REVIEW ARTICLE

Biology, Ecology, Fisheries, & Conservation Management of "*Galunggong*" or "*Roundscads*" (*Decapterus* spp.) in the Philippines: A Review

Jobelle R. Tapia*[1,3] **and Mudjekeewis D. Santos**[1,2,4,5]

[1]The Graduate School, University of Santo Tomas, España Blvd, Sampaloc, Manila, 1008 Metro Manila, Philippines
[2]Bureau of Fisheries and Aquatic Resources, Regional Office 1, Government Center, Brgy. Sevilla,, San Fernando, La UnionSan Fernando, La Union
[3]Our Lady of Fatima University, 120 MacArthur Hwy, Valenzuela City, Metro Manila, Philippines
[4]National Fisheries Research and Development Institute, Department of Agriculture, 101 Mother Ignacia St., Quezon City, Metro Manila, Philippines
[5]Central Luzon State University Science City of Muñoz, Nueva Ecija, Philippines

ABSTRACT

The genus *Decapterus*, locally known as *roundscads* or *galunggong,* is one of the most harvested pelagic fishes in the Philippines and is considered a common source of protein among Filipinos. It was known as "poor man's fish" in the 1990s because of its cheap price and abundant supply. However, its production has been substantially decreasing since 2007, which consequently affects its price. This review paper analyzed published research papers, the National Stock Assessement Program (NSAP), Philippine Statistics Authority (PSA) databases, and technical reports to identify the current status of the biology, ecology, fisheries, and management of roundscads in the Philippines. At the end, research gaps were identified to streamline future research. Proper monitoring of stocks and integration of multiple management approaches are recommended to design a sustainable management plan for the fisheries of roundscads.

*Corresponding Author: *tapia.jobelle04@gmail.com*

Received: *September 7, 2023*
Accepted*: August 27, 2024*

Keywords: *Decapterus, galunggong, Philippine fisheries, roundscads*

1. INTRODUCTION

The Philippines is the center of the center of marine biodiversity (Carpenter & Springer 2005; Hoeksema 2007). It is surrounded by the South China Sea in the west, the Pacific Ocean in the north and east, and the Celebes Sea and Sulu Sea in the south. It has 266 thousand km^2 of coastal waters and 1.93 million km^2 of oceanic waters, for a total of 2.20 million km^2 of territorial waters (BFAR 2022). The 12% coastal waters (Barut et al. 2003) are made up of narrow continental shelves, deep and isolated basins, and steep slopes thar are connected by shallow sills (Villanoy et al. 2011). Its varying bathymetry and warm water create different habitats for rich marine biodiversity.

One of the most economically important pelagic fishes in the Philippines is the genus *Decapterus*, locally known as "roundscads" or "galunggong." The genus *Decapterus* is a small pelagic fish characterized by the absence of scutes in the anterior curved part of the lateral line, two papillae on the shoulder girdle, and a single finlet posterior to the anal and dorsal fins (Smith-Vaniz 1999). It is available in the Philippines all year round (Calvelo 1992) and has similar taste and texture to chub mackerel (*Rastrelliger* Jordan & Dickerson, 1908) (Tiews et al. 1971). Before World War II, the production of roundscads in the Philippines was low. However, the introduction of purse seine and bagnet fisheries and the improvement of light fishing caused a massive increase in its production (Ronquillo 1970).

Currently, roundscads ranked third in the major marine harvests in the Philippines. The catch of roundscads alone contributes to 4.60% of the 4,403.71 metric tons of fisheries production in 2020 (Philippine Statistics Authority 2020). However, there are reports of decreasing production of roundscads. The annual production of roundscads in 2020 is 202.66 thousand metric tons (Philippine Statistics Authority 2020), which is lower than the production in 2013 by 25.83% (PSA 2013). As a consequence, its average retail price continues to rise. From an average retail price of 26 pesos per kilogram in the 1990s, it soared to 107.68 pesos in 2012 and 185.23 pesos in 2021 (Bureau of Agricultural Statistics 2001-2013, PSA 2013-2021). It is no longer a poor man's fish, contrary to its label in the 1990s (Ani 2016).

The development of roundscads fisheries in the 20th century was supported by various studies on their production, recruitment pattern, biology, and stock assessment. These were consolidated in the seminal papers of Ronquillo (1970, 1973), Pauly & Navaluna (1983), Ingles & Pauly (1984), Calvelo & Dalzell (1987), Lavapie-Gonzales (1991), Calvelo (1992), and Lavapie-Gonzales et al. (1997). The papers of Ronquillo (1970, 1973) and Calvelo & Dalzell (1987) focused on roundscad fisheries, while the remaining papers dealt with population structures like growth rate, mortality, and recruitment. The only review paper that focuses on both the biology and fisheries of roundscads in the Philippines is by Calvelo (1992). After three decades, there is a need to have an updated review of the fisheries, biology, and ecology of roundscads in the Philippines.

This review paper consolidates information on roundscads in the Philippines from papers published from 1950 to May 2023, accessed from The Philippine Journal of Fisheries (TPJF) and Google Scholar, with keyword combinations such as "Roundscads + Philippines" and "Decapterus + Philippines." The production, importation, and prices of roundscads were retrieved from the databases of the National Stock Assessment Program (NSAP) and the Philippine Statistics Authority (PSA). Only published papers in peer-reviewed journals were considered. This updated review will succinctly present the current understanding of roundscads in the Philippines, highlight gaps, and recommend actions for their sustainable management.

2. BIOLOGY

2.1.Taxonomy

The genus *Decapterus* (Bleeker, 1851) is classified under the phylum Chordata, subphylum Vertebrata, infraphylum Gnathostomata, superclass Actinopteri, order Carangiformes, family Carangidae, and subfamily Caranginae. Members of the order Carangiformes have adherent cycloid scales and one to two tubular ossifications around the extension of the nasal canal. Like the members of the family Carangidae, genus *Decapterus* has two detached anal spines in the anal fin, two dorsal fins, a forked caudal fin, a slender peduncle, and a deep and laterally compressed body (Fig 1) (Nelson et al. 2016). The genus *Decapterus* has scutes covering the straight portion of the lateral line, as shared with the subfamily Caranginae (Nelson et al. 2016). *Decapterus* species have the following shared characteristics: a pair of finlets after the anal and second dorsal fins; well-developed adipose eyelids; the absence of scutes in the anterior part of the lateral line; a pair of finlets posterior to the second dorsal fin and anal fin; and two papillae in the shoulder girdle (Gushiken 1983, Smith-Vaniz 1999). Like other pelagic fishes, it displays countershading, which may appear silvery ventrally and bluish dorsally (Smith-Vaniz 1999).

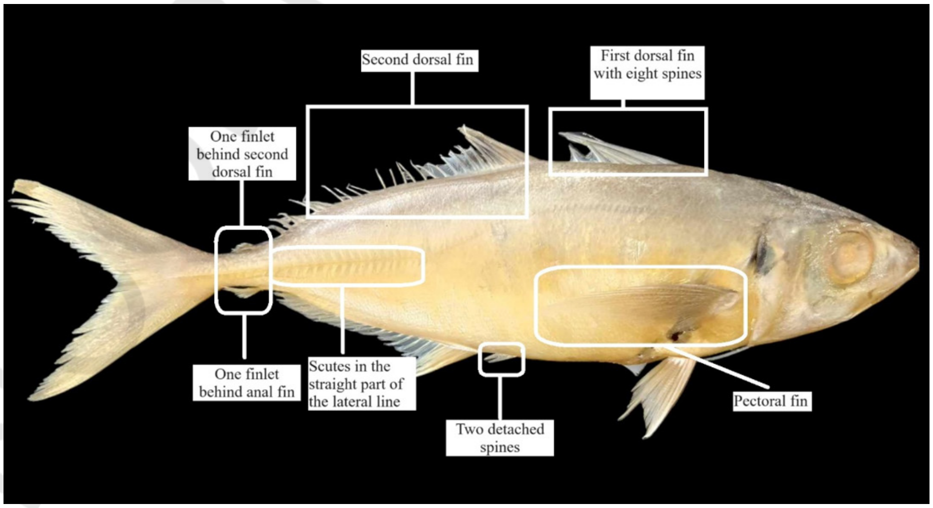

Figure 1. Genus *Decapterus* Bleeker.

There are 11 validly accepted species under the genus *Decapterus*, namely *D. punctatus* (Cuvier, 1829); *D. ruselli* (Ruppell, 1830); *D. macarellus* (Cuvier, 1833); *D. maruadsi* (Temminck & Schlegel, 1843); *D. muroadsi* (Temminck & Schlegel, 1844); *D. macrosoma* Bleeker, 1851; *D. akaadsi* Abe, 1958; *D. koheru* (Hector, 1876); *D. kurroides* Bleeker, 1855; *D. tabl* Berry, 1968; and *D. smithvanizi* Kimura, Katahira & Kuriiwa, 2013. In the Philippines, there is inconsistency in the total number of reported roundscads. Herre (1953) declared that there are four species, namely *D. macrosoma, D. russelli, D. kurroides,* and *D. lajang.* However, Tiews et al. (1971) have concluded that *D. lajang* is inseparable from *D. macrosoma.* Currently, *D. lajang* is considered a synonym of *D.russelli* and is usually misapplied to *D. macrosoma* (Smith-Vaniz 1999). Rau & Rau (1980) and Schroeder (1980) reported the presence of *D. maruadsi* and *D. macarellus* in Philippine waters. Moreover, Delloro et al. (2021) reported the presence of *D. smithvanizi* in the coastal waters of Panay Island. Although there is no taxonomic paper that first reported the presence of *D. tabl* in the Philippines, there are stock assessment studies of *D. tabl* (e.g., Belga et al. 2013, Villanueva et al. 2018). The presence of *D. akaadsi* in the Philippine waters may not yet be confirmed. Although Smith-Vaniz et al. (2018a) in IUCN Red List Assessment included the Philippines in the natural range of *D. akaadsi*, there could have been an error in the generation of the listing, especially since references in the IUCN assessment did not explicitly report the presence of *D. akaadsi* in the Philippines. Moreover, there are no published journal articles or technical reports that provide evidence for its presence in the Philippines. Its suspected extension range in the Philippines requires further evidence. Taken together, the Philippines has seven confirmed species of roundscads, which include *D. macrosoma, D. macarellus, D. maruadsi, D. russelli, D. kurroides, D. tabl,* and *D. russelli.* The general information for each species is shown in Tables 1 and 2.

2.2 Life stages

In terms of gonad development, individual rounscads can be classified into six stages: immature (I), developing (II), mature (III), ripe (IV), running (V), and spent (VI). These are identified based on the appearance and location of the ovary and testes (Brown-Peterson et al. 2011). The percent occurrence of these stages per month can aid in determining their reproductive behavior. However, there are limited studies that explore the percent occurrence of these stages among roundscad species.

Generally, roundscads that are available in fisheries are juveniles (Stages I and II) (Tiews et al. 1971). Mature roundscads leave the fisheries to breed in unknown waters (Magnusson 1968), and few were observed returning to their fishing grounds except for some stragglers (Ronquillo 1970).

2.3 Sex ratio

The majority of pelagic fishes are sexually monomorphic, in which sexes can only be differentiated by gonad examination. However, Uba (2019) had observed sexual dimorphism in *D. macrosoma* through morphometric analysis of their body shape. The landmark-based geometric morphometric analysis of *D. macrosoma* samples from the Northern Sulu Sea reveal that females have deeper body depth, a bigger head, a wider caudal fin, and a broader belly. Although these were not as evident as

Table 1. List of *Decapterus* species in the Philippines and their basic information. Common names are from Fishbase (Froese & Pauly 2023).

Species	Local Name	Common Name	Depth (m)	IUCN Status
D. macrosoma	*Galunggong lalaki*	Shortfin scad	30–170 (Myers 1999)	Least Concern (Smith-Vaniz & Williams 2016)
D. macarellus	*Galunggong balsa*	Mackerel scad	40–200 (Smith-Vaniz 1986)	Least Concern (Smith-Vaniz et al. 2015a)
D. russelli	*Galunggong babae*	Indian scad	40–275 (Pauly et al. 1996)	Least Concern (decreasing) (Collen et al. 2010)
D. maruadsi	*Galunggong*	Japanese scad	0–20 (FAO-FIGIS 2001)	Least Concern (Smith-Vaniz et al. 2018b)
D. tabl	*Galunggong/Pulang-buntot*	Roughear scad	150–220 (Cervigón et al. 1992)	Least Concern (stable) (Smith-Vaniz et al. 2015)
D. kurroides	*Burot/Budloy/Tabilos/ Butsawan/ Pulang-buntot*	Redtail scad	100–300 (Smith-Vaniz 1986)	Least Concern (decreasing) (Smith-Vaniz et al. 2018c)
D. smithvanizi	*Galunggong/Pulang-buntot*	Slender red scad	Unknown	Least concern (Smith-Vaniz et al. 2018d)

Table 2. Counts and measurements of roundscad species present in the Philippines (Temminck &Schlegel 1843, Smith-Vaniz 1999, Kimura et al. 2013).

	Characters										
	Curved part of lateral line	Straight part of lateral line	Tip of upper jaw	Head length	Body depth	Distance from snout to anus	Pectoral fin	Number of spines and rays in the anal fin	Number of spines and rays in the dorsal fins	Predorsal scale	Number of Gill rakers
Red-fin *Decapterus*											
D. kurroides	Cycloid scales 45–51; scutes 0–2	Cycloid scales 0; scutes 30–32	Posterior end straight above and slightly concave, and slanted anteroventrally; not hooked	30.3–33.0% SL	23.4–26.4% SL	56.0–60.4% SL)	Posterior tip reaching to or beyond the origin of second dorsal fin	II + I, 21–24	VIII + I, 27–31	Reaching anteriorly to or beyond the level of the center of the eye	U: 9–12 L: 27–30
D. tabl	Cycloid scales 61–72; scutes 0	Cycloid scales 0–8; Scutes 30–40	Posterior end almost truncate, rarely concave; hooked in adults	25.4–32.0% SL	16.6–23.0% SL	52.0–62.0% SL	Posterior tip not reaching the origin of second dorsal fin	II + I, 23–28	VIII + I, 28–33	Reaching anteriorly to or beyond the level of the center of the eye	U: 9–12 L: 29–33
D. smithvanizi	Cycloid scales 54–62; scutes 0–3	Cycloid scales 0–8; scutes 28–33	Posterior end almost truncate, slightly concave not; hooked	28.8–31.6% SL	19.4–22.5% SL	54.5–59.2	Posterior tip reaching to or beyond the origin of second dorsal fin	II + I, 23–26	VIII + I, 28–33	Reaching to the level of the of the anterior margin of the eye; top-view area w-shaped	U: 9–12 L: 25–31
Non-red-fin *Decapterus*											
D. macarellus	Cycloid scales 58–75; scutes 0	Scutes 0; cycloid scales 18–36	Posterior end straight above, moderately rounded an slanted anteroventrally	ND	ND	ND	Posterior tip not reaching the origin of second dorsal fin	II + I, 27–31	VIII + I, 31–37	Reaching at the level or beyond the level of the center of the eye; top-view area m-shaped	U: 10–13 L: 34–41

Note: ND= no data. The counts of scales and scutes in the lateral line for the red-fin *Decapterus* group are from Kimura et al. (2013), while the counts of scales and scutes for the non-red-fin *Decapterus* group are from Smith-Vaniz (1999).

Continuation of Table 2. Counts and measurements of roundscad species present in the Philippines (Temminck &Schlegel 1843, Smith-Vaniz 1999, Kimura et al. 2013).

	Characters										
	Curved part of lateral line	Straight part of lateral line	Tip of upper jaw	Head length	Body depth	Distance from snout to anus	Pectoral fin	Number of spines and rays in the anal fin	Number of spines and rays in the dorsal fins	Predorsal scale	Number of Gill rakers
D. macrosoma	Cycloid scales 58–72; scutes 0	Cycloid scales 14–29; scutes 24–40	Concave above and rounded below	ND	ND	ND	tip appressed falling short of a vertical line from 2nd dorsal fin origin	*II + I, 27–31*	VIII + I, 33–39	Not Reaching anteriorly to or beyond the level of the center of the eye; Area m-shaped	U: 10–12 L:34–38
D. maruadsi	Cycloids scales 42–62	Entirely covered with scutes	Posterior end broadly rounded	ND	20.8–25.4% SL	ND	Posterior margin reaching to or beyond the origin of second dorsal fin	II + I, 28	VIII + I, 32	ND	L: 32–39
D. ruselli	Cycloids scales 42–62; scutes 0–4	Cycloid scales 0–4; scutes 30–40	Posterior end straight above, slightly concave and not noticeably slanted anteroventrally	ND	20.8–25.4% SL	ND	Size 76.5–97 % of head length, tip falling short of to slightly beyond from the origin of ventral scales	II + I, 25–29	VIII + I, 28–33	Falling short of to slightly beyond the level of the 2nd dorsal fin	U: 10–14 L: 30–39

Note: ND= no data. The counts of scales and scutes in the lateral line for the red-fin *Decapterus* group are from Kimura et al. (2013), while the counts of scales and scutes for the non-red-fin *Decapterus* group are from Smith-Vaniz (1999).

sexual dimorphism through colors, the differences in body shape can be used as a preliminary examination that should be further supplemented with a gonad examination. No sexual dimorphism is recorded in other species of roundscads in the Philippines.

The sex ratio in species may vary on location. Tiews et al. (1971) reported an equal ratio between males and females in the population of *D. macrosoma* and *D. russelli* in Northern Palawan, but more males in Manila Bay. The variation in the sex ratio among populations may be influenced by environmental factors like temperature (Geffroy & Wedekind 2020) and salinity (Neves et al. 2019). For example, in the Sibuyan Sea, the sex ratio of *D. macrosoma* changes seasonally. Females outnumbered males during September and October, but there was an equal ratio in the months of May (Rada et al. 2019). The same pattern is also being observed in the population of *D. kurroides population* in Iligan Bay (Dela Rosa et al. 2022). In Iligan Bay, females of *D. kurriodes* are more dominant in the rest of the months except in February, when the sex ratio is 1:1 (Dela Rosa et al. 2022). The difference between males and females is more prominent in October and December, which coincides with the peak of spawning season. No sex ratio data is available for *D. macarellus*, *D.maruadsi*, and *D. smithvanizi*.

