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Fisheries Resources in Brunei Darussalam: A Review

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ABSTRACT

Even though Brunei Darussalam has a high richness of fish and fisheries resources, relatively little research has been done on them to date. The nation's freshwater, brackish, and marine fishing resources are a blessing. The fishing state of Brunei Darussalam, which occupies 5,765 km² of territory and is officially separated into four districts (Brunei-Muara, Tutong, Belait, and Temburong), is situated in the northwest of the island of Borneo. The government of Brunei has implemented several National Development Plans since 1965 to try to move the nation's economy away from the traditional oil and gas industry. The increasing demand for high-quality fish products in both domestic and international markets, along with the availability of viable sites, have made fisheries and aquaculture one of the development priorities. This systematic review will assist to the planners and decision makers in Brunei Darussalam to take initiatives taking research projects on these fish and fishery resources.

Keywords: Fishing zonation, Marine, Brackish, Freshwater, Invasive, Fish

1. Introduction

In the northwest of Borneo Island in South-East Asia sits the equatorial nation of Brunei Darussalam (4°30′N 114°40′E). A total of 5, 765 square kilometers (km^2) make up the nation's land area, and its coastline stretches 161 kilometers (km) toward the South China Sea. The state of Sarawak, Malaysia, borders the nation and divides Brunei's Belait, Tutong, and Muara districts from Temburong district. An estimated 41,188 km^2 of Brunei Darussalam's marine coastal domain extends from the shore to 200 nautical miles (nm) of the Exclusive Economic Zone (EEZ), making it six times larger than the country's entire land area. Because of its vast mangrove forests and coral reefs, Brunei Darussalam's coastal waters are home to some of the most diverse ecosystems (Yasuaki, 2016; Silvestre et al., 1992). According to unpublished information presented at the Biodiversity Conference, Brunei Darussalam is home to 801 fish species from freshwater and saltwater environments, 410 coral species, and 331 marine mollusk species.

2. Overview of Brunei Darussalam's Water Resources' Environment

2.1 Fishing Zonation

The fisheries sector has four zones to adapt different forms of fishing, thereby setting resource management boundaries based on the type and power of fishing vessels, as shown in Fig.1. Table 1 shows that the agency recently amended the fishing zones for Zones 1 and 2, as of January 2024 (SEAFDEC website). The assessment has changed Zone 2, enlarging the area available to small-scale fishers in Zone 1 (DoF, 2024).

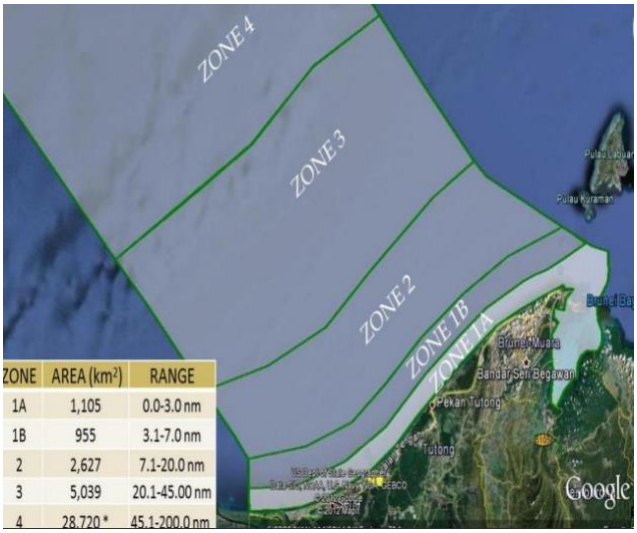

Fig. 1. The fishing area and fishing zonation of Brunei Darussalam's waters (Source : DoF, 2024).

Table 1: The re-delineation of fishing zones. Modified from Department of Fisheries, 2024.

Zone	Sub-zone	Area (km^2)	Range (nm)	Description
1	1A	1,105	0 – 3	Exclusive for small-scale or part-time fishermen
	1B	955	3.1 – 7	Exclusive for fishermen operating small companies
2		2,627	7.1 – 20	For commercial fishing vessels with no more than 350 horsepower (hp) engines and 60 tonnages
3		5,039	20.1 – 45	For commercial fishing vessels with 351 to 600 hp engines and 60 to 150 tonnages
4		28, 720	45.1 – 200	For commercial fishing vessels with 600 to 800 hp engines and 150.1 to 230 tonnages

2.2 Marine Waters

Marine waters are saltwater environments in oceans and seas that have a salinity concentration more than 20 parts per thousand (ppt). Salt tends to rise as distance from the coast rises; Brunei Darussalam's salt content has been measured up to 34.6 ppt (Fakhriedzwan et al., 2013; ThiaEng et al., 1987). They support a variety of ecosystems and serve an important role in regulating the planet's climate and maintaining marine life. The South China Sea's marine and coastal biodiversity is thought to be among the richest in the world in terms of flora and fauna (Burke et al., 2002; Wang et al., 2021).

Brunei Darussalam's coastal waters contain shallow shoals and patch reefs that provide critical habitat for a variety of corals, fish, mollusks, crustaceans, and echinoderms, resulting in the registration of 711 reef fish species, 331 mollusks, and 17 stomatopods in marine areas (The Forestry Department & Ministry of Industry and Primary Resources, 2014. Because the country is located on the border of the "Coral Triangle," which is known as the heart of reef biodiversity, there is a robust population of marine life in this area (Allen, 2009). Furthermore, coral diversity in Brunei Darussalam is especially high when compared to other locations of the South China Sea; the country has reported over 400 out of 478 coral species present in the South China Sea Eco Region (DeVantier & Turak, 2009). Coral diversity was discovered around 4 kilometers from the coast in places with higher salinity levels, as opposed to corals found around Pelumpong Island, which has significant turbidity and low salinity levels due to land drainage (Tanaka, 2016). The total reef habitat in the country is approximately 50 km^2, however some estimate it to be around

200 km^2 at distances of up to 35 km from the coast (Burke et al. 2002). Shoals rise 7 m to 30 m above the surface of Brunei Darussalam, where the average water temperature is 29.5°C and the saline level is 31 ppt (DeVantier & Turak, 2009). Temperatures as low as 24.5°C have been recorded further offshore, such as Fairley (Hollyoak et al., 2005). Coral reef ecosystems provide critical breeding and nursery grounds for both bottom-dwelling (demersal) and open-water (pelagic) fish species (Arai, 2015).

