

## Ethnoichthyological perspectives on anchovy utilization and classification in the Malacca Strait

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**Abstract.** Ginting JH, Afrida A, Budarsa G, Jatmiko KA. 2025. *Ethnoichthyological perspectives on anchovy utilization and classification in the Malacca Strait*. *Asian J Ethnobiol* 8: 171-181. This study investigates the ethnoichthyological dimensions of anchovy-based livelihoods in Tanjungbalai, a coastal community located along the eastern shoreline of North Sumatra, Indonesia. Anchovies (*Stolephorus* spp. and *Stolephorus waitei*), locally known as *ikan teri*, function not only as economic commodities but also as cultural agents deeply embedded within social, ecological, and gendered systems. Based on twelve months of ethnographic fieldwork using participant observation, interviews, and focus group discussions, this research explores how traditional ecological knowledge enables fishers to classify anchovy species using folk taxonomy, recognize ecological patterns, and adapt to seasonal environmental changes. The study documents a detailed folk taxonomy that distinguishes anchovy types based on morphology, behavior, habitat, and economic value. This local knowledge directly contributes to community-level biodiversity monitoring and supports ecosystem-based fisheries management. In addition, the findings reveal a gender-complementary division of labor, the operation of informal financial networks, and intergenerational modes of knowledge transmission that uphold socioeconomic resilience. By positioning TEK as a living system of field-based biodiversity observation and resource stewardship, the study offers critical insights for integrating local knowledge into participatory marine conservation strategies and sustainable fisheries governance in the Malacca Strait.

**Keywords:** Anchovy, biodiversity, ethnoichthyology, folk taxonomy, Malacca Strait, traditional ecological knowledge

### INTRODUCTION

Indonesia, as the world's largest archipelagic state, possesses exceptional marine biodiversity, where small pelagic fisheries are vital for ecological balance and coastal livelihoods. Among these, anchovies (*Stolephorus* spp. and *Stolephorus waitei*), locally called *ikan teri*, play a prominent role in marine ecosystems and the cultural and economic lives of coastal communities. The *ikan teri* Medan label, widely recognized across Indonesia, signifies high-quality anchovy products that symbolize both regional identity and national culinary heritage (Ginting et al. 2024). Contrary to its name, these anchovies are predominantly harvested from Tanjungbalai and the Asahan Estuary, not Medan city.

Renowned for their soft texture and delicate flavor, *ikan teri* Medan are highly sought after in local and regional markets, including exports across Southeast Asia (Harper et al. 2012). This demand has shifted anchovies from subsistence food to a commercial commodity (Mulya et al. 2021). In Tanjungbalai, their commodification has shaped distinct labor hierarchies and gendered work divisions (Afrida and Ginting 2025), illustrating the importance of an ethnobiological lens that integrates biodiversity, traditional ecological knowledge, and local economies (Hutubessy et al. 2017). The Blue Revolution in the 1970s introduced modern fishing tools, significantly altering production systems (Putma et al. 2025). North Sumatra's coastal

waters remain ecologically productive, hosting various small pelagic species including anchovies, especially in the nutrient-rich Malacca Strait (Warningsih et al. 2020). Annual landings reach 15,000-22,000 metric tons, largely caught by artisanal sondong fishers (North Sumatra Marine and Fisheries Agency 2023). Current harvesting is considered ecologically sustainable (FAO 2021), forming a baseline for understanding socio-ecological practices in the region (Setiabudi et al. 2018).

However, anchovies' cultural and epistemological values remain underexplored. While much research in Indonesia and Southeast Asia emphasizes resource management and policy (Adhuri et al. 2016; Pauly and Zeller 2016), it often overlooks embedded social relations, localized knowledge systems, and labor dynamics. Community resilience is closely tied to fisher capacity and adaptive livelihood strategies like occupation diversification and informal social networks.

This study focuses on the socio-ecological entanglements of anchovy fisheries in Tanjungbalai, viewing anchovies not merely as biological species but as central figures in shaping labor roles, gender dynamics, and knowledge transfer within households. Drawing on an ethnoichthyological approach, it explores how local ecological knowledge informs species recognition, fishing strategies, and responses to change (Alves et al. 2018; Djidohokpin et al. 2020). As a subfield of ethnozoology, ethnoichthyology links folk taxonomy and emic ecological

descriptors with biodiversity research (Hurn 2015; Oishi 2016; Hounkanrin et al. 2022; Basumatary et al. 2023).

