial value. Fish sampling was conducted at three major fish markets in Weh Island, and these specifically were Cangkoan Fish Market, Kuta Timu Fish Market, and Balohan Fish Market. A total of 50 fish species belonging to 8 orders and 24 families were documented. Carangidae (12%, 6 species) was the predominant family, followed by the Scaridae (10%, 5 species) and other families (78%, 22 families, 39 species). Based on the IUCN red list, commercial marine fish species in Weh Island were dominated by the "Least Concern" category (78%, 39 species), followed by the "Not Evaluated" (14%, 7 species), the "Near Threatened" (4%, 2 species), and the "Data Deficient" (4%, 2 species). The market price of the fish ranged from 0.34 USD/kg to 6.19 USD/kg, with three fish families included in the high commercial value, namely the Clupeidae, Carcharhinidae, and Serranidae.

Keywords: Carangidae, distribution pattern, fish market, high commercial value, least concern category

INTRODUCTION

The waters around Weh Island are considered one of the world's highest marine biodiversity ecosystems (Baird et al. 2011; Rudi et al. 2012). At least 350 coral fish species, including 30 families, were documented in earlier research (e.g., Rudi et al. 2012; Hastuty et al. 2014; Fadli et al. 2020). To date, studies conducted on the fish fauna in Weh Island are scarce. For example, some studies focused only on identifying reef fishes (Fadli et al. 2020; Fadli et al. 2021), reef fish diversity (Baird et al. 2011; Rudi et al. 2012), reef fisheries management (Yulianto and Wiryawan 2011; Campbell et al. 2012), and coral reef conservation programs (Fadli et al. 2012; Kusumawati and Huang 2015). To the best of our knowledge, there is a dearth of information on the checklist, distribution, conservation status, and commercial value of commercial marine fish species (mainly for pelagic fish) collected from this area. Nevertheless, these data are indispensable as the first step in developing fisheries management plans, conservation strategies, and sustainable exploitation. Studies related to fish species inventory are required to ensure both effective

ecological and economic management (Chang 2014; Shamsuzzaman et al. 2020).

Fish exploitation in Weh Island has been practiced since the 17th century and has risen significantly over the last three decades (Yulianto and Wiryawan 2011; Campbell et al. 2012). To date, Weh Island waters have suffered from intense tourism and human intervention (Arif et al. 2020), over-exploitation (Kusumawati and Huang 2015), climate change (Ilhamsyah et al. 2014) and the use of destructive fishing equipment (Campbell et al. 2012). These serious problems may have an adverse impact on the ecosystem and the sustainability of fish. Moreover, Indonesia is one of the countries in Asia comprising predominantly vulnerable and endangered fish species (Dharmadi et al. 2015). Some fish species with vulnerable (VU), endangered (EN), and critically endangered (CR) conservation status are still traded in Indonesia, especially sharks and rays, for instance, *Alopias pelagicus*, *A. superciliosus*, *Isurus paucus*, *Prionace glauca*, *Maculabatis gerrardi* and *Rhina ancylostoma* (Dharmadi et al. 2015; Sembiring et al. 2015; Prasetyo et al. 2021). In addition to this, previous reports have shown that some coral reef fish that play an important

role in the reef ecosystem, such as families Acanthuridae, Siganidae, Pomacentridae, and Scaridae, are still sold in huge numbers with improper or negligent management (Campbell et al. 2014; Ferse et al. 2014; Madduppa et al. 2014).

The market value of fish is closely related to its abundance, including supply and demand, as well as its exploitation rate (Alfian et al. 2020). For example, low stocks or declining stocks increase the market value of several fish (Nur et al. 2022). Unfortunately, the exploitation rate rises with increasing demand for fish. Fish with high economic value and high demand are more vulnerable than those without these characteristics. At the same time, the fisheries sector can improve the socio-economic status of coastal communities directly by providing employment and sources of livelihood (Shamsuzzaman et al. 2020). Based on several studies, small-scale fisheries have become the most important sector of fish supply and livelihoods in many developing countries, including Indonesia (Béné et al. 2016; Stacey et al. 2019; Stacey et al. 2021). According to the Food and Agriculture Organization (FAO 2016), 95% of fishery production in Indonesia has come from small-scale fisheries where over six million people are involved. Thus, with effective and proper management, small-scale fisheries can contribute to the sustainability of the livelihoods of coastal communities (Halim et al. 2019).

Administratively, 16 of 18 villages in Weh Island are located along with the coastal areas (Yulianto and Wiryawan 2011). Thus, the dependence of coastal communities on fisheries resources is very high. Weh Island has seven fish markets; three of them are larger and more popular than the others, namely Cangkoan Fish Market, Kuta Timu Fish Market, and Balohan Fish Market. Fish markets are ideal places to investigate commercial fish species in a given area (Chang 2014). A fish market assessment can be a promising tool to gather baseline fisheries data, including fish composition, distribution pattern, exploitation rate, conservation status, and commercial value (Shellem et al. 2021). To the best of our knowledge, information related to commercial marine fish assessments collected from Weh Island's fish markets is still unexplored. Hence, this study was designed to provide a checklist of commercial marine fishes from Weh Island, focusing on their market distribution pattern, understanding the conservation status and assessing their commercial value.

MATERIALS AND METHODS

Study area and data collection

Weh Island (95°13'02"-95°22'36" E and 05°46'28"-05°54'-28" N) is located on the northern tip of Sumatra and surrounded by Andaman Sea, Malacca Strait, and Indian Ocean (Campbell et al. 2012; Fadli et al. 2020). Its coastal topography is characterized by a rocky substrate and white sand, with approximately 10% to 57% coral cover in the littoral waters zone (Baird et al. 2011; Utama and Hadi 2018). Data (fish fauna, local name, Indonesian name and fish price) were collected from the three fish markets in

Weh Island, namely Cangkoan Fish Market (95°18'56,36462" E, 5°50'39,0097" N), Kuta Timu Fish Market (95°18'56,36462" E, 5°50'39,0097" N), and Balohan Fish Market (95°20'45,47688" E, 5°49'44,65866" N). Briefly, Cangkoan Fish Market began operating in June 2020. This market operates every day during 06.30-12.00 Western Indonesian Time (WIB). The distance between the market and the closest fish landing place is around 250 m. Kuta Timu Fish Market is located on the north of Weh Island and is larger than the other two markets. The market operates every day during 06.30-13.00 WIB. The distance between the market and the closest fish landing place is around 1.5 km. Balohan Fish Market is located on the southeast of Weh Island, alongside the fish landing place of Balohan. The market operates every day from 07.00 to 12.00 WIB.

Collecting data started when fishmongers began supplying, displaying, and selling the fish and stopped when the market closed for the day (approximately from 06.00 to 13.00 WIB). Survey and sampling were conducted every day in each market during the wet season (September-November). Each fish species was documented using *Canon EOS 90D* from a vertical angle on a contrasting background and equipped with a ruler as a comparison scale. The photographs were edited using *Photoshop CS6*. The fish specimens that were difficult to identify via photography were preserved in 10% buffered formalin solution. Then they were transported to the Laboratory of Ecology, Faculty of Science and Technology, Universitas Islam Negeri Ar-Raniry for further identification.

Fish identification, distribution, conservation status and economic importance

Nomenclature and classification of the collected fish were identified by comparing the morphology and morphometric characteristics as well as fish color based on previous literature (White et al. 2013; Nelson et al. 2016; Betancur-R et al. 2017) and online references (<http://www.fishbase.org>). Local names and prices of each fish species were obtained by face-to-face interview and focus group discussion (FGD) with fishermen, fishmongers, and the district fisheries officers. In total 31 fishmongers (7 from Balohan Fish Market, 6 from Cangkoan Fish Market, and 18 from Kuta Timu Fish Market), 50 fishermen (10 from Balohan Fish Market, 10 from Cangkoan Fish Market, and 30 from Kuta Timu Fish Market) and 3 district fisheries officers (one person from each location) were interviewed for this research. Fish price was presented in Indonesian rupiah and United States dollar (1 USD = Rp 14,500). The commercial value of fish was divided into three categories, namely low commercial value (< Rp. 15,000/kg or < USD 1.03/kg), middle commercial value (Rp. 15,000 - 35,000/kg or USD 1.03-2.41/kg) and high commercial value (> Rp. 35,000/kg or > USD 2.41/kg). The market distribution pattern was noted based on the availability of fish in each of the three surveyed fish markets. The conservation status of each fish species was determined based on the Red List of Threatened Species by accessing the International Union

for Conservation of Nature (IUCN) website (<https://www.iucnredlist.org>). The obtained data were sorted based on taxonomy, distribution, conservation status, and commercial value. Data were presented in tables and diagrams and analyzed descriptively.