2.3 Brackish Waters

When freshwater and saltwater interact, they form a mixture known as brackish water, which has a salinity of 5 to 20 parts per thousand. Brackish waters can be found where freshwater from rivers or streams mixes with saltwater from oceans or seas, such as estuaries, mangrove swamps, and coastal lagoons. Estuaries are diverse habitats in which freshwater from rivers and streams meets saltwater from the ocean. These habitats are critical for water purification, flood prevention, and human settlement. Because the estuary and sea have no clear limit, species that live in estuarine settings can be found many kilometers offshore (Blaber, 2000). Estuaries are crucial for preserving mangroves and seagrasses because they provide habitat and abundant fish resources. These environments, in turn, support the estuarine food web. The vast untouched mangrove forests in Brunei Darussalam fertilizes the waters, providing an ideal environment for fish to spawn, allowing the juvenile fishes to inhabit the waters and act as feeding grounds.

Although there are estuaries in each of the four districts, the Belait, Tutong, and Brunei estuaries—collectively referred to as Inner Brunei Bay—consist of the largest estuaries, with an area of 400 km^2 (The Forestry Department & Ministry of Industry and Primary Resources, 2014). Where rivers meet the sea in Brunei Darussalam, estuarine habitats can be found along the coastlines leading to mangrove forests. The Belait Estuary is located in western Brunei Darussalam, where the Belait River drains into the South China Sea. It has a salinity of 0.5 to 24.46 parts per thousand and is a long, shallow coastal plain estuary that spans 90 kilometers upstream from Kampong Apak Apak (Ukotije-Ikwut et al., 2023). Meanwhile, the Tutong estuary is constructed between two sand spits, with rivers flowing from the northeast and Sungai Telamba entering from the southwest (Badrie, 2023). This area stretches 10 kilometers from Tutong town to the sea at Kuala Tutong. The Brunei Estuarine System (BES) in Brunei Muara district is 45 kilometers long and consists of shallow marine water bodies. It is also known as the Inner Brunei Bay (IBB).

The IBB is Brunei Darussalam's largest estuary, located in the northeastern region, where waters from the Brunei River, Temburong River, Limbang River, and Trusan River from Sarawak, Malaysia flow into the South China Sea (Jolkifli & Wahab, 2018; Thia-Eng et al., 1987). The salinity rises from 3.0 to 15.5 ppt between Bengkurong and Sungai Besar, whereas values at the river's mouth, such as Pulau Pepatan and Muara, range between 9.3 and 28.0 ppt (Bolhuis et al., 2014). Water salinity is regulated by the South China Sea's semi-diurnal tides and freshwater influx (Marshall et al., 2016). Brunei Darussalam has two monsoon regimes: the Northeast Monsoon, which occurs from November to March with strong northeast winds, and the Southwest Monsoon, which occurs from June to September with southwest winds that may cause occasional squalls. The Northeast Monsoon causes harsher currents, with seas flowing clockwise around West Borneo's coast. (Holyoak et al. 2005; Satyanarayana et al. 2018).

2.4 Freshwater

Freshwater is described as water that contains low levels of salts, often less than 0.5 ppt. Although this analysis concentrates on saline waterways in Brunei Darussalam, some freshwater fish will be mentioned because some species can endure brackish or salty settings. Brunei Darussalam has 104 freshwater fish species recorded so far (Zohrah Sulaiman et al., 2018). According to an article in the Borneo Bulletin, BruDirect states that the freshwater aquaculture business in Brunei Darussalam is still in its infancy when compared to other ASEAN nations because freshwater fish are not as popular with consumers as marine or brackish water species. Only 30 metric tonnes were produced annually on average over the previous five years in Brunei Darussalam, mostly from the primary species that were cultivated, including hybrid oreochromis, nile tilapia, common carp, and a few local species of catfish, snakehead, and puntius.

Developing freshwater aquaculture has enormous potential, however Brunei's Department of Fisheries (DoF) has pointed out this gap. About 13 hectares of land were created for the activities, which include 225 ponds and are run and maintained by 118 part-time farmers. The constructed ponds range in size from one hundred to five hundred square meters. The majority of the ponds are run by residents in isolated places whose main source of protein, in addition to meat and poultry, is freshwater fish caught from the rivers. They raise the fish for their personal use, and the rest is sold to the locals.

Brunei has a lot of 'undistributed' inland land, and the water is clean and unpolluted, thus there is a lot of opportunity for growing freshwater aquaculture there. The government intends to develop the sites that have been identified and give them basic access to roads, electricity, and water supplies so that commercial freshwater fish and prawn farming can begin.

3. Fish and Fisheries resources in Brunei Darussalam

3.1 Brunei Darussalam Fisheries

The combined value of Brunei Darussalam's catch fisheries, aquaculture, and seafood processing sector was expected to reach $211.11 million in 2022 as per Borneo Bulletin Yearbook 2025 (https://borneobulletinyearbook.com.bn/aquaculture/#:~:text=89%20million%20in%202002%20to,amounted%20to%206%2C018%20metric%20tonnes). It has been determined that the industry has the ability to reduce the country's reliance on gas and oil. The majority of the fishery's output comes from capture fisheries; 16,178.24 metric tons (MT) of fish were collected from Brunei Darussalam's waters, which range in depth from 0 to 200 nm. Small-scale fisheries account for 13, 714.83 MT of this total, whilst commercial fisheries account for 2,463.41 MT. Fish aggregating devices and fishing operations enforcement in 2019 may have contributed to the rise in part-time small-scale fishermen from 1,265 to 5,903 in 2022 (DoF,2023). Meanwhile, the aquaculture business generates 5, 018.34 MT, mostly from freshwater fish, mud crab, marine shrimp, and shrimp fry. Fishery management and policy development have made use of the data since the 1980s, when commercial fishing statistics were first collected. Among the highest in the region, the country consumes 47 kilograms of fish per person (kg/capita). The current fish self-sufficiency rate, as determined by the government's Fisheries Department, is 80%, indicating a favorable indication of local fish production.