2.4 Spawning

Spawning seasons in fishes vary among species and location. Roundscads spawn in all year round (Ronquillo 1970). However, there are only a few studies in the Philippines that have explored the peak spawning period of roundscads in these areas. Among the Philippine roundscad species, only three species have identified spawning seasons (Table 3). No records are found for *D. macarellus, D. maruadsi, D. tabl*, and *D. smithvanizi*.

Generally, *D. macrosoma* in the Philippines spawns all year-round, but the peaks and length vary by location. For example, the population of *D. macrosoma* in Palawan spawns from November to March, with peaks in the latter half of the year. The spawning period in the west of Manila Bay is shortened and delayed by one to two months compared to Palawan (Tiews et al., 1971). Moreover, the northern part of the Sibuyan Sea, particularly on the coast of San Fernando Romblon, has two spawning periods: February and August to October (Rada et al. 2019). Likewise, Romblon Pass and Tablas Strait have two spawning peaks. Both locations have spawning peaks in the dry season, but the second peak in Romblon Pass is delayed by one month compared to Tablas Strait (Gonzales et al. 2021).

Furthermore, *D. russelli* in Manila Bay and Palawan have the same spawning season as *D. macrosoma* (Tiews et al. 1971). *D. kurroides* in Iligan Bay is also observed to have 3 spawning peaks, but of unequal strength. A major peak is found in December, and minor peaks are in March and August (dela Rosa et al. 2022).

The determination of spawning peaks among species in different areas is needed in deciding the timing and span of closed fishing season. For example, the closed fishing season of roundscads for particular fishing gears in Northern Palawan is from November to January (Joint DA-DILG Administrative Order No. 1 series of 2015), which is based on the peak spawning season of *D. macrosoma* and *D. russelli* as identified by Tiews et al. (1971). The importance of Northern Palawan in managing the population of roundscads is also being supported by the findings of Nepomuceno et al. (2023), in which they found that Northern Palawan displays the highest density of carangid larvae among the different areas in the Philippines. However, the peak season of carangid larval population in Northern Palawan is in July and September (Nepomuceno et al. 2023), in contrast to the November to March spawning season of roundscads based on the study of Tiews et al. (1970). Although Nepomuceno et al. (2023) were not able to identify the carangid larvae at species level, there is an emerging need to further explore and update the peak spawning season of roundscads in Northern Palawan, especially since spawning may be affected by water temperature (Lima et al. 2022), salinity, primary production (Maynou & Raya 2020), and photoperiod (Abdollahpour et al. 2020). Integration of DNA barcoding in the identification of fish larvae and further studies on environmental factors that affect spawning and recruitment are needed to ratify the timing and span of the closed fishing season in Northern Palawan.

2.5 Length at first sexual maturity (L_m or L_{m50})

Length at first maturity refers to the minimum length at which 50% of the population has reached sexual maturity and is able to reproduce for the first time (Stage III). It can be estimated using logistic models (Chen & Paloheimo 1994) based on microscopic examination of the gonads and the determination of gonadosomatic index (GSI) (Fontoura et al. 2009). The L_m may vary per species and population and may be affected by environmental conditions and fishing pressure (Wootton 1990). The L_m can be used to assess

Table 3. Information on the reproductive biology of roundscad species present in the Philippines.

Species	Area	k (cm/ yr)	Total Length (cm)	L_c (cm)	L_m (cm)	Spawning Period	Sex Ratio (F:M)	References
D. macrosoma	Manila Bay	0.65	ND	19.2		April–May	ND	Ingles & Pauly 1984
	Manila Bay	6–7	ND	19.2	18.0–20.0	April–May	F > M	Tiews et al. 1971
	Palawan	6–7	ND	ND	18.0–20.0	November-March	1:1	Tiews et al. 1971
	San Fernando, Romblon (part of Sibuyan Sea)	ND	11.50–22.00	ND	15.29–17.22 F: 15.29 M: 17.22	February August -October	0.87:1	Rada et al. 2019
	Romblon Pass	ND	ND	ND	ND	December-February April-June	ND	Gonzales et al. 2021
	Tablas Strait	ND	18.3–23.0	ND	F: 20.30 M: 24.36	October-May	ND	Gonzales et al. 2021
	Babuyan Channel	ND	F:12.1–27.5 M: 12.2–27.5	ND	F: 15.31 M: 15.02	February–May July–November	0.86–0.95:1	Villarao & Encarnacion 2023
D. russelli	Manila Bay	6–7	ND	ND	18.0–20.0	April-May	F > M	Tiews et al. 1971
	Palawan	6–7 cm/ yr			18.0–20.0	November-March	1:1	Tiews et al. 1971
D. kurroides	Iligan Bay	ND	M: 10.2–44.5 F: 9.20–31.4	ND	ND	December March-August	1.20:1	Dela Rosa et al. 2022
D. tabl	Davao Gulf	ND	ND	14.12–17	16.00	ND	ND	Villanueva 2018
D. macarellus	Davao Gulf	ND	ND	24.21–18.8	22.00	ND	ND	Villanueva 2018

the intensity of fishing pressure for roundscads (see Retnoningtyas et al. 2023a) and can help in designing regulations for sustainable fishing practices, ensuring that roundscads have spawned before being harvested.

There are minimal studies exploring the reproductive biology of roundscads, and some fishing grounds need an updated assessment of roundscad reproductive biology (Table 3). Recent data on the L_m of roundscads are provided by Rada et al. (2019), Gonzales et al. (2019), and Villarao & Encarnacion (2023) for *D. macrosoma*, Dela Rosa et al. (2022) for *D. kurroides*, and Villanueva et al. (2018) for *D. tabl* and *D. macarellus.* All of the recent data is gathered from a narrow spatial scope and is considered minor fishing grounds for roundscads. The major fishing ground, which is Northern Palawan (Tiews et al. 1971, Ronquillo 1973, Patoral et al. 2000, Geronimo et al 2018), has outdated data provided by Tiews et al. 1971. The impacts of high fishing pressure and the implementation of the closed fishing season in Northern Palawan will be better understood and evaluated through more updated data on roundscads L_m.

2.6 Fecundity

Fecundity is the total number of eggs produced by females before spawning (Bagenal 1966). This can be influenced by environmental factors like dissolved oxygen, level of rainfall, rate of sunshine, water pH (Issa et al. 2005), and fishing pressure (Rochet et al. 2000). It is also directly proportional to fish size and conditions (Kjesbu et al. 1991). Identification of species fecundity in different locations and times can aid in the assessment of reproductive potential and recruitment (Lambert 2008). It can be estimated using any or a combination of the following methods: gravimetric, volumetric, stereometric, dissector, and auto-diametric (see Murua et al. 2003). There are only a few species of Philippine roundscads with reported fecundity. The reports are usually concentrated on *D. macrosoma, D. russelli,* and *D. kurroides.*

As shown in Table 4, there is limited data on the fecundity of roundscads in the Philippines. The data on *D. macrosoma* and *D. russelli* focused on one area only and is outdated. These values may change over time due to the influence of environmental and evolutionary factors (Issa et al. 2005, Rochet et al. 2000). More recent data was provided by Dela Rosa et al. (2022) on *D. kurroides* in Iligan Bay. In general, the fecundity of roundscads in the Philippines is understudied and merits further investigation.

Table 4. Fecundity of roundscads in the Philippines.

Species	Area	Number of Eggs	References
D. macrosoma	Manila Bay & Palawan	67,900–106,200	Tiews et al. 1971
D. russelli	Manila Bay and Palawan	28,000–48,000	Tiews et al. 1971
D. kurroides	Iligan Bay	6,416–97,672	Dela Rosa et al. 2022

2.7 Recruitment

Recruitment is the number of juveniles that enter fisheries. It is dependent on the size of the spawning stock and survival of larval population. The spawning stock size determines the larval population, but environmental factors like temperature, food availability, and transport or advection directly affect recruitment (Houde 2009).

The recruitment pattern of roundscads is observed all year round, but the number and intensity of peaks vary depending on location and species (Table 5). The stocks of *D. macrosoma* in Manila Bay, Lagonoy Gulf, and Northern Palawan have one protracted recruitment peak (Ingles & Pauly 1984, Ramos et al. 2018), contrary to the stocks in Leyte Gulf, Tayabas Bay, Tawi-tawi, and Camotes Sea, which have two pulses or bimodal recruitment, but the primary pulse is stronger than the others (Lavapie-Gonzales et al. 1997, Ramos et al. 2018, Aripin & Showers 2000, Ingles & Pauly 1984).

The stocks of *D. russelli* in Manila Bay and Northern Palawan have alternating unimodal and bimodal recruitment (Ingles & Pauly 1984). In 1958, *D. russelli* in Manila Bay had one protracted recruitment peak, followed by two asymmetrical peaks in the next two years. Conversely, this is also being observed in the stocks of *D. russelli* in Northern Palawan. Two unequal peaks were observed in 1958, and one protracted peak in 1959.

D. macarellus in Davao Oriental, *D. maruadsi* in Tayabas Bay and Davao Gulf (Lavapie-Gonzales 1991, Ramos et al. 2018), and *D. tabl* in Camotes Sea (Narido et al. 2016) have unimodal recruitment. On the other hand, *D. kurroides* in Davao Gulf, *D. maruadsi* in Camotes Sea (Lavapie-Gonzales 1991), and *D. tabl* in Tayabas Bay (Ramos et al. 2018) has bimodal and asymmetrical recruitment.

The observed bimodal and asymmetrical recruitment patterns of the Philippine roundscads enumerated above may be influenced by emanating monsoons, as postulated by Pauly & Navaluna (1983). The two (2) pulses have a span of four (4) and eight (8) months, respectively, which is close to five and seven months of monsoon winds. Specifically, surface temperature and wind speed can influence the recruitment of coral reef fishes (Abesamis & Russ 2010). High density and species richness of recruits are observed when the surface temperature is high and the wind is weak. Since roundscads may spawn in shallow waters, the influence of wind and surface temperature may be evident, but this requires further studies. The pattern, duration, and timing of the recruitment of all roundscad species and the influence of environmental factors should be further explored to have a sustainable management policy.

2.8 Migration

Roundscads are migratory fishes like other small pelagics. However, there are no published studies on the migratory patterns and routes of roundscads in the Philippines.

2.9 Nutrient content

Roundscads are common source of proteins among Filipinos (Tiews et al. 1971). In fact, the average annual per capita consumption of roundscads in 2018 was 3.90 kg, a bit higher than the annual consumption of milkfish, *Chanos chanos*, and tilapia, *Oreochromis niloticus*, in the same year (PSA 2021). It means that one Filipino consumed an estimated amount of 3.90 kg of roundscads in 2018. Definitely, roundscads have been part of the Filipino diet.

Roundcads do not only contain proteins but also minerals and fatty acids. Specifically, *D.macrosoma* is composed of 71.34% edible protein, 28.76% nonedible protein, 74.19% moisture, and

Table 5. Stock assessment data of roundscads in the Philippines.

Area	Year	L∞ (cm)	k (yr-1)	Ǿ (yr-1)	Z (yr-1)	M (yr-1)	F (yr-1)	E	NRP	References
D. macrosoma										
East Sulu Sea	2019-2020	26.18	1.00	2.84	4.66	1.88	2.78	0.60	2	Magallanes et al. 2022
Manila Bay	1957-1958	31.50	2.05	ND	3.74	1.33	2.41	0.64	ND	Ingles & Pauly 1984
	1958	31.50	ND	ND	3.80	1.41	ND	0.69	1	Ingles & Pauly 1984
Palawan	1957-1958	26.80	0.71	2.82	4.71	1.47	4.32	0.69	ND	Ingles & Pauly 1984
	1960	33.00	0.50	ND	4.80	1.10	ND	0.77	1	Ingles & Pauly 1984
	1965-1966	25.5	0.85	ND	4.14	1.68	ND	0.59	1	Ingles & Pauly 1984
	1966	25.5	0.80	ND	5.26	1.62	ND	0.69	2	Ingles & Pauly 1984
	1968	33.0	0.65	ND	3.38	1.31	ND	0.61	1	Ingles & Pauly 1984
Lagonoy Gulf	1998-2012	26.22	1.14	2.89	9.53	2.02	7.52	0.76	1	Olaño et al. 2018
Tayabas Bay	2004-2013	26.69	0.55	2.593	1.84	1.25	0.59	0.32	2	Ramos et al. 2018
Eastern Sulu Sea and Basilan Strait	2013	22.09	0.37	2.257	3.53	1.02	2.52	0.71	1	De Guzman et al. 2018
Leyte Gulf	1983-1988	27.30	1.40	ND	4.67	2.28	2.39	ND	2	Lavapie-Gonzales et al. 1997
Visayan Sea	1984-1988	31.30	ND	ND	ND	ND	ND	ND	ND	Lavapie-Gonzales et al. 1997
Guimaras Strait	1984-1986	31.70	ND	ND	ND	ND	ND	ND	ND	Lavapie-Gonzales et al. 1997
Samar Sea	1985-1987	27.00	ND	ND	ND	ND	ND	ND	ND	Lavapie-Gonzales et al. 1997
Camotes Sea	1985-1987	28.00	1.60	ND	5.13	2.47	2.66	0.51	2	Lavapie-Gonzales et al. 1997
Davao Gulf	1983-1986	29.90	ND	ND	ND	ND	ND	ND	ND	Lavapie-Gonzales et al. 1997
South Sulu Sea	1983-1988	27.80	1.20	ND	7.25	2.45	4.80	0.72	ND	Lavapie-Gonzales et al. 1997
Moro Gulf	1983-1988	21.40	2.30	ND	4.25	3.28	0.97	0.20	ND	Lavapie-Gonzales et al. 1997
Tawi-tawi	1994-1995	24.90	0.77	2.68	3.49	1.59	1.90	0.54	2	Aripin & Showers 2000
Camotes Sea	1983-1987	25.00	0.88	ND	2.05	1.73	ND	0.16	ND	Belga et al. 2018
Camotes Sea	2003-2012	27.56	0.99	ND	5.44	1.56	3.88	0.71	ND	Belga et al. 2018
D. russelli										
Manila Bay	1958-1959	27.00	0.80	ND	6.89	1.59	ND	0.77	1	Ingles & Pauly 1984
	1959	30.00	0.54	ND	2.06	1.19	ND	0.42	2	Ingles & Pauly 1984
Palawan	1958	26.90	0.69	ND	4.34	1.44	ND	0.67	2	Ingles & Pauly 1984
	1959	26.00	0.73	ND	3.69	1.51	ND	0.59	1	Ingles & Pauly 1984

Note: L∞ = asymptotic length; k= growth rate; Ǿ= growth performance index; Z= total mortality; N= natural mortality; E=exploitation level; NRP= number of recruitment pulses; ND= no data

Continuation of Table 5. Stock assessment data of roundscads in the Philippines.

Area	Year	L∞ (cm)	k (yr-1)	Ǿ (yr-1)	Z (yr-1)	M (yr-1)	F (yr-1)	E	NRP	References
	1968	33.00	0.45	ND	2.62	1.03	ND	0.61	2	Ingles & Pauly 1984
Lagonoy Gulf	1998–2012	24.92	0.95	2.77	8.72	1.82	6.90	0.77	1	Olaño et al. 2017
Visayan Sea	1984–1987	38.64	ND	ND	ND	ND	ND	ND	ND	Lavapie-Gonzales 1991
Camotes Sea	1985–1988	35.10	1.40	ND	6.71	2.13	ND	ND	ND	Lavapie-Gonzales 1991
Hinatuan Passage	2004	23.54	1.03	2.76	6.79	1.95	4.84	0.71	ND	Baclayo et al. 2016
	2005	23.70	1.15	2.81	4.71	2.09	2.62	0.56	ND	Baclayo et al. 2016
	2006	21.80	1.15	2.74	5.25	2.14	3.11	0.53	ND	Baclayo et al. 2016
	2007	21.80	1.20	2.46	6.50	2.20	4.30	0.66	ND	Baclayo et al. 2016
	2008	22.40	1.50	ND	7.63	2.53	5.10	0.67	ND	Baclayo et al. 2016
	2009	24.30	1.30	2.88	7.09	2.25	4.84	0.68	ND	Baclayo et al. 2016
	2011	23.40	1.10	2.76	4.72	2.05	2.67	0.57	ND	Baclayo et al. 2016
	2012	24.30	1.30	2.89	5.97	2.25	3.72	0.62	ND	Baclayo et al. 2016
	2013	23.50	1.30	2.86	6.65	2.27	4.38	0.66	ND	Baclayo et al. 2016
D. macarellus										
Davao Gulf	2004–2013	ND	ND	ND	ND	ND	ND	0.6–0.7	ND	Villanueva 2018
Pujada Bay, Davao Oriental	1986	24.3	1.8	ND	3.7	ND	ND	ND	1	Lavapie-Gonzales 1991
D. kurroides										
Davao Gulf	1985–1986	25 cm	0.88	ND	4.31	1.62	2.68	0.62	2	Lavapie-Gonzales 1997
Visayan Sea	1983–1988	29.80	ND	ND	ND	ND	ND	ND	ND	Lavapie-Gonzales et al. 1997
Samar Sea	1983–1986	31.40	ND	ND	ND	ND	ND	ND	ND	Lavapie-Gonzales et al. 1997
D. maruadsi										
Tayabas Bay	2006–2013	21.71	0.9	2.628	2.37	1.83	0.54	0.23	1	Ramos et al. 2018
Davao Gulf	1987	27.30	1.10	ND	5.39	1.95	3.44	ND	1	Lavapie-Gonzales et al. 1997
Camotes Sea	1987–1988	31.17	ND	ND	6.86	2.10	4.76	ND	2	Lavapie-Gonzales et al. 1997
D. tabl										
Camotes Sea	2012–2013	32.55	0.97	ND	5.57	1.71	3.86	0.69	1	Narido et al. 2016
Tayabas Bay	2006–2013	25.14	0.73	2.664	3.21	1.53	1.68	0.52	2	Ramos et al. 2018
Davao Gulf	2004–2013	ND	ND	ND	ND	ND	ND	0.45–0.68		Villanueva 2018

Note: L∞ = asymptotic length; k= growth rate; Ǿ= growth performance index; Z= total mortality; N= natural mortality; E=exploitation level; NRP= number of recruitment pulses; ND= no data

1.81% minerals (Sulit et al. 1953). *D. macrosoma* and *D. russelli* has substantial fat content, which is 5.20–4.40% and 6.80–19.30% of their mass, respectively (Tiews et al. 1971). Roundscads are low-fat fishes, but they can be a potential source of fish oil. *D. macarellus* and *D. kurroides* were found to have high levels of stearic acid (Metillo & Aspiras-Eya 2014). *D. maruadsi* was reported to be rich in polyunsaturated fatty acids (PUFA) like eicosapentaenoic acid (EPA) and docosahexaeoic acid (DHA) (He et al. 2020). Moreover, roundscads have additional health benefits. *D. maruadsi* is a potential source of natural antioxidants (Hu et al. 2020) and *D. macrosoma* has antihypertensive properties (Ishak et al. 2020). Hence, roundscads are considered to be highly valuable in fisheries, not only because of their abundance in Philippine waters but also because of their nutritional content and health benefits. Further research is needed to explore the other health benefits of roundscads.