Global studies demonstrate the value of this approach. Fishing communities use nuanced ecological knowledge to classify over 100 fish species (Silvano and Valbo-Jørgensen 2008; Turgo and Di Sciara 2021), assess seasonal changes and habitats (Rahman et al. 2022; Santos et al. 2023), and foster biodiversity monitoring and participatory governance (Kichwa de Rukullakta Community 2022; Montaña and Aranda 2022). Children in these communities also acquire LEK through daily interaction, reinforcing its transmission (Bottazzi and Boillat 2021). Scholars now increasingly recognize folk taxonomy knowledge as essential to inclusive marine conservation (Łuczaj and Svanberg 2020).

By situating anchovies (*Stolephorus* spp. and *S. waitei*) within both ecological and social frameworks, this study highlights their dual role as biological species and cultural actors. Drawing on twelve months of ethnographic fieldwork in Tanjungbalai's anchovy fishing communities along the Asahan Estuary, this research employs an ethnoichthyological approach to reveal how local ecological knowledge and folk taxonomy shape fishing practices, labor divisions, and intergenerational knowledge transmission. Ethnoichthyology allows for an integrated understanding that transcends the dichotomy between nature and culture: the biological traits and migratory patterns of anchovies inform local social organization, while folk taxonomy classifications, naming practices, and use strategies influence their conservation and management (Catelani et al. 2021; Gregory et al. 2024). In doing so, this study not only advances ethnoichthyological scholarship but also contributes to participatory, community-informed, and ecologically grounded marine resource governance in the Malacca Strait.

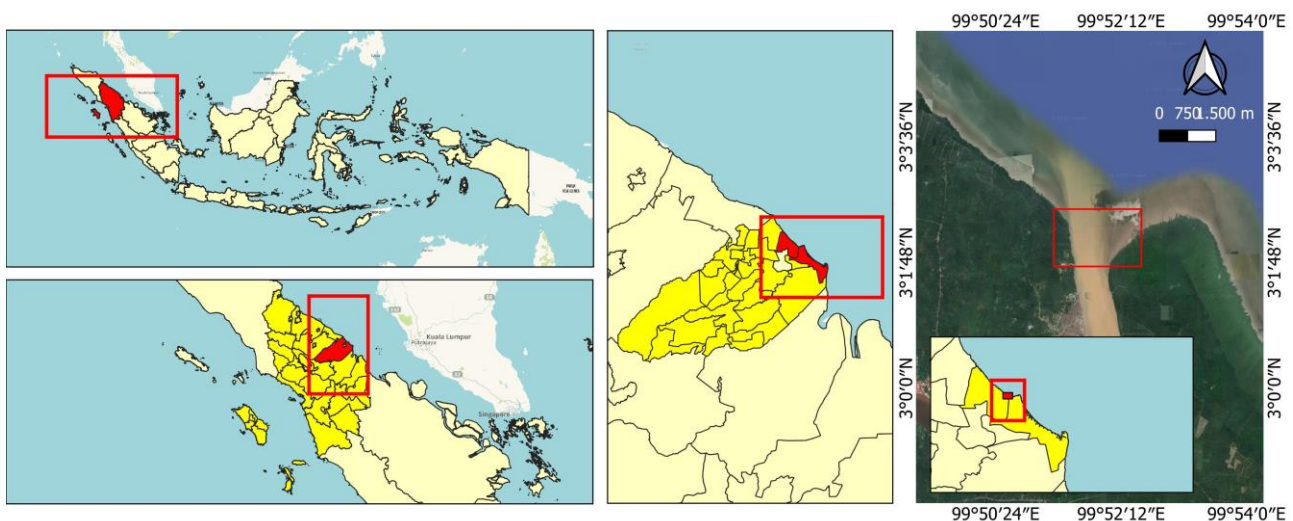
## MATERIALS AND METHODS

### Study area

This research was conducted in the coastal fishing communities of Tanjungbalai and the surrounding areas, in the eastern coastline of North Sumatra Province, Indonesia (Figure 1). The area encompasses the Asahan Estuary, which flows into the Malacca Strait, one of the world's richest fishing grounds for small pelagic species, including anchovies (*Stolephorus* spp. and *S. waitei*). Tanjungbalai has long been recognized as a major center for anchovy harvesting, processing, and export. Although popularly branded as the source of *ikan teri Medan*, the anchovies are predominantly harvested from this region rather than from the city of Medan itself. The community predominantly practices small-scale artisanal fisheries, where familial labor systems prevail and patron-client relationships with middlemen (*tengkulak*) shape the socioeconomic dynamics. The fishing fleet consists mainly of small vessels locally referred to as *sondong*, typically operated by a boat owner and a hired laborer (*anak buah kapal*, or ABK).

### Research design

The study adopted an ethnographic design, following methodological traditions described by Spradley (2016) and refined by Hammersley and Atkinson (2019). Ethnography was selected because of its capacity to explore complex human-environment interactions, social practices, labor organization, and cultural meanings embedded in natural resource utilization. The research design incorporated participant observation, ethnographic interviews, and domain analysis based on Spradley's model. The broader inquiry was also informed by Creswell's (2018) qualitative research framework, emphasizing flexibility and reflexivity in the research process. An ethnobiological perspective was integrated throughout, focusing on the interplay between traditional ecological knowledge, biodiversity, and social organization.



