BILLFISH FISHERY RESOURCES IN SRI LANKA; PRESENT CONTEXT AND RESEARCH CHALLENGES

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Billfish, an important bycatch resource in the Sri Lankan tuna fishery, currently contributes approximately 13% of the country's large pelagic fish production. Among the billfish landings, the swordfish (*Xiphias gladius*) has emerged as the dominant species, with 90% of the catch originating from tuna longlines. Other billfish species; sailfish (*Istiophorus platypterus*) and three marlin species; blue marlin (*Makaira nigricans*), black marlin (*Istiompax indica*), and striped marlin (*Kajikia audax*) are commonly recorded in both longline and gillnet fisheries. The catch efficiency of billfish (measured in number of individuals per 1,000 hooks) is approximately twice as high during nighttime compared to daytime. Since most billfish harvested on longlines are cut open at sea for storage and available as pieces at the landing sites, obtaining length frequency data has become challenging. Efforts are ongoing to develop reliable length-length conversion metrics. Given the realities at landing sites, updating identification guides with the external appearance of billfish parts is crucial. Continuous monitoring of billfish landings is conducted through port sampling, but the de-headed and de-gutted condition of the landings hinders scientific research on some biological aspects of billfish. Understanding the essentility of these biological aspects in fisheries management, it is recommended to strengthen the billfish research through regional collaborations with special focus on the development of standardized maturity keys, maintenance of a regional level database for biological aspects and increased financial support.

Key words: catch, species, gillnet, long line, biology, billfish

INTRODUCTION

Billfish are among the most exciting fish distributed in oceans worldwide (Surya et al, 2023). Their speed, incredible leaps out of the water, and impressive strength and power have given them an incomparable nature (Kadagi et al., 2022). These large predatory fish species are caught in artisanal, recreational, and commercial fisheries; however, limited knowledge is acquired on the interactions among these fisheries and the ecology and biology of billfish in the Indian Ocean (Kadagi et al., 2022).

Among the major billfish species, the blue marlin and striped marlin stocks have been threatened by overfishing, while swordfish and Indo-Pacific sailfish stocks have been idenitified as not overfished and not subject to over fishing. However, the stock status of black marlin remains uncertain (IOTC–WPB21, 2023). Recognizing the importance of conservation and management measures to reduce fishing pressure on billfish, the Indian Ocean Tuna Commission (IOTC) adopted Resolution 18/05 to maintain annual species-specific catches below their estimated Maximum Sustainable Yield (MSY) (IOTC compendium, 2018). However, it is noted that the catches of black marlin and Indo-Pacific sailfish have currently exceeded the limits set out in Resolution 18/05 (IOTC–WPB21, 2023). Focus has also been given to tagging programs, which provide valuable scientific data to further understand the distribution, migration, and growth of billfish species (Billfish Foundation, 2024; IOTC–WPB21, 2023) as well as laboratory studies on reproductive biology and feeding ecology (IOTC–WPB21, 2023).

In Sri Lanka, billfish are among the most important fishery resources as they significantly contribute to the country's large pelagic fish production (Haputhantri and Maldeniya, 2011) and thereby to the Sri Lankan economy, mainly through swordfish exports (EDB, 2024). This top predatory group is commonly harvested as a by-catch in the tuna fishery, mostly by using longlines and gillnets (Haputhantri and Maldeniya, 2011; Rathnasuriya et al., 2016).

In many cases, unlike other species, whole billfish are not landed by Sri Lankan fishing vessels. Instead, billfish caught at sea are cut into two or three pieces for the convenience of storage and brought onboard to the port (Haputhantri and Perera, 2014). This practice gains several challenges for data collection and biological sampling of this fascinating group. However, Sri Lanka is currently exploring feasible ways to overcome those challenges.

This paper provides updated information on the trends and current status of billfish landings in Sri Lanka while discussing research challenges and potential solutions for the future.

SOURCES OF DATA

Two databases were used for this review: the published database of the Indian Ocean Tuna Commission (IOTC) and the PELAGOS database of the National Aquatic Resources Research and Development Agency (NARA) of Sri Lanka.

SIGNIFICANCE OF BILLFISH RESOURCES IN SRI LANKA

Billfish have become the second-largest group of fish reported in large pelagic fish production in Sri Lanka. Currently, billfish contribute around 13% of the large pelagic production (Figure 1), representing a notable increase from 10% in the early 2010s (Haputhantri and Maldeniya, 2011). The commonly recorded billfish species in the fish landings are swordfish (*Xiphius gladius*) followed by sailfish (*Istiophorus platypterus*), and three marlin species; black marlin (*Istiompax indica*), blue marlin (*Makaira nigricans*), and striped marlin (*Kajikia audax*) (Haputhantri and Maldeniya, 2011; Samaraweera and Amarasiri, 2004). The occurrence of shortbill spearfish (*Tetrapturus angustirostris*) had also been reported in commercial catches (Joseph and Amarasiri 1986, Maldeniya et al., 1987) but does not appear to be common in recent catches (Figure 2).

