DIVERSITY OF MARINE FISH AND THEIR CONSERVATION STATUS IN PUSONG BAY, LHOKSEUMAWE CITY, ACEH PROVINCE, INDONESIA

ADRIAN DAMORA[1,*], AGUNG S. BATUBARA[1], ZUHDI ZUHDI[2], YOKE HANY RESTIANGSIH[3], FACHRUROZI AMIR[2], MUHAMMAD IRHAM[2], NUR FADLI[1], FIRMAN M. NUR[4], and RIZAL RIZAL[5]

[1] Department of Aquaculture, Faculty of Marine and Fisheries, Universitas Syiah Kuala, 23111 Banda Aceh, Indonesia
[2] Department of Fishery Resources Utilization, Faculty of Marine and Fisheries, Universitas Syiah Kuala, 23111 Banda Aceh, Indonesia
[3] Research Institute for Marine Fisheries, Ministry of Marine Affairs and Fisheries Republic of Indonesia, 16912 Cibinong, Indonesia
[4] Doctorate Programme in Mathematics and Applied Sciences, Graduated Studies, Universitas Syiah Kuala, 23111 Banda Aceh, Indonesia
[5] Directorate of Marine and Fisheries – Aceh Program, WWF-Indonesia, 23244 Banda Aceh, Indonesia
* Corresponding author: adamora@unsyiah.ac.id

ABSTRACT

Marine fish have been decreasing in abundance over the last few decades due to environmental destruction and human exploitation. The aim of this study was to produce an inventory of the fish in Pusong Bay, Lhokseumawe City, Aceh Province, Indonesia by means of an exploratory survey of the area. The data was analysed descriptively using tables and graphs. A total of 71 species of fish were identified belonging to 54 genera, 37 families and 15 orders. Fish belonging to the Perciformes dominated the area with 33 species or 46.48% of the total number of fish identified. Based on the IUCN red list status, 62% of the species recorded in this study are categorized as of Least Concern, 35% Not Evaluated and 3% Data Deficient. Based on CITES, 71 species of the fish in Pusong Bay are categorized as Not Evaluated. Current data on these fish is important for future evaluations of their status.

Keywords: bay; order; Pusong; species

Introduction

Bay waters are zones subject to high levels of human activity, such as industry, port facilities, tourism and fishing (Bunce et al. 1999; Walker 2001; Poulard and Léauté 2002; Wesley et al. 2016; Sahetapy et al. 2018), which result in sedimentation, pollution and erosion (Auernheimer and Chinchon 1997; Ruilian et al. 2008; Wei et al. 2008; Gao and Chen 2012). In addition, bays are habitats for marine organism and one of the main sources of livelihood for local communities (Deng and Jin 2000; Jin and Deng 2000; van-der-Meij et al. 2009; Zakaria and Rajpar 2015), which in Aceh is mainly fishing.

The coastline of Aceh province is 1865 km long and encompass 591,089 km^2 of ocean, which is utilized by industries, port facilities and fisheries. Aceh also includes 663 islands in the Straits of Malacca and Indian Ocean (BPS Aceh 2019). One of the bays in this province is Pusong Bay, which is governed by the Lhokseumawe City Government.

Pusong Bay is in the Fisheries Management Area (FMA) 571 of the Republic of Indonesia, which includes the Straits of Malacca and Andaman Sea (KKP 2014). Around 3500 fishermen fish in this area and harvest on average 8944 tones/year (DKP Kota Lhokseumawe 2018). Based on this data, Pusong Bay is one of the best fishing grounds on the north coast of Aceh. Therefore, it is essential for the future management of the fisheries to have an inventory of the species of fish in this area.

There are inventories of the species of fish for several areas in Aceh, such as Aceh Besar Regency (Rizwan et al. 2017; Dekar et al. 2018; Dewiyanti et al. 2019; Nur et al. 2019a), Banda Aceh (Muchlisin et al. 2017a; Fadli et al. 2018; Perdana et al. 2018), Sabang (Rudi et al. 2009; Rudi et al. 2012), Pidie (Nasir et al. 2018), Central Aceh (Muchlisin et al. 2013) and South-West Aceh (Muchlisin et al. 2015; Batubara et al. 2017; Muchlisin et al. 2017b; Batubara et al. 2018; Irhami et al. 2018; Timorya et al. 2018; Nur et al. 2019b), but not for Pusong Bay, Lhokseumawe. Therefore, the aim of this study is to collect data that will be important for the management of fisheries and conservation of endangered species of fish in the future. In addition, the diversity of fish is a good indicator of the effect of climate change, environmental degradation and pollution in an area (Fausch et al. 1990; Schiemer 2000; Daufresne and Boet 2007; Brodeur et al. 2008; Villéger et al. 2010).