**Figure 1.** Map of study area showing the anchovy (*Stolephorus* spp.) fishing grounds in the coastal waters of North Sumatra, Indonesia

### Data collection

Data were collected through year-long ethnographic fieldwork conducted between March 2023 and February 2024. Intensive participant observation enabled the researcher to engage directly with the daily routines of fishers, female sorters, and market traders, covering the entire production chain of anchovies (*Stolephorus* spp. and *S. waitei*), from offshore harvesting to onshore sorting and distribution. Participation in multiple fishing trips aboard *sondong* boats offered firsthand exposure to local fishing techniques and the ecological knowledge possessed by fishers.

Semi-structured and unstructured interviews were conducted with 26 key informants strategically selected to represent various nodes in the anchovy commodity chain. These included boat owners, captains (*tekong*), male crew members (ABK), female processors (wives of fishers and hired sorters), local middlemen (*tengkulak*), and market traders. The interviews followed Spradley's (2016) ethnographic strategies, employing both grand tour and mini-tour questions, and were supplemented with techniques from Creswell's (2018) qualitative interviewing model and Bernard's (2017) anthropological research methodology.

Three focus group discussions (FGDs) were held with fisher families to explore community perceptions surrounding the ecological and economic importance of anchovies. These discussions illuminated adaptive strategies in response to environmental pressures, fluctuating market conditions, and changes in social organization. Secondary data, including government fisheries production reports, legal and policy documents, and academic literature on North Sumatran fisheries, were also examined to contextualize the empirical findings. Visual ethnography was employed to document fishing practices, processing stages, and transactions in local markets, complementing oral narratives with photographic and video data. Fieldnotes were systematically recorded in line with the practices proposed by Emerson et al. (2011), combining thick description with analytic reflection to support iterative interpretation throughout the fieldwork.

A particular emphasis was placed on documenting local ecological knowledge (LEK), especially folk taxonomic systems related to anchovy species. Informants were asked to identify and differentiate anchovy types based on folk taxonomy names and associated morphological characteristics such as body size, coloration, scale texture, and flesh density. Ecological descriptors including habitat preference, behavior, and seasonal availability were also explored. Data were collected through semi-structured interviews, guided sorting sessions at landing sites, and observational activities during fish processing, allowing researchers to directly witness and validate local classification systems.

### Sampling strategy

A purposive sampling strategy was applied to ensure that informants represented a wide range of roles within the anchovy fishery system. This approach was designed to capture the perspectives of individuals directly involved in

production, processing, and trade. Snowball sampling was further employed to access individuals in critical yet less visible roles, such as those involved in informal debt arrangements between fishers and middlemen. The sampling process accounted for demographic diversity across age, gender, and occupational status, ensuring that the findings reflected the plurality of lived experiences within the community.

### Folk taxonomy data analysis

Data were transcribed and analyzed thematically. Thematic coding focused on labor organization and gender roles, traditional ecological knowledge, patron-client economic relations, and community perceptions of environmental and market changes. Domain and taxonomic analysis methods from Spradley (2016) were applied to identify cultural categories and their interrelationships. The analytic process followed the ethnographic analysis strategies outlined by Spradley (2016). The analysis was also grounded in ethnobiological frameworks, which emphasize the interdependency of ecological knowledge and social organization. To trace the movement and transformation of anchovies as commodities, the research incorporated concept of the social life of things, from Appadurai (Evans 2018), situating the biological species within broader cultural and economic systems.

## RESULTS AND DISCUSSION

In contemporary anthropological discourse, the scope of inquiry has broadened significantly to encompass the intricate relationships between humans and their environment. This expansion has led to the flourishing of fields such as Ethnozoology and Anthrozoology. Ethnozoology, as a distinct field, systematically investigates the interrelationships between human cultures and the animals within their ecosystems, exploring indigenous knowledge systems, cultural practices, and symbolic meanings associated with various fauna (Medeiros 2018). Anthrozoology, on the other hand, examines the complex and multifaceted interactions between humans and other animals, considering ethical, social, and ecological dimensions (Hurn 2015; Verheggen et al. 2017).

Building upon these foundations, our study introduces an ethnoichthyological perspective, which specifically delves into the profound and reciprocal relationship between human societies and fish populations. This approach acknowledges that ecological factors play a determining role in shaping how humans interact with specific fish species, subsequently influencing their livelihoods and cultural practices (Hounkanrin et al. 2022). This concept is well-explored in the emerging literature on ethnoichthyology across diverse contexts (Oishi 2016; Catelani et al. 2021; Basumatary et al. 2023; Gregory et al. 2024).