RESULTS AND DISCUSSION

Fish composition

A total of 50 different species of commercial marine fish belonging to 8 orders and 24 families were reported from the study (Table 1; Figures 1-4). Perciformes comprised the predominant order (17 families and 42 species; 84% of total species), followed by Tetraodontiformes (1 family and 2 species; 4% of total species). Meanwhile, Beloniformes, Beryciformes, Carcharhiniformes, Clupeiformes, Gonorynchiformes, and Mugiliformes were represented by 1 family and 1 species (2% of total species for each order). From 50 species collected, the most abundant family in descending order were the Carangidae (12%, 6 species), followed by the Scaridae (10%, 5 species), the Caesionidae, Lutjanidae, Scombridae, and Serranidae (8% of each, 4 species), and Mullidae and Nemipteridae (6% of each, 3 species). Additionally, the remaining 14 families consisted of each of one species (Table 1). Based on fish size, *Selaroides leptolepis* and *Carcharhinus melanopterus* were the shortest and the longest fish species observed during study with a total length of 12 cm (Figure 2.15) and 85 cm (Figure 1.3), respectively.

Market distribution pattern

The distribution patterns of fish species collected from three different fish markets are illustrated in Table 1, Figure 5, and Figure 6b. The highest number of fish species was reported in the Kuta Fish Market (47 species), followed by the Balohan fish market and Cangkoan fish market with 35 and 34 species, respectively (Table 1). Carangidae was a predominant family in all fish markets, ranging from 12-14% (Figure 5, lower graphic). There were differences in the next predominant family after Carangidae among three fish markets. For instance, Lutjanidae and Scombridae were predominant at the Cangkoan Fish Market, Scaridae and Serranidae at Kuta Timu Fish Market, and Scaridae and Scombridae dominated what was sold at the Balohan Fish Market. Twenty-six of 50 fish species (52%) were reported in all three markets. Nine fish species, including *Carcharhinus melanopterus*, *Caesio* sp. 1, *Caranx melampygus*, *Coryphaena hippurus*, *Halichoeres hortulanus*, *Parupeneus cyclostomus*, *Mulloidichthys vanicolensis*, *Scarus rubroviolaceus*, *Aethaloperca rogaa*, were only found at Kuta Timu fish market, while *Scarus niger* was only recorded at Balohan Fish Market (Figure 6b).

Conservation status

Based on the IUCN red list, 39 species (78%) of the collected fish were classified as the "Least Concern" category, which was dominated by the Carangidae family (6 species). Seven (14%) species were categorized as "Not Evaluated". The "Not Evaluated" category was dominated by the Caesionidae and Balistidae families that consisted of 2 species of each. Moreover, 2 species (4%) were categorized as "Near Threatened" which consisted of Carcharhinidae and Scombridae families. Two species (4%) belonging to the family Scombridae were categorized as "Data Deficient" (Table 1 and Figure 6a).

Economic importance

In terms of economic importance, 3 families were categorized as the high commercial value, including Clupeidae, Carcharhinidae, and Serranidae. Six families were categorized as of low commercial value: Kyphosidae, Belonidae, Siganidae, Coryphaenidae, Mugilidae, Balistidae. Meanwhile, 15 families were categorized as of medium commercial value category (Figure 7). Moreover, based on fish price, *Cephalopholis miniata* had the highest price range (Rp. 65,000-90,000/kg) while *Kyphosus cinerascens* had the lowest price-range (Rp. 5,000-7,000/kg) (Table 1).

Discussion

This study reported 50 commercial marine fish species belonging to 8 orders and 24 families. The number of fish orders reported in this study was slightly higher than a previous study conducted in Simeulu Island, Aceh (7 orders) (Batubara et al. 2017). This was still lower compared to different regions such as Pusong Bay, Aceh (15 orders) (Damora et al. 2020), Chiapas Mexico (30 orders) (González-Acosta et al. 2018), and the Persian Gulf (27 orders) (Eagderi et al. 2019). The fewer orders in our study might be due to the collected fish samples being limited to commercial marine fish, while other research considered the inventory for both commercial and non-commercial fish. To the best of our knowledge, research related to commercial marine fish inventories in Indonesia is still rare. Consequently, it is difficult to directly compare the composition of commercial marine fish among regions.

In our study, Perciformes was the predominant order of commercial marine fish in Weh Island, reaching 84% of the total surveyed fish (belonging to 17 families and 42 species). Virtually the same results were reported in several other studies in the Teluk Pusong Lhokseumawe (46%) (Damora et al. 2020), Simeulue Island (87%) (Batubara et al. 2017), Mangaluru coast (57%) (Kumar et al. 2020), Chiapas Mexico (46%) (González-Acosta et al. 2018), and the Persian Gulf (63%) (Eagderi et al. 2019). Taxonomically, the Perciformes order belongs to the highest number of families compared to other fish orders (160 families and ~10,000 species).

Table 1. Taxonomic classification, common name, local name, market distribution pattern, conservation status and price range of commercial marine fishes collected from the Weh Island, Indonesia.

Order/Family/Species	Common Name	Local Name	CN	KT	BN	IUCN	Price Range/Kg (Rp)
CLUPEIFORMES							
Clupeidae							
<i>Decapterus russelli</i>	Indian scad	Dencis	+	+	+	LC	30,000-50,000
GONORYNCHIFORMES							
Chanidae							
<i>Chanos chanos</i>	Milkfish	Muloh	+	+	+	LC	25,000-30,000
BERYCIFORMES							
Holocentridae							
<i>Myripristis berndti</i>	Blotcheye soldierfish	Serendang	+	+	+	LC	25,000-30,000
BELONIFORMES							
Belonidae							
<i>Tylosurus pacificus</i>	Pacific agujon needlefish	Todak	-	+	+	LC	10,000-12,000
MUGILIFORMES							
Mugilidae							
<i>Liza macrolepis</i>	Largescale mullet	Kadra	-	+	+	LC	10,000-20,000
TETRAODONTIFORMES							
Balistidae							
<i>Balistoides viridescens</i>	Titan triggerfish	Leubim	+	+	-	NE	10,000-20,000
<i>Odonus niger</i>	Redtooth triggerfish	Leubim sawi	+	+	-	NE	10,000-20,000
PERCIFORMES							
Caesionidae							
<i>Pterocaesio pisang</i>	Fusilier fish	Pisang biru	-	+	+	LC	15,000-18,000
<i>Caesio</i> sp. 1	Fusilier fish	Pisang karang	-	+		NE	25,000-30,000
<i>Caesio</i> sp. 2	Dark-banded fusilier	Pisang merah	+	+	+	NE	10,000-20,000
<i>Pterocaesio tile</i>	Dark-banded fusilier	Pisang perleng merah	+	+	+	LC	10,000-15,000
Carangidae							
<i>Caranx sexfasciatus</i>	Bigeye trevally	Aneuk merah mata	+	+	+	LC	30,000-40,000
<i>Gnathanodon speciosus</i>	Golden trevally	Aneuk langitok	+	+	+	LC	30,000-35,000
<i>Caranx melampygus</i>	Bluefin trevally	Langguran		+		LC	30,000-40,000
<i>Caranx tille</i>	Tille trevally	Rambeu	-	+	+	LC	30,000-40,000
<i>Selaroides leptolepis</i>	Yellowstripe scad	Turok	+	+	+	LC	20,000-25,000
<i>Selar crumenophthalmus</i>	Bigeye scad	Sumboo	+	+	+	LC	35,000-40,000
Coryphaenidae							
<i>Coryphaena hippurus</i>	Common dolphinfish	Parang	-	+	-	LC	12,000-15,000
Kyphosidae							
<i>Kyphosus cinerascens</i>	Blue sea chub	Arun	+	+	+	LC	5,000-7,000
Gerreidae							
<i>Gerres erythrourus</i>	Deep-bodied mojarra	Kapas-kapas	+	+	+	LC	25,000-30,000
Labridae							
<i>Halichoeres hortulanus</i>	Checkerboard wrasse	Bayam-bayam warna warni	-	+	-	LC	25,000-30,000