3. ECOLOGY

3.1 Habitat

Roundscads are open-water schooling fishes that are usually caught in neritic waters, ranging from 40–200 m deep (Calvelo 1992). The depths may vary among roundscad species, as shown in Table 1. *D. maruadsi* is usually caught in the shallowest depth and is observed to have a high catch per unit effort (CPUE) in the coastal waters and continental shelf part of the East China Sea (Hino et al. 2023). *D. macarellus, D. tabl,* and *D. macrosoma* are observed to have high CPUE in Kuroshio areas and shelf breaks in the East China Sea (Hino et al. 2023), which supports the observed depths of these species enumerated in Table 1.

The habitat preference of roundscad species may also be attributed to environmental factors like salinity. For example, Tiews et al. (1971) inferred that the low catch of roundscads inside Manila Bay is due to the avoidance of roundscads away from areas with low salinity (< 30 ppt) and a high abundance of phytoplankton. Moreover, Zhao et al. (2021) reported a high CPUE of *D. maruadsi* in areas of the Northern South China Sea with a salinity range of 32.90–34.00 ppt in the autumn and 31.80–34.00 ppt in the rest of the year. Therefore, the water depth and salinity of the water have a significant influence on the habitat preference of roundscads. However, further research is needed on the different environmental factors that characterize the habitat of roundscads.

3.2 Food habits

Roundscads are generalists that feed on any species of planktons and small fishes (Tiews et al. 1971). In particular, *D. russelli* and *D. macrosoma* feed on zooplanktons like copepods and smaller fishes (Tiews et al. 1971, Ronquillo 1970). *D. maruadsi* is reported to be a plankton feeder (Yang et al. 2016). With this diet, roundscads like other small pelagic fishes play a link between low and high trophic levels. Small pelagic fishes may exert a "wasp-waist" type of control that may influence the population dynamics of planktons and smaller fishes (top-down control) and larger pelagic predators (bottom-up control) (Rice 1995). In upwelling areas of the tropics, a decrease in the population of small pelagic fishes has no inferred influence on plankton biomass but has significant disruption in upper pelagic predators (Duarte & Garcia 2004). The influence of roundscads on the population dynamics of planktons and predators in Philippines waters could also be explored in the future to have a holistic and sustainable approach to the management of fisheries.

3.3 Parasite infestation

Based on the current published studies on the parasite infestation of roundscads, there are three groups of parasites. These are the nematodes, isopods, and myxozoa. Roundscads can be intermediate hosts of nematode parasites like *Anisakis.* Nematode larvae were found in *D. macrosoma* and *D. russelli* collected from Manila Bay and Palawan (Tiews et al. 1971). Although the study lacks the identification of nematode species, the degree of infestation was found to be directly related to fish size. Anisakid parasites were also observed in *D. maraudsi, D. macrosoma,* and *D. tabl* collected in the Caraga Region (Tiempo et al. 2020). These three species of roundscads were also infested with *Anisakis typica* and *Raphidascaris (Ichthyascaris) lophii* in samples collected in Tayabas Bay and Balayan Bay (Dela Cruz et al. 2022). Surveys on the occurrence of nematode infestations on roundscad species are few. Although there have been no reports of anisakiasis among Filipinos, it still poses a potential health hazard for foodborne allergies (Umehara et al. 2010).

Norileca indica, a cymothoid isopod, was also observed in the branchial cavities of *D. kurroides* collected in the Panay Gulf (Cruz-Lacierda & Nagasawa 2017). This is the first report of isopod infestation among roundscads collected in the Philippines. The prolonged occupancy of isopods on their host fish can cause atrophy of gill filaments, damage to gill rakers, lesions on gills, pale coloration of gills, and the formation of deep holes in gill chamber floor (Kottarathil et al. 2019, Rameshkumar & Ravichandran 2014). *N. indica* is known to be host-specific (Panakkool-Thamban et al. 2016). Although *D. kurroides* is the only reported roundscad species in the Philippines that is infested with isopods, *N. indica* was also found in *D. russelli* in Indonesia (Pattipeiluhu and Gill 1998). There is a possibility that other roundscad species in the Philippines may be infested with isopods, which may affect the conditions of roundscads.

Myxosporean parasites like *Kudoa trachuri* and *Kudoa longichorda* were isolated from *D. tabl* collected in the Philippine Sea, particularly in the northwest part of the Pacific Ocean (Inoue et al. 2022). This is the only report of myxosporean infestation on roundscads in the Philippines. Infested fish with myxospores develop "post-harvest soft flesh" or "jelly meat" (Yokoyama et al. 2004), which is characterized by having macroscopic spots made up of aggregated spores or pseudocysts and fibrous tissues in the fish meat (Matsukane et al. 2010). *Kudoa* may also cause infections in humans by consuming infested fishes (Shamsi & Barton 2024). The symptoms like diarrhea, abdominal pain, nausea, and vomiting can be misdiagnosed, especially since they may also be evident in viral and bacterial infections (Tachibana & Kudoa 2020).

In general, there are few studies exploring the parasite infestation of roundscads. Although reports of nematode, isopod, and myxosporean infestation are scarce, continuous monitoring of these parasites is recommended to ensure the quality of the roundscads harvested and the general safety of Filipino consumers.

3.4 Metal contamination

Fish can bioaccumulate different heavy metals like chromium, copper, lead, cadmium (Rajeshkumar & Li 2018), manganese (Partridge et al. 2009), arsenic (Pei et al. 2019), and mercury (Burger et al. 2011). These can be present in their liver, gills, muscles, head, and other internal organs (Garai et al. 2021). Once the fish has been consumed by humans, it can cause health issues. Like other fish, roundscads can bioaccumulate pollutants in water.

There are reports on the bioaccumulation of lead, cadmium, and mercury by roundscads. For example, the roundscad samples collected in Nepa-Q Mart, a market in Metro Manila, contain a low level of mercury, about 0.05 mg/kg of fish, or 0.05 ppm (Africa et al. 2009). It is below the 0.46 μg/g screening value of methylmercury for fish (US Food and Drug Administration n.d.).

Lead was also recorded in the head, flesh, and internal organs of *D. macrosoma* collected in Batangas Bay, but the concentration is within the allowable limit for lead in fish samples (Sangalang & Quinay 2015). The lead concentration in the internal organ of the collected *D. macrosoma* is higher than the head and flesh, but the difference is not significant. Despite being safe for human consumption, the accumulation of lead in fish, even at low concentrations, may cause hypocalcemia, damage to the central and peripheral nervous systems, oxidative stress (Lee et al. 2019), and death (Kim and Kang 2015).

Moreover, Solidum et al. (2013) reported a high amount of cadmium in *D. macarellus* samples collected in a market in Metro Manila with a mean value of 0.0608 ppm, which is beyond the allowable limit of 0.05 ppm. The samples also contain chromium and lead, but within the allowable limits of 0.10 ppm and 0.50 ppm (US Food and Drug Administration n.d.). Cadmium has no known biological function in humans, but bioaccumulation of it causes oxidative stress, resulting in disruption of antioxidant defense system (Suhani et al. 2021). It can cause damages on the respiratory system (e.g., pneumonitis, destruction of mucus membrane), reproductive system (e.g., testicular necrosis and estrogen-like effects), skeletal system (e.g., Itai-itai disease and lack of bone density), and kidney (e.g., kidney stones, glomerular and tubular damages, and proteinuria) (Godt et al. 2006). Likewise, the large amount of enriched cadmium in fish affects the antioxidant enzymes, causing multiple organ and tissue damages (Liu et al. 2022).

Generally, the heavy metal content of roundscad species in the Philippines is not yet alarming. However, monitoring their heavy metal content and their fishing grounds is advisable to prevent possible health risks among consumers.

4. FISHERIES

4.1. Fishing gears

Philippine fisheries are divided into aquaculture, municipal, and commercial fishing. Municipal and commercial fisheries are different based on the size of the fishing vessel and fishing location. Municipal fishing vessels have a weight not greater than three tons and fish in offshore waters. On the other hand, commercial fishing vessels fish in inland and coastal areas and have a weight greater than three tons (The Philippine Fisheries Code of 1998). The commercial vessels are required to pay for licensing fee by the national government. However, depending on municipal ordinances, municipal fishing vessels may pay local government fees (Dalzell et al. 1990). Roundscads are common catches in both municipal and commercial fishing vessels. In fact, the municipal and commercial catches of roundscads in 2020 are 43,499.06 metric tons and 158,403.99 metric tons, respectively (Philippine Statistics Authority 2020).

Small pelagic fishes like roundscads are caught using basnigan or bag net, purse siene, ringnet, trawls, and danish seine. Ringnet is the precursor of purse seine and is commonly used by small to medium-sized fishing vessels. A nylon-made net surrounds the school of pelagic fish and is closed by drawing up the purse string. The size of the net depends on the size of the vessel. Municipal ringnet fishing is common practice in Batangas, Antique, Bohol, Davao, and Davao del Sur. Commercial ringnets are practiced in Zambales, Cavite, Palawan, Capiz, Cebu, and South Cotobato (Ruangsivakul et al. 2004).

Bagnet, or basnigan, was developed in the early 1950s and introduced to Manila Bay. It uses a large scoop net or bag net, suspended on the outriggers of boats, that catches fish in shallow waters. The introduction of basnigan and purse seine and the use of powerful incandescent lamps after World War II increased the production of roundscads and other pelagic fishes (Ronquillo 1970). In exploiting roundscads, municipal fisheries rely much on gillnet among other methods. Commercial fishing of roundscads uses varying gears like gillnets, purse seines, trawls, and ringnets (Arce & Gonzales 1995). These fishing gears have enabled Filipinos to exploit roundscads better.

4.2 Fishing grounds

Roundscads live in shallow and coastal seas all throughout the Philippines (Fig 2). It is usually caught at 40–200 m depth adjacent to the continental shelf (Calvelo 1997). Most species of roundscads live in warm tropical and subtropical water, which explains its abundance in the Philippines.

The major fishing grounds of roundscads are Northern Palawan, Sibuyan Sea, Visayan Sea, Ragay Gulf, Busuanga Gulf, San Miguel Bay, Tayabas Bay, Manila Bay, Moro Gulf, Lamon Bay, Camotes Sea, Samar Sea, Bohol Sea, Babuyan Channel, Davao Gulf, and Sulu Sea (Tiews et al. 1971, Ronquillo 1973, Pastoral et al. 2000). The majority of these were identidified as core fishing areas (CFAs) characterized by high-light-assisted fishing activities (Geronimo et al. 2018).

According to Calvelo (1992, 1997), the most productive fishing ground for roundscads is the West Sulu Sea, which accounted for 60% of roundscad production in 1980–1987. This is supported by the study of Geronimo et al. (2018) on the most suitable core fishing area for light-assisted fishing based on bathymetry, chlorophyll a, and sea surface temperature. The northeast of Palawan and the west of Palawan are the most suitable areas for roundscad fishing, regardless of monsoons and years. These areas are generally shallow, not exceeding 200 m in depth, and provide suitable habitat for roundscads. Furthermore, Northern Palawan has been observed to have the highest concentration of carangid larvae (Nepomeceno et al. 2023). These prove that Northern Palawan is the most important fishing ground for roundscads, and further research on their stock is more than necessary.

Most fishing grounds have fishing seasonality based on monsoons. As an example, fishing operations in Northern Palawan are concentrated on the western coast during the northeast monsoon, or "amihan," and

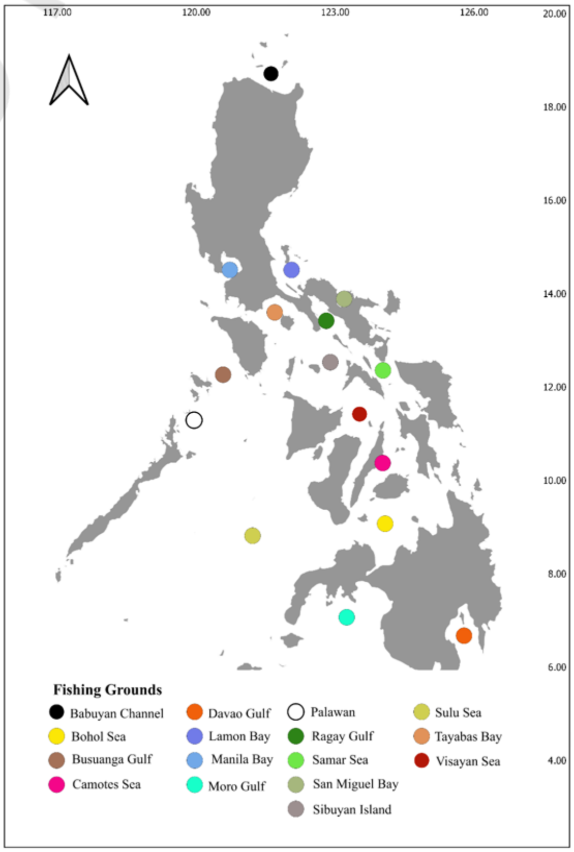

Figure 2. Fishing grounds of roundscads in the Philippines (Tiews et al. 1971, Ronquillo 1973; Pastoral et al. 2000).

on the eastern coast during the southwest monsoon, or "habagat" (Ronquillo 1975). Likewise, prevailing monsoons also have an influence on the pattern of fishing activities in the Philippines. During *habagat,* fishing activities are high in the northeastern section of the Philippines; on the contrary, the fishing activities are high in the western section during *amihan* (Ronquillo 1970).

4.3. Stock assessment

Stock assessment is the application of mathematical and statistical tools to draw quantitative predictions about the fish population in response to management choices (Hilborn and Walters 1992). The purpose of stock assessment is to provide guidelines on the "optimum exploitation" of fish (Sparre & Venema 1992). Stock assessment of roundscads in various fishing grounds is essential to determine the current status of stocks, predict their dynamics over time, and draw inform management decisions, such as imposing restrictions on highly exploitative fishing gear, setting catch limits, and determining the timing and the span of closed fishing season. Table 5 summarizes the population parameters and recruitment patterns of different roundscad species found in various fishing grounds. The different variables being derived in the majority of these studies are the asymptotic length (L_{∞}), growth rate (k), growth performance index (Ø), total mortality (Z), natural mortality (M), fishing mortality (F), and exploitation level.

The asymptotic length is the maximum length a fish population can attain if it will live indefinitely. It is a function of the growth rate, which is the rate at which fish length changes over time (King 2007). Both the asymptotic length and growth rate are functions of the growth performance index, which is the growth potential of fish population. These are used to estimate the growth of stocks. Growth may vary among populations depending on fishing pressure (Tu et al. 2018) and various environmental factors like temperature, salinity, photoperiod, and oxygen concentration (Dutta 1994). A high growth rate has a value greater than 0.3 and may indicate that the stock will reach maturity rapidly and can sustain a high level of mortality as they can reproduce at a faster rate (Magallanes et al. 2022).

The mortality of fish population can be classified as natural mortality or fishing mortality. The latter was brought on by the deaths due to fishing activities. The former refers to natural death causes like predation, competition, diseases, senescence, and pollution (Froese & Pauly 2019). Natural mortality is calculated based on growth function and mean annual water temperature. The ratio of fishing mortality to total mortality is the exploitation level. Exploitation level indicates the degree of overfishing in a fish population. The optimum exploitation level for fish is 0.50; values higher than this indicate overfishing (Gulland 1983). In response to poor survival of fish population due to environmental factors and fishing, there is an increase in the growth rates and a decrease in the length at maturity of the survivors (Heino & Godo 2002).

Among the species of roundscads in the Philippines, the stocks of *D. macrosoma* are widely assessed (Fig. 3), but some of the studies were conducted in the late 1900s (Table 5). The growth parameters for *D.macrosoma* have the following mean: L_{∞} is 27.72 cm; k is 1.04 yr^{-1}; and Ø is 2.58. The high growth rate indicates that the stocks of *D. macrosoma* in the Philippines are growing rapidly due to high fishing mortality (F = 2.83) and overfishing (E = 0.58). The majority of the stocks of *D. macrosoma* are overfished except in Tayabas Bay (E = 0.32; F = 0.59).