### Folk taxonomy and local ecological knowledge of anchovies: An integrated ethnoichthyological perspective

Anchovies (*Stolephorus* spp. and *S. waitei*; see Figure 2) in the coastal waters of North Sumatra transcend their biological classification and function as cultural materials embedded within the socioeconomic and ecological fabric of Tanjungbalai's fishing communities. The eastern Sumatran coastline, which borders the Malacca Strait, possesses unique ecological features such as shallow waters ranging from one to five meters in depth, calm currents, and muddy to sandy seabeds. These conditions collectively create an ideal habitat for specific anchovy species. This environmental specificity significantly shapes the local ichthyofaunal profile. Unlike the larger and often more bitter-tasting anchovies harvested along the western coast of Sumatra, anchovies from the Malacca Strait are generally smaller and possess a milder, more desirable flavor. These qualities elevate their status as a high-value commodity and reinforce their essential role in local livelihoods. Anchovies also have nutritional and pharmacological value, containing bioactive peptides, omega-3 fatty acids, and antioxidants with health potential (Widowati et al. 2025).

From an anthropological perspective, this ecological embeddedness directly informs the complex human-fish relationship that is foundational to the coastal economy. The biological characteristics of anchovy species, including their size, palatability, preference for shallow estuarine habitats, and behavioral patterns such as nocturnal activity, influence the development of fishing technologies such as the *sondong* boat. These characteristics also determine the seasonality of harvesting activities and structure the organization of labor within fishing households. This interplay, where ecological features influence technological adaptation and social dynamics, lies at the heart of ethnoichthyological analysis.

Within the Tanjungbalai community, fisherfolk articulate a highly refined folk taxonomy that reflects deep empirical knowledge of local marine biodiversity (Table 1). Our research identified several locally prominent anchovy types, each distinguished by economic value as well as morphological and ecological characteristics. The most

highly valued is *teri nasi*, characterized by its small, delicate body, shiny white coloration, and mild flavor. This type of anchovy commands a premium price, typically around IDR 65,000 per kilogram, and is considered the finest among local varieties. In contrast, *teri pekto*, referring to *S. waitei*, is larger, slightly duller in appearance, and of moderate quality, with a market price around IDR 45,000 per kilogram.

Beyond these primary anchovy types, fisherfolk recognize a diverse group of incidental catch referred to as *ikan sampah* or mixed fish. This category includes species such as *pakang* (*Anabas testudineus*), *cekong* (*Hemibagrus nemurus*), *kotip* (Leiognathidae), *gulama* (*Johnius* spp.), and *tamban* (*Spratelloides gracilis*). These species are generally less valued, sold at an average price of IDR 20,000 per kilogram. Fishers distinguish these species using a range of observable features such as body shape, size, skin texture, coloration, and behavioral traits, including how they swim or associate with anchovy schools. Although informal, this folk classification system is essential for sorting catch, setting market prices, and guiding fishing strategies.

Fisherfolk in Tanjungbalai distinguish anchovy species based on a systematic integration of morphological and behavioral cues. The primary comparison lies between *teri nasi* and *teri pekto*. *Teri nasi* is recognized by its small, fine-textured body, bright silver-white scales, and softer meat, making it preferred for sun-drying and short-distance trade. *Teri pekto*, by contrast, is larger, thicker-bodied, and less lustrous, with firmer flesh that requires longer drying time. Behaviorally, fishers report that *teri nasi* forms dense surface-level schools and is most abundant during nighttime spring tides, whereas *teri pekto* is more dispersed and appears predominantly during transitional monsoon periods near river mouths. These distinctions guide fishers in determining fishing location, net type, and sorting priorities. The practical classification based on morphology, ecology, and commercial value reflects a folk taxonomy that aligns with species-level differentiation, demonstrating the epistemic sophistication of local ecological knowledge.



**Figure 2.** Morphological differences between locally recognized anchovy types. A. *Stolephorus* spp., B. *Stolephorus waitei*

**Table 1.** Summary of folk taxonomy and local ecological knowledge of anchovy species in Tanjungbalai, North Sumatra, Indonesia