Leiognathidae							
<i>Eubleekeria splendens</i>	Splendid ponyfish	Ciriek	+	+	+	LC	20,000-30,000
Lutjanidae							
<i>Aphareus rutilans</i>	Rusty jobfish	Cangak	+	+	-	LC	30,000-35,000
<i>Lutjanus bengalensis</i>	Bengal snapper	Reumeng	+	+	-	LC	30,000-35,000
<i>Lutjanus lutjanus</i>	Bigeye snapper	Tapak-tapak	+	+	+	LC	15,000-20,000
<i>Pristipomoides multidens</i>	Goldbanded jobfish	Tuih/koli	+	-	+	LC	25,000-35,000
Menidae							
<i>Mene maculata</i>	Moonfish	Pilok	+	+	+	NE	30,000-40,000
Mullidae							
<i>Parupeneus cyclostomus</i>	Gold-saddle goatfish	Jenggot kuning	-	+	-	LC	30,000-35,000
<i>Mulloidichthys vanicolensis</i>	Yellowfin goatfish	Jenggot merah	-	+	-	LC	30,000-35,000
<i>Upeneus moluccensis</i>	Goldband goatfish	Biji nangka	-	+	+	LC	30,000-35,000
Nemipteridae							
<i>Scolopsis ciliata</i>	Saw-jawed monocle bream	Timun-timun sisek kuneng	+	+	+	LC	25,000-30,000
<i>Scolopsis bilineata</i>	Two-lined monocle bream	Korek api	+	+	-	LC	25,000-30,000
<i>Nemipterus isacanthus</i>	Teardrop threadfin bream	Top	+	-	+	NE	20,000-25,000
Pempheridae							
<i>Pempheris oualensis</i>	Silver sweeper	Sepat	+	+	+	NE	15,000-25,000
Pomacentridae							
<i>Abudefduf vaigiensis</i>	Indo-pacific sergeant	Beulang	+	+	+	LC	15,000-20,000
Scaridae							
<i>Scarus tricolor</i>	Tricolour parrotfish	Bayam-bayam iku oren	+	+	+	LC	25,000-30,000
<i>Scarus quoyi</i>	Quoy's parrotfish	Bayam-bayam ijo	+	+	+	LC	25,000-30,000
<i>Scarus rubroviolaceus</i>	Ember parrotfish	Bayam-bayam mirah hitam	-	+	-	LC	25,000-30,000
<i>Calotomus carolinus</i>	Caroline parrotfish	Bayam-bayam oren	-	+	+	LC	25,000-30,000
<i>Scarus niger</i>	Dusky parrotfish	Bayam-bayam mirah	-	-	+	LC	25,000-30,000
Scombridae							
<i>Rastrelliger kanagurta</i>	Indian mackerel	Jeunara	+	+	+	DD	30,000-35,000
<i>Thunnus tonggol</i>	Longtail tuna	Tuna	+	+	+	DD	25,000-40,000
<i>Euthynnus affinis</i>	Kawakawa	Sure keumong	+	+	+	LC	20,000-25,000
<i>Scomberomorus commerson</i>	Narrow-barred spanish mackerel	Tenggiri	+	+	+	NT	30,000-40,000
Serranidae							
<i>Cephalopholis miniata</i>	Coral hind	Grapee mirah	+	+	+	LC	65,000-90,000
<i>Cephalopholis argus</i>	Peacock grouper	Grapee minyeuk	+	+	+	LC	35,000-70,000
<i>Epinephelus spilotoceps</i>	Foursaddle grouper	Grapee delima	+	+	+	LC	40,000-80,000
<i>Aethaloperca rogaa</i>	Redmouth grouper	Grapee hitam	-	+	-	LC	30,000-60,000
Siganidae							
<i>Siganus javus</i>	Java rabbitfish	Baronang	+	+	-	LC	10,000-15,000
CARCHARHINIFORMES							
Carcharhinidae							
<i>Carcharhinus melanopterus</i>	Blacktip reef shark	Yee	-	+	-	NT	40,000-45,000

Note: Market Location: CN: Cangkoan fish market, KT: Kuta Timu fish market and BN: Balohan fish market. Global conservation status according to IUCN (2020): NE: not evaluated, LC: least concern, NT: near threatened and DD: data deficient. Price range presented in Indonesian Rupiah (1USD = Rp 14,500)

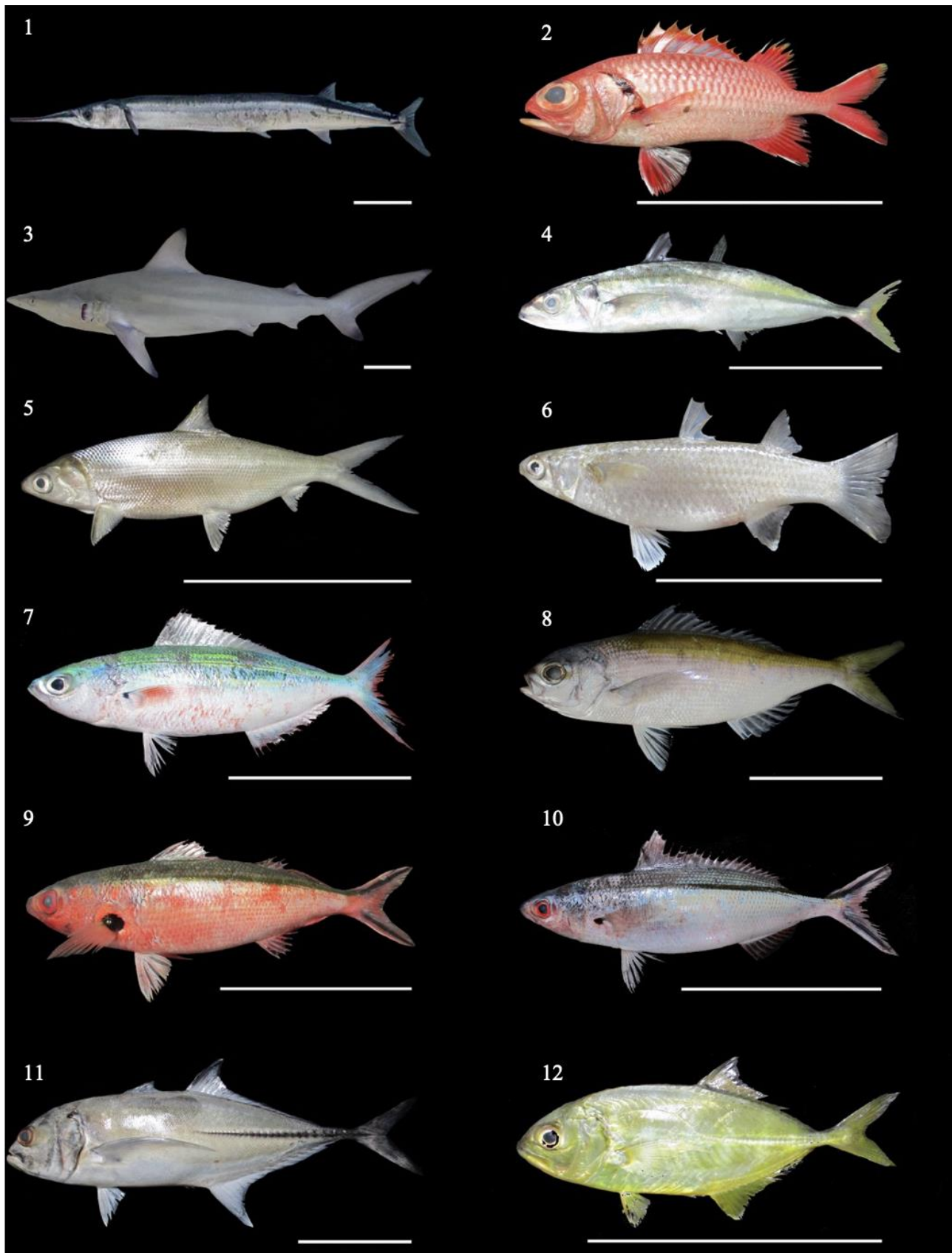


Figure 1. Commercial marine fish species from family Belonidae (1. *Tylosurus pacificus*), Holocentridae (2. *Myripristis berndti*), Carcharhinidae (3. *Carcharhinus melanopterus*), Clupeidae (4. *Decapterus russelli*), Chanidae (5. *Chanos chanos*), Mugilidae (6. *Liza macrolepis*), Caesionidae (7. *Pterocaesio pisang*; 8. *Caesio* sp. 1; 9. *Caesio* sp. 2; 10. *Pterocaesio tile*) and Carangidae (11. *Caranx sexfasciatus*; 12. *Gnathanodon speciosus*). Scale bar = 10 cm. (All photographs by Apriansyah)

