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Utilization of Fish Resources and Conservation Efforts in Ambon Bay, Indonesia

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ABSTRACT

Fish resources are critical for the livelihoods of local communities in Ambon Bay, which has historically served as a key area for small-scale bait fisheries, particularly small pelagic species. However, these resources have experienced a significant decline, with species now becoming increasingly scarce. This reduction is primarily attributed to anthropogenic impacts and overexploitation. Addressing this decline requires a scientific understanding of fish resource utilization and the development of community awareness regarding sustainable practices, though research in this area remains limited. This study employed a combination of ichthyofauna diversity surveys, participant observations, and forty-two interviews conducted in four locations across Ambon Bay. Respondents included fishermen, government officials, researchers, and academics. The involvement of these stakeholders provided insights into local knowledge, traditional practices, and the community's role in fish resource management. Observations focused on fish reproductive maturity, habitat conditions, and fishing seasons, creating a comprehensive overview of resource utilization. The findings indicated a notable decline in the abundance, species variety, and size of fish resources in the bay. Community-based initiatives to shift from capture fisheries to aquaculture, proposals for the transplantation of *Stolephorus indicus* and *Encrasicholina heteroloba*, and the enforcement of regional regulations emerge as viable strategies for mitigation. This study underscored the importance of collaborative efforts among stakeholders to ensure the sustainable utilization of fish resources in Ambon Bay, aiming to secure ecological and socioeconomic benefits for future generations.

INTRODUCTION

Ambon Bay, located in Ambon City, Maluku Province, is renowned for its natural beauty, rich marine biodiversity, and vibrant culture. This bay attracts divers and marine enthusiasts worldwide, thanks to its stunning coral reefs and diverse marine life. However, Ambon Bay faces several environmental challenges, including sedimentation due to land clearing **(Patty *et al.*, 2017)**, marine pollution from household and agricultural waste **(Manullang, 2019)**, and habitat loss from infrastructure development, which threaten critical ecosystems such as mangrove forests, seagrass meadows, and coral reefs **(Herdiansyah *et al.*, 2021)**. Additionally, overfishing poses a significant threat to the sustainability of fish resources in the bay **(Salampessy *et al.*, 2015)**.

These environmental pressures not only endanger the bay's ecosystems but also impact the socio-economic well-being of local communities reliant on fishing. The decline in fish populations and biodiversity has jeopardized food security and traditional livelihoods, underscoring the urgent need for sustainable management practices. Effective conservation in Ambon Bay requires a multi-stakeholder approach that includes community participation, scientific research, and enforcement of sustainable policies.

Various initiatives have been launched to address these issues, such as waste management programs involving collection, sorting, and recycling **(Maryati *et al.*, 2017)**, coral reef rehabilitation **(Limmon & Marasabessy, 2019; Limmon *et al.*, 2023)**, and community education on environmental conservation **(Astuti, 2023)**. Mangrove reforestation efforts aim to reduce coastal erosion, create wildlife habitats, and filter pollution **(Prayudha *et al.*, 2021)**. Despite these efforts, sustainable fishing practices and resource conservation, particularly for fishery resources linked to mangrove ecosystems, remain underdeveloped due to limited community understanding **(Salampessy *et al.*, 2015)**.

This study addressed these gaps by examining the local community's perceptions of fish resources, particularly pelagic species, and their role in conservation. Through literature review and direct observations, historical and current catch data were analyzed to assess changes in fish quantity, species, and size. The objectives of this study were to (1) describe the utilization of fish resources in Ambon Bay over time and (2) to identify conservation efforts and opportunities for improvement. This research is essential for promoting the sustainable management of Ambon Bay’s fish resources, ensuring ecological balance and long-term benefits for future generations.