Local classification	Local name (Folk taxonomy)	Scientific name	Distinguishing features (According to fisherfolk)	Habitat/Behavior (Local knowledge)	Seasonal availability	Local use/Value
<i>Ikan Teri</i>	<i>Teri Nasi</i>	<i>Stolephorus</i> spp.	Small, shiny white body; soft, fine-textured flesh; highest market value	Active at night; caught in shallow estuarine waters with <i>pukat sondong</i>	Peak Jan-Mar & Oct-Dec	High-value drying & local delicacy
	<i>Teri Pekto</i>	<i>Stolephorus waitei</i>	Larger and duller than <i>teri nasi</i> ; thicker body; moderate quality	Found near river mouths; common during seasonal transition periods	Transitional months	Moderate quality, processed longer
<i>Ikan Sampah</i> (Mixed Fish)	<i>Ikan Pakang</i>	<i>Anabas testudineus</i>	Thick body, rough scales; hardy freshwater fish	Occasionally caught near brackish areas during anchovy fishing	Irregular	Sold as low-value mixed fish
	<i>Ikan Cekong</i>	<i>Hemibagrus nemurus</i>	Flat head, dark body; strong smell; whiskered predator	Resides along riverbanks; bottom-dweller; rarely targeted	Irregular	Less preferred, sold cheap
	<i>Ikan Kotip</i>	Leiognathidae	Small, flat silvery body; fast swimmer; often mixed with anchovies	Bycatch from surface nets; swims close to anchovy schools	Irregular	Sold as low-value mixed fish
	<i>Ikan Gulama</i>	<i>Johnius</i> spp.	Heavy, yellowish body; firm texture; less favored	Bottom-dweller near muddy seabeds; caught unintentionally	Irregular	Sold as low-value mixed fish
	<i>Ikan Tamban</i>	<i>Spratelloides gracilis</i>	Slender silver body; smooth texture; suitable for smoking or drying	Appears seasonally; netted in coastal shallows alongside anchovies	Irregular	Sold as low-value mixed fish

The seasonal abundance of anchovy species varies considerably and is closely linked to local climatic and oceanographic patterns. Field observations indicate that harvests peak between January and March, and again from October to December, with daily catches ranging from 90 to 130 kg. During off-peak periods, particularly between April and August, catches drop significantly, sometimes yielding as little as 10 to 15 kg per day. These fluctuations have a direct impact on household income and economic security. Drawing on traditional ecological knowledge passed down through generations, local fishers often prefer to conduct fishing operations at night, based on their understanding that anchovies are more active and easier to capture in darkness. While this study does not specifically address reproductive biology, data from the North Sumatra Marine and Fisheries Agency (2023) indicate that provincial anchovy landings average between 15,000 and 22,000 metric tons annually.

According to the Food and Agriculture Organization (FAO 2021), anchovy fisheries in the Malacca Strait remain ecologically sustainable, with mortality levels indicating normal exploitation intensity. This environmental stability supports a dynamic local economy, where approximately 80 percent of households in areas such as Teluk Nibung sub-district participate in the anchovy value chain. These households engage in activities ranging from harvesting and sorting to drying and marketing. The dominant fishing fleet consists of small-scale *sondong* boats, typically operated by a boat owner and one or more crew members (ABK). These boats are carefully constructed from local timbers such as *kayu malas*, *kayu meranti*, *kayu moli*, *kayu haloban*, and *kayu lunas*. They are powered by single-cylinder engines and cruise at speeds of five to seven knots, making them ideal for shallow-water operations targeting anchovy-rich habitats. Most of these boats are under 10 gross tonnage, a classification that exempts them from the requirement of holding formal fishing licenses under current Indonesian maritime regulations. This regulatory status shapes not only local fishing practices but also how communities interface with national fisheries management systems (Stori et al. 2019; Sari et al. 2022).

The integration of ecological adaptation, regulatory frameworks, and artisanal fishing practices exemplifies the core principles of ethnoichthyology. The technical design of *sondong* vessels and the fishers' deep knowledge of lunar cycles, tides, spawning zones, and species behavior form an adaptive system rooted in cultural resilience and ecological insight. As seen in comparable studies, traditional ecological knowledge contributes significantly to biodiversity research. It helps identify species (Catelani et al. 2021), map dynamic fishing grounds, and monitor population health in marine ecosystems (Gregory et al. 2024). In Tanjungbalai, fisherfolk distinguish species not solely by commercial value, but also through detailed understanding of anatomical, behavioral, and ecological traits. These forms of knowledge, developed through sustained interaction with local waterscapes, act as dynamic, field-based biodiversity observations.

The anchovy fishery of Tanjungbalai thus constitutes an active interface between ecological knowledge and social organization. The folk taxonomy practiced by fishers, when documented and engaged in dialogue with scientific frameworks, holds potential to enhance formal fisheries management and biodiversity conservation. Integrating such knowledge into policy opens pathways for participatory, adaptive, and culturally grounded marine governance. Rather than anecdotal, traditional ecological knowledge represents a living, cumulative system of observation and interpretation that remains essential to both the resilience of coastal communities and the sustainability of the marine environment (Houkanrin et al. 2022; Chambon et al. 2024).