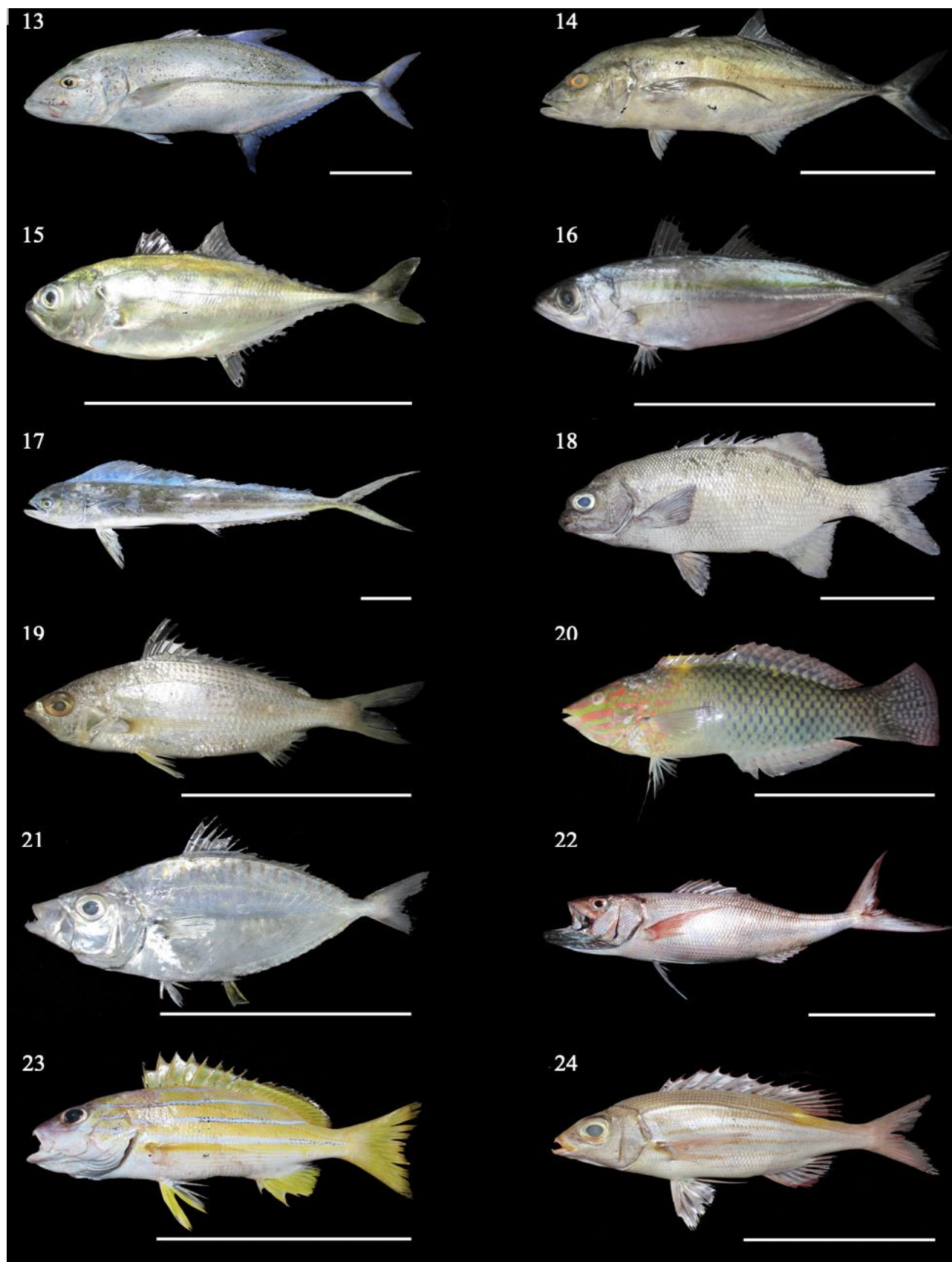


Figure 2. Commercial marine fishes species from family Carangidae (13. *Caranx melampygus*; 14. *Caranx tille*; 15. *Selaroides leptolepis*; 16. *Selar crumenophthalmus*), Coryphaenidae (17. *Coryphaena hippurus*), Kyphosidae (18. *Kyphosus cinerascens*) Gerreidae (19. *Gerres erythrourus*) Labridae (20. *Halichoeres hortulanus*), Leoignathidae (21. *Eubleekeria splendens*) and Lutjanidae (22. *Aphareus rutilans*; 23. *Lutjanus bengalensis*; 24. *Lutjanus lutjanus*). Scale bar = 10 cm. (All photographs by Apriansyah)