Material and Methods

This study was carried out from April to May 2019 at Teluk Pusong, Lhokseumawe City, Aceh Province, Indonesia (Fig. 1). Fish were sampled using a local fishing boat to sweep an area of the bay. A mini fish trawl with mesh size of 2 inches in the wing net, 1.5 inches in the body net and 0.5 inches in the cod end, was used. The Sparre and Venema (1992) equation was used to calculate fish stock abundance:

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$a = V \times t \times hr \times X2 \times 1.852 \times 0.001$

$D = (1/a) \times (c/f)$

Where:
a – swept area (km^2),
V – net pull velocity (knot),
T – time for which the net was towed (hour),
hr – head rope length (m),
$X2$ – head rope length fraction of 0.5 according to Pauly (1980) as the width swept by trawl,
1.852 – conversion from miles to kilometres,
0.001 – conversion from meter to kilometres,
D – fish stock abundance (ton km^{-2}),
c – catch rate (kg hr^{-1}),
f – escapement factor of 0.5 as an estimate of the proportion of fish in the swept area that were caught by the net (Saeger et al. 1976).

The data collected was analysed in the Laboratory of Ichthyology, Faculty of Marine and Fisheries, Universitas Syiah Kuala, Banda Aceh, Indonesia. This study used an explorative survey (Muchlisin and Siti-Azizah 2009) after identifying locations with a high abundances of fish using information provided by local fisherman. Fish caught were identified using Allen (2000), Schultz (2004), Vida and Kotai (2006), Ambak et al. (2010) and Kottelat (2013).

Samples were collected from several areas in Pusong Bay, the location of which was based on information from local fishermen. Sampling was carried out between 07:00 PM and 08:00 AM. Fish were caught using a mini trawl (net and pocket length of 6 meters). The gear was pulled randomly for 2 hours in a particular area of Pusong Bay at a depth between 8–40 meters. Hauling took 15 minutes during which the fish were grouped based on species and the mini trawl was set for fishing. The trawl was operated approximately 5 to 6 times per night.

Fish caught were processed in terms of total and standard length measurement using a digital caliper (Mitutoyo, CD-6CS. Error = 0.01 mm) and weight using a digital scale (Toledo, AB-204. Error = 0.01 g). Fish were documented using a digital camera (Nikon D5300). Fish samples were then preserved in 10% formaldehyde solution.

The threat status of the identified species of fish was determined by reference to the IUCN red list of threatened species website (https://www.iucnredlist.org/) and its trade status using the CITES website (https://checklist.cites.org/#/en). Data was analysed descriptively by means of tables and graphs based on (Batubara et al. 2017) and compared with the results of similar studies.

Environmental data used in this study was obtained from Aqua-MODIS L3 8Day composite satellite images with a 4 km spatial resolution, which was downloaded from http://oceancolor.gsfc.nasa.gov. Chlorophyll-a and sea surface temperature (SST) data were analysed using the SeaDAS 7.5.3 program and visualized using QGIS 3.4.14.

Results

In this study, 71 species of fish were recorded in Pusong Bay, Lhokseumawe City (Table 1), belonging to 15 orders, 37 families and 54 genera (Table 2). The dominant group were those belonging to the order Perciformes, based on the number of families (14 families), genera (24 genera) and species (33 species) (Table 2). Based on the number of species, the family Carangidae in the order Perciformes dominated the bay with 8 species (Table 1).