The Brunei Darussalam Fisheries Department has promoted the growth of aquaculture in the country to satisfy the needs for both domestic consumption and exportation. One of the

industries with the greatest rate of growth in the nation is aquaculture, with 17,322 hectares (ha) recently approved for offshore cage culture. Since the 1970s, when the first marine cultivation of the mangrove oysters, Saccostrea cucullate, which are indigenous to Brunei Darussalam, was carried out, the aquaculture business has been established in the nation.

Meanwhile, ten years after the start, the culture of marine shrimp and fish was started. The following species of saline finfish and shellfish are currently being raised in Brunei Darussalam: Bluefin Trevally (*Caranx* spp.), Big Eye Trevally (*Caranx* spp.), Red Tilapia (*Oreochromis* spp.), Whiteleg shrimp or Vannamei (*Litopenaeus vannamei*), Blue Shrimp (*Litopenaeus stylirostris*), Golden Pompano (*Trachinotus blochii*), Snubnose Pompano (*Trachinotus* spp.), Seabass (*Lates calcarifer*), Snapper (*Lutjanus* spp.), Lobster (*Panulirus ornatus*), Milkfish (*Chanos chanos*), and Tiger Shrimp (*Penaeus monodon*) are among the species that are currently being aquacultured (Jolkifli & Wahab, 2018; Tamat et al., 2019). Not only do Brunei Darussalam's fish resources serve its people with food, but they are also imported into eight other nations. Australia, China, Japan, Malaysia, Singapore, and Taiwan were the destinations of 6,623.52 MT of processed fish products exported in 2022 (DoF, 2023). The output of the fisheries sector increased by 1, 073.93 MT compared to 2021, when 5, 549.59 MT of processed and live fish were shipped to the previously mentioned nations, including Hong Kong and New Zealand (DoF, 2022).

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3.2 Marine Water Fish

A wide range of fish species depend on Brunei Darussalam's salty waters for vital habitat, including seagrass beds, coral reefs, and open coastal waters. This has enhanced local fisheries and diversity. The coral reefs of Brunei Darussalam, which span 210 km2, are made up of patch reefs, atoll reefs, and bordering reefs. These reefs are home to a wide variety of marine life and are home to colorful fish (Tanaka, 2016). According to The Forestry Department & Ministry of Industry and Primary Resources (2014), the nation is home to 711 species from 259 genera and 82 families, with the most common species found in the Gobies (93 species), Wrasses (79 species), Damselfishes (66 species), Cardinal fishes (45 species), Groupers (36 species), Butterflyfishes (Chaetodontidae) (31 species), Parrotfishes (Scaridae) (25 species), Snappers (Lutjanidae) (23 species), Surgeonfishes (Acanthuridae) and Trevallies (Carangidae) (The Forestry Department & Ministry of Industry and Primary Resources, 2014). Numerous studies have been conducted to evaluate Brunei Darussalam's marine fish population, including evaluations of fish in both natural and artificial reefs.

Brunei Darussalam has a strong oil and gas sector that plays an important role in the economy; hence, oil platforms and underwater pipelines present in the country's waters serve as artificial reefs. In 1992, the fish communities of natural reefs, tire reefs, oil platforms, and buoy lines were evaluated, giving a total of 144 pelagic and coral reef species. It indicated a large number of 26 Damselfish (Pomacentridae) and 22 Wrasse (Labridae) fish species in the surroundings and around the reefs. In Brunei Darussalam, the oil rigs housed 14 families of fish eaten in grades I through IV. The Table 3 gives the families of fishes found in natural and artificial habitats, these include Serranidae, Lutjanidae, Carangidae, Siganidae, Latidae, Sphyraenidae, Latidae, Sphyraenidae, and Caesionidae.

Table 2: Fish species found in natural and artificial habitats. Modified from Silvestre et al., 1992.

Grade	Family	Species
I	Serranidae	*Cephalopholis argus*
		C. boenak
		C. pachycentron
		Cephalopholis sp. *1*
		Cromileptes altivelis
		Epinephelus caeruleopunctatus
		E. fasciatus
		E. morrhua
		E. tauvina
		Epinephelus sp.*1*
		Plectropomus maculatus
	Lutjanidae	*Lutjanus bohar*
		L. carponotatus
		L. decussatus
		L. ehrengergii
		L. fulviflamma
		L. johnii
		L. kasmira
		L. madras
		L. gibbus
		Lutjanus sp.*1*
	Carangidae	*Atule mate*
		Caranx sexfasciatus
		Carangoides ferdau
		C. fulvoguttatus
		Elagatis bipinnulata
		Gnathodon speciosus
		Selaroides leptolepis
	Siganidae	*Siganus corallinus*
		S. guttatus
		S. javus
		S. virgatus
	Latidae	*Lates calcarifer*
	Sphyraenidae	*Shyraena barracuda*
		S. flavicauda
	Caesionidae	*Caesio teres*
		Pterocaesio diagramma
		P. tile
II	Haemulidae	*Plectorhynchus diagrammus*
		P. picus
		P. pictus
III	Mullidae	*Parupeneus indicus*
		P. multifasciatus
		P. trangula
		Paruupeneus sp.*1*
	Pomacanthidae	*Pomacanthus annularis*
		P. sexstriatus
IV	Ephippididae	*Platax orbicularis*
		P. pinnatus
	Carcharhinidae	
	Dasyatidae	*Taeniura lymma*
	Kyphosidae	Seachubs

Grade	Family	Species
Other food fishes	Scaridae	Parrotfishes
	Acanthuridae	Surgeonfishes