MATERIALS AND METHODS

Study area

Ambon Bay is divided into two sections: Outer Ambon Bay (OAB) and Inner Ambon Bay (IAB). These are separated by a narrow water passage with a depth of approximately 12.8 meters and a mouth width of around 74.5 meters, with the shoreline stretching from Tanjung Marthafons to Galala **(Syahailatua *et al.*, 2024)**. Inner Ambon Bay covers an area of approximately 12.1km^2 **(Likumahua *et al.*, 2022)**. Due to its small size, this bay is at risk of narrowing and shallowing from various land development activities **(Pelasula *et al.*, 2022)**. The research locations included Halong, Lateri, Waiheru, and Poka villages (Fig. 1), chosen based on fishermen's perspectives on fish resource utilization and conservation efforts in Ambon Bay.

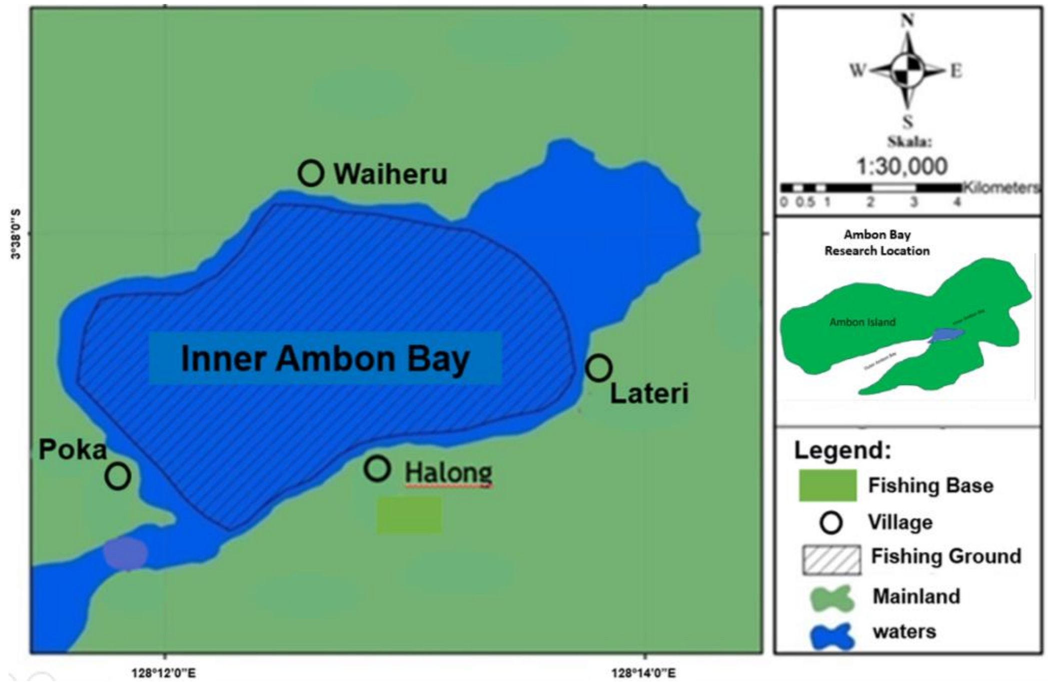

Fig. 1. Map of the study area

These four villages represent fish resource collection areas in IAB, each with distinct habitats, including sandy beaches, mudflats, mangrove forests, and rocky shores. At least ten respondents from each location participated in the questionnaire. Detailed field notes were recorded, covering fish diversity (ichthyofauna) and habitat characteristics. Additionally, several students assisted in conducting surveys and interviews to gather comprehensive data on fish resources utilized by local communities and conservation efforts.

Data collection methods

Data collection was conducted through interviews with coastal communities in IAB and continuous monthly fish sampling over a period of two years (2021-2022). Forty-two respondents from four villages were interviewed to explore their perceptions of fish resource utilization in Ambon Bay, the benefits derived from these resources, and local conservation efforts. The interview guide included questions on changes in fish resource utilization over the past 20 years, such as whether the number of fish resources in the bay had increased or decreased, if species composition had changed, if certain species were no longer found, if fish sizes had declined, and if local communities contributed to fish resource conservation in the bay. Respondents were selected in each location using the snowball sampling method, involving eight women aged 33 to 62, most of whom were fish traders and one academician. Additionally, 34 men aged 24 to 60 were interviewed, including active fishermen, retired fishermen, boat owners, two government officials, and one researcher. The largest age group was between 33 and 42 years (36%), followed by ages 43-52 (29%), 53-62 (21%), and 22-32 (14%).