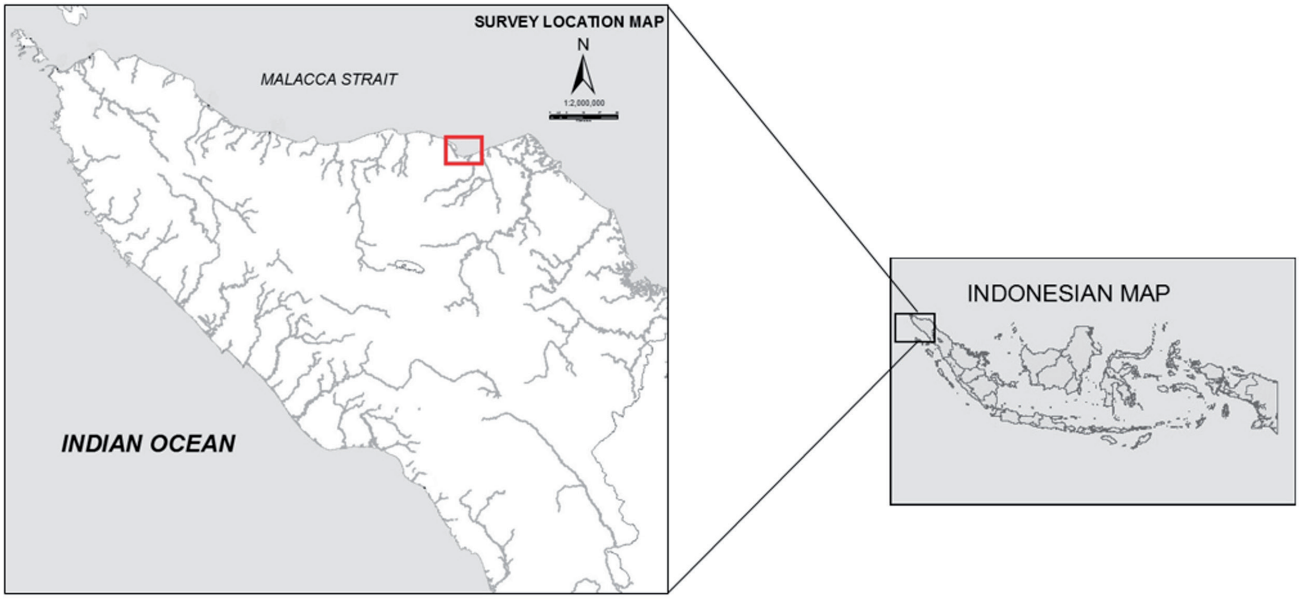

Fig. 1 Maps showing the location (red square) of Pusong bay, the site of this study.

Table 1 Species of fish recorded in Pusong Bay, Lhokseumawe.