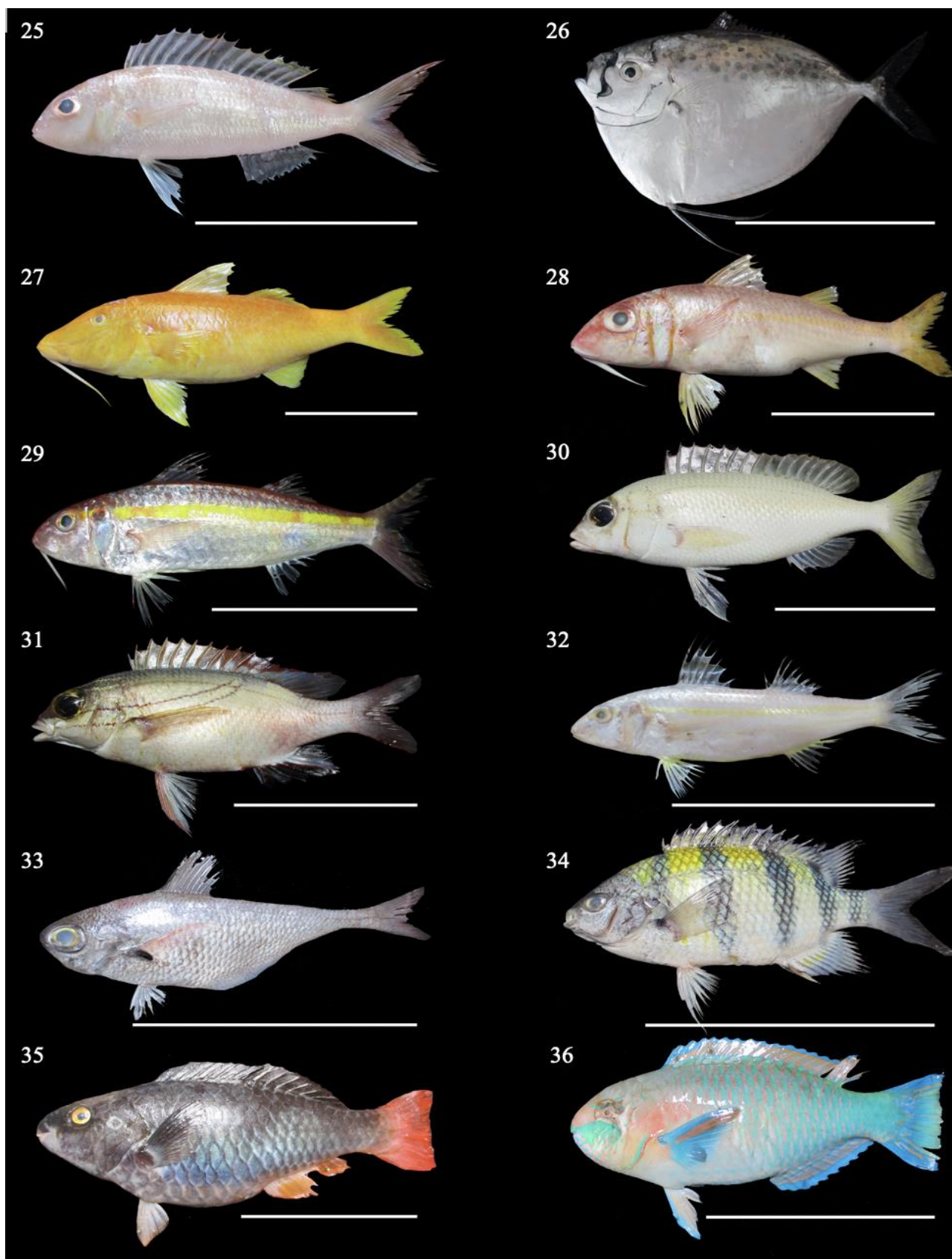


Figure 3. Commercial marine fishes species from family Lutjanidae (25. *Pristipomoides multidens*), Menidae (26. *Mene maculata*), Mullidae (27. *Parupeneus cyclostomus*; 28. *Mulloidichthys vanicolensis*; 29. *Upeneus moluccensis*), Nemipteridae (30. *Scolopsis ciliata*; 31. *Scolopsis bilineata*; 32. *Nemipterus isacanthus*), Pempheridae (33. *Pempheris oualensis*), Pomacentridae (34. *Abudefduf vaigiensis*) and Scaridae (35. *Scarus tricolor*; 36. *Scarus Quoyi*). Scale bar = 10 cm. (All photographs by Apriansyah)

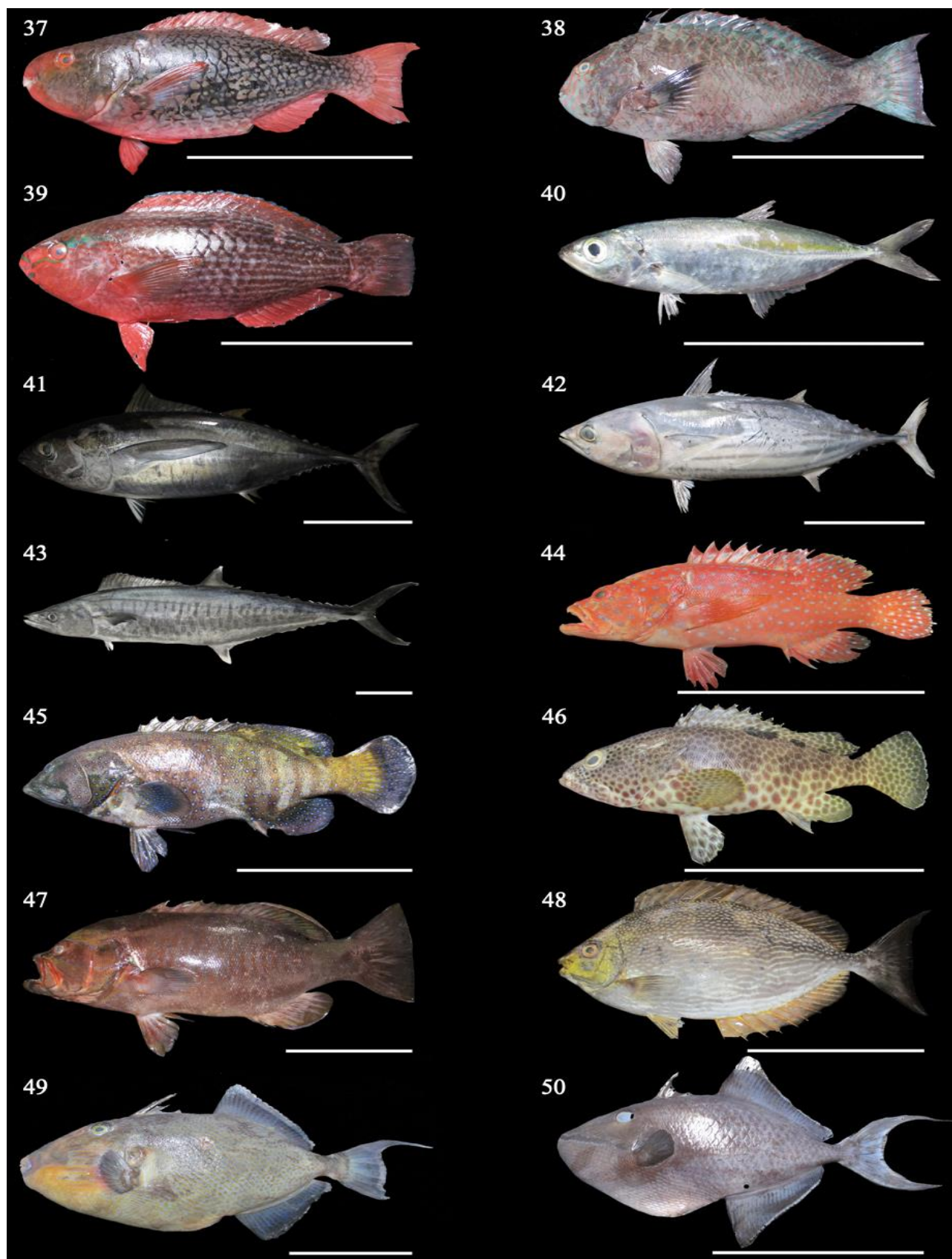


Figure 4. Commercial marine fishes species from family Scaridae (37. *Scarus rubroviolaceus*; 38. *Calotomus carolinus*; 39. *Scarus niger*), Scombridae (40. *Rastrelliger kanagurta*; 41. *Thunnus tonggol*; 42. *Euthynnus affinis*; 43. *Scomberomorus commerson*), Serranidae (44. *Cephalopholis miniata*; 45. *Cephalopholis argus*; 46. *Epinephelus spilotoceps*; 47. *Aethaloperca rogaa*), Siganidae (48. *Siganus javus*) and Balistidae (49. *Balistoides viridescens*; 50. *Odonus niger*). Scale bar = 10 cm. (All photographs by Apriansyah)