The analysis discovered that 21 kinds of sought-after food fish, including snappers, groupers, carangids, wrasses, and damselfishes, were more regularly found around oil platforms than natural reefs in the country. Pelagic fish are found to congregate near floating items and midwater structures. A marker buoy is a floating device to indicate the location of the platform, it is anchored to concrete blocks on the seafloor. Pelagic fishes observed from marker buoy lines were Carangids (*Caranx sexfasciatus*), Barracudas, Small Snappers (*Lutjanus madras*), Yellowtail Scad (*Atule mate* and *Selaroides leptolepis*), Damselfishes (*Abudefduf saxatilis* and *Neopomcentrus* spp). Meanwhile in midwater species, Fussilers (*Pterocaesio diagramma*), Yellow and blueback Fusilier (*Caesio teres*), Carangids (*Gnathodon speciosus*, *Carangoides ferdau*, and *C. fulvoguttatus*), Rainbow Runners (*Ebgatis bipinnulata*), Barracudas, Batfishes (*Platax orbicularis* and *P. pinnatus*) were observed. Midwater species spotted were of Snappers (*Lutjanus madras, L. bohar, L. decussatus,* and other *Lutjanus* species), Sweetlips (*Plectorhynchus pictus, P. picus* and *P. diagrammus*), Groupers (*Cephalopholis pachycentron, Cephalopholis argus, Plectropomus maculatus, Chromileptes altivelis, Epinephelus fasciatus,* and *Epinephelus morrhua*), Rabbitfishes (*Siganus guttatus, S. javus*, and *S. virgatus*), and Seabass (*Lates calcarifer*), Sea chubs (*Kyphosus bigibbus*), puffer (*Arothron stellatus*), Moorish idols (*Zanclus cornutus*), chaetodontidae, and Filefish (*Aluterus scriptus*) (Silvestre et al., 1992).

A subsequent survey was conducted to better understand the marine environment of offshore platforms, specifically the SouthWest Ampa Field and Fairley Field platforms off the coast of Belait District. The survey recorded 100 fish species, ranging from reef fishes to benthic species. Pelagic fish spend most of their time in open water, yet they will approach oil rigs for shelter and food.

These include the Yellowtailed Barracuda (*Sphyraena jello*), Great Barracuda (Sphyraena barracuda), Bigeye Trevally (*Caranx sexfasciatus*), Chevron Barracuda (*Sphyraena qenie*), Dogtooth Tuna (*Gymnosarda unicolor*), Hawksbill Turtles (*Eretmochelys imbricata*), and Eagle Rays (Holyoak et al., 2005). A total of 673 fish species were later found to inhabit the reef ecosystem in Brunei Darussalam, according to assessments conducted by Gerald R. Allen and Dr. Mark Erdman between November 2008 and May 2009. Every reef area has a large number of fish belonging to the families Gobiidae, Labridae, and Pomacentridae (Allen, 2009). Speaking with fishermen can yield important information about fish movement and behavior since they have direct knowledge of changes in habitat conditions, water quality, temperature, and fish species composition and size. The ecology, seasonal cycles, fish migration routes, and spawning grounds are also well-known to the local fishermen. Red snapper (*Lutjanus erythropterus*), which are typically fished farther offshore, were once abundant in shallow inshore seas, according to a 2013 Ebil evaluation of Brunei Darussalam's demersal fishing resources conducted through interviews with both experienced and inexperienced fishermen. In the shallow water of Zone 2 of Brunei Darussalam's fishing zonation, red snapper are commonly found. They can dive as deep as 111 meters around reefs, shipwrecks, and oil rigs.

According to the first shifting baseline syndrome (SBS) study conducted from the viewpoint of fishermen, the number of Red Snapper and Grouper declined between the 1990s and 2000. The investigation has revealed which seas in Brunei Darussalam are frequently used for the

commercial capture of demersal fish. The same site, time of year, and phase of the moon are used for the annual spawning aggregation of groupers and snapper. Since they are frequently found in coral reefs or estuaries, fishermen's statement that over 2000 kg of red snapper were captured from the Sowthwest Ampa oilfield is supported (Ebil, 2013).

3.2.1 Snappers

Snappers in the family Lutjanidae are one of the most diverse groups of perciform fish, with 17 genera and 113 species. They live in a variety of habitats throughout the Atlantic and Indo-Pacific, including marine seas, estuaries, and freshwater environments (Arai et al., 2023). Snappers, which are often associated with coral reefs, enter estuaries to reproduce. Juvenile snappers form schools and thrive in seagrass habitats, whereas adult members of the Lutjanus species are often found in reef ecosystems, which offer abundant feeding possibilities as well as protection from predators and harsh environmental conditions. They are carnivorous hence their diet consists of smaller fish, crabs, shrimps, squids, and sea snails. There are approximately 45 species of snappers within the *Lutjanus* genus in the Indo-Pacific region (Iwatsuki et al., 2015). In 2023, the Yellowfin Snapper (*Lutjanus xanthopinnis*) was recorded to be present in Brunei Darussalam through DNA barcoding. This species was newly discovered in the Indo-western Pacific region and is similar to the Indian Snapper (Lutjanus madras) (Arai et al., 2023; Iwatsuki et al., 2015). One of the most prized fish in aquaculture is the snapper. Notably, the species' high fertility and spawning season, which runs from October to February, make them of great interest to fisheries. Both the Mangrove Red Snapper (*Lutjanus argentimaculatus*) and the Golden Snapper (*Lutjanus johnii*) are raised in open sea cages in Malaysia. Among eight other commercially important fish, the Red Snapper has the greatest ash concentration, according to the proximate analysis, suggesting a rich mineral content. It also has significant levels of pyridoxine (vitamin B6) and riboflavin (vitamin B2). According to Arshad and Lee (2024), both snappers are categorized as low-fat fish. In Brunei Darussalam, the cultivation of red and golden snapper in sea cages has been established.

3.2.2 Seabass

Estuaries and coastal seas in Australia and Southeast Asia are home to the seabass, *Lates calcarifer*, a fish that is mostly used for commercial purposes. According to Abu Khair Mohammad Mohsin and Mohd Azmi Ambak (1996), they are referred to as Asian Seabass, Selungsong in Brunei Darussalam, and Siakap Putih, Kakap, and Bukai-bukai in Malaysia. These fishes are frequently found in estuary environments, where they favor slow-moving waters and seek cover near shore. Being catadromous, they immigrate to estuaries, lakes, and rivers as fry to feed and grow after spawning and hatching in the ocean. Being protandrous hermaphrodites, they begin their lives as male fry before migrating upstream into freshwater or brackish environments. They go downstream for gonadal development and spawning after three to five years, and when they grow to a size of 85 to 100 cm, they finally change into females. As these fish mature, their eating patterns vary significantly. They are 4 mm in size and mostly eat microcrustaceans, including copepods and amphipods. When they get to be 80 mm, they start eating microcrustaceans like palaemonids and penaeids. By the time they are 300 mm, fish from families including Mungilidae, Engraulididae, and Arridae make up around 80% of their diet. Additionally, certain members of the Asian Seabass population consume approximately 11% of their food through cannibalism. Because their size affects their preferences for environment, this behavior is less prevalent. Usually found in shallow areas, smaller juveniles lessen the chance of cannibalistic encounters.