No	Ordo	Family	Genus	Species	Common Name	IUCN Red List	CITES
1.	Aulopiformes	Synodontidae	*Saurida*	*Saurida gracilis*	Gracile Lizardfish	LC	NE
2.				*Saurida undosquamis*	Brush tooth Lizardfish	LC	NE
3.	Beloniformes	Hemiramphidae	*Hemiramphus*	*Hemiramphus far*	Black-Barred Halfbeak	NE	NE
4.	Clupeiformes	Clupeidae	*Sardinella*	*Sardinella gibbosa*	Gold stripe Sardinella	LC	NE
5.		Engraulidae	*Stolephorus*	*Stolephorus indicus*	Indian Anchovy	LC	NE
6.			*Thryssa*	*Thryssa hamiltonii*	Hamilton's Thryssa	LC	NE
7.				*Thryssa mystax*	Moustached Thryssa	LC	NE
8.	Elopiformes	Megalopidae	*Megalops*	*Megalops cyprinoides*	Indo-pacific Tarpon	DD	NE
9.	Kurtiformes	Apogonidae	*Apogon*	*Apogon ellioti*	Flag-in Cardinalfish	NE	NE
10.				*Apogon quadrifasciatus*	Broad banded Cardinalfish	NE	NE
11.				*Apogon* sp.	Cardinalfish	NE	NE
12.				*Apogon timorensis*	Timor Cardinalfish	NE	NE
13.	Lophiiformes	Antennariidae	*Antennarius*	*Antennarius striatus*	Striated Frogfish	LC	NE
14.	Myliobatiformes	Dasyatidae	*Himantura*	*Himantura toshi*	Black-Spotted Whip ray	LC	NE
15.	Perciformes	Ambassidae	*Ambasis*	*Ambassis nalua*	Scalloped Perch let	LC	NE
16.		Carangidae	*Alectis*	*Alectis indica*	Indian Thread fish	LC	NE
17.			*Carangoides*	*Carangoides ferdau*	Blue Trevally	LC	NE
18.				*Carangoides uii*	Coastal Trevally	LC	NE
19.			*Caranx*	*Caranx sexfasciatus*	Bigeye Trevally	LC	NE
20.			*Scomberoides*	*Scomberoides lysan*	Double spotted Queen fish	LC	NE
21.			*Selaroides*	*Selaroides leptolepis*	Yellow stripped scad	LC	NE
22.			*Ulua*	*Ulua aurochs*	Silver mouth Trevally	LC	NE
23.				*Ulua mentalis*	Longrakered Trevally	LC	NE
24.		Gerreidae	*Gerres*	*Gerres longirostris*	Strong spine Silver-Biddy	LC	NE
25.		Gobiidae	*Istigobius*	*Istigobius spence*	Pearl Goby	LC	NE
26.		Haemulidae	*Diagramma*	*Diagramma labiosum*	Painted Sweetlips	LC	NE
27.			*Pomadasys*	*Pomadasys kaakan*	Javelin Grunter	NE	NE
28.		Leiognathidae	*Gazza*	*Gazza minuta*	Toothed Pony fish	LC	NE
29.			*Leiognathus*	*Leiognathus equulus*	Common Pony fish	LC	NE
30.				*Leiognathus leuciscus*	Whip fin Pony fish	LC	NE
31.				*Leiognathus splendens*	Splendid Pony fish	LC	NE
32.			*Secutor*	*Secutor* sp.	Pony fish	NE	NE
33.				*Secutor indicius*	Pony fish	NE	NE
34.				*Secutor interruptus*	Pig-Nosed Pony fish	NE	NE
35.		Lutjanidae	*Etelis*	*Etelis carbunculus*	Ruby Snapper	LC	NE
36.			*Lutjanus*	*Lutjanus lutjanus*	Bigeye Snapper	LC	NE
37.				*Lutjanus apodus*	Schoolmaster Snapper	LC	NE
38.				*Lutjanus fulviflamma*	Dory Snapper	LC	NE
39.			*Pristipomoides*	*Pristipomoides multidens*	Gold banded Job fish	LC	NE
40.		Mullidae	*Upeneus*	*Upeneus sulphureus*	Sulphur Goatfish	LC	NE
41.		Nemipteridae	*Nemipterus*	*Nemipterus isacanthus*	Teardrop Threadfin Bream	NE	NE
42.				*Nemipterus nematophorus*	Double whip Threadfin Bream	LC	NE
43.		Polynemidae	*Polydactylus*	*Polydactylus nigripinnis*	Black fin Threadfin	NE	NE
44.		Priacanthidae	*Priacanthus*	*Priacanthus hamrur*	Moon tail Bullseye	LC	NE
45.		Sciaenidae	*Johnius*	*Johnius amblycephalus*	Bearded Croaker	NE	NE
46.		Serranidae	*Epinephelus*	*Epinephelus lanceolatus*	Giant Grouper	DD	NE
47.		Siganidae	*Siganus*	*Siganus canaliculatus*	White-Spotted Spine foot	LC	NE