The stocks of *D. russelli* were only assessed in six fishing grounds—Manila Bay, Palawan, Lagonoy Gulf, Visayan Sea, Camotes Sea, and Hinatuan Passage (Table 5). Among which, only the stock in Hinatuan

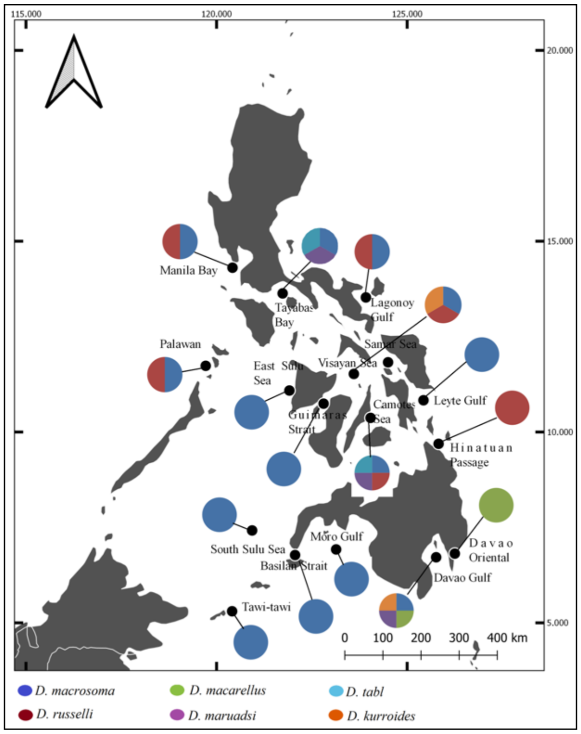

Figure 3. Fishing grounds of roundscads in the Philippines with stock assessment studies.

Passage and Lagonoy Gulf were assessed in the 21st century. The majority of the information was from the seminal study of Ingles & Pauly (1984). The mean $L\infty$ of *D. russelli* in the Philippines is 29.83 cm, and the mean k is 0.97 yr^{-1}. The stocks in Hinatuan Passage and Lagonoy Gulf have a low asymptotic length but have a high growth rate and growth performance index. The highest $L\infty$ is in the Visayan Sea, but no other parameters were indicated by Lavapie-Gonzales (1991). *D. russelli* can have a maximum length of 45.00 cm (Frimodt 1995), which indicates that the total length of *D. russelli* in the Philippines is generally small. All of the stocks of *D. russelli* are overfished as stipulated by their exploitation level.

There are only three fishing grounds where stocks of *D. maruadsi* were assessed. Only the stock in Tayabas Bay was assessed in the 21st century. Stock assessments in Davao Gulf and Tayabas Bay were already outdated. *D. maruadsi* in the Camotes Sea has the highest $L\infty$ (31.17 cm). *D. maruadsi* in the Tayabas Bay has lower k and $L\infty$ than the stocks in the Davao Gulf. Only the stock of *D. maruadsi* in Tayabas Bay has computed the exploitation level. *D. maruadsi* in the Tayabas Bay is less exploited. Although there is no computed exploitation level of stocks in the Davao Gulf and Camotes Sea, it can be inferred that the stocks were overfished based on their fishing mortality (M).

The growth parameters of *D. macarellus* are only assessed in two fishing grounds—the Davao Gulf and the coast of Davao Oriental (Lavapie-Gonzales 1997). Stocks caught within the Davao Gulf have a smaller $L\infty$ than in Pujada Bay, Davao Oriental. *D. macarellus* is fast-growing as indicated by a k of 1.80 yr^{-1}. There is not enough data to infer on its exploitation, but it has a high total mortality ($Z = 3.70$). The stock assessment of *D. maruadsi* is sparse and outdated.

Likewise, *D. kurroides* has limited and outdated stock assessment studies. It was just assessed in three fishing grounds, namely the Visayan Sea, the Samar Sea, and the Davao Gulf. The data in the Samar Sea and Visayan Sea were insufficient to estimate the other growth parameters except for $L\infty$ (Lavapie-Gonzales, 1997). The stocks of *D. kurroides* in the Davao Gulf have a high growth rate but are lower than the stocks of *D. russelli*. It is also overexploited, as indicated by its E value of 0.62. Both *D. maruadsi* and *D. kurroides* have outdated and limited stock assessment studies.

There are also limited stock assessments for *D. tabl*. The stock of *D. tabl* in the Camotes Sea has a larger $L\infty$ than in Tayabas Bay. Although it also has a higher exploitation level, high $L\infty$ is balanced with a high k of 0.97 yr^{-1} (Narido et al. 2016). The stocks in the Camotes Sea are fast growing in response to high exploitation level. There is no published stock assessment conducted for *D. smithvanizi* because it was just in 2021 that it was first recorded in the Philippines. It is almost similar to *D. tabl* by having a slender body and a red caudal fin. There is a possibility that there are samples of *D. smithvanizi* which is counted in the stock assessment of *D. tabl*.

In general, rounscads on different fishing grounds are highly exploited, and stock assessment studies of roundscads in the Philippines are limited. However, the establishment of the NSAP Atlas (https://nsap.nfrdi.da.gov.ph) provides researchers with access to the monitored catch data of different aquatic resources in the country. The majority of the recent stock assessment studies enumerated in Table 5 (Villanueva et al. 2018, Ramos et al. 2018, Baclayo et al. 2016, Olaño et al. 2018, Belga et al. 2018, De Guzman et al. 2018, Magallanes et al. 2022) extracted and encoded their data from and in the NSAP database. With an accessible database, stock assessments of roundscad species in different fishing grounds are expected to increase in the future, filling the gaps enumerated above. Moreover, stock assessment studies in Northern Palawan and Zamboanga (Region IX) are highly recommended, especially since Northern Palawan is considered as a core fishing ground for roundscads and Zamboanga has the highest percent contribution of roundscad catch from 2015-2020 (Fig 7).

4.4. Stock identification

Stocks are intraspecific groups of randomly mating and reproductively isolated individuals characterized by spatial and temporal limits (Begg and Waldman 1999). Stock, as a subset of one species, have the same growth and mortality parameters and have minimal mixing with nearby groups (Sparre & Venema 1998). Stock delineation is a process of identifying fish populations based on genetic markers (Milner et al. 1985, Farrell et al. 2022), phenotypic markers (Mahfuj et al. 2023), and biological tags like parasites (Retnoningtyas et al. 2023b). Since roundscads are migratory and the waters of the archipelago are continuous, stock delineation can prevent overestimation of stocks and manage assessment efforts. In the Philippines, there are limited studies that delineate stocks of roundscad species.

In the study of Jamaludin et al. (2020) using the mitochondrial cytochrome b (Cyt b) gene, there are two discrete stocks of *D. maruadsi* that are present in the Central Indo-West Pacific Regions. These are the Sundaland-Rosario-Ranong and northern Vietnam populations. There is only one common stock of *D. maruadsi* present in the waters of Sundaland, Rosario, Philippines, and Ranong Adaman Sea, as revealed by their low nucleotide diversity. On the other hand, the stock of *D. maruadsi* in Vietnam is an admixed group. Jamaludin et al. (2020) recommended a separate and independent management of the two populations based on their separate stock structures.

Moreover, Barnuevo et al. (2023) distinguished two populations of *D. kurroides* using otolith morphometry. An otolith is a composite of calcium carbonate and protein located in the inner ear of fish for balance and sound detection (Corrêa et al. 2022). Otolith morphometric analysis has been used to separate stocks of various species (e.g., Duncan et al. 2018, Moreira et al. 2019) and delineate closely related species (e.g., Morales et al. 2023 in delineating *D. tabl, D. smithvanizi,* and *D. kurroides*). Using otolith morphometry, Barneuva et al. (2023) identified a separate stock of *D. kurroides* in the Sibuyan Sea from a nearby Sulu Sea. The otolith of *D. kurroides* population in the Sibuyan Sea is more elliptical, heavier, and larger than the population in the Sulu Sea, which suggests two different stocks of *D. kurroides*.

There is no study yet on the application of biological tags in delineating roundscad stocks in the Philippines. However, in the study of Retnoningtyas et al. (2023b), they were able to identify two stocks of *D. macarellus* in eastern Indonesia using metazoan fish parasites as biological tags. Parasites can be used as biological tags because fish can only be infected with parasites if they live in parasite-endemic areas (MacKenzie & Abaunza 2014). This method can also be applied to delineate roundscad stocks in the Philippines, especially since there are already studies on parasite infestation in the Philippines (see Section 3.3).

In general, there are few studies on the stock identification of roundscads in the Philippines. Accurate identification of fish stocks is necessary to lessen the cost and overestimation of multiple stock assessments. It is also important to identify the response of highly exploited stock to the implemented management policies like closed fishing season policy. As Cadrin & Secor (2009) emphasized, "stock identification is an important prerequisite for stock assessment." There are increasing studies on stock assessment of roundscads in the Philippines, but these simply define stocks based on locality (Table 5). Stock identification of roundscads using multiple approaches is recommended to establish a stock unit for stock structure studies towards sustainable management of fisheries.

4.5. Production

The data presented here are from the Fisheries Situation Report, Statistics on Agriculture, and OpenSTAT (https://openstat.psa.gov.ph/) of the Philippine Statistics Authority (PSA), Fisheries Statistics of the Philippines of the Bureau of Agricultural Statistics (BAS), and from the National Stock Assessment Program (NSAP) of the Bureau of Fisheries and Aquatic Resources (https://nsap.nfrdi.da.gov.ph/home). In an NSAP database search, possible misidentified entries such as *D. muroadsi, D. punctatus, D. koheru, and D. akaadsi* were disregarded since their presence in the Philippines is not yet verified. *D. koheru* is distributed only in the waters of New Zealand and Australia; *D. punctatus* is found only in the Atlantic Ocean. On the other hand, *D. akaadsi* and *D. muroadsi* occurred in East Asia (Fricke et al., 2023). Although Delloro et al. (2021) have confirmed the presence of *D. smithvanizi,* there is no available data on its production in the database. Hence, this section presents the production of six species only, namely *D. macrosoma, D. macarellus, D. russelli, D. maruadsi, D. kurroides,* and *D. tabl.* Moreover, as of the writing of this manuscript, there is also no data on the production of roundscads in Region XIII (CARAGA) that can be retrieved from the NSAP database. This report only presents data from 14 regions.

Based on the Philippine Statistics Authority, there was an increase in roundscad production from 1980 to 2004, from 132,100 MT to 293,900 MT (Table 6). The highest production for 40 years was in 2007, recording a production of 320,200 MT. However, the production eratically dwindled from 2008 to 2021 (Fig. 4, Table 6). The lowest production from 2008–2021 was in 2018 with 171,300 MT, which is also the year when the Philippines started importing roundscads of more than 5,000 MT.

Among the Regions, Region IX has the highest production of roundscads in the Philippines, accounting for 59.94% of total production from 2015 to 2020 (Fig. 5, Table S1). This is contrary to the data from Calvelo (1992), in which the South Sulu Sea is ranked fifth among the most important fishing grounds based on production from 1980–1987. According to Calvelo (1992), the West Sulu Sea accounts for 60% of production, followed by the Visayas Sea and the Moro Gulf. The observed decrease in the production

Table 6. Production, price, and volume of imported roundscads in the Philippines from 1980–2021 (source: Philippine Statistics Authority 1980–2021; Bureau of Agricultural Statistics 2001–2013).

Year	Production ('000 MT)	Wholesale price (Php/kg)	Retail price (Php/kg)	Volume of Imported Roundscads (MT)
1980	132.10	6.19	7.55	ND
1981	149.90	7.42	8.68	ND
1982	183.30	6.99	8.83	ND
1983	165.00	7.30	9.88	ND
1984	131.60	14.39	16.51	ND
1985	131.70	16.95	20.63	ND
1986	175.90	15.93	20.63	ND
1987	182.00	15.85	20.45	ND
1988	168.10	15.61	24.32	ND
1989	209.80	18.02	26.32	ND
1990	249.30	19.65	26.11	ND
1991	277.33	22.92	28.42	ND
1992	296.98	24.13	31.27	ND
1993	233.20	24.09	34.44	ND
1994	233.20	29.05	40.57	ND
1995	259.80	28.79	39.53	ND
1996	223.90	30.59	43.38	ND
1997	228.90	31.93	44.97	ND
1998	245.10	34.45	47.42	ND
1999	248.50	40.03	53.91	ND
2000	256.00	41.49	54.90	ND
2001	286.20	44.50	59.44	104.96
2002	279.30	43.80	60.41	818.93
2003	310.60	43.87	59.81	1607.84
2004	293.90	48.07	66.19	1514.69
2005	280.80	47.43	66.99	81.07
2006	260.10	53.31	73.43	197.71
2007	320.20	52.47	74.97	ND
2008	294.10	61.08	84.04	650.29
2009	243.70	64.82	87.99	544.08
2010	268.20	64.25	87.45	361.07
2011	239.60	77.58	100.47	55.77
2012	233.50	83.14	107.68	24.01
2013	270.80	82.29	108.02	198.30
2014	260.60	86.3	113.84	195.24
2015	225.10	91.42	118.27	369.46
2016	211.80	90.39	116.59	923.05
2017	183.10	97.24	127.50	2751.30
2018	171.30	ND	144.22	5454.69
2019	189.00	ND	150.23	53071.72
2020	202.00	ND	163.92	24045.29
2021	181.50	ND	185.23	61588.30

Note: ND = No data

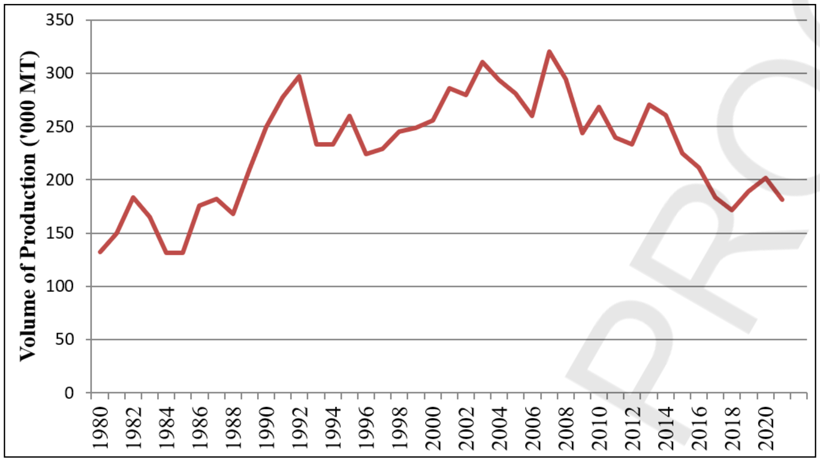

Figure 4. Volume of production of roundscads in the Philippines from 1980-2022 (data from PSA)

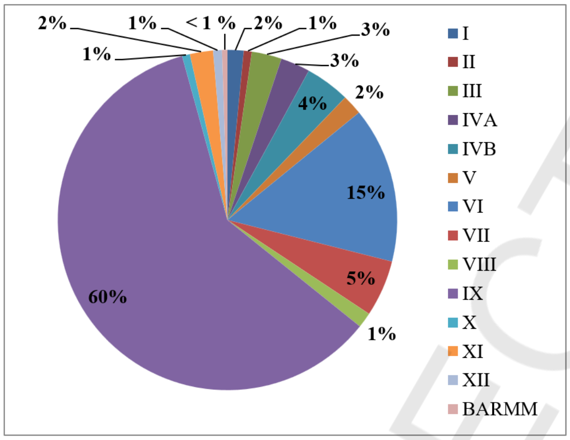

Figure 5. Percent contribution of Regions to the total volume of roundscad production in the Philippines from 2015-2020 (data from NSAP).

of roundscads in the West Sulu Sea might be due to the implementation of a closed fishing season for round scads in Northern Palawan, a part of the West Sulu Sea, since 2015 (JAO No. 1 series of 2015). It is the only area where a closed fishing season for roundscads is implemented. The second most productive region in terms of roundscad production is Regions VI and VII, with 14.81% and 6.57% contribution to the total production, respectively. Regions VI and VII fish on the Visayan Sea, a major fishing ground for roundscads, accounting for a roundscad production of 20-30 thousand metric tons from 1980-1987 (Calvelo 1992).

The roundscad production from 2015-2020 is composed predominantly of *D. macrosoma* (57.03%), followed by *D. tabl* (14.82%), and *D. macarellus* (11.37%) (Fig. 6). From 2015 to 2020, the production of *D. macrosoma* has increased by 35.75% (Fig. 7, Table S2) . The same pattern is also observed in *D. macarellus.* The production of *D. russelli* from 2015-2022 seems to plateau, and no significant changes are observed. However, *D. tabl, D. kurroides,* and *D. maruadsi* have a downward trend.

Each region has varying dominant roundscad species caught from 2015 to 2020. *D. macrosoma* is the dominant roundscad species that is caught in Regions II, VI, IX, XI, XII, and BARMM (Fig. 8, Table S1). *D. macarellus* dominates the roundscad production in Regions I, III, and V. *D. kurroides* is the dominant roundscads in Region X. *D. maruadsi* is dominant in Region VIII, while *D. russelli* dominates the roundscads captured in Region IVB.

The production of roundscads on the different fishing grounds in the Philippines is generally thought to be all-year-round, but there are Regions that report the seasonality of specific species of roundscads in their fish landings. Region II reported *D. tabl* in the

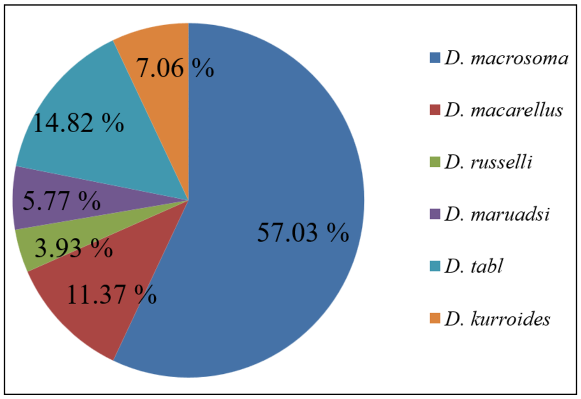

Figure 6. Percent contribution of roundscad species in the total volume production of roundscads from 2015-2020 (data from NSAP).