Fish sample collection

Fish samples were collected using beach seines and drift gill nets. After capture, different species were separated for identification following the guidelines of **Allen and Adrim (2003)**, **White *et al.* (2013)** and **Limmon *et al.* (2020)**, as well as references from the *FishBase* website **(Froese & Pauly, 2023)**. Samples were selected using a stratified random sampling method, followed by simple random sampling of 30% from each fish species group **(Conquest *et al.*, 2023)** to ensure representativeness of the fish population in IAB. Each specimen's body length was measured with a vernier caliper (accuracy of 1 mm), and gonad maturity was assessed through abdominal dissection **(Effendie, 2002)**. The samples were collected from two fishing gears across four villages.

This study also referred to data from previous years for comparative analysis, helping to understand changes in fish populations or utilization patterns **(Radinger *et al.*, 2019)**. The collected data were analyzed descriptively, with the results presented in Tables and Figs. **(Perler *et al*., 2019)**. This method provides essential insights into the captured fish species, their numbers, sizes, reproduction, and life cycles in the IAB, serving as the basis for drawing relevant conclusions and recommendations for the conservation and management of fish resources.

RESULTS

The study's findings reveal a marked decline in fish catches in both quantity and species diversity, as shown in Tables (1, 2). Additionally, there has been a reduction in the body size of dominant fish species captured (Table 3). This decline indicates a significant degradation of fishery resources in Ambon Bay, driven by high fishing pressure stemming from varied fishing gear use and unregulated fishing practices. These factors have not only diminished catch numbers but have also impacted the diversity of fish species (Table 1) and certain key utilization aspects (Table 2). This decline is particularly evident in the body size of two baitfish species, *Stolephorus indicus* and *Encrasicholina heteroloba*, which are primarily caught with beach seine nets (Table 3).

Table 1. Catch results of beach seine fishermen in Inner Ambon Bay

No	Type of fish			Years		Catch composition (%)	
	Scientific name	**Standard name**	**Local name**	**2009**	**2022**	**Beach seines**	**Drift gillnets**
1	*Acanthurus triostegus*	Convict surgeonfish	Bendera strep	√			
2	*Amblygaster sirm*	Spotted sardinella	Tatari anak	√			
3	*Anodontostoma chacunda*	Chacunda gizzard shad	Kapas ramping	√			