No	Ordo	Family	Genus	Species	Common Name	IUCN Red List	CITES
48.	Pleuronectiformes	Bothidae	*Grammatobothus*	*Grammatobothus polyophthalmus*	Three spot Flounder	LC	NE
49.		Cynoglossidae	*Paraplagusia*	*Paraplagusia bilineata*	Double lined Tongue sole	NE	NE
50.		Paralichthyidae	*Pseudorhombus*	*Pseudorhombus arsius*	Large tooth Flounder	NE	NE
51.				*Pseudorhombus* sp.	Flounder	NE	NE
52.		Psettodidae	*Psettodes*	*Psettodes erumei*	Indian Halibut	NE	NE
53.				*Psettodes* sp.	Halibut	NE	NE
54.	Scombriformes	Sphyraenidae	*Sphyraena*	*Sphyraena novaehollandiae*	Australian Barracuda	NE	NE
55.	Scorpaeniformes	Platycephalidae	*Inegocia*	*Inegocia harrisii*	Harris's Flathead	NE	NE
56.		Scorpaenidae	*Brachypterois*	*Brachypterois serrulatus*	Saw cheek Scorpionfish	NE	NE
57.			*Parascorpaena*	*Parascorpaena mcadamsi*	McAdam's Scorpionfish	LC	NE
58.			*Pterois*	*Pterois russelii*	Plain tail Turkey fish	LC	NE
59.			*Scorpaenodes*	*Scorpaenodes hirsutus*	Hairy Scorpionfish	LC	NE
60.			*Scorpaenopsis*	*Scorpaenopsis venosa*	Raggy Scorpionfish	LC	NE
61.		Synanceiidae	*Erosa*	*Erosa erosa*	Pitted Stonefish	LC	NE
62.	Siluriformes	Plotosidae	*Plotosus*	*Plotosus lineatus*	Striped Eel Catfish	NE	NE
63.	Syngnathiformes	Fistulariidae	*Fistularia*	*Fistularia petimba*	Red Cornet fish	LC	NE
64.	Tetraodontiformes	Balistidae	*Balistoides*	*Balistoides viridescens*	Titan Triggerfish	NE	NE
65.		Tetraodontidae	*Arothron*	*Arothron reticularis*	Reticulated Pufferfish	LC	NE
66.			*Carinotetraodon*	*Carinotetraodon lorteti*	Redeye Puffer	LC	NE
67.			*Lagocephalus*	*Lagocephalus lunaris*	Lunar tail Puffer	LC	NE
68.		Triacanthidae	*Triacanthus*	*Triacanthus biaculeatus*	Short-Nosed Tripod fish	NE	NE
69.	Trachiniformes	Uranoscopidae	*Uranoscopus*	*Uranoscopus cognatus*	Yellowtail Stargazer	NE	NE
70.				*Uranoscopus kaianus*	Kai Stargazer	NE	NE
71.		Labridae	*Xiphocheilus*	*Xiphocheilus typus*	Blue-Banded Wrasse	LC	NE

Table 2 Classification of the 71 species of fish recorded in terms of the order, family, genus and species to which they belong.

No.	Order	Family		Genus		Species	
		Number	%	Number	%	Number	%
1.	Aulopiformes	1	2.70	1	1.85	2	2.82
2.	Beloniformes	1	2.70	1	1.85	1	1.41
3.	Clupeiformes	2	5.41	3	5.56	4	5.63
4.	Elopiformes	1	2.70	1	1.85	1	1.41
5.	Kurtiformes	1	2.70	1	1.85	4	5.63
6.	Lophiiformes	1	2.70	1	1.85	1	1.41
7.	Myliobatiformes	1	2.70	1	1.85	1	1.41
8.	Perciformes	14	37.84	24	44.44	33	46.48
9.	Pleuronectiformes	4	10.81	4	7.41	6	8.45
10.	Scombriformes	1	2.70	1	1.85	1	1.41
11.	Scorpaeniformes	3	8.11	7	12.96	7	9.86
12.	Siluriformes	1	2.70	1	1.85	1	1.41
13.	Syngnathiformes	1	2.70	1	1.85	1	1.41
14.	Tetraodontiformes	3	8.11	5	9.26	5	7.04
15.	Trachiniformes	2	5.41	2	3.70	3	4.23
Total		37	100	54	100	71	100

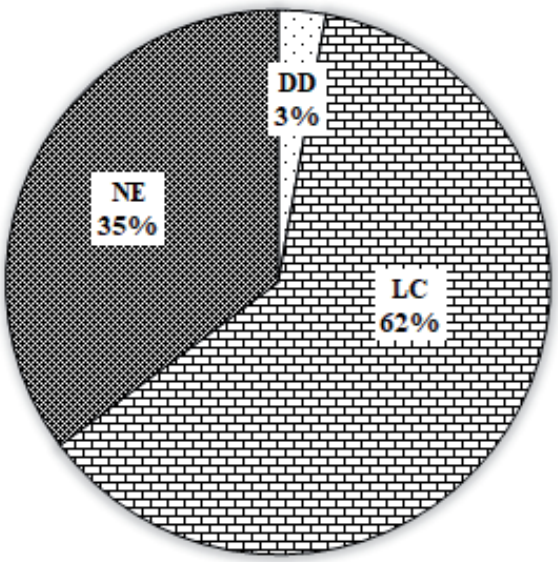

Fig. 2 Pie diagram of the IUCN red list status of the 71 species of fish species caught at Teluk Pusong, where DD is data deficient, LC least concern and NE not evaluated.