### Economic dynamics and livelihood outcomes

Anchovies (*Stolephorus* spp.) are not only economically important for fishers, but also offer emerging value as marine nutraceuticals, due to their rich content of bioavailable micronutrients and bioactive compounds (Widowati et al. 2025). The anchovy fishery in Tanjungbalai, while a vital economic driver, operates within complex financial dynamics characterized by significant fluctuations in income and a challenging cost structure for fishing households. Our ethnographic findings, supplemented by concrete quantitative indicators from fieldwork, illustrate the economic realities faced by various actors within this value chain.

The daily wages for crew members (ABK) and captains (*tekong*) are fixed at IDR 100,000 per person per day, regardless of the catch volume. This model provides a degree of income stability for laborers, distributing economic risks more evenly compared to profit-sharing systems common elsewhere. Female sorters, crucial to post-harvest processing, are compensated at a rate of IDR 30,000 per boat for their sorting efforts. However, their daily earnings can increase significantly as many sorters handle fish from multiple boats, potentially reaching IDR 100,000 per day if they sort for several vessels. Monthly income for female sorters, for instance, can range from IDR 500,000 during periods of abundant catches to a more modest IDR 200,000-300,000 during lean seasons. This income is often used to supplement household needs, purchase children's snacks, or, in some cases, for personal expenditures or participation in informal savings groups like *arisan*.

Boat owners, positioned at the apex of the labor hierarchy, bear the primary financial risks and expenses. Their gross income from a single fishing trip (typically lasting 3-4 days) can range from IDR 3,000,000 to IDR 7,000,000. However, this is a gross figure, subject to substantial operational costs and profit-sharing arrangements. Fishing operations, especially for *sondong* boats, involve significant initial outlays. A new *sondong* boat can cost up to IDR 100,000,000, while a used one ranges from IDR 60-80 million. Daily operational expenses for a 3-5 day trip are considerable, estimated between IDR 2,000,000 to IDR 4,000,000. This includes fuel (solar), which costs IDR 300,000 per jerrycan (15 liters), with 7 jerrycans needed for a 5-day trip; gas (typically 10 units of

3 kg gas cylinders for a trip); salt (IDR 200,000 per sack, with 3-4 sacks needed); and food supplies for the crew (Table 2). Additionally, there are costs for maintaining the boat, repairing engines, and purchasing fishing gear. A detailed calculation from our fieldwork illustrates the financial tightrope walked by boat owners. For a 3-day trip yielding 50 kg of anchovies, with anchovy prices from *tengkulak* at IDR 65,000/kg (Table 3).

This net profit of IDR 900,000 for a 3-day trip, while seemingly modest, highlights the constrained profit margins for boat owners, especially when considering initial investments and the unpredictable nature of catches. This situation often forces boat owners to rely on loans from *tengkulak* (middlemen) (see Figure 3), perpetuating a cycle of indebtedness. This economic vulnerability is further exacerbated during periods of low catch, leading to mounting debts that can hinder long-term economic mobility and bargaining power within the patron-client system.

The market price of anchovies exhibits considerable volatility. While *tengkulak* might purchase anchovies from fishers at around IDR 65,000/kg (even during times of scarcity), the same product can be retailed at IDR 110,000/kg in the market, illustrating the significant profit margins captured by middlemen in the distribution chain. This price disparity, combined with declining catches, severely constrains the income of fishers and processors, compelling them to adapt through informal financial networks and diversified household incomes.

### Patron-client relations, environmental uncertainty, and adaptive strategies

Patron-client relationships in the anchovy fisheries of Tanjungbalai create both economic opportunities and power asymmetries. Boat owners and *tengkulak* not only provide employment and credit but also control market access and pricing structures. Crew members and female workers often remain economically dependent on patrons, particularly when credit arrangements evolve into long-term debt obligations (Husni et al. 2022).

While these relationships offer stability in uncertain economic contexts, they also perpetuate social stratification and dependency. As Crona and Bodin (2010) observed, such power asymmetries can hinder governance transformability and labor mobility. Environmental changes compound these economic vulnerabilities. Fishers reported declining anchovy catches over recent years,

attributing reductions to sedimentation, coastal development, increased competition, and unpredictable weather patterns—observations consistent with regional scientific literature (Winarno and Salsabila 2024).

These environmental uncertainties have prompted adaptive strategies such as modifying fishing gear, shifting fishing grounds, and diversifying household incomes through small-scale aquaculture or trade. Local ecological knowledge remains central to these adaptations. Fishers employ detailed understandings of tides, lunar cycles, and fish behavior, reflecting a resilience-oriented approach to environmental change (Muawanah et al. 2018; Ullah et al. 2023).

However, this knowledge system faces erosion as younger generations seek alternative livelihoods and as technological shifts outpace traditional learning. Framing this within Appadurai's concept of the social life of things (Evans 2018), anchovies are not passive resources but agents that mediate labor relations, gender roles, and economic structures. As they move through production and distribution networks, anchovies accumulate social meanings and economic values, reinforcing their role as both ecological and cultural keystones.