4	*Atherinomorus lacunosus*	Wide-banded hardyhead silverside	Gete-gete	√	√	1.28	
5	*Atule mate*	Yellowtail scad	Palala ekor kuning	√			
6	*Caranx sexfasciatus*	Bigeye trevally	Bubara tipis	√	√	0.04	
7	*Caranx melampygus*	Bluefin trevally	Bubara biru	√			
8	*Chirocentrus dorab*	Dorab wolf-herring	Puri mulut keatas	√	√		1.50
9	*Crenimugil buchanani*	Bluetail mullet	Bulana	√	√		0.16
10	*Decapterus macrosoma*	Shortfin scad	Momar putih	√	√	0.38	0.07
11	*Decapterus ruselli*	Indian scad	Ikan layang	√			
12	*Dussumieria acuta*	Rainbow sardine	Teri pelangi	√			
13	*Encrasicholina heteroloba*	Shorthead anchovy	Teri merah	√	√	16.59	
14	*Equulites leuciscus*	Whipfin ponyfish	Pete	√	√	0.08	
15	*Fistularia commersonii*	Bluespotted cornetfish	Kornet biru	√			
16	*Gazza achclamys*	Smalltoothed ponyfish	Paperek	√	√	0.26	
17	*Gerres oyena*	Common silver-biddy	Kapas-kapas	√	√	0.34	
18	*Herklotsichtys quadrimaculatus*	Bluestripe herring	Teri biru	√	√	7.40	
19	*Leiognathus equula*	Common ponyfish	Papere	√	√		6.16
20	*Leiognathus leuciscus*	Whipfin ponyfish	Poni	√			
21	*Lutjanus sebae*	Emperor red snapper	Bendera	√	√	0.04	
22	*Lutjanus malabaricus*	Malabar blood snapper	Kakap merah	√			
23	*Megalaspis cordyla*	Torpedo scad	Taruri	√	√		0.72
24	*Mugil cephalus*	Flathead grey mullet	Bulana	√	√	0.15	0.09
25	*Parupeneus chrysopleuron*	Yellow striped goatfish	Kambing kuning	√			
26	*Pelates quadrilineatus*	Fourlined terapon	Kerong-kerong	√			
27	*Pranesus pinguis*	Narrow-banded hardyhead silverside	Sisi perak	√			
28	*Rastrelliger brachysoma*	Short mackerel	Anak tatari	√	√		0.14
29	*Rastreliger kanaguarta*	Indian mackerel	Lema	√	√	0.32	12.41
30	*Saurida gracilis*	Gracile lizardfish	Ikan kadal	√	√		0.02
31	*Saurida tumbil*	Greater lizardfish	Gigi sikat	√			
32	*Sardinella atricauda*	Bleeker's blacktip sardinella	Sardunela bintik hitam	√			
33	*Sardinella fimbriata*	Fringescale sardinella	Make moncong	√	√	10.94	0.55
34	*Sardinella gibbosa*	Goldstripe sardinella	Sardin	√	√	2.17	
35	*Selar boops*	Oxeye scad	Palala	√	√		0.16
36	*Selar crumenophtalmus*	Bigeye scad	Kawalinya	√	√		57.69
37	*Selaroides leptolepis*	Yellowstripe scad	Selar kuning	√	√	0.88	15.89
38	*Siganus vermiculatus*	Vermiculated spinefoot	Samandar daun	√	√		0.07
39	*Sphyraena barracuda*	Great barracuda	Piskada	√			
40	*Stolephorus buccanieri*	Buccaneer anchovy	Teri perak	√			
41	*Stolephorus commersonii*	Commerson's anchovy	Teri transparan	√			
42	*Stolephorus indicus*	Indian anchovy	Teri putih	√	√	59.12	3.76
43	*Strongylaura leiura*	Banded needlefish	Terompet	√			
44	*Syngnatoides biaculeatus*	Alligator pipefish	Ikan pipa	√			
45	*Terapon jarbua*	Jarbua terapon	Kerong-kerong strep	√	√		0.21
46	*Thryssa encrasichoilodes*	False baelama anchovy	Ikan teri	√			
47	*Trachinotus carolinus*	Florida pompano	Bubara loreng	√	√		0.35
48	*Trichiurus savala*	Savalai hairtail	ekor rambut	√			
49	*Upeneus sulphureus*	Sulphur goatfish	Salmaneti putih	√			
50	*Upeneus tragula*	Freckled goatfish	Salmaneti bitnik	√	√		0.05
51	*Zenarchopterus dispar*	Feathered river-garfish	Garfis	√			

Note: The year 2009 (representing the past) **(Ongkers *et al.*, 2009)**; the year 2022 (the present; this study)

Table 2. Percentage of respondents regarding perception of fish resources in IAB

	Total fish resources		Species composition		Certain species		Fish size		Community contribution	
Respondent's perception	Increase	Decrease	Changed	Not Changed	Found	Not Found	Decrease	fixed	Contribute	Not contribute
Percentage (%)	42.86	57.14	52.38	47.62	38.1	61.9	59.52	40.48	35.71	64.29

Tabel 3. Dominant fish lengths collected from beach seine nets in Inner Ambon Bay