Threat status of the 71 species of fish in Pusong Bay based on The IUCN Red List indicates that 62% are categorized as of Least Concern (LC), 35% Not Evaluated (NE) and 3% as Data Deficient (DD) (Fig. 2). Moreover, based on the Convention on International Trade in Endangered Species (CITES), all of the species are categorized as Not Evaluated (Table 1).

The mini fish trawl used in this study was used to sweep an area of 34.42 km^2 and caught 70.6 kg of fish. This indicates that the fish stock in Pusong Bay is 0.065 tonnes km^{-2}. SST and chlorophyll concentrations also influence the abundance of fish in these waters. SST within Pusong Bay ranged between 30.9–31.1 °C (Fig. 3) and the chlorophyll concentration between 2–4 mg m^{-3} (Fig. 4).

Discussion

The 71 species of fish collected in Pusong Bay, Lhokseumawe City (Table 2) belonged to 15 orders, which is higher than that recorded in other areas in Aceh Province, such as Simeulue Island (12 orders) (Batubara et al. 2017; Batubara et al. 2018), Meurebo River (7 orders) and Mifa Bersaudara Inc. Area (7 orders) in the West Aceh Regency (Irhami et al. 2018; Nur et al. 2019b), Aceh River (12 orders) in the Aceh Province (Dekar et al. 2018), Sabee River in the Aceh Jaya Regency (Timorya et al. 2018) and Lhoknga and Lhok Mata Ie Coast (8 orders) in the Aceh Besar Regency (Nur et al. 2019a). Thus based on the number of orders of fish, there is a higher diversity fish in the bay than in the river and coastal waters in Aceh Province.

A higher number of families of fish (37) were recorded in Pusong Bay than at other locations in Aceh such as Simeulue Island (26 families) (Batubara et al. 2017) and Lhoknga and Lhok Mata Ie Coast in the Aceh Besar Regency (11 families) (Nur et al. 2019a). However, the number of families of marine fish recorded in Pusong Bay is lower than that of families of freshwater fish in Aceh Province, which is 41 families (Muchlisin and Si-