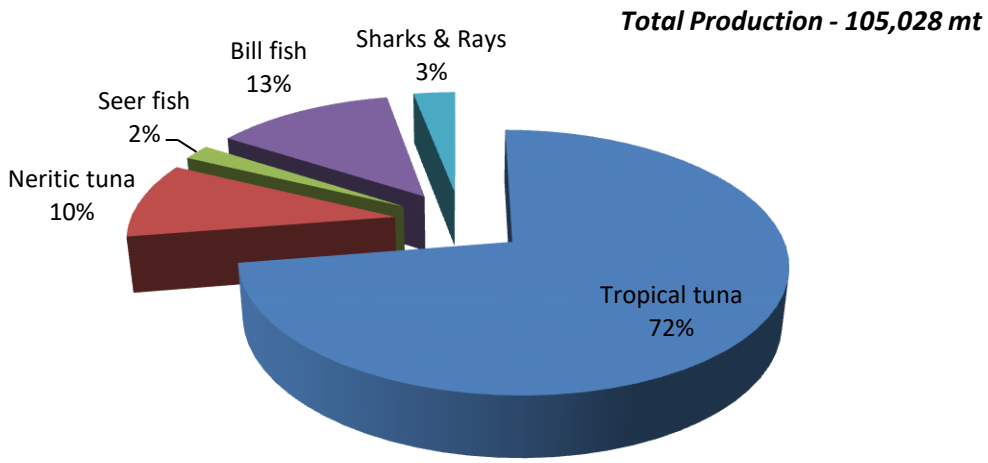


Figure 1. Species composition of large pelagic fish production in Sri Lanka in 2023 (MOF, 2023)

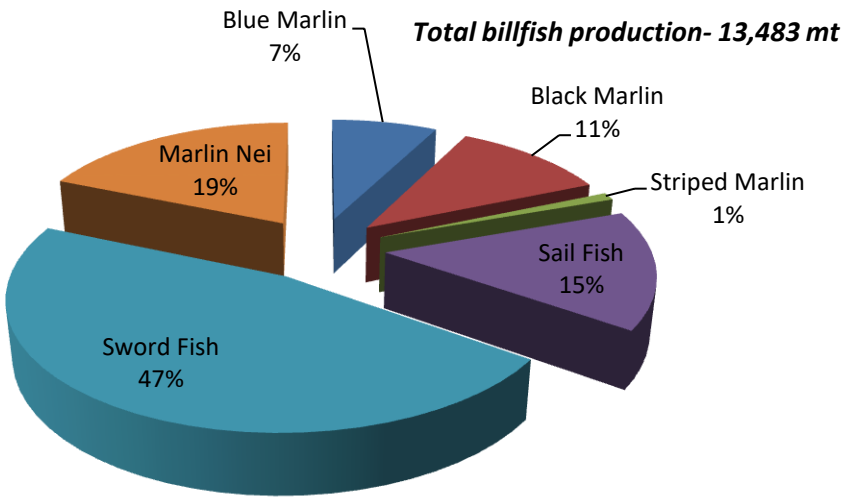


Figure 2. Species composition of billfish production in Sri Lanka in 2023 (Source: MOF, 2023)

Trend of billfish production in Sri Lanka

The species composition of billfish has changed dramatically over the past two decades. Until 2012, billfish production in the country was dominated by marlins, followed by sailfish and swordfish respectively. However, a considerable change was noted after 2012, when swordfish became the dominant species (Figure 3). Swordfish are mainly caught by longline operations, while other species are recorded in both longline and gillnet operations (Figure 4). Converging on more selective gear i.e. longline (Hewapathirana et al., 2023) may have resulted in increased swordfish catches reported during the recent decade. Moreover, the increased number of hooks per set (1,000-1,200 hooks) in longlines (Hewapathirana et al., 2023), and the utilization of efficient bait types (Bandaranayake et al., 2023) could also have contributed to the increased swordfish catches.

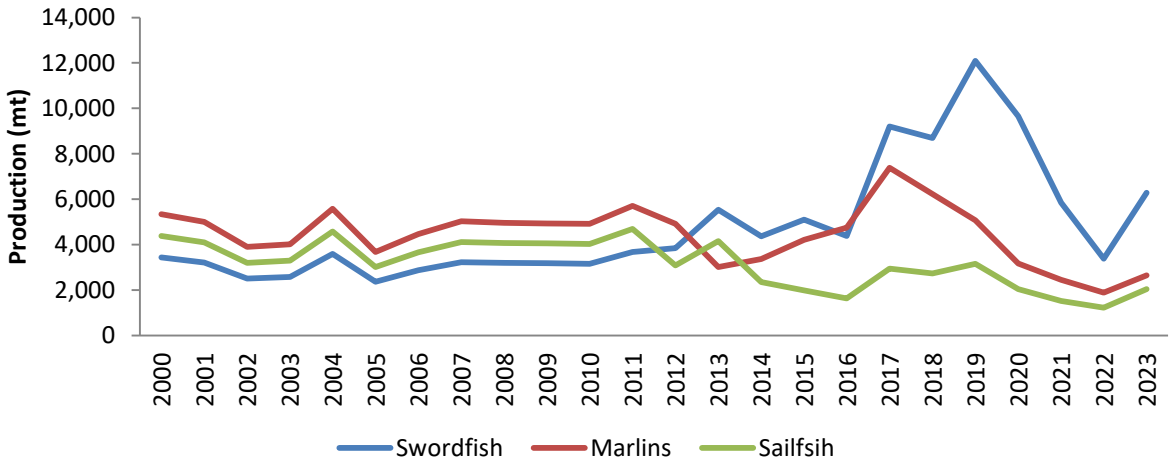


Figure 3. Billfish production in Sri Lanka over the past two decades (Source: IOTC, 2023)