The Asian Seabass is one of the most sought-after cultured products in Malaysia, second only to marine fish, because to its rapid growth, resistance to some diseases, and ability to withstand different salinities (Mohd Nor et al., 2019). After cobia, grouper, lobster, and mudcrabs, they are likewise regarded as highly prized species in Vietnam (Petersen et al., 2011). The average cost of producing one seabass in Vietnam is USD 2.85/kg, while in Malaysia it is USD 3.12/kg. The cage culture of seabass began in 1988 after Brunei Darussalam acquired its first seabass broodstocks from Thailand (Tamat et al., 2019). The global demand for Asian seabass has increased in tandem with the rise in production levels. In order to diversify its revenue streams, Brunei Darussalam has also been aggressively encouraging foreign investment in its fisheries and aquaculture industry. The Barramundi Group, a Singaporean corporation, is the region's biggest producer of Asian seabass (Estrebillo et al., 2021).

3.2.3 Grouper

Groupers, or Kerapu in Malay, are food fishes belonging to the Serranidae family. From coral reefs, seagrass beds, and estuary habitats, more than 400 species of groupers have been identified worldwide. The two most common groupers in Terrenganu, Malaysia, are the Areolate grouper (*Epinephelus areolatus*) and the Six-barred grouper (*E. sexfasciatus*). These species are highly valuable on the market because of their potential for growth, diversity, and exports. Groupers mature sexually between 22.00 and 36.00 cm after spawning from January to May (Nor H. et al., 2016). It has been observed that grouper populations in the South China Sea of Malaysia are not very abundant. Because of their high commercial values and high demand for export, overexploitation has been blamed for this reduction.

To ensure long term viability of grouper populations in Malaysia, aquaculture of several species of grouper such as Orange spotted grouper (*E. coioides*), Greasy grouper (*E. tauvina*), Brown marbled grouper (*E. fuscoguttatus*), Giant grouper (*E. lanceolatus*), Leopard coral grouper (*Plectropomus leopardus*), and Mouse grouper (*Cromileptes altivelis*)are done in floating cages (Arai, 2015). There are approximately 40 species of groupers found in Brunei Darussalam waters, of these only a few are cultured in the country these include the Estuarine grouper (*Epinephelus* spp.), Yellow spotted grouper (*E. timorensis*), Black spotted grouper (*E. fuscoguttatus*), Dragon grouper (*E. lanceolatus*), Tiger grouper (*Mycteroperca tigris*) and, Mouse grouper (*Cromileptes altivelis*) (Hamid, 2001; Tamat et al., 2019). The culture of grouper through floating cages in Brunei Darussalam was initiated in 1996. Floating cages for hybrid groupers are located along Tanjong Pelumpong, where salinity is higher due to exposure to the South China Sea. In contrast, Kaingaran features lower salinity because it is situated in an estuarine environment (Azmey et al., 2020).

3.3 Brackish Water Fish

According to Silvestre et al. (1992), Brunei Darussalam's estuaries have yielded 79 species of fish from 34 families and 12 species of shrimp from 3 genera. For young fish, the zooplankton and phytoplankton that blanket the riverbed provide sustenance. In addition, the complex mangrove forests and their entangled roots offer young fish, prawns, and crabs a haven where they can hide from predators. Common species found in the brackish waters are Archerfish (*Toxotes chatareus*), Milkfish (*Chanos chanos*), Catfish (*Arius maculatus* and *A. microcephalus*), Mangrove Red Snapper (*Lutjanus argentimaculatus*), Groupers (*Epinephelus* spp.), and Asian seabass (*Lates calcarifer*). Fish found in mangrove areas or estuaries don't necessarily live their whole lifetime in the area. The **Table 4** represents fish that have been recorded in Brunei Darussalam mangrove

areas and that tolerates brackish waters. Fish species like Russell's snapper (*Lutjanus russelli*), Greasy grouper (*Epinephelus tauvina*), Mangrove Red Snapper (*Lutjanus argentimaculatus*), Bludger Trevally (*Carangoides gymnostethus*), Malabar Trevally (*Carangoides malabaricus*), White spotted puffer (*Arothron hispidus*), and African pompano (*Alcetis ciliaris*) enters brackish waters to spawn, enabling their juveniles to thrive in this environment. However, the adult fish will return to the coral reefs for food and shelter. Meanwhile fish species like Archerfish (*Toxotes chatareus*) and (*Toxotes jaculatrix*), and Giant Sea catfish (*Arius thalassinus*) inhabit brackish environment throughout their lifetime. Fish species commonly found in schools are the Commmerson's anchovy (*Stolephorus commersonii*), Orange spotted spinefoot (*Siganus guttatus*), Streamlined spinefoot (*Siganus argenteus*), Hamilton's thryssa (*Thryssa hamiltonii*), and Flat needlefish (*Ablennes hians*). These fishes are mainly coastal and reef associated fish species though, they also inhabit the brackish areas (Badrie, 2023).

Table 3: Fish species found in mangrove areas in Brunei Darussalam.

Common name	**Scientific name**
Flat needlefish	*Ablennes hians*
African pompano	*Alcetis ciliaris*
Chacunda gizzard shad	*Anodontostoma chacunda*
Giant sea catfish	*Arius thalassinus*
White spotted puffer	*Arothron hispidus*
Bludger Trevally	*Carangoides gymnostethus*
Malabar Trevally	*Carangoides malabaricus*
Crocodile flathead	*Cociella crocodilus*
Areolate grouper	*Epinephelus areolatus*
Greasy grouper	*Epinephelus tauvina*
Karut croaker	*Johnius carutta*
Blackmouth angler	*Lophiomus setigerus*
Russell's snapper	*Lutjanus russelli*
Torpedo scad	*Megalaspis cordyla*
Asian swamp eel	*Monopterus albus*
Tiger tooth croaker	*Otolithes ruber*
Gray eel-catfish	*Plotosus canius*
Silver grunt	*Pomadasys argenteus*
Spotted scat	*Scatophagus argus*
Streamlined spinefoot	*Siganus argenteus*
Orange spotted spinefoot	*Siganus guttatus*
Sawtooth barracuda	*Sphyraena putnamae*
COMM Merson's anchovy	*Stolephorus commersonii*
Hamilton's thryssa	*Thryssa hamiltonii*
Archerfish	*Toxotes chatareus*
Banded archerfish	*Toxotes jaculatrix*

3.3 Freshwater Fish

A checklist survey was conducted on freshwater fish species in Brunei Darussalam by Zohrah et al., (2018). Total 104 number freshwater fish species were identified under 24 families and 10 orders. Table 4 illustrated the 104 numbers freshwater fish species.