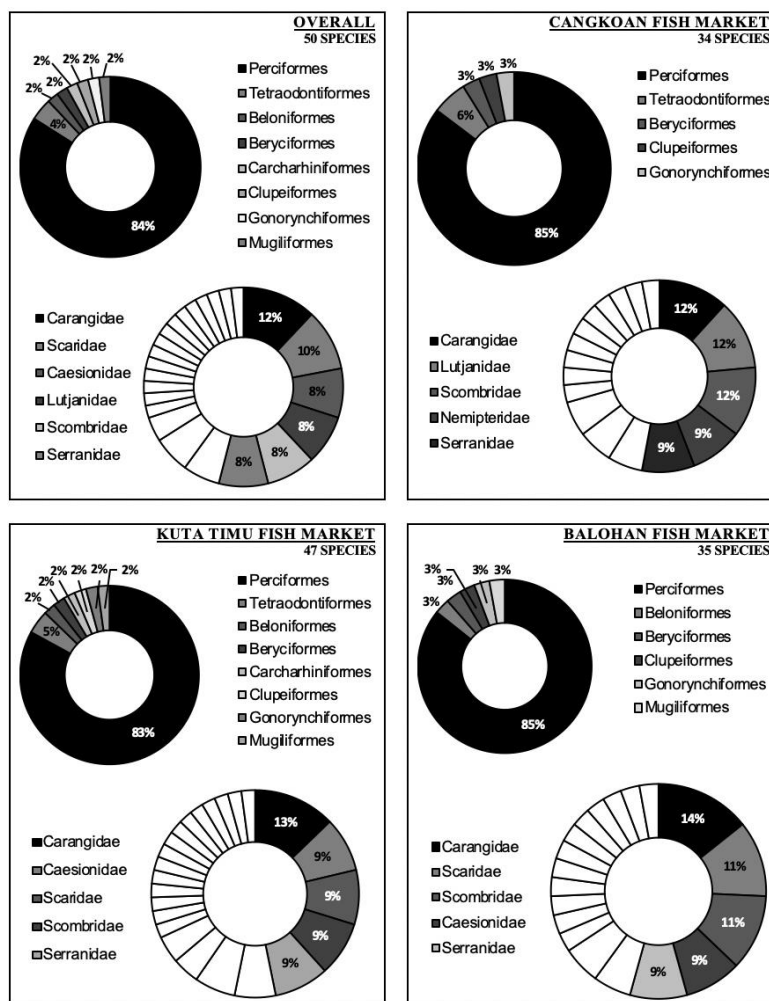


Figure 5. Percentages of the different commercial marine fish orders (upper graphic) and the most diverse families (lower graphic) in the three fish markets as a whole (Overall), Cangkoan fish market, Kuta Timu fish market and Balohan fish market. The blank segments represent families with less than 8% of the total species richness

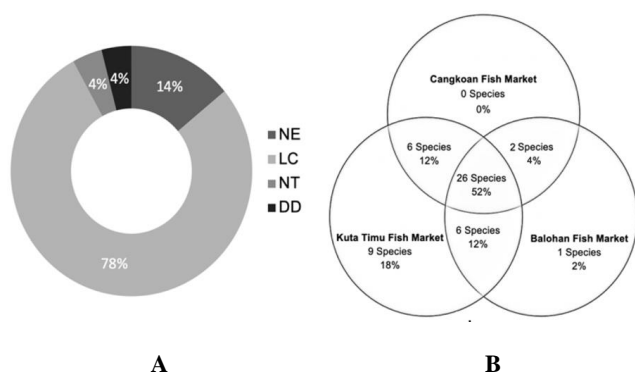


Figure 6. A. Diagram of the IUCN red list status of 50 species of commercial marine fish collected from Weh Island, B. Venn diagram of distribution of 50 species of commercial marine fish species in three markets. NE: not evaluated, LC: least concern, NT: near threatened and DD: data deficient

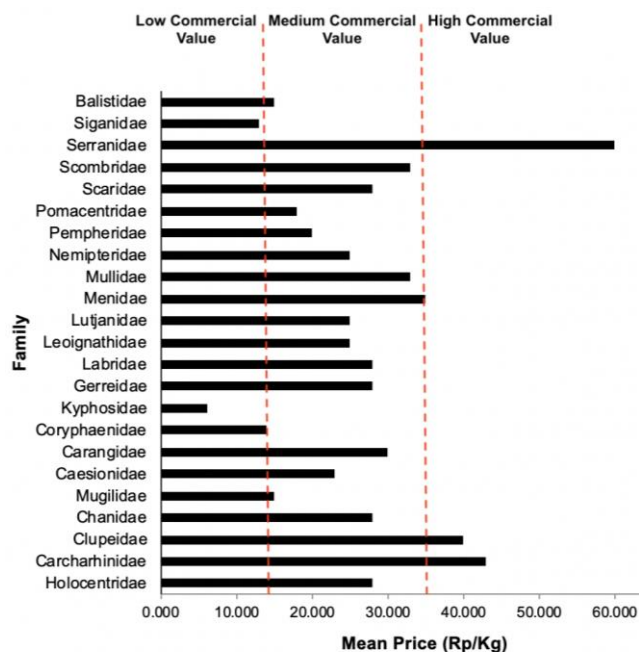


Figure 7. Mean price and commercial value of commercial marine fish species family from Weh Island (1 USD = Rp 14,500)

Carangidae is the most dominant fish family in Weh Island (12% of the total fish species), followed by the Scaridae family (10% of the total fish species). The findings of our study agree with other investigations in the Teluk Pusong area, Lhokseumawe (Damora et al. 2020) and the Coastal Island of Rio de Janeiro (Monteiro-Neto et al. 2013). In contrast, the results tend to be different from other regions, such as the waters of Chiapas Mexico, which were dominated by the Sciaenidae family (González-Acosta et al. 2018), while the Persian Gulf was dominated by the Gobiidae family (Eagderi et al. 2019). Meanwhile the Eastern Coast Bays of the Novaya Zemlya Archipelago were dominated by the Zoarcidae family (Bolshakova & Bolshakov 2018). High composition of reef fish species particularly Carangidae and Scaridae families, might be influenced by coral reef ecosystems around Weh Island. According to Utama and Hadi (2018), Weh Island water has a 10% to 57% coverage of live coral, and most of this coral is still in good condition. As many as 82 species, 13 families and 31 genera of coral reefs were found in the waters of Weh Island and dominated by the families Poritidae (17%), Acroporidae (3%), Helioporidae (3%), and Faviidae (2%). Furthermore, according to Baird et al. (2011) and Rudi et al. (2012), the diversity of Acropora in the waters of Weh Island is comparable to the coral triangle area, an area of eastern Indonesia which is considered as the most diverse marine area in the world.

In the present survey, 26 species of fish are distributed in all three fish markets. Most of them are from the Carangidae (4 species) and Scombridae (4 species) families. As the largest fish market, Kuta Timu Fish Market has a more diverse fish species composition compared to other two markets. Besides, its location is near the city center and the largest Fish Landing Site (FLS) of Weh Island compared to the other two markets. Consequently, the number of fishermen around this market tends to be higher and they work in a wider fishing area with more varied fishing gears. Currently, Weh Island's fishermen use 8 types of fishing gear, i.e., gill net, fishing line, circular net, muroami (Japanese trawl), purse seine, trolline, speargun, and longline (Yulianto and Wiryawan 2011). Based on our own observations and interview results, the fishing area around the Kuta Timu fish market comprises the northern waters of Weh Island, which is known as the highest potential for fish and excluded from the marine conservation area. *Scarus niger* was the only one recorded in Balohan Fish Market and this may have been due to the limited nature of this species; it can only be found in protected areas around Weh Island. Geographically, the Balohan fish market is close to the marine protected area, which is on the eastern coast of Weh Island. Besides having a highly diverse coral reef environment, the fishing activity using destructive fishing equipment in this marine protected area is prohibited, yet fishing rods and spearguns are allowed (Kusumawati and Huang 2015).

Based on the IUCN red list, the commercial marine fish in the Weh Island was dominated by the LC category (78%, 39 species), followed by the NE category (14%, 7 species), the NT category (4%, 2 species) and the DD

category (4%, 2 species). Very similar results were reported in other studies. For instance, the LC category dominated the conservation status list of fishes collected from Pusong Bay, Lhokseumawe City (62%) (Damora et al. 2020), Coastal Island, Rio de Janeiro City (54.2%) (Monteiro-Neto et al. 2013), Chiapas waters, Mexico (73 %) (González-Acosta et al. 2018), and Spanish waters (70%) (Báez et al. 2019). According to IUCN red list, the dominant status of LC and NE category may indicate the lack of information on the bioecological characteristics of fish in the area. Nevertheless, although fish in these categories do not need additional protection as required for the other categories, sustainable management practices are still needed (Sadovy et al. 2013).

Nowadays, overfishing or excessive exploitation of the coral fish not only disrupts the structure of the fish population but also causes an imbalance in the coral reef ecosystem. In the aquatic ecosystem, coral reefs play an important role in supporting fish species. Jones et al. (2004) stated that 11% of the 538 species of reef fish have a close relationship with living coral. For example, herbivorous fish from the Scaridae family (*Scarus tricolor*, *Scarus quoyi*, *Scarus rubroviolaceus*, *Calotomus carolinus*, and *Scarus niger*) are reported to play an important role in maintaining the health of coral reefs by consuming algae that grow on the reef substrate and in clearing new sites for coral larvae (Rogers et al. 2018; Rassweiler et al. 2021). Thus, changes in certain families of fish hamper the coral's existence. Bozec et al. (2016) suggested that the Scaridae family has to be properly managed by limiting its exploitation to a maximum of 10% of the total population, and the minimum length of each fish caught should be 30 cm. However, fish from this family that were sold in the three fish markets were actually < 30 cm.