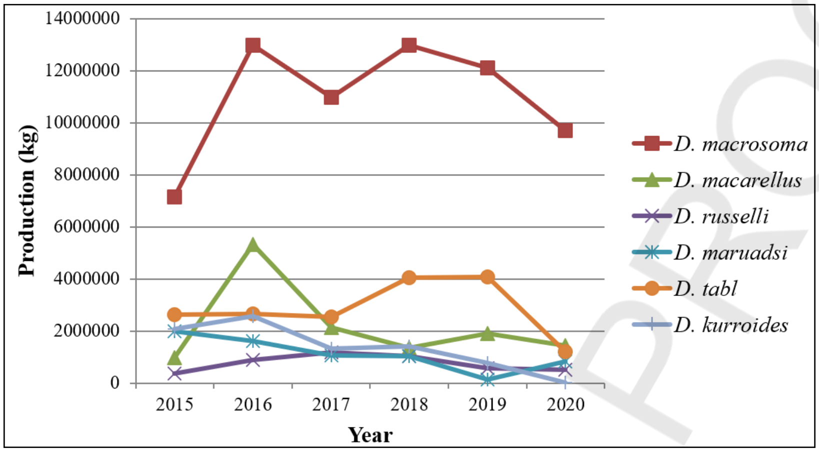

Figure 7. Trends on the production (kg) of roundscad species in the Philippines from 2015-2020 (data from NSAP).

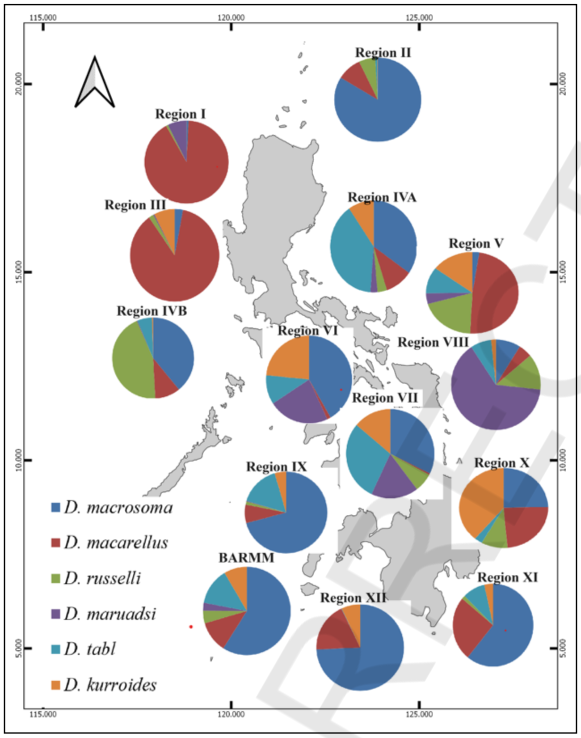

Figure 8. Percent contribution of roundscad species to the total production of roundscads per Regions (data from NSAP).

months of September to December only in 2021, May and June only in 2022, and January only in 2023. Likewise, *D. kurroides* is usually caught in Region II in one to two months only. It is reported in Region II in the month of September in 2019, May and June in 2022, and April in 2023. There are no reports on the landed catch of *D. kurroides* from 2020 and 2021. Fishing activities in Region II, particularly in Babuyan Channel, are seasonal due to monsoons (Villarao & Encarnacion 2023). Monsoons may have influenced the landing of *D. kurroides* and *D. tabl* in Region II. However, the observed pattern in the catch of *D. kurroides* and *D. tabl* in Region II may not be totally dependent on monsoons, but also on the migration of these species, especially since other roundscad species display a different pattern than these two species. *D. macrosoma,* for example, has landed catch in Region II for 2021 from February to October, with a peak of landed catch in August. In the same year, *D. macarellus* in Region II is present all year, but the peak of landed catch is in December. The seasonal landings of *D. tabl* and *D. kurroides* in Region II possibly reflect the migration of these species in the Philippines. Further studies on the possible migration pattern of roundscad species like *D. tabl* and *D. kurroides,* and the environmental factors that mediate these patterns are recommended.

D. macrosoma is the most dominant *Decapterus* species in the Philippines (Fig. 6). As shown in Figure 9, Region IX is the major producer of *D. macrosoma*, followed by Region VI. The South Sulu Sea is the major fishing ground for *D. macrosoma* which accounts for 76% of its production in the Philippines. Likewise, the major fishing ground of *D. macarellus* is the South Sulu Sea, contributing to 40% of the total production of *D. macarellus* in 2015–2020. On the other hand, *D. russelli* is dominantly caught in Region IVB, in which the fishing grounds are the Sibuyan Sea and North Sulu Sea. Region VI tops the production of *D. maruadsi*, almost 56% of the total production of *D. maruadsi*. This is being followed by Regions VIII and VII. Hence, the interior seas of the Philippine archipelago are the major fishing grounds of *D. maruadsi*. The 60% of *D. tabl* production is also from the South Sulu Sea. Lastly, Regions VI and IX are the major contributors to *D. kurroides* production with 42% and 32% respectively.

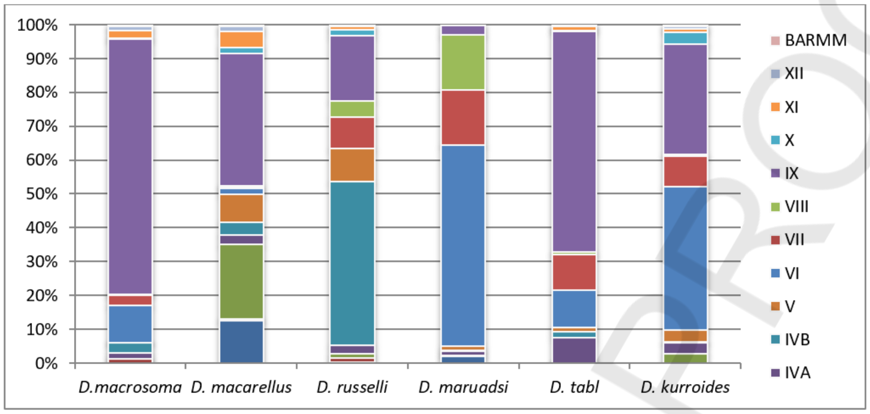

Figure 9. Percent contribution of different Regions to the total production of each roundscad species (data from NSAP).

Generally, the production of roundscads in the Philippines has notably increased from 1980 to 2007, but has continually declined since 2008. Among the coastal regions of the Philippines, Region IX, whose fishing grounds are in South Sulu Sea, has the highest production of roundscads from 2015-2020. *D. macrosoma* is the major species of roundscad in the Philippines based on production. Hence, this paper recommends studying the stock structure and reproductive biology of *D. macrosoma* in the South Sulu Sea to ensure that the exploitation level of the stock does not compromise their population's reproduction.

4.6 Price

Contrary to the decreasing production of roundscads, the retail and wholesale price of a kilogram of roundscads has been continually increasing since 1980 (Fig. 10). In 1980, the retail and wholesale prices of roundscads were Php 7.55 and Php 6.19, respectively, but these ballooned to Php 127.50 and Php 97.24 in 2017 (Table 6). In terms of percent increase in the retail price, a sudden increase in price happened in 1984, a year when the consumer price index was 50.3%, an indication that all commodities had an increase of more than average due to political and economic turmoil (National Economic and Development Authority 1984). But the highest percent increase from 2000-2021 was in 2011 (14.89%), followed by 2018 (13.11%). Both years have marked the lowest production since 2000-2011 and 2013-2021, respectively. This further substantiates the causality of the production of roundscads with its price.

4.7 Importation

According to Fisheries Administrative Order (FAO) 195 series of 1999, importation of fish (frozen, fresh, or chilled) and fishery or aquatic products shall be allowed to achieve food security, taking into consideration safety and public welfare. Food security entails ensuring an adequate supply of appropriate food at affordable prices. As mandated by FAO 195, the importation of roundscads can be implemented when the food supply is threatened or the price has soared, making it less accessible to the masses. The implementation of a three-month ban on roundscad fishing in Northern Palawan has been the major reported reason for its importation (see DA-BFAR 2021). The imported roundscads are intended to fill the supply gap due to the implementation of a closed fishing season in Northern Palawan, a major source of roundscad catch landed at Navotas Fishport Complex in 2022 by 89% (DA-BFAR, 2022).

The importation had caused opposition, speculation, and investigations among fishing groups, legislators, and consumers. There were speculations of an intentional and made-up shortage by business monopolies, organizational corruption, and the effect of illegal fishing activities by China in the West Philippine Sea (see Senate of the Philippines 2022). The imported roundscads were claimed as "balikbayan" or returnees by Pambansang Lakas ng Kilusang Mamalakaya ng Pilipinas (PAMALAKAYA), a fisherfolk group, because these were possibly caught in the Philippine waters (Punay 2022). Once there is an oversupply of roundscads in the market, prices may crash, threatening the income of fishermen. These controversies catapulted the filing of House Resolution 2467 in 2021 to the House of Representatives to probe the importation of roundscads (Punay 2022).

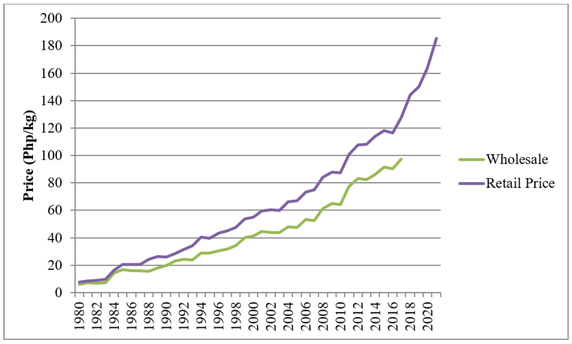

Figure 10. Average annual retail price of roundscads from 2012-2021 (data from PSA).

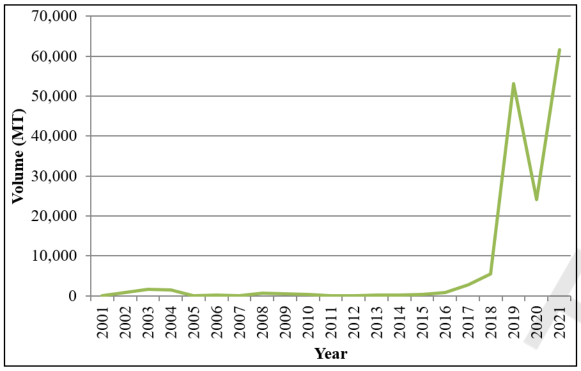

Figure 11. Volume of imported roundscads from 2001-2021 (in MT) (data from PSA).

The Philippines has been importing roundscads since 2001 from nearby countries like Taiwan, China, Vietnam, Malaysia, and Indonesia (PSA 2001). China has been the major source of roundscads in the Philippines since 2001, and in 2013, the Philippines received roundscads from Southeast Asian countries like Indonesia and Vietnam (Fig. 12, Table S3) (PSA 2021).

From 2001-2015, the volume of imported roundscads ranged only from 24 MT in 2012 to 1,608 MT in 2003, but the importation has soared to 61,588 MT in 2021.Since the implementation of the closed fishing season in Northern Palawan, the Philippines has been importing more than 2,000 MT. From 2019, the Philippines has imported more than 20,000 MT. The importation in 2019 has grown by 873% from the previous year. The upward trend in the importation of roundscads from 2007 to 2021 is also reflected on the supply utilization accounts, which are derived from food security indicators like self-sufficiency ratio and self-dependency ratio (PSA 2022). The self-sufficiency ratio indicates the dependence of a country on its own production to meet its domestic utilization. Accordingly, the self-dependency ratio is the reliance of a country on imports (PSA 2019).

The Philippines has maintained a self-sufficiency ratio of near 100% in 2016-2018, but it substantially plummeted in 2019 and 2020 when the volume of imported roundscads soared to 53,000 metric tons from 5,000 MT (Fig. 13). As indicated by the 21.9% import dependency ratio in 2019, the Philippines relied on importation to meet the demand for roundscads. Hence, the decreasing production during the implementation of the closed fishing season in Northern Palawan has effects on the increasing volume of imported roundscads. However, further study is needed to identify the gravity of the effects of the closed-fishing season policy to the total production of roundscads and importation in the country.

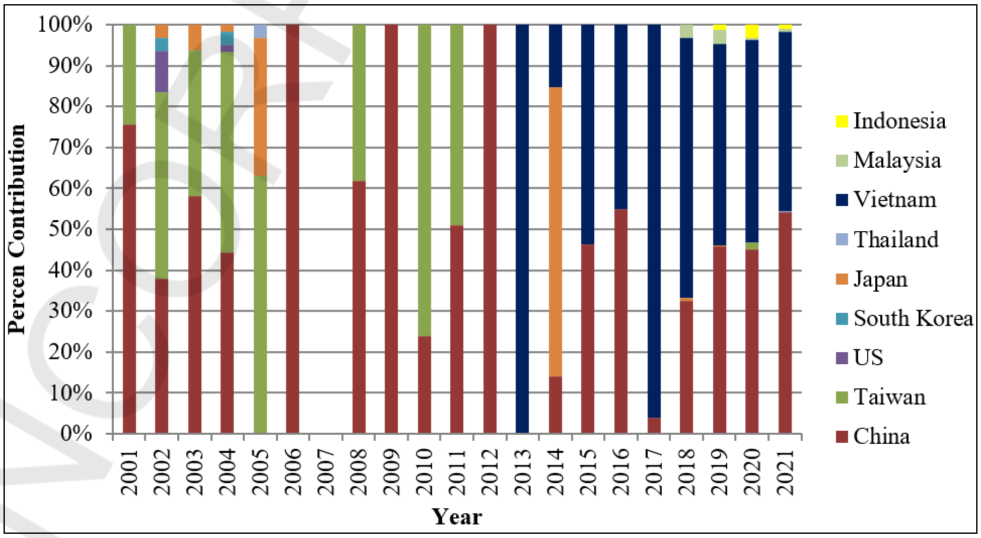

Figure 12. Percent contribution of country of origin of imported roundscads from 2001-2021 (data from PSA).

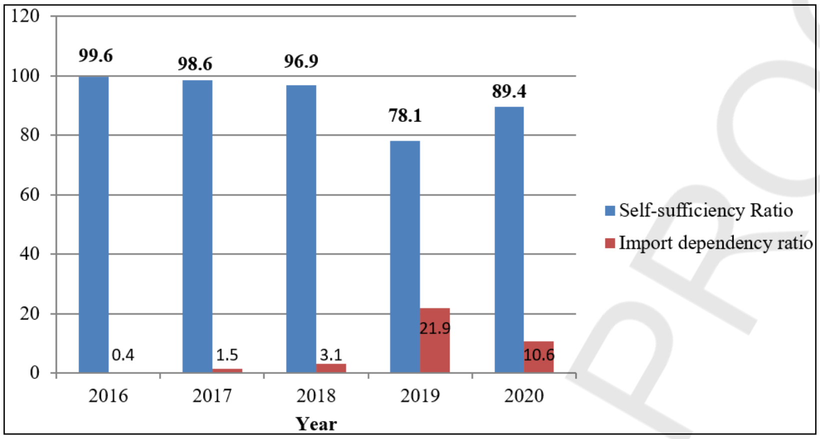

Figure 13. Self-sufficiency ratio and import dependency ratio of the Philippines from 2016-2020 (data from PSA).

4.8 Farming Efforts

Due to the declining supply of roundscads amidst its increasing demand, research efforts on the possible farming of *D. macrosoma* were initiated by the Southeast Asian Fisheries Development Center/ Aquaculture Department (SEAFDEC/AQD) in 2021. As communicated in the newsletter of SEAFDEC (2022) by Aranas (2022), they have successfully grown roundscad juveniles with 20% survival after 25 days of being hatched. The broodstocks were collected from the wild and spawned in the hatchery. If this effort becomes successful, roundscad can be farmed in addition to captured fish production.

5. CONSERVATION AND MANAGEMENT

Roundscads, like other commercial marine fishes, are heavily exploited. All roundscad species are considered "Least Concern" in the IUCN Redlist (Table 1), but the populations of *D. kurroides* and *D. russelli* are globally decreasing (Smith-Vaniz 2015-2018). To manage fish stocks, closed fishing seasons were implemented in the major fishing grounds in the Philippines. Under the Philippine Fisheries Code of 1998 (RA 8550), a closed fishing season is applied to a period in which a specified gear is prohibited from capturing a specified fish species in a specified area. This is to protect the specified fish populations during spawning season from exploitation, consequently ensuring that fish breed successfully and replenish their population.

Currently, the only closed fishing season exclusively for roundscads is the Joint DA-DILG Administrative Order (JAO) No. 1 series of 2015 in Northern Palawan. It mandates that the following fishing gears—purse seines, ring nets, and bag nets—are prohibited in capturing roundscads in Northern Palawan from November 1 to January 31 of the following year, which is the spawning season of *D. macrosoma* and *D. russelli* in Northern Palawan (Tiews et al. 1971). Furthermore, the roundscads fishery is also prohibited in the Davao Gulf, together with other pelagic fish, during the closed fishing season of June to August. In the virtue of DA-DILG Joint Administrative Order No. 02 series of 2014, the fishery of pelagic fishes in Davao Gulf using bagnets/ basnigan and ringnets are prohibited from June to August of every year.

Currently, there is no published study yet evaluating the effectiveness of seasonal fishery closures (SFC) in Davao Gulf and Northern Palawan on roundscad population structure and production. The DA-BFAR (2021) had preliminarily assumed its success based on the increase in catch estimates of roundscads caught by ring net and purse seine in Northern Palawan from 2015-2020. A robust and comprehensive study that entails analysis of roundscad population dynamics should be conducted to determine the success of SFC in these areas.

However, management policies like SFC require cooperation among stakeholders and livelihood support for the displaced fishermen during closures. In the span of the implementation of SFC, fishermen are apt to look for other livelihoods such as working in construction industry, public transportation, and market (Macusi et al. 2022). Violations are more likely when there are no livelihood support and financial aid, ineffective policy dissemination, and insufficient safety nets (Brillo et al. 2017). The cooperation of the community with SFC is highly influenced by economic motivation, stricter enforcement, better organization, and informed communication (Macusi et al. 2021).