Table 4: 104 identified freshwater fish list (Source: Zohrah et al., 2018)

ORDER	FAMILY	SPECIES
OSTEOGLOSSIFORMES	Notopteridae	*Chitala borneensis*
		Chitala borneensi
ANGUILLIFORMES	Anguillidae	*Anguilla marmorata*
CYPRINIFORMES	Cyprinidae	*Barbodes banksi*
		Puntius binotatus
		Puntius banksi
		Barbodes sealei
		Puntius sealei
		Barbodes xouthos
		Barbodes binotatus
		Puntius banksi
		Systomus banks
		Systomus xouthos
		Barbonymus balleroides
		Barbonymus schwanenfeldii
		Barbonymus collingwoodii
		Puntius collingwoodi
		Barbodes collingwoodi
		Barbonymus collingwoodii
		Cyclocheilichthys apogon
		Cyclocheilichthys armatus
		Cyclocheilichthys enoplos
		Cyclocheilichthys repasson
		Desmopuntius johorensis
		Barbodes fasciatus
		Puntius johorensis
		Puntius eugrammus
		Desmopuntius pentazona
		Barbodes hexazona
		Puntius pentazona
		Puntius johorensis
		Systomus hexazona
		Hampala bimaculata
		Hampala macrolepidota
		Leptobarbus hoevenii
		Leptobarbus hosii
		Lobocheilos ovalis
		Lobocheilos bo
		Lobocheilos ovalis
		Nematabramis steindachneri
		Nematabramis steindachneri
		Nematabramis borneensis
		Osteochilus microcephalus
		Osteochilus sarawakensis
		Osteochilus spilurus
		Osteochilus vittatus
		Osteochilus haseltii
		Osteochilus waandersii
		Osteochilus waandersii
		Oxygaster anomalura
		Paracrossochilus acerus
		Paracrossochilus vittatus
		Puntioplites bulu
		Puntioplites waandersi

ORDER	FAMILY	SPECIES
		Rasbora argyrotaenia
		Rasbora caudimaculata
		Rasbora cephalotaenia
		Rasbora dusonensis
		Rasbora einthovenii
		Rasbora hosii
		Rasbora sumatrana
		Rasbora cf. sumatrana
		Rasbora hubbsi
		Rasbora kottelati
		Rasbora kalochroma
		Rasbora tornieri
		Rasbora cf. tornieri
		Rasbora trilineata
		Rasbora tubbi
		Striuntius lineatus
		Puntius lineatus
		Tor tambra
		Tor douronensis
		Tor tambroides
		Trigonopoma pauciperforatum
		Rasbora taeniata
		Rasbora cf. pauciperforata
		Rasbora pauciperforata
	Cobitidae	*Pangio agma*
		Acanthophthalmus agmus
		Pangio mariarum
	Balitoridae	*Homalopteroides stephensoni*
	Gastromyzontidae	*Gastromyzon aeroides*
		Gastromyzon ridens
		Gastromyzon cranbrook
		Gastromyzon borneensis
		Gastromyzon fasciatus
		Gastromyzon punctulatus
		Gastromyzon lepidogaster
		Gastromyzon venustus
		Gastromyzon monticola
		Glaniopsis hanitschi
		Glaniopsis gossei
		Neogastromyzon brunei
		Neogastromyzon nieuwenhuisii
		Parhomaloptera microstoma
		Protomyzon griswoldi
		Protomyzon whiteheadi
	Nemacheilidae	*Nemacheilus spiniferus*
		Nemacheilus selangoricus
		Nemacheilus sp.*(?)*
		Sundoreonectes sabanus
SILURIFORMES	Sisoridae	*Glyptothorax major*
	Siluridae	*Phalacronotus apogon*
		Kryptopterus limpok
		Kryptopterus baramensis
		Ompok borneensis
		Ompok jaynei

ORDER	FAMILY	SPECIES
		Ompok platyrhynchus
		Ompok sp.
		Pterocryptis furnessi
		Silurichthys hasselti
		Silurichthys marmoratus
		Silurichthys hasseltii
		Wallago leerii
	Clariidae	*Clarias aff. Batrachus*
		Clarias gariepinus
		Clarias leiacanthus
		Clarias teijsmanni
		Clarias teijsmanii
		Clarias meladerma
		Clarias nieuhofii
	Pangasiidae	*Pseudolais micronemus*
	Bagridae	*Bagrichthys macropterus*
		Hemibagrus baramensis
		Mystus baramensis
		Hemibagrus capitulum
		Mystus sp.
		Hemibagrus nemurus
		Hemibagrus baramensis
		Hemibagrus hoevenii
		Hemibagrus sabanus
		Leiocassis micropogon
		Mystus castaneus
		Mystus micracanthus
		Mystus cf. singaringan
		Nanobagrus fuscus
		Pseudomystus fuscus
ATHERINIFORMES	Phallostethidae	*Phenacostethus smithi*
BELONIFORMES	Zenarchopteridae	*Hemirhamphodon kuekenthali*
		Hemirhamphodon pogonognathus
GASTEROSTEIFORMES	Syngnathidae	*Doryichthys deokhatoides*
SYNBRANCHIFORMES	Synbranchidae	*Monopterus javanensis*
	Mastacembelidae	*Macrognathus keithi*
		Macrognathus maculatus
		Mastacembelus erythrotaenia
		Mastacembelus unicolor
PERCIFORMES	Ambassidae	*Parambassis wolffii*
	Nandidae	*Nandus nebulosus*
	Gobiidae	*Eugnathogobius siamensis*
		Pseudogobiopsis siamensis
		Parawaous megacephalus
		Parawaous sp.
		Pseudogobiopsis oligactis
		Pseudogobiopsis campbellianus (?)
	Anabantidae	*Anabas testudineus*
	Helostomatidae	*Helostoma temminckii*
	Osphronemidae	*Betta akarensis*
		Betta pugnax
		Betta climacura
		Betta macrostoma
		Luciocephalus pulcher