Scientific name	**Common name**	**Length (cm)**			**Source**
		Average	**Min**	**Max**	
Stolephorus indicus (van Hasselt, 1823)	Indian anchovy	6.7	2.5	14.1	**Syahailatua (2005)** (Jan-Dec)
		6.4	2.0	10.2	**Ongkers (2008)** (Jan-Dec)
		4.0	1.8	6.7	**Tuapetel *et al.* (2022)** (Sep-Okt)
Encrasicholina heteroloba (Rüppel, 1837)	Shorthead anchovy	6.8	3.6	11.0	**Syahailatua (2005)** (Jan-Dec)
		6.5	3.5	10.5	**Ongkers (2006)** (Jan-Dec)
		5.2	3.4	6.9	**Latumeten and Latumeten (2021)** **(**Dec-Jan)

DISCUSSION

The research further underscores the shift in the condition of fishery resources over time in Ambon Bay. Of particular concern is the alignment of the fish spawning season in Inner Ambon Bay—from May to August—with the peak fishing period. During this critical reproductive period, fishing pressure remains high, which poses a threat to fish population sustainability. Conversely, in the non-spawning season, catch yields decrease, and fishing activity slows. Notably, between November and April, fishing activity halts, marking a "paceklik" period when baitfish are nearly absent in Ambon Bay (Fig. 2). Interview data reveal that this period coincides with the eastern monsoon, characterized by intense rainfall, which increases sediment and waste runoff into the bay. This influx contributes to high turbidity levels, heavily impacting Inner Ambon Bay's water clarity and leading to habitat degradation. Together, high fishing pressure and poor water quality have drastically reduced baitfish populations, leaving only a few resilient species, such as *Stolephorus indicus*, which can adapt to these challenging conditions.

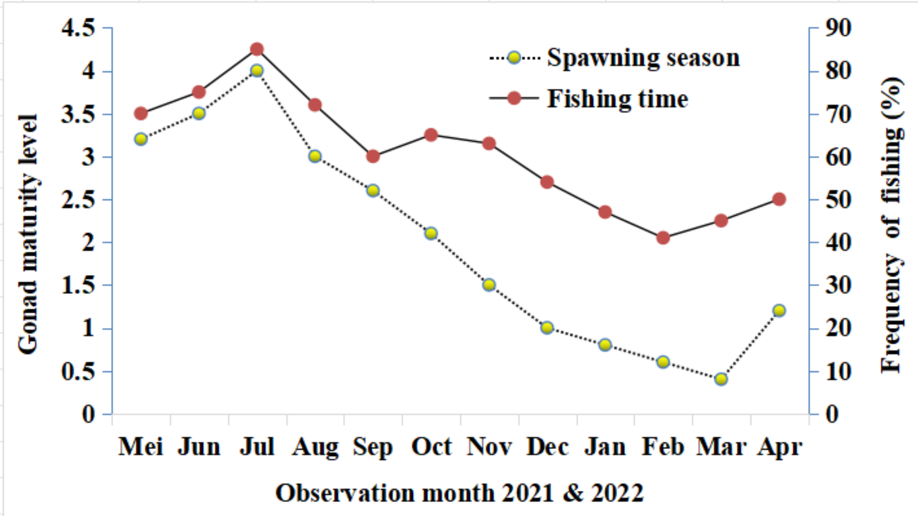

Fig. 2. Fishing time coinciding with the spawning season of fish in Inner Ambon Bay

Efforts to mitigate and preserve pelagic fish resources in Ambon Bay include several steps and actions aimed at minimizing negative impacts on pelagic fish populations and ensuring the sustainable use of these resources. Here are some of the efforts that can be outlined: One concrete step to restore Ambon Bay as a live baitfish field is to conduct restocking along with the restoration of its original habitat. Restocking involves separating native fish in Ambon Bay from their original habitat and then cultivating them in a different location with healthier aquatic environments, free from sedimentation, turbidity, and waste. Transplantation locations could include areas outside Ambon Bay, such as the waters of Batu Kapal in Alang Village or Hative Besar Village. Once these native species have multiplied, they can be reintroduced to their original habitat. It is advisable to simultaneously undertake habitat restoration efforts for Ambon Bay due to sedimentation and waste issues before transplanting fish. Several suggestions have been proposed to address these issues from upstream to downstream, including addressing waste or sedimentation at their sources. Awareness is needed from all communities living from the highlands to the coastal areas around the bay to dispose of waste properly. Additionally, land clearing for settlements should have stricter regulations to reduce sedimentation that flows into the bay.