### Gendered labor and economic rights in anchovy production

The anchovy fishery in Tanjungbalai represents a socioeconomic system where gender roles are clearly defined yet complementary. Men dominate the production side, particularly fishing at sea using *sondong* boats, while women undertake post-harvest processing tasks, mainly sorting and grading the catch. This division of labor is not merely traditional but forms a resilient economic model where both genders contribute uniquely to household and community livelihoods.

**Table 3.** Fishing trip revenue and profit calculation

Description	Calculation	Amount (IDR)
Total revenue	50 kg × 65,000/kg	3,250,000
Total expenses	Fuel, gas, salt, food, wages (ABK, tekong, sorter, dryer, tukang becak)	2,350,000
Net profit (boat owner)	IDR 3,250,000 - IDR 2,350,000	900,000

Note: 1 USD = ~ 16,000 IDR

**Table 2.** Breakdown of fishing trip operational costs

Item	Quantity (Estimate per 3-5 day trip)	Unit cost (IDR)	Total cost (IDR) (Estimate)
Solar fuel	7 jerrycans (15 liters/jerrycan)	300,000/jerrycan	2,100,000
LPG gas 3 kg	10 cylinders	Variable	250,000
Salt	3-4 sacks	200,000/sack	600,000-800,000
Crew food needs	Optional	Variable	200,000
ABK wages	3 days (per person)	100,000/day	300,000 (per ABK)
Captain ( <i>tekong</i> ) wages	3 days	100,000/day	300,000
Sorter wages	1 person (per boat)	30,000/boat	30,000
Dryer/spreader wages	Based on kg	800-1,500/kg	60,000 (for 17 kg)
Becak driver wages	1 boat	10,000/boat	10,000

Onboard *sondong* vessels, only men serve as captains and crew due to the physical demands and sanitary challenges of multi-day fishing trips (Figure 5). Once ashore, women sort the catch into various commercial grades. Their work determines the final market value of the anchovies, particularly prized varieties like *teri seppo* and *teri kase*, while less valuable bycatch such as *kotip* fish is either sold cheaply or retained for household consumption. Despite the skill involved, female sorters typically earn low daily wages, often IDR 30,000.00 per boat, with no formal contracts or social security. This reflects a broader trend in small-scale fisheries across Southeast Asia, where women play indispensable roles yet face persistent economic marginalization (Teniwut et al. 2022; Nurhayati et al. 2023). Women's labor is often seen as an extension of domestic responsibilities rather than professional work warranting equitable remuneration (Nurhayati et al. 2023).

In Tanjungbalai, even though women's sorting work enhances the efficiency and profitability of fishing operations, their contributions remain undervalued in both economic and policy frameworks (Figure 4). However, recent studies emphasize that these gendered divisions are not static. They often evolve into systems of gender complementarity where women exercise considerable agency in managing household finances and diversifying income sources (Gustavsson and Riley 2018). Financial autonomy among women in Tanjungbalai is further reinforced by their participation in rotating savings groups (*arisan*) and informal credit systems (Spyrou et al. 2021). Such mechanisms provide liquidity for daily needs, children's education, and even fishing operations, including fuel purchases and gear repairs. This mirrors findings from similar fisheries in Malaysia and North Borneo, where women leverage social capital and informal financial networks to navigate labor inequities and economic uncertainty.

#### **Knowledge transmission, cultural continuity, and the future of anchovy fisheries in Tanjungbalai**

In the anchovy fisheries of Tanjungbalai, knowledge transmission is not merely a cultural practice but a critical component sustaining the ecological and economic viability of the sector. Traditional ecological knowledge encompasses a wealth of local expertise, from precise fishing techniques (e.g., operating *sondong* boats and interpreting subtle signs of the sea) to intricate seasonal patterns and efficient post-harvest processing skills. This knowledge is primarily passed down across generations through embedded social learning processes rather than formal instruction. Fathers often impart fishing wisdom and practical skills to sons during shared fishing trips (Ginting and Anwar 2024), while mothers diligently transmit sorting and grading expertise to daughters and younger female relatives during daily post-harvest activities. This hands-on, experiential learning is crucial for the preservation of local expertise.

However, this vital transmission model confronts significant challenges, particularly from external socioeconomic pressures and internal dynamics within the community. Younger generations are increasingly expressing disinterest in pursuing traditional fishing livelihoods. This disinclination stems from a perception of low economic returns, coupled with the allure of more stable, less arduous urban employment opportunities. This trend represents a substantial threat to the cultural continuity of TEK, as fewer individuals are available or willing to inherit and perpetuate these specialized skills and knowledge systems.