6. WAYS FORWARD

6.1 Filling in the research gaps

The majority of the studies on roundscads are about stock assessments, exploring the population structure and recruitment of roundscads in the major fishing grounds. Most of the knowledge on the biology and ecology of roundscads is contributed by Calvelo (1992), and some of the reproductive biology data is from more recent studies (e.g., Rada et al. 2019, Dela Rosa et al. 2022). However, these are not enough for a science-based management of roundscads. There is a need to further explore the reproductive biology, food habits, migration behavior, and ecology of roundscads in the major fishing grounds. There is also a need to evaluate the impacts of JAO series of 2015 or the closed fishing season in Northern Palawan on the population of roundscads.

Moreover, roundscad species are unequally represented in research per se. The majority of researches focused on *D. macrosoma,* followed by *D. russelli* and *D. tabl.* Few research studies are conducted on *D. macarellus, D. maruadsi,* and *D. tabl.* Since it was just 2021 that *D. smithvanizi* was documented in the Philippines, it is understandable why it receives less research focus. This trend is also evident in the distribution of stock assessment studies for each species (Fig. 3). There are only a few studies that have assessed the stocks of *D. kurroides, D. macarellus, D. tabl,* and *D. maruadsi.* Likewise, there are also limited studies on the reproductive biology of *D. kurroides, D. tabl,* and *D. macrosoma;* no study on the reproductive biology of *D. maruadsi* is published as of the writing of this manuscript (Table 3). Although *D. macrosoma* contributes to 57.03% of total production for 2015–2020 (Fig. 7), there is still a need to fill the research gaps for these equally important species.

6.2 Stock identification and continuous stock assessment

There is also a limited study on the stock identification of roundscads, which is a prerequisite for stock assessment. Stock is an arbitrary term that was initially defined by Milton & Shaklee (1987) as an exploited group of fish species in a specific area. Stock assessment studies analyzed in this review paper define stocks in this manner. However, stocks based on locality only may lead to laborious and repeated assessments in various fishing grounds that actually share a common stock. The stock concept is being structured based on geographic variation of phenotypic traits, closed migration circuits, and reproductive isolation (Cadrin & Secor 2009). These must be considered prior to stock assessment, which can be aided using phenotypic (e.g., otolith microstructure and shape analysis, scale morphology, meristics, and morphometrics), biological tags, and genetic methods (Cadrin et al. 2014).

Establishing geographic boundaries using both morphological and genetic techniques is recommended to have a cost-effective, relevant, and reliable stock assessment of roundscads. In this way, stock assessments would not be repetitive but progressive. Monitoring the identified stocks can also be one of the bases for evaluating management policies, like the imposition of SFC.

6.3 Multiple approaches in roundscad management

SFC implemented in breeding season may result in increased reproductive output and an increase in population size for aggregate spawners like roundscads if the breeding population is not harvested or disturbed and/or there is a reduction in annual fishing efforts (Arendse et al. 2007). SFC should not displace fishing efforts in the months outside its implementation. In this manner, fishing mortality decreases, allowing the surviving population to recover from overexploitation. As an example, the implementation of SFC for sardines in the Visayan Sea results in a significant increase in catch at the end of the seasonal closure for both commercial and municipal fisheries but a decreasing trend in interannual analysis, despite its strict implementation in 2012 (Bagsit et al. 2021). The fishing effort might remain the same without allowing the species to recover its population size over time. Hence, sustainable management of fisheries is not solely based on the strict implementation of SFC but should be supported with other strategies that reduce fishing efforts while considering economic gains.

SFC should be complemented by other strategies like setting catch limits, registrations of boats and gear, limiting the allowable number of boats per fishing gear, regulation of mesh size, and establishments of Marine Protected Areas (MPA) (Macusi et al. 2022, Olaño et al. 2018). But designing a long-term management plan for roundscads requires accurate stock assessments, rigorous data, and comprehensive studies on the biology and ecology of roundscads.

7. CONCLUSION

Roundscads, or *galunggong*, is one of the most harvested pelagic fishes in the Philippines and a common source of protein among Filipinos. However, based on a 30-year PSA dataset, there is a decreasing catch of *galunggong* in the country. The catch in 2008 to 2021 has never been higher than the catch in 2001 to 2007. There has been a downward trend in its production even before the implementation of the closed fishing season in Northern Palawan. Due to the decreasing production and the implementation of closed fishing season, the Philippines has been importing roundscads of not less than two thousand metric tons since 2017. Indeed, the scarcity of supply, its soaring market price, and massive importation are rooted in the decreasing stock size of round scads in the Philippines.

Science-based management of roundscads is based on continuous research and comprehensive data. However, this review identifies research gaps on the biology and ecology of roundscads, most especially in terms of reproductive biology and migration, to some extent, in terms of stock assessment based on accurately defined stocks. The evaluation of the SFCs in Northern Palawan and Davao Gulf in terms of reproductive output, implementation and compliance, and socio-economic impact should be further explored. In order to have a science-based and sustainable management of roundscads, relevant and comprehensive research and continuous stock monitoring are needed, which can be achieved through citizen science and cooperation among research institutions and academic community.

CONFLICTS OF INTEREST

There is no conflict of interest in conducting this study.

ETHICS STATEMENT

There are no laboratory animals used in this review paper.

SUPPLEMENTARY MATERIAL

Link to the electronic supplementary material. Supplementary file

REFERENCES

Abesamis RA, Russ GR. 2010. Pattern of recruitment of coral reef fishes in monsoonal environment. Coral Reefs. [accepted 2023 March 20];29:911–921. https://doi.org/10.1007/s00338-010-0653-y.

Abdollahpour H, Falahatkar B, Lawrence C. 2020. The effect of photoperiod on growth and spawning performance of zebrafish, *Danio rerio*. Aquaculture Reports. [accessed 2023 March 17];17:100295. https://doi.org/10.1016/j.aqrep.2020.100295.

Africa C, Pascual A, Santiago E. 2009. Total mercury in three fish species sold in a Metro Manila public market: monitoring and health risk assessment. Science Diliman. [accessed 2023 April 28];21(1):1–6. https://journals.upd.edu.ph/index.php/sciencediliman/article/view/1530

Ani PA. 2016. Enriching the Philippine Fisheries Resources through Closed Fishing Season Policies. FFTC Agricultural Policy Platform (FFTC-AP). [accessed 2022 November 2]. https://ap.fftc.org.tw/article/1119.

Aranas JMD. 2022. Research breakthrough seen to curb shortage of poor man's fish [news article]. AQD Matters: Newsletter of the SEAFDEC Aquaculture Department, Tigbauan, Iloilo, Philippines. [accessed 2022 April 15]; January-February Issue. https://www.seafdec.org.ph.

Arce FM, Gonzales CL. 1996. The fisheries and biology of roundscads mackerels and neritic tunas in the Philippines. In: Report of second regional workshop on shared stock in the South China Sea Area, Kuala Terengganu, Malaysia 18-20 July 1995. Marine Fishery Resources Development and Management Department, Southeast Asian Fisheries Development Center. p. 59–77.

Arendse CJ, Govender A, Branch GM. 2007. Are closed fishing seasons an effective means of increasing reproductive output? Fisheries Research. [accessed 2023 May 23];85(1–2), 93–100. https://doi.org/10.1016/j.fishres.2007.01.001.

Aripin IE, Showers PA. 2000. Population Parameters of Small Pelagic Fishes Caught off Tawi-Tawi, Philippines. Fishbyte. [accessed 2022 May 20]. 23(4), 21–26.

Baclayo JM, Deligero RC, Holoyohoy LM, Eunice C. 2016. Status of dominant small pelagic in Hinatuan passage Caraga region, Philippines. International Journal of Fisheries and Aquatic Studies. [accessed 2022 June 4];4(4):286–303. https://www.fisheriesjournal.com/archives/2016/vol4issue4/PartD/4-2-49-194.pdf.

Bagenal TB. 1966. The ecological and geographical aspects of the fecundity of the plaice. Journal of Marine Biological Association of the United Kingdom. [accessed 2024 June 7];46(1):161–186. https://doi.org/10.1017/S0025315400017628.

Bagsit FU, Frimpong E, Asch RG, Monteclaro HM. 2021. Effect of a seasonal fishery closure on sardine and mackerel catch in the Visayan Sea, Philippines. Frontiers in Marine Science. [accessed 2023 May 23];8:640772. https://doi.org/10.3389/fmars.2021.640772.

Barnuevo KD, Morales CJ, Calizo JK, Delloro Jr E, Añasco CP, Barbaran R, Lumayno SD 2023. Distinct Stocks of the Redtail Scad *Decapterus kurroides* Bleeker, 1855 (Perciformes: Carangidae) from the Northern Sulu and Southern Sibuyan Seas, Philippines Revealed from Otolith Morphometry and Shape Analysis. Fishes. [accessed 2023 April 10];8(1):12. https://doi.org/10.3390/fishes8010012.

Barut NC, Santos MD, Mijares LL, Subade R, Armada NB, Garces LR. 2003. Philippine coastal fisheries situation. In: Silvestre G, Garces LR, Stobutzki I, Ahmed M, Valmonte-Santos RA, Luna C, Lachica-Aliño L, Munro P, Christensen V, Pauly D (eds). Assessment, Management and Future Directions for Coastal Fisheries in Asian Countries. Manila: ICLARM. p. 885-914.

Belga P, Abrenica B, Paran JH, Bacalso RT. 2018. Stock Assessment of Small Pelagic Fishes Caught by Ring Net Fishery in the Camotes Sea, Central Visayas, Philippines (2003-2012). The Philippine Journal of Fisheries. [accessed 2022 June 16];25(1): 95-106. https://doi.org/10.31398/tpjf/25.1.2017C0009.

Begg GA, Waldman JR. 1999. An holistic approach to fish stock identification. Fisheries Research. [accessed 2023 May 4];43(1–3):35–44. https://doi.org/10.1016/S0165-7836(99)00065-X.

Bleeker P. 1855. Zesde bijdrage tot de kennis der ichthyologische fauna van Amboina. Natuurkd Tijdschr Neder Indie¨ 8:391–434.

Bleeker P. 1851. Over eenige nieuwe geslachten en soorten van Makreelachtige visschen van den Indischen Archipel. Natuurkd Tijdschr Neder Indie¨ 1:341–372

Brillo BB, Elazegui DD, Cervantes CP, Rola A. 2016. Assessing the formulation and implementation of the closed fishing season policy for sardines in Zamboanga Peninsula, Philippines. Philippine Journal of Science. [accessed 2023 May 23];145:395-404.

Brown-Peterson N, Wyanski D, Saborido-Rey F, Macewicz B, Lowerre-Barbieri S, Peterson N, Macewicz F, Barbieri L. 2011. A Standardized Terminology for Describing Reproductive Development in Fishes. Marine and Coastal Fisheries. [accessed 2022 December 20];3. https://doi.org/10.1080/19425120.2011.555724.

Bureau of Fisheries and Aquatic Resources. 2023. Fisheries Resources. In: 2022 Philippine Fisheries Profile. Quezon City: Bureau of Fisheries and Aquatic Resources [2024 June 30]. p. 2. https://www.bfar.da.gov.ph/wp-content/uploads/2024/02/2022-Philippine-Fisheries-Profile.pdf.

Bureau of Agricultural Statistics. 2001. Fisheries Statistics of the Philippines, 1997–2001. [accessed 2022 November 23]. https://library.psa.gov.ph.

Bureau of Agricultural Statistics. 2003. Fisheries Statistics of the Philippines, 2001–2003. [accessed 2022 November 23]. https://library.psa.gov.ph.

Bureau of Agricultural Statistics. 2006. Fisheries Statistics of the Philippines, 2004–2006. [accessed 2022 November 23]. https://library.psa.gov.ph.

Bureau of Agricultural Statistics. 2008. Fisheries Statistics of the Philippines, 2005-2007. [accessed 2022 November 23]. https://library.psa.gov.ph.

Bureau of Agricultural Statistics. 2011. Fisheries Statistics of the Philippines, 2008-2010. [accessed 2022 November 23]. https://library.psa.gov.ph.

Bureau of Agricultural Statistics. 2013. Fisheries Statistics of the Philippines, 2010-2012. [accessed 2022 November 23]. https://library.psa.gov.ph.

Burger J, Gochfeld M. 2011. Mercury and selenium levels in 19 species of salt water fish from New Jersey as a function of species size, and season. Science of the Total Environment. [accessed 2023 April 28];409:1418–1429. https://doi.org/10.1016/j.scitotenv.2010.12.034.

Cadrin SX, Secor DH. 2009. Accounting for spatial population structure in stock assessment: past, present, and future. In: Beamish RJ, Rothschild BJ, editors. The Future of Fisheries Science in North America. Fish & Fisheries Series, vol 31. Dordrecht: Springer. https://doi.org/10.1007/978-1-4020-9210-7_22. p. 405.

Cadrin SX, Karr LA, Mariani S. 2014. Stock identification methods: an overview. In: Cadrin SX, Karr LA, Mariani S, editors. Stock Identification Methods: Applications in Fishery Science, Second Edition. Amsterdam: Elsevier Academic Press. p. 1–5. https://doi.org/10.1016/B978-0-12-397003-9.00001-1.

Calvelo R, Dalzell P. 1987. A review of the recent status of exploited stocks of roundscads in the Philippines. International Center for Living Resources (ICLARM) Report. [accessed 15 November 2022];33:257-268.

Calvelo R. 1992. Synopsis of Biological and Related Data on the Philippine Roundscads. The Philippine Journal of Fisheries. [accessed 2022 Dec 15]; 23: 51–80.

Calvelo R. 1997. Review of the Philippine Small Pelagic Resources and their Fisheries. Small Pelagic Resources and their Fisheries in the Asia-Pacific Region. [accessed 2022 June 11]. p. 259–299. https://www.fao.org/3/an020e/an020e.pdf.

Carpenter KE, Springer VG. 2005. The center of the center of marine shore fish biodiversity: The Philippine Islands. Environmental Biology of Fishes. [accessed 2022 Dec 15]; 72(4): 467–480. https://doi.org/10.1007/s10641-004-3154-4

Cervigón F, Cipriani R, Fischer W, Garibaldi L, Hendrickx M, Lemus AJ, Márquez R, Poutiers JM, Robaina G, Rodriguez B. 1992. Fichas FAO de identificación de especies para los fines de la pesca. Guía de campo de las especies comerciales marinas y de aquas salobres de la costa septentrional de Sur América. Rome:FAO. p. 513. http://www.fao.org/docrep/010/t0544s/t0544s00.htm.

Chen Y, Paloheimo JE. 1994. Estimating fish length and age at 50% maturity using a logistic type model. Aquatic Science. [accessed 2023 March 10];56:206–219. doi.org/10.1007/BF00879965.

Collen B, Richman N, Beresford A, Chenery A, Ram M. 2010. D*ecapterus russelli*. The IUCN Red List of Threatened Species. [updated 2017; accessed 2022 July 18];2010: e.T155043A115263553. https://dx.doi.org/10.2305/IUCN.UK.2010-4.RLTS.T155043A4711571.en.

Corrêa GM, Coletto JL, Castello JP, Miller N, Tubino R, Monteiro-Neto C, da Costa MR. 2022. Identification of fish stock based on otolith as a natural marker: The case of *Katsuwonus pelamis* (Linnaeus, 1758) in the Southwest Atlantic Ocean. Fisheries Research. [accessed 2024 July 23];255:106436. https://doi.org/10.1016/j.fishres.2022.106436.

Cruz-Lacierda E, Nagasawa K. 2017. First Record of *Norileca indica* (Isopoda, Cymothoidae) Parasitic on *Selar crumenophthalmus* and *Decapterus kurroides* (Perciformes, Carangidae) in the Philippines. Comparative Parasitology. [accessed 20 May 2022];84(1):60-63. https://doi.org/10.1654/1525-2647-84.1.60.

Cuvier G, Valenciennes A. 1833. Histoire naturelle des poissons. Tome neuvie`me. Suite du livre neuvie`me. Des Scombe´roı¨des. Histoire naturelle des poissons 9:1–512.

Dalzell P, Corpuz P, Arce F, Ganaden R. 2008.

Philippine small pelagic fisheries and their management. Aquaculture Research. [accessed 2022 April 5];21:77‑94.

De Guzman R, Calangit RM, Munap P, Alberto J, Orinza M. 2018. Current Status of Dominant Pelagic Fish Species Caught by Purse Seine in the Eastern Sulu Sea and the Basilan Strait. The Philippine Journal of Fisheries. [accessed 2022 June 16];25(1):156-162. https://doi.org/10.31398/tpjf/25.1.2017C0012.

Dela Cruz TTM, Llanes KKR, Toledo JMS, Catabay JA, Fornillos RJC, Fontanilla IKC, Paller VGV. 2022. Prevalence and Molecular Characterization of Ascaridoid Parasites of Philippine *Decapterus* Species. Journal of Nematology. [accessed 24 February 2023];54(1), :20220030. doi: 10.2478/jofnem-2022-0030. PMID: 36060477; PMCID: PMC9400525.

Delloro Jr ES, Babaran RP, Gaje AC, Cambronero PT, Alama UB, Motomura H. 2021. First record of slender red scad, *Decapterus smithvanizi* (Actinopterygii: Perciformes: Carangidae), from the Philippines. Acta Ichthyologica et Piscatoria. [accessed 2022 February 18];51(3):233–239. https://doi.org/10.3897/aiep.51.63117

Dela Rosa HK, Rosa T, Quiñones M, Jimenez C, Garcia J, Molina D, Samson J, Paghasian M. 2023. First Report on the Reproductive Biology of the Redtail Scad, *Decapterus kurroides* Bleeker, 1855 in Iligan Bay, Southern Philippines. The Philippine Journal of Fisheries. [accessed 2022 October 4];29:193-208. https://doi.org/10.31398/tpjf/29.2.2022-0024.

Department of Agiculture-Bureau of Fisheries and Aquatic Resources. 2021. Closed Fishing Season in Northern Palawan Begins [press release]. https://www.bfar.da.gov.ph/2021/11/04/da-bfars-press-release-galunggong-closed-fishing-season-in-northern-palawan-begins/#:~:text=Already%20in%20its%207th%20year,of%20galunggong%20in%20the%20area.