Furthermore, the community can be encouraged to transition from fishing to fish farming. This can help reduce fishing pressure in the waters of Ambon Bay while still meeting local fish needs. Fish farming can also be carried out while adhering to sustainable principles and good management practices. Additionally, implementing and strengthening existing regulations and rules within the Ambon Bay area is essential. This includes restrictions on fishing seasons, catch quotas, and protection of crucial habitats for pelagic fish. It is important to enhance the local community's understanding of the importance of preserving pelagic fish resources. Through educational programs, communities can be informed about the consequences of overexploitation and ways to participate in marine resource conservation. Collaboration between the government, fishermen, researchers, academics, and community groups is crucial in mitigation and preservation efforts. Good coordination can ensure that the steps taken are the most effective and tailored to local needs. Continuous monitoring of pelagic fish populations, habitat conditions, and environmental changes is vital. Ongoing scientific research can provide in-depth insights into population dynamics and implementable solutions.

Although there has been a decline in pelagic fish resource stocks in Ambon Bay, it can still be restored, albeit requiring a relatively long time and expensive technology. Management efforts begin with maintaining the recruitment of fish resources in Ambon Bay by considering the spawning patterns and life cycles of each fish species. For example, *S. indicus* reaches its peak in July each year **(Ongkers, 2008)**. This information is crucial as the basis for managing these fish resources, supported by local regulations stipulating that this type of fish should not be caught in July, considering that the peak spawning occurs in that month, which forms the basis for recruiting fish stocks **(Tuapetel *et al*., 2022)**. However, July is the peak of the rainy season with the highest rainfall on Ambon Island, and the sea becomes turbid due to very high sedimentation. Consequently, it is very difficult for *S. indicus* species to increase their population because the food and feeding habits of the Engraulidae family are highly dependent on phytoplankton. Yet, this season is dominated by sedimentation originating from land clearing in the upper areas, thus control measures should be implemented swiftly. The highlands, which are the primary source of sedimentation, need to be controlled as soon as possible.

Furthermore, the largest mangrove forest in Ambon Bay is in Passo (IAB), but its condition is deteriorating due to excessively high sedimentation, including plastic waste. However, much of it is buried. In Tantui and Galala, it has become very difficult to find seagrass beds. The coral reefs are in a very poor condition. The conditions in Poka, Halong, and Hunuth are considered good (coral cover > 50%), while they are fair (25-50%) to poor (<25%) in some areas. Eri, which had a pristine coral condition (> 75%), has changed to a good condition (51%). The data indicate a decline in the quality of the coastal ecosystem in Ambon Bay. Once an ecosystem is damaged, it is very difficult to restore it to good condition and requires an advanced technology and significant costs. Therefore, the coastal ecosystem, as a habitat for fish resources, requires extra attention to ensure proper management. Mangrove reforestation should continue to be promoted, and the placement of fishing equipment in these areas should be prohibited **(Arkham *et al*., 2015; Nabila, 2021)**. Nets should be placed at the mouths of rivers flowing into the bay to filter plastic waste. Likewise, garbage cleaning equipment should operate continuously in the bay to maintain the cleanliness and beauty of the enchanting bay landscape **(Basir *et al.*, 2014; Widad & Pranatal, 2020)**. All these measures need to be implemented and enshrined in local regulations to ensure the recovery of fish resource stocks in Ambon Bay for the sake of future generations.

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CONCLUSION

Ambon Bay has experienced a significant decline in pelagic fish resource stocks, both in terms of quantity, fish species, and size. This is due to irregular fishing practices and the low level of environmental awareness among the local community. To address these negative changes, comprehensive mitigation and preservation efforts are required, such as the transplantation of remaining baitfish, aquaculture, and the enforcement of local regulations. Additionally, the protection and rehabilitation of coastal ecosystems as fish habitats must be the focus of attention and commitment from all parties to achieve the goal of conserving and preserving the bay's resources.

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