The economic value of commercial marine fish might be shaped by the economic conditions of the local people of Weh Island; therefore, it cannot be applied globally. There is a significant difference in fish prices between Weh Island and other regions, both regionally and internationally. In this study, the Serranidae family had the highest price range (USD 2-6.2/kg) compared to other families. However, this price range is lower than those with the other places such as Saleh Bay (USD 7-21/kg) (Efendi et al. 2020), Saudi Arabia (USD 4.5-26.44/kg), and Hong Kong (USD 50/kg) (Melanie et al. 2019). In this study, the entire Serranidae family marketed in Weh Island was caught from an easily accessible fishing area. In contrast, most fish in other regions were obtained from imported and aquaculture activities with high production costs. Fish from this family are known as fishery commodities that have a high sale price in both the domestic and international markets. Most of the Serranidae fish species (70%) have export potential and the rest (30%) are for local consumption. Fish are sold by fishermen to distributor agents and then exported abroad, such as in China (including Hong Kong), Taiwan, Japan, and South Korea.

In conclusion, the present study provides an overview of commercial marine fish species collected from the three largest fish markets operating on Weh Island. A total of 50 species belonging to 8 orders and 24 families was recorded,

where Perciformes and Carangidae dominated the orders and families, respectively. Our study reveals that the fish market, which is closest to the city center and the largest Fish Landing Site (FLS) tends to have the most fish than the others. Moreover, the fish market, which is closest to a marine protected area, tends to have fewer species. Based on IUCN data, 39 fish species (78%) were categorized as the "Least Concern", indicating there is a lack of complementary information on biological aspects of these fish. The market price of the fish ranged from USD 0.34/kg to USD 6.19/kg, with three fish families included in the high economic class, namely the Clupeidae, Carcharhinidae, and Serranidae. This research indicated that several indicator species of fish in coral reef ecosystem, such as the Scaridae family, were still hugely commercialized on the Weh Island fish markets. Future studies related to biological and ecological aspects of fish based on its conservation status are indispensable to improve our knowledge and effort in the utilization of fishery resources.

ACKNOWLEDGEMENTS

The study was financially supported by the Center for Aquatic Research and Conservation (CARC), Universitas Islam Negeri Ar-Raniry, Aceh, Indonesia (Grant no. CARC/BIO/FST/GN.11/2020).

REFERENCES

- Alfian RL, Iskandar J, Iskandar BS, Ermandara DP, Mulyanto D, Partasasmitha R. 2020. Fish species, traders, and trade in traditional market: Case study in Pasar Baru, Balikpapan City, East Kalimantan, Indonesia. *Biodiversitas* 21 (1): 393-406. DOI: 10.13057/biodiv/d210146.
- Arif AA, Machdar I, Achmad A. 2020. Land use change based on analysis of the carrying capacity of environment on small island (A case study in Weh Island, Aceh Province, Indonesia). *J Comput Theor Nanosci* 17 (7): 3164-3171. DOI: 10.1166/jctn.2020.9155.
- Báez JC, Rodríguez-Cabello C, Banon R, Brito A, Falcon JM, Mano T, Baro J, Macias D, Meléndez MJ, Camiñas JA. 2019. Updating the national checklist of marine fishes in Spanish waters: An approach to priority hotspots and lessons for conservation. *Mediterr Mar Sci* 20 (2): 260-270. DOI: 10.12681/mms.18626.
- Baird AH, Campbell SJ, Fadli N, Hoey AS, Rudi E. 2011. The shallow water hard corals of Pulau Weh, Aceh, Indonesia. *AACL Bioflux* 5 (1): 23-28.
- Batubara AS, Muchlisin ZA, Thamren MY, Usnardi U, Fadli N. 2017. Check list of marine fishes from Simeulue Island waters, Aceh Province, Indonesia. *Aceh J Anim Sci* 2 (2): 77-84. DOI: 10.13170/ajas.2.2.9584.
- Béné C, Arthur R, Norbury H, Allison EH, Beveridge M, Bush S, Campling L, Leschen W, Little D, Squires D, Thilsted SH, Troell M, Williams M. 2016. Contribution of fisheries and aquaculture to food security and poverty reduction: assessing the current evidence. *World Dev* 79 (3): 177-196. DOI: 10.1016/j.worlddev.2015.11.007.
- Betancur-R R, Wiley EO, Arratia G, Acero A, Bailly N, Miya M, Lecointre G, Ortí G. 2017. Phylogenetic classification of bony fishes. *BMC Evol Biol* 17 (1): 162. DOI: 10.1186/s12862-017-0958-3.
- Bolshakova YY, Bolshakov DV. 2018. Ichthyofauna of the Eastern Coast Bays of the Novaya Zemlya Archipelago. *Oceanology* 58 (2): 228-232. DOI: 10.1134/S0001437018020017.
- Bozec Y-M, O'Farrell S, Bruggemann JH, Luckhurst BE, Mumby PJ. 2016. Tradeoffs between fisheries harvest and the resilience of coral reefs. *Proc Natl Acad Sci* 113 (16): 4536-4541. DOI: 10.1073/pnas.1601529113.
- Campbell SJ, Cinner JE, Ardiwijaya RL, Pardede S, Kartawijaya T, Mukminin A, Herdiana Y, Hoey AS, Pratchett MS, Baird AH. 2012. Avoiding conflicts and protecting coral reefs: Customary management benefits marine habitats and fish biomass. *Oryx* 46 (4): 486-494. DOI: 10.1017/S0030605312000348.
- Campbell SJ, Mukminin A, Kartawijaya T, Huchery C, Cinner JE. 2014. Changes in a coral reef fishery along a gradient of fishing pressure in an Indonesian marine protected area. *Aquat Conserv Mar Freshw Ecosyst* 24 (1): 92-103. DOI: 10.1002/aqc.2359.
- Chang S-K. 2014. Constructing logbook-like statistics for coastal fisheries using coastal surveillance radar and fish market data. *Mar Policy* 43 (1): 338-346. DOI: 10.1016/j.marpol.2013.07.003.
- Damora A, Batubara AS, Zuhdi Z, Restiangsih Y, Amir F, Irham M, Fadli N, Nur F, Rizal R. 2020. Diversity of marine fish and their conservation status in Pusong Bay, Lhokseumawe City, Aceh Province, Indonesia. *Eur J Environ* 10 (2): 115-123. DOI: 10.14712/23361964.2020.13.
- Dharmadi, Fahmi, Satria F. 2015. Fisheries management and conservation of sharks in Indonesia. *Afr J Mar Sci* 37 (2): 249-258. DOI: 10.2989/1814232X.2015.1045431.
- Eagderi S, Fricke R, Esmaili HR, Jalili P. 2019. Annotated checklist of the fishes of the Persian Gulf: Diversity and conservation status. *Iran J Ichthyol* 6 (1): 1-171. DOI: 10.22034/iji.v6i0.454.
- Efendi DS, Adrianto L, Wardiatno Y, Agustina S. 2020. The performance of stock indicators of grouper (Serranidae) and snapper (Lutjanidae) fisheries in Saleh Bay, Indonesia. *AACL Bioflux* 13 (5): 2431-2444.
- Fadli N, Campbell SJ, Ferguson K, Keyse J, Rudi E, Riedel A, Baird AH. 2012. The role of habitat creation in coral reef conservation: a case study from Aceh, Indonesia. *Oryx* 46 (4): 501-507. DOI: 10.1017/S0030605312000142.
- Fadli N, Mohd Nor SA, Othman AS, Sofyan H, Muchlisin Z. 2020. DNA barcoding of commercially important reef fishes in Weh Island, Aceh, Indonesia. *Peer J* 8: e9641. DOI: 10.7717/peerj.9641.
- Fadli N, Muchlisin ZA, Siti-Azizah MN. 2021. DNA barcoding of commercially important groupers (Epinephelidae) in Aceh, Indonesia. *Fish Res* 234: 105796. DOI: 10.1016/j.fishres.2020.105796.
- FAO [Food and Agriculture Organization of the United Nations]. 2016. The State of World Fisheries and Aquaculture 2016: Contributing to Food Security and Nutrition for All. FAO, Rome.
- Ferse SCA, Glaser M, Neil M, Schwerdtner MK. 2014. To cope or to sustain? Eroding long-term sustainability in an Indonesian coral reef fishery. *Reg Environ Change* 14 (6): 2053-2065. DOI: 10.1007/s10113-012-0342-1.
- González-Acosta AF, Rodiles-Hernández R, González-Díaz AA. 2018. Checklist of the marine and estuarine fishes of Chiapas, Mexico. *Mar Biodivers* 48 (3): 1439-1454. DOI: 10.1007/s12526-016-0630-y.
- Halim A, Wiryawan B, Loneragan NR, Hordyk A, Sondita MF, White AT, Koeshendrajana S, Ruchimat T, Pomeroy RS, Yuni C. 2019. Developing a functional definition of small-scale fisheries in support of marine capture fisheries management in Indonesia. *Mar Policy* 100: 238-248. DOI: 10.1016/j.marpol.2018.11.044.
- Hastuty R, Yonvitner, Adrianto L. 2014. Tutupan karang dan komposisi ikan karang didalam dan luar kawasan konservasi pesisir timur Pulau Weh, Sabang. *Depik* 3 (2): 99-107. DOI: 10.13170/depik.3.2.1468. [Indonesia]
- Ilhamsyah Y, Fadli N, Setiawan I, Haridhi HA. 2014. Coral reef bleaching in Weh Island, Indonesia, a natural climate variability or global climate change impact?. *AACL Bioflux* 7 (6): 508-515.
- Jones GP, McCormick MI, Srinivasan M, Eagle JV. 2004. Coral decline threatens fish biodiversity in marine reserves. *Proc Natl Acad Sci of U S A* 101 (21): 8251-8253. DOI: 10.1073/pnas.0401277101.
- Kumar J, Benakappa S, Naik A, Rawat S. 2020. Seasonal variation of ichthyofauna in trawling grounds off Mangaluru coast, Southwest coast of India. *Indian J Mar Sci* 49 (3): 364-372.
- Kusumawati I, Huang H-W. 2015. Key factors for successful management of marine protected areas: A comparison of stakeholders' perception of two MPAs in Weh island, Sabang, Aceh, Indonesia. *Mar Policy* 51 (1): 465-475. DOI: 10.1016/j.marpol.2014.09.029.
- Madduppa HH, von Juterzenka K, Syakir M, Kochzius M. 2014. Socio-economy of marine ornamental fishery and its impact on the population structure of the clown anemonefish *Amphiprion ocellaris* and its host anemones in Spermonde Archipelago, Indonesia. *Ocean Coast Manag* 100 (11): 41-50. DOI: 10.1016/j.ocecoaman.2014.07.013.
- Melanie K, Rianjuanda D, Zulfahmi I, Indra I, Dirgantara R. 2019. Fish species of fishermen's catches in Siumat Island, Simeulue Timur Sub-District, Simeulue, Aceh Province, Indonesia. *IOP Conf Ser Earth*