**Figure 4.** Fisherman's wife works as an anchovy sorter



**Figure 5.** *Sondong*, anchovy fishing vessel in Tanjungbalai

Women play a particularly pivotal role in both the economic and knowledge spheres of this fishery. Female fish sorters not only directly determine the market value of the catch through their meticulous work but also serve as key knowledge bearers and transmitters. Through daily interactions at the dock, these women actively share information about fluctuating market trends and innovative processing techniques. Crucially, information concerning changing ecological conditions (e.g., shifts in fish behavior or habitat) is primarily received by women from the male fishers who work at sea and observe these changes firsthand. This collected information is then summarized and analyzed by women from various sources, significantly increasing their role in the communication and dissemination of knowledge within the community. This informal, yet highly effective, social learning environment among women is essential for maintaining the socio-ecological resilience of fisheries, mirroring findings from other regions where women are recognized as central to adaptive capacity and knowledge persistence.

More critically, this knowledge base empowers women to engage in co-decision-making within their families regarding adaptive strategies. For instance, when women observe a consistent decline in the quantity or quality of anchovies brought ashore, and combine this with information from fishers about changes in fish behavior or habitat, they often initiate discussions with their husbands or male relatives about modifying fishing locations or techniques. They might suggest exploring alternative fishing grounds based on their market observations, or propose diversifying household income by expanding the production of processed anchovy products (e.g., *kerupuk ikan*) when raw catches are low. This active participation extends to financial decisions, where women, leveraging their roles in *arisan* and informal credit systems, collaboratively decide on investments for fishing gear repair or even to manage household expenditures during lean fishing seasons. Such collaborative decisions underscore the shared responsibility and mutual influence of men and women in ensuring the livelihood's sustainability.

Nevertheless, the informal nature of TEK makes it inherently vulnerable to erosion, especially as the fishing workforce ages and fewer young people enter the sector. Formal documentation efforts are scarce, and existing national fisheries policies often fail to adequately recognize or integrate TEK into official management frameworks (Muawanah et al. 2018; Purwanti et al. 2021). Without systematic efforts to record, validate, and disseminate this invaluable local knowledge, a significant portion of it risks being permanently lost, diminishing the community's adaptive capacity.

Despite these challenges, social learning environments, such as the communal sorting areas, continue to facilitate the transmission of innovative adaptive strategies. For instance, women have collectively developed and refined informal credit systems and rotational savings groups (*arisan*) to manage income volatility and buffer against economic shocks (Spyrou et al. 2021). Such practices not only provide immediate financial stability but also foster

intergenerational learning about resource management, financial literacy, and collective resilience. Efforts to bridge traditional knowledge with modern science are gaining traction. Collaborative initiatives involving fishers, researchers, and policymakers have demonstrated that integrating TEK with scientific data can significantly enhance fisheries management outcomes. In Raja Ampat, for example, the inclusion of fishers' ecological knowledge in anchovy management plans led to improved compliance and conservation results (Sari et al. 2022), serving as a replicable model for Tanjungbalai.

Women's empowerment is central to effectively integrating TEK and fostering long-term resilience. Empowerment programs that provide technical training, financial literacy, and leadership opportunities have shown immense promise in other Indonesian fisheries (Alami and Raharjo 2017; Sornkliang et al. 2018). By enhancing women's roles not just as workers but as active decision-makers in resource management and economic planning, these initiatives strengthen both knowledge transmission pathways and overall community resilience. Furthermore, integrating local fisheries knowledge into school curricula can encourage youth engagement and foster pride in traditional livelihoods (Spyrou et al. 2021), potentially reversing the trend of disinterest. Innovative digital documentation methods, such as videos and social media platforms, also offer powerful avenues to preserve and share TEK with younger, tech-savvy generations (Schiemer et al. 2024). In other coastal areas, similar integration of local ecological knowledge into tourism practices has shown that fishermen can create unique tourism experiences that attract environmentally conscious tourists and contribute to the sustainability of the tourism industry by leveraging their ecological expertise and cultural heritage (Zamzami 2024).

This study highlights the complex socio-ecological relationships surrounding anchovy (*Stolephorus* spp.) fisheries in Tanjungbalai, emphasizing how local ecological knowledge, labor hierarchies, and market dynamics converge to shape coastal livelihoods. Anchovies are not only a vital economic commodity but also a cultural and ecological keystone that reflects the adaptive strategies of fishing communities in navigating fluctuating environmental conditions and capitalist market demands. By documenting folk taxonomy and traditional ecological practices, this research demonstrates that local knowledge systems are indispensable for understanding species diversity and maintaining sustainable marine resource management. In this light, collaborative governance models that integrate community-based knowledge with modern fisheries policies could enhance both biodiversity conservation and socioeconomic resilience in the Malacca Strait.

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