ORDER	FAMILY	SPECIES
		Osphronemus septemfasciatus
		Trichopodus pectoralis
		Trichopodus trichopterus
ANABANTIFORMES	Channidae	*Channa baramensis*
		Channa lucius
		Channa striata

3.4 Non-indigenous Species

Non-indigenous species (NIS) are not recorded in Brunei Darussalam; nonetheless, Malaysia, a neighboring country, possesses seven species. Due to the widespread cultivation of Whiteleg Shrimp (*Penaeus vannamei*) during the 1980s, the shrimp have become established in the nation's seas. Because there is a shortage of wild-caught fish to meet demand, some fish are being imported from the aquarium trade. Coastal waters in Brunei Darussalam have reported sightings of the Bumphead Parrotfish (*Bolbometopon muricatum*), however it has been identified as a NIS (Allen, 2009; Wang et al., 2021).

The biodiversity of marine life is constantly impacted by the presence of invasive alien species (IAS), some of which have been identified as risks to Brunei Darussalam. According to Wang et al. (2021), the Bluestripe Snapper (Lutjanus Kasmira) is an IAS species that is found in Brunei Darussalam. The mangrove environment and floating cages along Muara Port have been adversely impacted by untreated ballast waters, making the Inner Brunei Bay vulnerable to IAS invasion. They have the ability to corrode and stick to ships, cage culture buildings, and equipment (Wang et al., 2021). The fisheries industry has had to pay $40 million for repairs and damages to aquculture equipment and water supplies (Jolkifli & Wahab, 2018).

4. Status of Fish Identification In Brunei Darussalam

In Brunei Darussalam, the aquaculture and fisheries industries are relatively new. Even though Brunei's Department of Fisheries (DoF) was founded in 1966, no research has been done on fish identification there except from the yearly statistical reports. There are no fisheries research institutes in the nation. In the middle of 2024, Universiti Islam Sulan Sharif Ali approved its first aquaculture program. As a result, there are no publications on the morphology, meristic, or molecular identification of fishes or shellfish in Brunei Darussalam, with the exception of a checklist survey that Zohrah et al. (2018) carried out on freshwater fish species in the country.

5. Conclusion

Although Brunei Darussalam is blessed with different types (fresh, brackish and marine) of waterbodies having different diversified fish and shellfishes, still there is a lack of fish identification data. Therefore, a systematic morphological, meristic as well as molecular barcoding analysis of existing fish and shellfishes is recommended.

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References

Abu Khair Mohammad Mohsin, & Mohd Azmi Ambak. (1996). *Marine Fishes & Fisheries of Malaysia and Neighbouring Countries*. Universiti Pertanian Malaysia Press.

Allen, G. R. (2009). *Reef Fishes of Brunei Darussalam*. Department of Fisheries, Ministry of Industry and Primary Resources, Government of Brunei Darussalam.

Arai, T. (2015). Diversity and conservation of coral reef fishes in the Malaysian South China Sea. *Reviews in Fish Biology and Fisheries*, *25*(1), 85–101. https://doi.org/10.1007/s11160-0149371-9

Arai, T., Taha, H., Alidon, N., Jumat, J., Azmey, S., Zan, N. D., Aimi Mat Jaafar, T. N., & Habib, A. (2023). Mitochondrial cytochrome c oxidase subunit I gene analysis of the yellowfin snapper, Lutjanus xanthopinnis in the Indo-Pacific region and a note on Lutjanus lutjanus population structure. *Heliyon*, *9*(9), e19348. https://doi.org/10.1016/j.heliyon.2023.e19348

Arshad, N., & Lee, L. K. (2024). Full nutritional spectrum and hazard risk assessment of high commodity value aquaculture species in Penang, Malaysia. *Aquaculture Reports*, *37*, 102213. https://doi.org/10.1016/j.aqrep.2024.102213

Azmey, S., Taruna, M., Taha, H., & Arai, T. (2020). Prevalence and infestation intensity of a piscicolid leech, *Zeylanicobdella arugamensis* on cultured hybrid grouper in Brunei Darussalam. *Veterinary Parasitology: Regional Studies and Reports*, *20*, 100398. https://doi.org/10.1016/j.vprsr.2020.100398

Badrie, M. A. (2023). *Mangroves of Brunei Darussalam Flora and Fauna*. Forestry Department Ministry of Primary Resources and Tourism.

Blaber, S. J. M. (2000). *Tropical Estuarine Fishes Ecology, Exploitation and Conservation*. Blackwell Science.

Bolhuis, H., Schluepmann, H., Kristalijn, J., Sulaiman, Z., & Marshall, D. (2014). Molecular analysis of bacterial diversity in mudflats along the salinity gradient of an acidified tropical Bornean estuary (South East Asia). *Aquatic Biosystems*, *10*, 10. https://doi.org/10.1186/20469063-10-10

Burke, L. M., Selig, E., & Spalding, M. (2002). *Reefs at risk in southeast Asia*. World Resources Institute.

Department of Fisheries. (2022). *Brunei Darussalam Fisheries Statistic in Brief*. Department of Fisheries, Ministry of Primary Resources and Tourism.

Department of Fisheries. (2023). *Brunei Darussalam Fisheries Statistic in Brief 2022*. Department of Fisheries, Ministry of Primary Resources and Tourism.

Department of Fisheries. (2024). *Re-delineation of fishing zones 1 & 2*. Department of Fisheries, Ministry of Primary Resources and Tourism.

DeVantier, L., & Turak, E. (2009). *Coral Reefs Of Brunei Darussalam*. Fisheries Department, Ministry of Industry and Primary Resources,Government of Brunei Darussalam.

Ebil, S. (2013). *Assessment of demersal fishery resources in Brunei Darussalam*. University of Warwick.

Estrebillo, A., Hiramoto, H., Ishida, Y., & Ono, D. A. (2021). *Brunei Darussalam Aquaculture Feasibility Study for Investment*. ASEAN-Japan Centre.