- Environ Sci 348 (1): 012118. DOI: 10.1088/1755-1315/348/1/012118.
- Monteiro-Neto C, Bertoncini AA, Chaves LdCT, Noguchi R, Mendonça-Neto JP, Rangel CA. 2013. Checklist of marine fish from coastal islands of Rio de Janeiro, with remarks on marine conservation. *Mar Biodivers Rec* 6 (1): e139. DOI: 10.1017/S1755267213000973.
- Nelson JS, Grande TC, Wilson MV. 2016. *Fishes of the World*. John Wiley & Sons, New Jersey.
- Nur FM, Batubara AS, Fadli N, Rizal S, Siti-Azizah MN, Muchlisin ZA. 2022. Diversity, distribution, and conservation status of Betta fish (Teleostei: Osphronemidae) in Aceh Waters, Indonesia. *Eur Zool J* 89 (1): 135-144. DOI: 10.1080/24750263.2022.2029587.
- Prasetyo AP, McDevitt AD, Murray JM, Barry J, Agung F, Muttaqin E, Mariani S. 2021. Shark and ray trade in and out of Indonesia: Addressing knowledge gaps on the path to sustainability. *Mar Policy* 133: 104714. DOI: 10.1016/j.marpol.2021.104714.
- Rassweiler A, Miller SD, Holbrook SJ, Lauer M, Strother MA, Lester SE, Adam TC, Wencélius J, Schmitt RJ. 2021. How do fisher responses to macroalgal overgrowth influence the resilience of coral reefs?. *Limnol Oceanogr*. DOI: 10.1002/lno.11921.
- Rogers A, Blanchard JL, Mumby PJ. 2018. Fisheries productivity under progressive coral reef degradation. *J Appl Ecol* 55 (3): 1041-1049. DOI: 10.1111/1365-2664.13051.
- Rudi E, Campbell SJ, Hoey AS, Fadli N, Linkie M, Baird AH. 2012. The coral triangle initiative: what are we missing? A case study from Aceh. *Oryx* 46 (4): 482-485. DOI: 10.1017/S0030605312000178.
- Sadovy MY, Craig MT, Bertoncini AA, Carpenter KE, Cheung WWL, Choat JH, Cornish AS, Fennessy ST, Ferreira BP, Heemstra PC, Liu M, Myers RF, Pollard DA, Rhodes KL, Rocha LA, Russell BC, Samoilys MA, Sanciangco J. 2013. Fishing groupers towards extinction: a global assessment of threats and extinction risks in a billion dollar fishery. *Fish Fish* 14 (2): 119-136. DOI: 10.1111/j.1467-2979.2011.00455.x.
- Sembiring A, Pertiwi NP, Mahardini A, Wulandari R, Kurniasih EM, Kuncoro AW, Cahyani ND, Anggoro AW, Ulfa M, Madduppa H, Carpenter KE. 2015. DNA barcoding reveals targeted fisheries for endangered sharks in Indonesia. *Fish Res* 164: 130-134. DOI: 10.1016/j.fishres.2014.11.003.
- Shamsuzzaman MM, Hoque MMM, Mitu SJ, Ahamad AF, Bhyuian MS. 2020. The economic contribution of fish and fish trade in Bangladesh. *Aquac Fish* 5 (4): 174-181. DOI: 10.1016/j.aaf.2020.01.001.
- Shellem CT, Ellis JJ, Coker DJ, Berumen ML. 2021. Red Sea fish market assessments indicate high species diversity and potential overexploitation. *Fish Res* 239 (7): 105922. DOI: 10.1016/j.fishres.2021.105922.
- Stacey N, Gibson E, Loneragan NR, Warren C, Wiryawan B, Adhuri DS, Steenbergen DJ, Fitriana R. 2021. Developing sustainable small-scale fisheries livelihoods in Indonesia: Trends, enabling and constraining factors, and future opportunities. *Mar Policy* 132: 104654. DOI: 10.1016/j.marpol.2021.104654.
- Stacey N, Gibson E, Loneragan NR, Warren C, Wiryawan B, Adhuri D, Fitriana R. 2019. Enhancing coastal livelihoods in Indonesia: an evaluation of recent initiatives on gender, women and sustainable livelihoods in small-scale fisheries. *Marit Stud* 18 (3): 359-371. DOI: 10.1007/s40152-019-00142-5.
- Utama RS, Hadi TA. 2018. Recent coral reef conditions in Weh Island, Aceh Province, Indonesia. *Indo Pac J Ocean Life* 2 (2): 47-53. DOI: 10.13057/oceanlife/o020202Recent.
- White WT, Dharmadi, Last PR, Faizah R, Chodriyah U, Prisantoso BI, Pogonoski J, Puckridge MSJMB. 2013. *Market Fishes of Indonesia*. Australian Centre for International Agricultural Research, Canberra.
- Yulianto I, Wiryawan B. 2011. Ecosystem approach to reef fisheries management in Weh Island, Nangroe Aceh Darussalam. *Indones Fish Res J* 17 (2): 53-61. DOI: 10.15578/iftj.17.2.2011.53-61.