Department of Agiculture-Bureau of Fisheries and Aquatic Resources. (2023). *55% of imported galunggong arrives ahead of closed fishing season lifting in Palawan* [press release]. https://www.bfar.da.gov.ph/2023/01/26/55-of-imported-galunggong-arrives-ahead-of-closed-fishing-season-lifting-in-palawan/

Duarte L, Garcia C. 2004. Trophic role of small pelagic fishes in a tropical upwelling ecosystem. Ecological Modelling. [accessed 2024 July 20];172:323‑338.

Duncan R, Brophy D, Arrizabalaga H. 2018. Otolith shape analysis as a tool for stock separation of albacore tuna feeding in the Northeast Atlantic. Fisheries Research. [accessed 2024 July 23];200:68‑74. https://doi.org/10.1016/j.fishres.2017.12.011.

Dutta H. 1994. Growth in fishes. Gerontology. [accessed 2023 May 30];40(2-4):97‑112. https://doi.org/10.1159/000213581. PMID: 7926860.

Farrell ED, Andersson L, Bekkevold D, Campbell N, Carlsson J, Clarke M, Egan A, Folkvord A, Gras M, Lusseau SM, Mackinson S, Nolan C, O'Connell S, O'Malley M, Pastoors M, Pettersson M, White E. 2022. A baseline for the genetic stock identification of Atlantic herring, *Clupea harengus*, in ICES Divisions. Royal Society of Open Science. [accessed 2023 May 28];9: 220453. https://doi.org/10.1098/rsos.220453.

FAO-FIGIS. 2001. *Decapterus maruadsi*. In: A world overview of species of interest to fisheries. FIGIS Species Fact Sheets. Species Identification and Data Programme-SIDP, FAO-FIGIS. p. 2. www.fao.org/figis/servlet/species?fid=2314.

Fontoura NF, Braun AS, Milani PCC. 2009. Estimating size at first maturity (L50) from Gonadossomatic index (GSI) data. Neotropical Ichthyology. [accessed 2023 March 17];7:217–222. https://doi.org/10.1590/S1679-62252009000200013.

Fricke R, Eschmeyer WN, van der Laan R (eds). 2023. Eschmeyer's Catalog of Fishes: Genera, Species, References. http://researcharchive.calacademy.org/ research/ichthyology/catalog/fishcatmain.asp. Electronic version accessed 15 October 2020

Froese R, Pauly D., editors. 2023. FishBase. London: World Wide Web electronic publication.

Garai P, Banerjee P, Mondal P. 2021. Effect of heavy metals on fishes: toxicity and bioaccumulation. Journal of Clinical Toxicology. [accessed 2023 April 28];11(18):1-10. https://www.longdom.org/open-access/effect-of-heavy-metals-on-fishes-toxicity-and-bioaccumulation-82260.html.

Geffroy B, Wedekind C. 2020. Effects of global warming on sex ratios in fishes. Journal of Fish Biology. [accessed 2023 January 15];97(3): 596-606. https://doi.org/10.1111/jfb.14429

Geronimo RC, Franklin EC, Brainard RE, Elvidge CD, Santos M, Venegas R, Mora C. 2018. Mapping fishing activities and suitable fishing grounds using nighttime satellite images and maximum entropy modelling. Remote Sensing. [accessed 2022 March 1];10(10):1604. https://doi.org/10.3390/rs10101604.

Godt J, Scheidig F, Grosse-Siestrup C, Esche V, Brandenburg P, Reich A, Groneberg DA. 2006. The toxicity of cadmium and resulting hazards for human health. Journal of occupational medicine and toxicology. [accessed 2023 April 28];1(22). https://doi.org/10.1186/1745-6673-1-22.

Gonzales BJ, Palla HP, Ylagan AR, Cabadongga BM, Manzano ZT, Mutia MM, Marcelino GO, Pasion TT, Luna AF. 2021. Spawning of *Decapterus macrosoma* (Bleeker, 1851) "Galunggong" in Tablas Island, Romblon, Philippines: with Inferences on its Reproductive Ecology and Management. Asian Journal of Biodiversity. [accessed 2022 October 4]; 12(1):1-22. https://doi.org/10.7828/AJOB.V12I1.1392.

Gulland JA. 1983. Fish stock assessment: a manual of basic method. Volume 1, FAO/Wiley Series on Food and Agricultural. New York: Wiley and Sons Inter-science. p. 233.

Gushiken S. 1976. Revision of the genus *Decapterus* Bleeker of Japan. Biological Magazine

Okinawa. [accessed 2022 October 14];14:41–54.

He C, Sun Z, Qu X, Cao J, Shen X, Li C. 2020. A comprehensive study of lipid profiles of round scad (*Decapterus maruadsi)* based on lipodomic with UPLC-Q-Exactive Orbitrap-MS. Food Research International. [accessed 2023 March 12];133:109138. https://doi.org/10.1016/j.foodres.2020.109138.

Heino M, Godo OR. 2002. Fisheries-induced selection pressures in the context of sustainable fisheries. Bulletin of Marine Science. [accessed 2023 May 30];70:639–656.

Herre AW. 1953. Check List of the Philippine Fishes. Washington: U.S. States Government Printing Office.

Hilborn R, Liermann M. 1998. Standing on the shoulders of giants: learning from experience in fisheries. Reviews in Fish Biology and Fisheries. [accessed 2024 July 22];8: 273–283. https://doi.org/10.1023/A:1008877912528.

Hinu H, Kurota H, Muko S, Ohshimo S. 2023. Estimation of preferred habitats and total catch amount of the round scad *Decapterus maruadsi* and five other scad species in the East China Sea and Sea of Japan. Japan Agricultural Research. [accessed 2024 July 19];57(2):153-163. https://doi.org/10.6090/jarq.57.153.

Hoeksema BW. 2007. Delineation of the Indo-Malayan centre of maximum marine biodiversity: the Coral Triangle. In: Renema W (ed.), Biogeography, Time, and Place: Distributions, Barriers and Islands. New York: Springer Dordrecht. p. 117-178.

Houde ED. 2009. Recruitment Variability. In: Jakobsen T, Fogarty M, Megrey B, Moskness E, editorss. Fish Reproductive Biology: Implications of Assessment and Management. Second edition. Blackwell Publishing Ltd. p 91–171. https://doi.org/10.1002/9781444312133.ch3

Hu X, Yang X, Wang T, Li L, Wu Y, Zhou Y, You L. 2020. Purification and identification of antioxidant peptides from round scad (*Decapterus maruadsi*) hydrolysates by consecutive chromatography and electrospray ionization-mass spectrometry. Food and Chemical Toxicology. [accessed 2022 May 2];135:110882. https://doi.org/10.1016/j.fct.2019.110882

Ingles J, Pauly D. 1984. An Atlas of the growth, mortality and recruitment of Philippine fishes. International Center for Living Resources (ICLARM) Technical Reports. [accessed 2022 November 30];13:1-127.

Inoue K, Kasai A, Argamjav B, Sato H. 2022. Four carangid fish species as new host records for *Kudoa trachuri* Matsukane, Sato, Tanaka, Kamata et Sugita-Konishi, 2011 (Myxozoa: Multivalvulida), and description of a new species, *Kudoa longichorda* sp. n., forming pseudocysts in the muscle of *Decapterus tabl* Berry. Folia parasitologica. [accessed 2022 May 15];69(17). https://doi.org/10.14411/fp.2022.017.

Issa EA, Olufeagba SO, Raji A. 2005. Effects of some environmental factors on the fecundity of Tilapia species (Family Cichlidae) in Kigera Reservoir, New Bussa. 19th Annual Conference of the Fisheries Society of Nigeria (FISON), 2004 November 29–December 3. [accessed 2023 May 15]. http://hdl.handle.net/1834/21773.

Jamaludin NA, Mohd-Arshaad W, Mohd Akib NA, Zainal Abidin DH, Nghia NV, Nor SM. 2020. Phylogeography of the Japanese scad, *Decapterus maruadsi* (Teleostei; Carangidae) across the Central Indo-West Pacific: evidence of strong regional structure and cryptic diversity. Mitochondrial DNA. Part A, DNA mapping, sequencing, and analysis. [accessed 2022 May 5];31(7):298–310. https://doi.org/10.1080/24701394.2020.1799996

Kim JH, Kang JC. 2017. Effects of sub-chronic exposure to lead (Pb) and ascorbic acid in juvenile rockfish: Antioxidant responses, MT gene expression, and neurotransmitters. Chemosphere. [accessed 2023 April 28];171:520–527. https://doi.org/10.1016/j.chemosphere.2016.1.

Kimura S, Katahira K, Kuriiwa K. 2013. The red-fin *Decapterus* group (Perciformes: Carangidae) with the description of a new species, *Decapterus smithvanizi.* Ichthyological Research. [accessed 2021 June 16];60(4):363–379. https://doi.org/10.1007/s10228-013-0364-9.

King MG. 2007. Fisheries biology, assessment and management. Second edition. Oxford: Blackwell. p. 382.

Kjesbu OS, Klungsoyr J, Kryvi H, Witthames PR, Greer Walker M. 1991. Fecundity, atresia, and egg size captive Atlantic cod (*Gadus morhua*) in relation to proximate body composition. Canadian Journal of Fisheries and Aquatic Sciences. [accessed 2023 14 May];48(12):2333–2343. https://doi.org/10.1139/f91-274.

Kottarathil HA, Sahadevan AV, Kattamballi R, Kappalli S. 2019. *Norileca indica* (crustacea: isopoda, cymothoidae) infects *Rastrelliger kanagurta* along the Malabar Coast of India - seasonal variation in the prevalence and aspects of host-parasite interactions. Zoological studies. [accessed 2022 May 20];58, e35. https://doi.org/10.6620/ZS.2019.58-35.

Lambert Y. 2008. Why Should We Closely Monitor Fecundity in Marine Fish Populations? Journal of Northwest Atlantic Fishery Science. [accessed 2023 May 24];41:93–106. https://doi.org/10.2960/J.v41.m628.

Lavapie-Gonzales F. 1991. Growth, mortality and recruitment of *Decapterus kurroides* in Davao Gulf, Philippines. Fishbyte. [accessed 2022 November 20];9(2):6–9. https://www.worldfishcenter.org/content/growth-mortality-and-recruitment-decapterus-kurroides-davao-gulf-philippines.

Lavapie-Gonzales F, Ganaden SR, Gayanilo FC. 1997. Some population parameters of commercially-important fishes in the Phillippines. Manila: Fisheries Resource Division, Bureau of Fisheries and Aquatic Resources. p. 3–25.

Lee JW, Choi H, Hwang UK, Kang JC, Kang YJ, Kim KI, Kim JH. 2019. Toxic effects of lead exposure on bioaccumulation, oxidative stress, neurotoxicity, and immune responses in fish: A review. Environmental Toxicology and Pharmacology. [accessed 2023 April 28];68:101–108. https://doi.org/10.1016/j.etap.2019.03.010.

Lima A, Garrido S, Riveiro I, Rodrigues D, Angélico M, Gonçalves EJ, Peck MA, Silva G. 2022. Seasonal approach to forecast the suitability of spawning habitats of a temperate small pelagic fish under a high-emission climate change scenario. Frontiers in Marine Science. [accessed 2023 February 4];9:956654. https://doi.org/10.3389/fmars.2022.956654.

Liu Y, Chen Q, Li Y, Bi L, Jin L, Peng R. 2022.

Toxic effects of cadmium on fish. Toxics. [accessed 2023 April 28];10(10). http://dx.doi.org/10.3390/toxics10100622.

MacKenzie K, Abaunza P. 2014. Chapter ten: parasites as biological tags. In: Cadrin S, Kerr L, Mariani S, editors. Stock identification methods. Second edition. London:Elsevier Inc. p. 185–203.

Macusi E, Morales ID, Macusi E, Pancho A, Digal L. 2022. Impact of closed fishing season on supply, catch, price and the fisheries market chain. Marine Policy. [accessed 2023 May 23];138:105008. https://doi.org/10.1016/j.marpol.2022.105008.

Magallanes S, Monteclaro H, Gonzales B, Quinitio G, Mediodia D. 2022. Population Parameters of Shortfin scad *Decapterus macrosoma* (Bleeker, 1851) in Antique, Philippines. The Philippine Journal of Fisheries. [accessed 2022 June 16];29(1):156–162. https://doi.org/10.31398/tpjf/29.1.2021-0026.

Magnusson J, Tan EO, Legasto RM. 1968. Zooplankton distribution and abundance in Lamon Bay and its approaches. The Kuroshio, A symposium on the Japan Current, East-West Centre Press, Honolulul, p. 353-360. Philippine Journal of Fisheries. [accessed 2022 December 15];11(1 & 2):73–85.

Mahfuj S, Islam SI, Jinia SS, Hossain MDF, Atigue U. 2023. Stock identification of Congaturi halfbeak (*Hyporhamphus limbatus*): insight into conventional and truss-based morphometrics. The Journal of Basics and Applied Zoology. [accessed 2023 May 30];84:10 https://doi.org/10.1186/s41936-023-00329-7.

Matsukane Y, Sato H, Tanaka S, Kamata Y, Sugita-Konishi, Y. 2010. *Kudoa iwatai* and two novel *Kudoa* spp., *K. trachuri* n. sp. and *K. thunni* n. sp. (Myxosporea: Multivalvulida), from daily consumed marine fish in western Japan. Parasitology Research. [accessed 2022 May 20];108(4):913–926. https://doi.org/10.1007/s00436-010-2133-2.

Maynou F, Sabatés A, Raya V. 2020. Changes in the spawning habitat of two small pelagic fish in the Northwestern Mediterranean. Fisheries Oceanography. [accessed 2022 October 4];29: 201– 213. https://doi.org/10.1111/fog.12464.

Metillo EB, Aspiras-Eya AA. 2014. Fatty acids in six small pelagic fish species and their crustacean prey from the mindanao sea, southern Philippines. Tropical life sciences research. [accessed 2022 March 30];25(1):105–115. https://doi.org/10.1016/S0165-7836(99)00065-X.

Milner G, Teel D, Utter F, Winans G. 1985. A genetic method of stock idenitification in mixed populations of pacific salmon, *Oncorhynchus* spp. Marine Fisheries Review 47(1):1–8. https://spo.nmfs.noaa.gov/sites/default/files/pdf-content/MFR/mfr471/mfr4711.pdf.

Milton DA, Shaklee JB. 1987. Biochemical genetics and population structure of blue grenadier, *Macruronus novaezelandiae* (Hector) (Pisces: Merluccidae), from Australian waters. Australian Journal of Marine and Freshwater Research. [accessed 2023 May 15];38:727–742. https://doi.org/10.1071/MF9870727.

Morales CJC, Barnuevo KDE, Delloro Jr. ES, Cabebe-Barnuevo RA, Calizo JKS, Lumayno SDP, Babaran RP. Otolith morphometric and shape distinction of three redfin species under the genus *Decapterus* (Teleostei: Carangidae) from Sulu Sea, Philippines. Fishes. [accessed 2023 May 15];8(2):95. https://doi.org/10.3390/fishes8020095.

Moreira C, Froufe E, Vaz-Pires P, Correia AT. 2019. Otolith shape analysis as a tool to infer the population structure of the blue jack mackerel, *Trachurus picturatus*, in the NE Atlantic. Fisheries Research. [accessed 2024 July 23];209:40–48. https://doi.org/10.1016/j.fishres.2018.09.010.

Murua H, Kraus G, Saborido-Rey F, Witthames PR, Thorsen A, Junquera S. 2003. Procedures to estimate fecundity of Marine Fish Species in Relation to their Reproductive Strategy. Journal of Northwest Atlantic Fishery Science. [accessed 2023 March 15];33:33–54. https://doi.org/10.2960/J.v33.a3.

Myers RF. 1999. Micronesian reef fishes: a comprehensive guide to the coral reef fishes of Micronesia. Third revised and expanded edition. Guam: Coral Graphics. p. 330.

Narido C, Palla H, Argente F, Geraldino P. 2016. Population Dynamics and Fishery of Roughear Scad *Decapterus tabl* Berry 1968 (Perciformes: Carangidae) in Camotes Sea, Central Philippines. Asian Fisheries Science. [accessed 2022 May 20];29(1). https://doi.org/10.33997/j.afs.2016.29.1.002.

National Economic and Development Authority. 1984. Philippine Statistical Yearbook 1984. https://psa.gov.ph/sites/default/files/1984%20Philippine%20Statistical%20Yearbook%20%28PSY%29.pdf.

National Stock Assessment Program. (n.d.). Department of Agriculture National Fisheries Research and Development Institute. [accessed 2022 May 23]. https://nsap.nfrdi.da.gov.ph/about.

Nelson JS, Grande TC, Wilson MVH, editors. 2016. Fishes of the World. Fifth Edition. New Jersey: John Wiley & Sons. https://doi.org/10.1002/9781119174844.

Nepomuceno L, Bacordo R, Camu DG, Ramiscal R. 2023. Abundance and distribution of the Larvae of Family Carangidae in the Philippine Waters. The Philippine Journal of Fisheries. [accessed 2022 October 11];30(1):in press. https://doi.org/10.31398/tpjf/30.1.2020-0009.

Neves L, Cipriano F, Lorenzini JP, Cipriano Jr L, Nakayama C, Kennedy L, Miranda Filho K. 2019. Effects of salinity on sexual maturity and reproduction of Poecilia velifera. Aquaculture Research. [accessed 20 January];50. https://doi.org/10.1111/are.14247.

Olaño V, Lanzuela N, Paredes K. 2018. Assessment of Fishery Resources in the Lagonoy Gulf, Philippines. The Philippine Journal of Fisheries. [accessed 2022 June 15];25(1):62-76. https://doi.org/10.31398/tpjf/25.1.2017C0007.