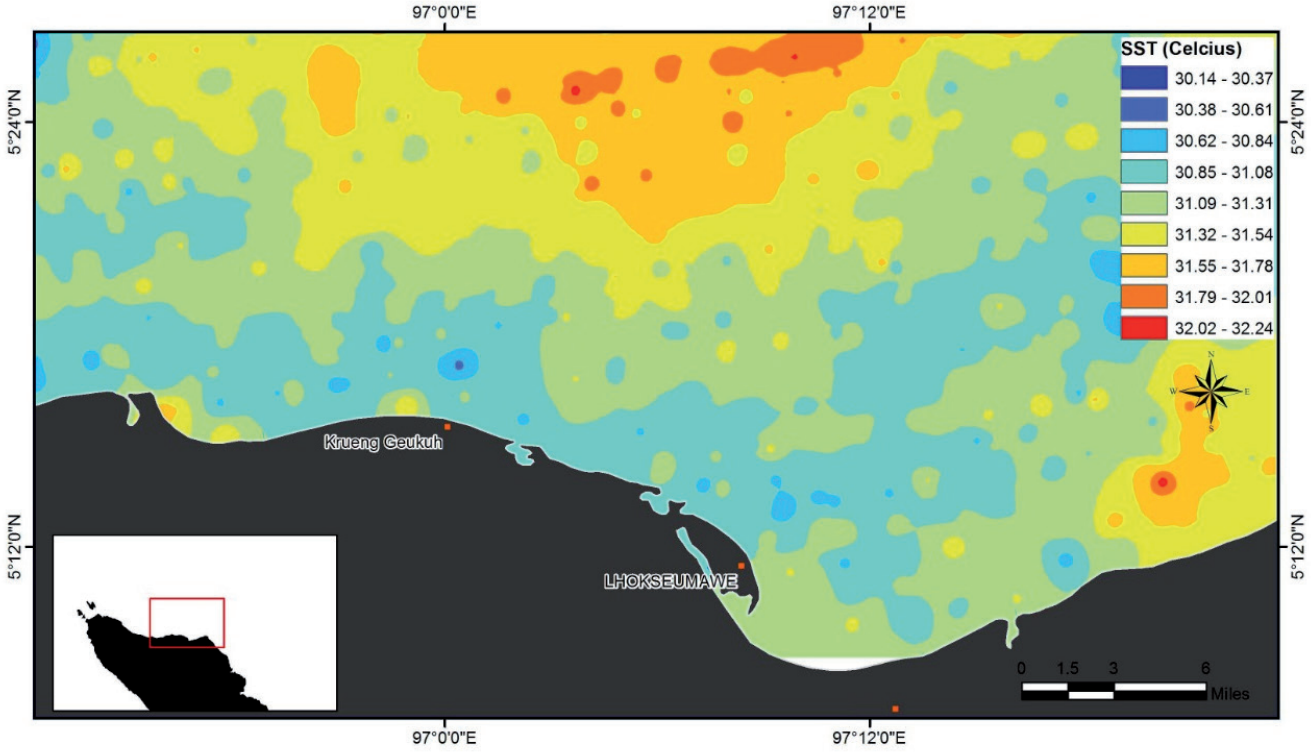

Fig. 3 Map showing sea surface temperatures (SST) in the Pusong Bay when the fish were sampled.

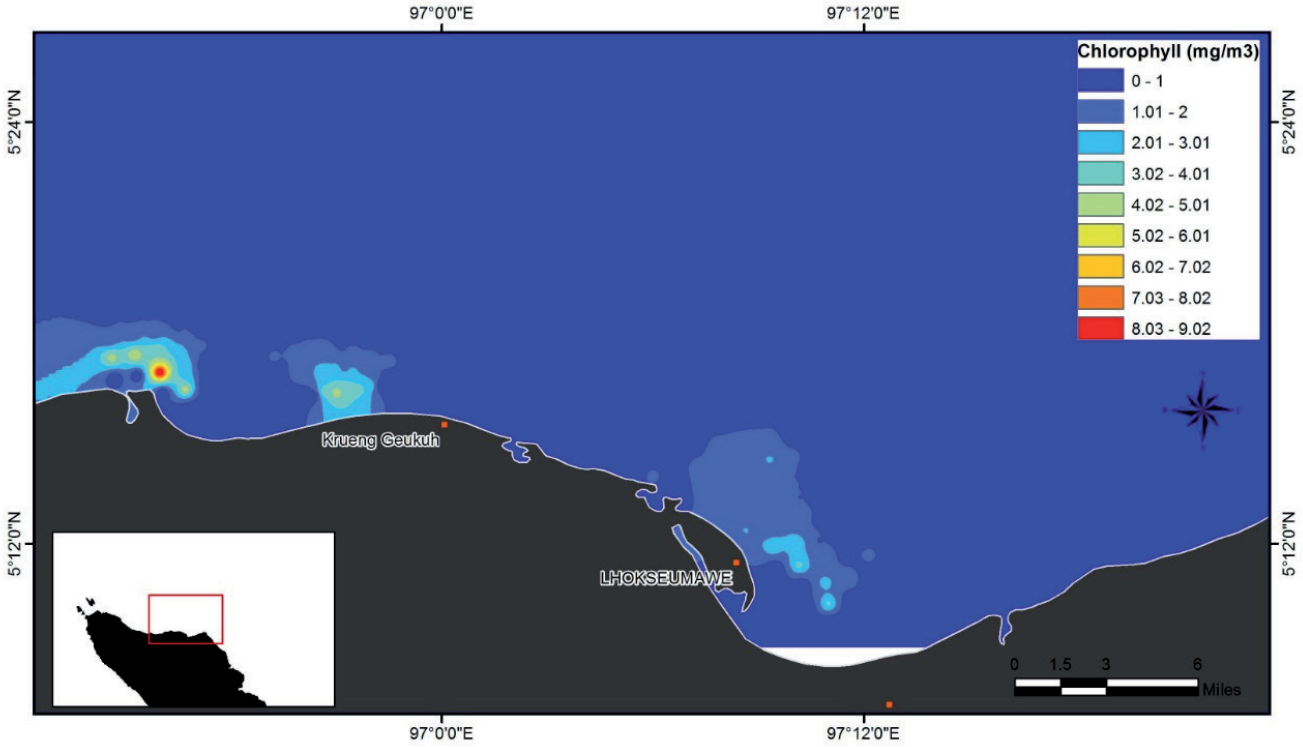

Fig. 4 Map showing the concentrations of chlorophyll recorded in Pusong Bay when the fish were sampled.

ti-Azizah 2009). The number of species of fish recorded in Pusong Bay (71) is also lower than the number recorded in several other areas in Aceh Province, such as Aceh River (44) (Dekar et al. 2018), Meureubo River (32) (Irham et al. 2018), Lhoknga and Lhok Mata Ie Coast (25) (Nur et al. 2019a) and Sabee River (12) (Timorya et al. 2018).