Fakhriedzwan Hj. Idris, Abdulai Usman, Sinnathamby N. Surendran, and Ranjan Ramasamy. (2013). Detection of Aedes albopictus pre-imaginal stages in brackish water habitats in Brunei Darussalam. Journal of Vector Ecology. Vol. 38, no. 1: 187-189.

Hamid, H. L. H. A. (2001). *Cage Culture of Grouper in Brunei Darussalam* (pp. 51–54). Asia Pacific Economic Cooperation (APEC), Fish Health Section of the Asian Fisheries Society (FHS/AFS), Aquatic Animal Health Research Institute (AAHRI), and Network of Aquaculture Centres in Asia Pacific (NACA).

Holyoak, S., Oakley, S., Elder, J., Bell, D., & Miller, L. (2005). *Understanding the Environmental Impact of De-Commissioning; the Established Marine Ecosystem Associated with Offshore Platforms, Brunei Darussalam*. SPE Asia Pacific Health, Safety and Environment Conference and Exhibition. https://dx.doi.org/10.2118/96447-MS

Iwatsuki, Y., Tanaka, F., & Allen, G. (2015). Lutjanus xanthopinnis, a new species of snapper (Pisces: Lutjanidae) from the Indo-west Pacific, with a redescription of Lutjanus madras (Valenciennes 1831). *Journal of the Ocean Science Foundation*, *17*, 22–42.

Jolkifli, H. Z. H., & Wahab, R. H. A. (2018). Ballast Water Control and Management in Brunei Darussalam. *ASEAN Journal on Science and Technology for Development*, *35*(1–2), 5–10. https://doi.org/10.29037/ajstd.466

Marshall, D., Proum, S., Hossain, M. B., Adam, A., Lim, L.-H., & Santos, J. (2016). Ecological responses to fluctuating and extreme marine acidification:lessons from a tropical estuary (the Brunei Estuarine System). *Scientia Bruneiana*, *15*, 1–12. https://doi.org/10.46537/scibru.v15i0.33

Mohd Nor, N., Mohd Yazid, S. H., Mohd Daud, H., Azmai, M. N. A., & Mohamad, N. (2019). Costs of management practices of Asian seabass (Lates calcarifer Bloch, 1790) cage culture in Malaysia using stochastic model that includes uncertainty in mortality. *Aquaculture*, *510*, 347– 352. https://doi.org/10.1016/j.aquaculture.2019.04.042

Nor H., A. K., Rumeaida, M. P., Mohd Azmi, A., & Nadirah, M. (2016). *Reproductive Aspects Of Areolate Grouper, Epinephelus Areolatus And Six-Barred Grouper, E. Sexfasciatus From Terengganu Waters, Malaysia*. http://umt-ir.umt.edu.my:8080/jspui/handle/123456789/5976

Petersen, E., Truong, H., Phuong, P., Dat, N., Tuan, V., & Truc, L. (2011). Bioeconomics of Asian seabass, Lates calcarifer, culture in Vietnam. *Advanced Choice Economics Discussion Paper 2011/3*.

Satyanarayana, B., Muslim, A. M., Horsali, N. A. I., Zauki, N. A. M., Otero, V., Nadzri, M. I., Ibrahim, S., Husain, M.-L., & Dahdouh-Guebas, F. (2018). Status of the undisturbed mangroves at Brunei Bay, East Malaysia: A preliminary assessment based on remote sensing and ground-truth observations. *PeerJ*, *6*, e4397. https://doi.org/10.7717/peerj.4397

SEAFDEC Website http://map.seafdec.org/Monograph/Monograph_brunei/marine.php

Silvestre, G., Hj Jafar, H. M., Pg Hj Yusof, P. S., De Silva, M. W. R. N., & Thia-Eng, C. (1992). *The Coastal Resources of Brunei Darussalam: Status, Utilization and Management*. Department of Fisheries, Ministry of Industry and Primary Resources, Bandar Seri Begawan, Brunei Darussalam and International Center for Living Aquatic Resources Management, Manila, Philippines.

Tamat, W., Pakar, E. F. B., & Pengiran Haji Abd Halim, D. S. N. (2019). Current Status, Issues and Gaps of Aquatic Emergency Preparedness and Response Systems Practiced in Brunei Darussalam. *Aquatic Emergency Preparedness and Response Systems for Effective Management of Transboundary Disease Outbreaks in Southeast Asia*.

Tanaka, Y. (2016). Coral diversity and coral reef environment in Brunei Darussalam. *Scientia Bruneiana*, *15*. https://doi.org/10.46537/scibru.v15i0.28

The Forestry Department & Ministry of Industry and Primary Resources. (2014). *The 5th National Report to the convention on biological diversity*.

Thia-Eng, C., Ming, C. L., & Sadorra, M. S. M. (1987). *The Coastal Environment Profile of Brunei Darussalam: Resource Assessment and Management Issues*. Fisheries Department, Ministry of Development, Brunei Darussalam International Center for Living Aquatic Resources Management on behalf of the Association of Southeast Asian Nations/ United States Coastal Resources Management Project.

Ukotije-Ikwut, P. R., Steiner, Z., Gledhill, M., Müller, M., Oakes, J. M., Sukri, R. S., Jiang, S., & Achterberg, E. P. (2023). The distribution and behaviour of Fe, Al, Si, Mn, Cu and Ni in ombrotrophic tropical peat draining blackwater estuaries on Borneo Island. *Frontiers in Marine Science*, *9*. https://doi.org/10.3389/fmars.2022.1075155

Wang, H., Xie, D., Bowler, P. A., Zeng, Z., Xiong, W., & Liu, C. (2021). Non-indigenous species in marine and coastal habitats of the South China Sea. *Science of The Total Environment*, *759*, 143465. https://doi.org/10.1016/j.scitotenv.2020.143465.

Yasuaki Tanaka (2016). Coral diversity and coral reef environment in Brunei Darussalam. Scientia Bruneiana- Special Issue. Reviews: Biology. Vol 15:13-17. https://doi.org/10.46537/scibru.v15i0.28

Zohrah Sulaiman, Z., Tan, H., & LIM, K. (2018). Annotated checklist of freshwater fishes from Brunei Darussalam, Borneo. *Zootaxa*, *4379*, 24. https://doi.org/10.11646/zootaxa.4379.1.2.