Panakkool-Thamban A, Kottarathil HA, Kappalli S. 2016. Branchial cymothoids infesting the marine food fishes of Malabar Coast. Journal of Parasitic Disease. [accessed 2022 March 20];40(4):1270–1277. https://doi.org/10.1007/s12639-015-0666-0.

Partridge GJ, Lymbery AJ. 2009. Effects of manganese on juvenile mulloway (*Argyrosomus Japonicus*) cultured in water with varying salinity-implications for inland mariculture. Aquaculture. [accessed 2023 April 28];290:311–316. https://doi.org/10.1016/j.aquaculture.2009.02.020.

Pastoral PC, Escobar SL, Lamarca NJ. 2000. Round Scad Exploration by Purse Seine in the South China Sea , Area III : Western Philippines. Proceedings of the SEAFDEC Seminar on Fishery Resources in the South China Sea, Area III: Western Philippines. [accessed 2022 March 15]. http://hdl.handle.net/20.500.12066/4344.

Pattipeiluhu SM, Gill ME. 1998. Ectoparasites of coral reef fishes and their value as biological indicators of pollution. Cakalele. [accessed 2022 May 15];9(1):25–29. http://hdl.handle.net/10125/4234.

Pauly D, Navaluna NA. 1983. Monsoon induced seasonality in the recruitment of Philippine fishes. In: Sharp GD, Csirke J, editors. Proceedings of the expert consultation to examine changes in abundance and species composition of neritic fish resources. FAO Fishery Report 291, vol. 3. p. 823-833.

Pauly D, Cabanban A, Torres Jr FSB. 1996. Fishery biology of 40 trawl-caught teleosts of western Indonesia. In: Pauly D, Martosubroto P, editors. Baseline studies of biodiversity:the fish resource of western Indonesia. ICLARM Studies and Reviews 23. p. 135-216.

Pei J, Zuo J, Wang X, Yin J, Liu L, Fan W. 2019. The bioaccumulation and tissue distribution of arsenic species in *Tilapia*. International Journal of Environmental Research and Public Health. [accessed 2023 April 28];16:757. https://doi.org/10.3390/ijerph16050757.

Philippine Statistics Authority. 2013. Fisheries Situation Report January-December 2013. [accessed 2022 November 23]. https://library.psa.gov.ph.

Philippine Statistics Authority. 2014. Fisheries Situation Report January-December 2014. [accessed 2022 November 23]. https://library.psa.gov.ph.

Philippine Statistics Authority. 2015. Fisheries

Statistics of the Philippines, 2012–2014. [accessed 2022 November 23]. https://library.psa.gov.ph.

Philippine Statistics Authority. 2016. Fisheries Situation Report January–December 2016. [accessed 2022 November 23]. https://library.psa.gov.ph.

Philippine Statistics Authority. 2017. Fisheries Statistics of the Philippines, 2015–2017. [accessed 2022 November 23]. https://library.psa.gov.ph.

Philippine Statistics Authority. 2017. Fisheries Statistics of the Philippines, 2014–2016. [accessed 2022 November 23]. https://library.psa.gov.ph.

Philippine Statistics Authority. 2017. Fisheries Statistics of the Philippines, 2017–2019. [accessed 2022 November 23]. https://library.psa.gov.ph.

Philippine Statistics Authority. 2018. Fisheries Situation Report January–December 2018. [accessed 2022 November 23]. https://library.psa.gov.ph.

Philippine Statistics Authority. 2019. Fisheries Situation Report January–December 2019. [accessed 2022 November 23]. https://library.psa.gov.ph.

Philippine Statistics Authority. 2020. Fisheries Situation Report January–December 2020. [accessed 2022 November 21]. https://library.psa.gov.ph.

Philippine Statistics Authority. 2022. Fisheries Statistics of the Philippines, 2019–2021. [accessed 2022 November 23]. https://library.psa.gov.ph.

Philippine Statistics Authority. 2021. Special release average annual per capita consumption of selected agricultural commodities, 2018. [accessed 2022 November 23];2021-525. https://www.psa.gov.ph/content/average-annual-capita-consumption-selected-agricultural-commodities-2018

Philippine Statistics Authority. 2022. Technical Notes on Supply Utilization Accounts of Selected Agricultural Commodities. [accessed 2022 March 20]. https://psa.gov.ph/content/supply-utilization-accounts-selected-agricultural-commodities

Philippine Statistics Authority. 2022. Fisheries Situation Report January–December 2021. [accessed 2022 November 21]. https://library.psa.gov.ph.

Philippine Statistics Authority. 2023. OpenSTAT. [accessed 2022 December 15]. https://openstat.psa.gov.ph.

Philippine Statistics Authority. 2023. Fisheries Situation Report January–December 2022. [accessed 2022 November 20]. https://library.psa.gov.ph.

Punay E. 2022, January 26. House probe on galunggong importation sought [news article]. The Philippine Star. [accessed 2023 May 23]. https://www.philstar.com/headlines/2022/01/26/2156370/house-probe-galunggong-importation-sought

Rada B, Ramos E, Riva C, Royo N. 2019. Preliminary Study on Spawning Period and Length at Maturity of Shortfin Scad, *Decapterus macrosoma*, (Bleeker, 1851, Perciformes:Carangidae) from the Coastal Waters of San Fernando, Romblon. The Philippine Journal of Fisheries. [accessed 2022 October 20];26(1):35–43. https://doi.org/10.31398/tpjf/26.1.2018-0014.

Rajeshkumar S, Li X. 2018. Bioaccumulation of heavy metals in fish species from the Meiliang Bay, Taihu Lake, China. Toxicology reports. [accessed 2023 April 28];5:288–295. https://doi.org/10.1016/j.toxrep.2018.01.007.

Rameshkumar G, Ravichandran S. 2014. Problems caused by isopod parasites in commercial fishes. Journal of parasitic diseases: official organ of the Indian Society for Parasitology. [accessed 2022 October 20];38(1):138–141. https://doi.org/10.1007/s12639-012-0210-4.

Ramos MH, Mendoza E, Fajardo W, Lavapie-Gonzales F. 2018. Assessment of the Tayabas Bay Fisheries. The Philippine Journal of Fisheries. [accessed 2021 March 15];25(1):34-51. https://doi.org/10.31398/tpjf/25.1.2017C0005.

Rau N, Rau A. 1980. Commercial marine fishes of the Philippines. Eschborn: Deutsche Gesellschaft fur Technische Zusammenarbeit (GTZ) GmbH.

Retnoningtyas H, Agustina S, Dhani A, Wiryawan B, Palm H, Natsir M, Hartati I, Prasetia R, Yulianto I. 2023a. Impact of Fishing Pressure on Reproductive Biology of Mackerel Scad, *Decapterus macarellus* (Cuvier, 1833) in Sulawesi Sea and Maluku Sea, Indonesia. Asian Fisheries Science. [accessed 2023 May 5];36:164–170. https://doi.org/10.33997/j.afs.2023.36.3.005.

Retnoningtyas H, Yulianto I, Wiryawan B, Kleinertz S, Palm H. 2023b. Stock discrimination of mackerel scad *Decapterus macarellus* (Cuvier, 1833) in the eastern Indonesia based on metazoan fish parasite composition. Regional Studies in Marine Science. [accessed 2023 July 31];61:102840. https://doi.org/10.1016/j.rsma.2023.102840.

Rice J. 1995. Food web theory, marine food webs, and what climate change may do to northern marine fish populations. In: Beamish RJ, editor. Climate Change and Northern Fish Populations. Canada: Canadian Specia Publication of Fisheries and Aquatic Sciences. Volume 121:p. 561–568.

Rochet MJ, Cornillon PA, Sabatier R, Pontier D. 2000. Comparative Analysis of Phylogenetic and Fishing Effects in Life History Patterns of Teleost Fishes. Oikos. [accessed 2023 May 15];91(2):255–270. http://www.jstor.org/stable/3547546.

Ronquillo IA. 1970. Status of the Roundscad (*Decapterus* spp.) Catch by Purse Seine. The Philippine Journal of Fisheries. [accessed 30 October 2022]; 12(1-2): 101–113.

Ronquillo IA. 1973. A Review of The Roundscad Fishery In The Philippines. The Philippine Journal of Fisheries. [accessed 20 October 2022]; 11(1 & 2): 86–126. http://www.nfrdi.da.gov.ph/tpjf/vol11/A Review Of The Roundscad Fishery In The Philippines.pdf.

Ruangsivakul N, Pratakphol PSC, Chindakarn S, Siriraksophon S, editors. 2004. Fishing gear and methods in Southeast Asia: III. Philippines, Part 2. Bangkok:SEAFDEC. pp. 248-286.

Ruppell E. 1830. Atlas zu der Reise im nordlichen Afrika. Fische des Rothen Meers. Heinrich Ludwig BrOnner, Frankfurt am Main, Part 3:95–141.

Sangalang RH, Quinay EB. 2015. Lead content of round scad (Decapterus macrosoma) from Batangas Bay, Philippines. Asia Pacific Journal of Multidisciplinary Research. [accessed 2023 April 28];3(4):118-124. https://www.apjmr.com/wp-content/uploads/2015/12/APJMR-2015-3.4.5.16.pdf.

Schroeder RE. 1980. Philippine shore fishes of the Western Sulu Sea. Manila: Bureau of Fisheries & Aquatic Resources.

Senate of the Philippines. 2022 January 19. Lacson: DA's plan to import galunggong threatens to "kill" our fishermen [news article]. [accessed 2022 May 14]. https://legacy.senate.gov.ph/press_release/2022/0119_lacson2.asp

Shamsi S, Barton DP. Exploring the potential role of the Genus *Kudoa* (Myxosporea: Kudoidae) as an emerging seafood-borne parasite in humans. Current Clinical Microbiology Reports. [accessed 2022 May 20];11:107–114. https://doi.org/10.1007/s40588-024-00220-1.

Solidum J, Vera M, Ar-Raquib A, Evangelista J, Nerosa M. 2013. Quantitative analysis of lead, cadmium and chromium found in selected fish marketed in Metro Manila, Philippines. International Journal of Environmental Science and Development. [accessed 2023 April 28];4:207-211. https://doi.org/10.7763/IJESD.2013.V4.336.

Smith-Vaniz WF. 1986. Carangidae. In: Smith MM, Heemstra PC, editors. Smiths' sea fishes. Berlin: Springer-Verlag. p. 638-661.

Smith-Vaniz WF. 1999. Carangidae. Jacks and scads (also trevallies, queenfishes, runners, amberjacks, pilotfishes, pampanos, etc.). In: Carpenter KE & Niem VH (eds.). FAO species identification guide for fishery purposes. The living marine resources of the Western Central Pacific. Vol. 4. Bony fishes part 2 (Mugilidae to Carangidae). Rome: FAO. p. 2069-2790.

Smith-Vaniz WF, Williams JT, Pina Amargos F, Curtis M, Brown J. 2015a. *Decapterus macarellus*. The IUCN Red List of Threatened Species. [updated 2017; accessed 2022 July 18];2015: e.T190117A115308983. https://dx.doi.org/10.2305/IUCN.UK.2015-4.RLTS.T190117A16510627.en.

Smith-Vaniz WF, Williams JT, Pina Amargos F, Curtis M, Brown J. 2015b. *Decapterus tabl*. The IUCN Red List of Threatened Species. [accessed 2022 July 18];2015: e.T190164A16510632. https://dx.doi.org/10.2305/IUCN.UK.2015-4.RLTS.T190164A16510632.en.

Smith-Vaniz WF, Williams I. 2016. *Decapterus macrosoma*. The IUCN Red List of Threatened Species. [updated 2017; accessed 2022 June 24]; 2016: e.T20431518A115379160. https://dx.doi.org/10.2305/IUCN.UK.2016-3.RLTS.T20431518A65927864.en. .

Smith-Vaniz WF, Larson H, Motomura H, Matsuura K, Carpenter KE. 2018a. *Decapterus akaadsi.* The IUCN Red List of Threatened Species 2018. [accessed 2022 December 20]; e.T20431493A67871615. https://dx.doi.org/10.2305/IUCN.UK.2018-2.RLTS.T20431493A67871615.en.

Smith-Vaniz WF, Larson H, Carpenter KE, Matsuura K, Polidoro B. 2018b. *Decapterus maruadsi.* The IUCN Red List of Threatened Species. [accessed 2022 July 18];2018: e.T20431525A65927888. https://dx.doi.org/10.2305/IUCN.UK.2018-2.RLTS.T20431525A65927888.en.

Smith-Vaniz WF, Borsa P, Carpenter KE, Obota C, Jiddawi N, Yahya S. 2018c. D*ecapterus kurroides.* The IUCN Red List of Threatened Species. [accessed 2022 July 18];2018: e.T20431513A67871600. https://dx.doi.org/10.2305/IUCN.UK.2018-2.RLTS.T20431513A67871600.en.

Smith-Vaniz WF, Carpenter KE, Jiddawi N, Borsa P, Obota C, Yahya S. 2018d. *Decapterus smithvanizi.* The IUCN Red List of Threatened Species. [accessed 2022 July 18];2018: e.T123424845A123494632. https://dx.doi.org/10.2305/IUCN.UK.2018-2.RLTS.T123424845A123494632.en.

Sparre P, Venema S. 1992. Introduction to tropical fish stock assessment. Part 1. Manual. Fisheries Technical Paper No. 306/1 Rev 1. Rome: FAO. p. 1

Suhani I, Sahab S, Srivastava V, Singh RP. 2021. Impact of cadmium pollution on food safety and human health. Current Opinion in Toxicology. [accessed 2023 April 28];27:1–7. https://doi.org/10.1016/j.cotox.2021.04.004.

Sulit JL, Navarro D, San Juan F, Caldito E. 1953. Proximate chemical composition of various species of Philippine market fishes. Philippine Journal of Fisheries. [accessed 2022 May 15];13(11):82-106.

Tachibana T, Watari T. 2020. *Kudoa septempunctata* infection: an underdiagnosed pathogen of acute gastrointestinal symptoms. QJM: An International Journal of Medicine. [accessed 2022 May 20];113(1):43–44. https://doi.org/10.1093/qjmed/hcz227.

Temminck CJ, Schlegel H. 1843. Pisces, Fauna Japonica, sive descriptio animalium quae in itinere per Japoniam suscepto annis 1823–30 collegit, notis observationibus et adumbrationibus illustravit P. F. de Siebold. Parts 2–4: p. 21–74.

Tiempo C, Reyna M, Sulapas R, Leonardo E. 2020. *Anisakid* parasite in scad fish (*Decapterus* spp.) from selected fishing grounds of Caraga Region, Philippines. Journal of Ecosystem Sciences and Eco-Governance. [accessed 2022 12 June]; 2(2):12–17.

Tiews K, Ronquillo IA, Cases-Borja P. 1971. On the Biology of Roundscads (*Decapterus* Bleeker) in Philippine Waters. The Philippine Journal of Fisheries. [accessed 2020 November 2]; 9: 45–71.

The Philippine Fisheries Code (RA 8550), Chapter I & section 4 (1998).

Tu CY, Chen KT, Hsieh CH. 2018. Fishing and temperature effects on the size structure of exploited fish stocks. Science Reports. [accessed 2023 May 31];8:7132. https://doi.org/10.1038/s41598-018-25403-x.

Uba KI. 2019. Sexual shape dimorphism in the monomorphic fish *Decapterus macrosoma* (Teleostei: Carangidae). Computational

Ecology and Software. [accessed 30 November 2022];9(4):134-142.

Umehara A, Kawakami Y, Ooi HK, Uchida A, Ohmae H, Sugiyama H. 2010. Molecular identification of *Anisakis* type I larvae isolated from hairtail fish off the coasts of Taiwan and Japan. International Journal of Food Microbiology. [accessed 20 November 2022];143(3):161–165. https://doi.org/10.1016/j.ijfoodmicro.2010.08.011.

U.S. Food & Drug Administration. (n.d.). Technical information on development of FDA/EPA advice on eating fish. [accessed 2023 April 28]. https://www.fda.gov/food/environmental-contaminants-food/technical-information-development-fdaepa-advice-about-eating-fish-those-who-might-become-or-are.

Villanoy CL, Cabrera OC, Yniguez A, Camoying M, De Guzman A, David L, Flament P. 2011. Monsoon-Driven coastal upwelling off zamboanga peninsula. *Oceanography*, *24*(1), 156–165. https://doi.org/10.5670/oceanog.2011.12.

Villanueva J. 2018. Assessment of commercially important small pelagic fishes in Davao Gulf CY 2004-2013. The Philippine Journal of Fisheries. [accessed 2022 May 15];25(1):163–182. https://doi.org/10.31398/tpjf/25.1.2017c0013.

Villarao M, Encarnacion A. 2023. Maturity and spawning period of shortfin scad, *Decapterus macrosoma* (Bleeker, 1851, Perciformes: Carangidae) in Babuyan Channel, Philippines. Kuroshio Science. [accessed 2023 April 19];17(1):14-21.

Wootton RJ. 1990. Reproduction. In: Wootton RJ,editor. Ecology of Teleost Fishes. London: Chapman and Hall. p.161-67.

Yang L, Cao W, Lin Y, Chen Y, Lin Z, Wang X. 2016. Preliminary study on the feeding habits and trophic niche of nine economic fish species in Beibu Gulf in summer. Journal of Tropical Oceanography. [accessed 2023 Feb 18];35(2):66-75. https://doi.org/10.11978/2014133.

Yokoyama H, Whipps CM, Kent ML, Mizuno K, Kawakami H. 2004. *Kudoa thyrsites* from Japanese flounder and *Kudoa lateolabracis* n. sp. from Chinese sea bass: causative myxozoans of postmortem myoliquefaction. Fish Pathology. [accessed 2022 May 15];39:79–85. https://www.jstage.jst.go.jp/article/jsfp1966/39/2/39_2_79/_pdf.

Zhao H, Feng Y, Dong C, Li Z. 2021. Spatiotemporal distribution *Decapterus maruadsi* in spring and autumn in response to environmental variation in the northern South China Sea. Regional Studies in Marine Science. [accessed 2024 July 19];45(101811):2352-4855. https://doi.org/10.1016/j.rsma.2021.101811.