The order Perciformes dominated Pusong Bay in terms of the number of species (33) and percentage composition of the total catch (46.48%). The same order of fish dominates in other areas such as Simeulue Island (67 species) (Batubara et al. 2017) and Aceh River (20 species) (Dekar et al. 2018). However, the order Cypriniformes dominates in area such as Rawa Teripa waters in Nagan Raya Regency (19% of all species caught) (Muchlisin et al. 2015), Mifa Bersaudara Inc. Area (39%) (Nur et al. 2019b) and Meureubo River in West Aceh Regency (12.5%) (Irhami et al. 2018).

Based on the IUCN red list status, 62% of the fish in Pusong Bay are categorized as of Least Concern (LC) and 38% as Data Deficient (DD) or Not Evaluated (NE). LC is attributed to species not listed in a higher threat category, which are usually widely distributed and abundant (Rodrigues et al. 2006). DD is attributed to species for which there is little or no data on their distribution or abundance (Gärdenfors et al. 2001). While NE is attributed to species for which the threat risk has not been evaluated (Hoffmann et al. 2008). Based on CITES, the 71 species of fish recorded in Pusong Bay have not been evaluated (CITES 2020).

A precautionary approach is recommended for managing the resources of fisheries that have a NE status. This approach aims to protect fish from both growth and recruitment overfishing (Lessa and Duarte-Neto 2004; Damora and Wagiyo 2012; Damora and Baihaqi 2013; Damora et al. 2018a, b).

The abundance of the fish stock recorded in this study is relatively low, compared with other studies in the Java Sea (Badrudin et al. 2011) that report fish stocks of 2.7–3.1 tonnes km^2. East and west monsoons influence the abundance of fish in the Pusong Bay, as during the east monsoon demersal fish tend to gather in shore due to the murky waters associated with the strong southeast wind, which create a whirlpool of schools of fish as a result of an interaction between the water currents and fish (Badrudin et al. 2011). Meanwhile, this study was conducted in the transitional season between the west and east monsoon, which created strong currents and waves within Pusong Bay.

The average gradient in SST in tropical waters is about 0.3–1 °C (Choudhury et al. 2007). SST gradient affects change in the water resulting in upwelling and accumulations of plankton usually affects fish behaviour, as they respond by modifying their metabolism, spawning, migrating, increasing food consumption and the salt concentration in their bodies (Laurs et al. 1984; Arnone 1987).

The concentration of chlorophyll in Pusong Bay is lower than in other areas in the Andaman Sea, such as the coastal waters of Bangladesh, Myanmar, Thailand and Malaysia. The Andaman Sea and Pusong Bay are located in the same bio-ecoregion and the concentration of chlorophyll in these areas is between 5–15 mg m^{-3}. In addition, Suwannathatsa et al. (2012)

report a concentration of 15–30 mg m^{-3} in the Malacca Straits.

February and May are the transition period between the west to east monsoon season in which the divergence of Ekman transport, equatorial Kelvin waves and Rossby waves create a strong current that spreads through the Nicobar Islands within the Andaman Sea. This strong current is neutralized during the transition period between the northeast and southwest monsoons, which results in murky conditions and an increase in the average SST (Suwannathatsa et al. 2012). During this transition, there is no runoff of rainwater into the bay, which along with the turbulence result in a decrease in the concentration of chlorophyll to its lowest level (Suwannathatsa and Wongwises 2013). Fish generally are only abundant where there are high concentrations of chlorophyll, which is an indicator of rich nutrient water where fish are likely to be abundant (Santos 2000; Zainuddin 2011).

Conclusion

In conclusion, the order Perciformes dominated the area with the highest number of species of fish. Based on the IUCN red list status, 62% of the species of fish are of Least Concern, 35% Not Evaluated and 3% Data Deficient. Based on CITES the 71 species of fish in Pusong Bay are categorized as Not Evaluated. Data on these species of fish are important in terms of evaluating their status in the future.

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