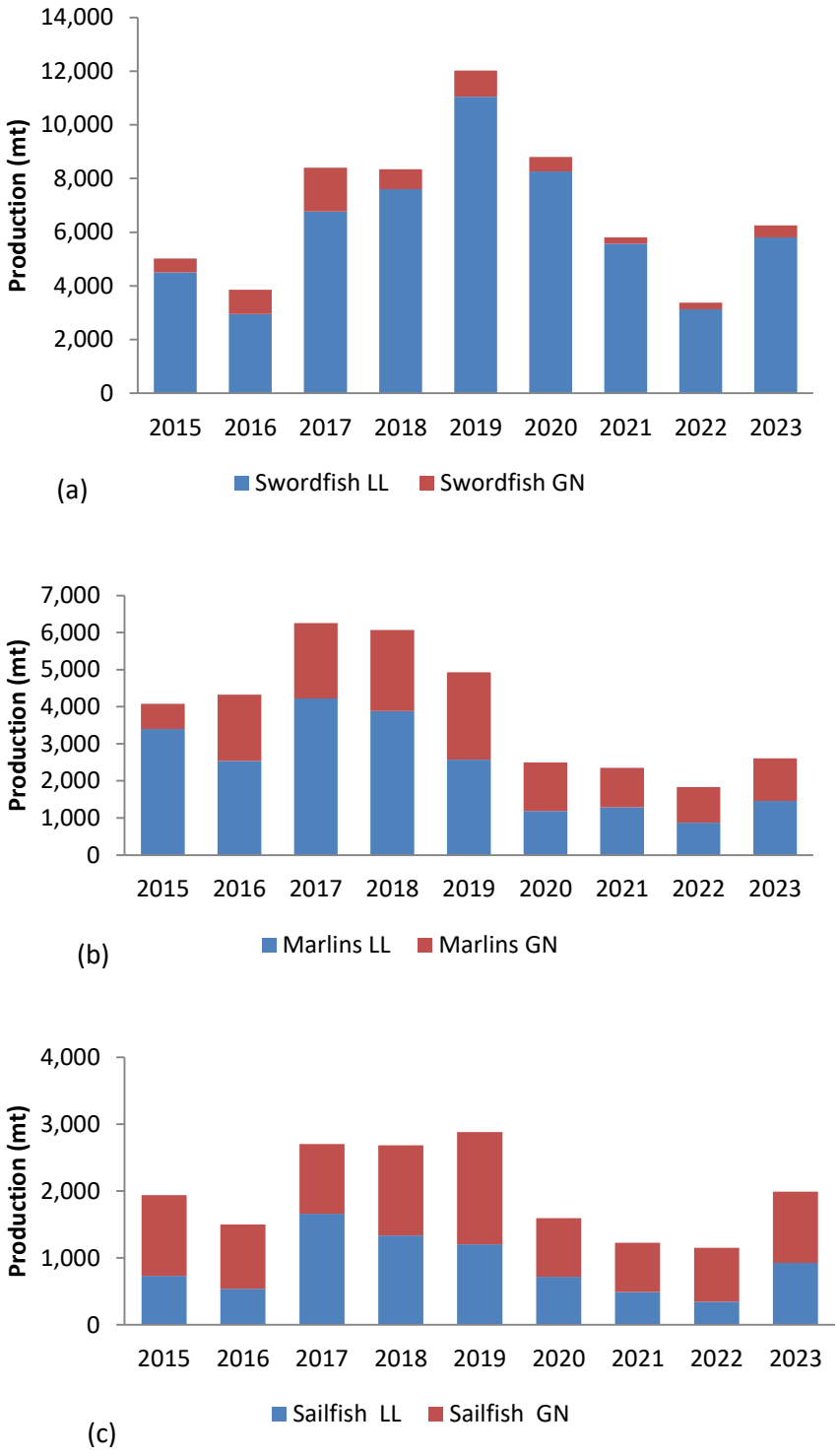


Figure 4. Billfish production by two major gear types (LL- Longline and GN-Gillnet): (a) Sword fish (b) Marlins (c) Sailfish (Source: IOTC, 2023 and MOF, 2023)

Billfish catch rates over the recent years

A decreasing trend in billfish catch rates (number of fish in 1,000 hooks) in longlines has been observed in recent years, with conspicuous inter-annual variations. This declining trend in catch

rates has also been reflected in billfish production over recent years and could be the result of multiple factors. Deviation in their horizontal and vertical migration due to climate change (Townhill et al., 2021) and stock depletion (IOTC–WPB21- 2023) are likely the primary drivers.

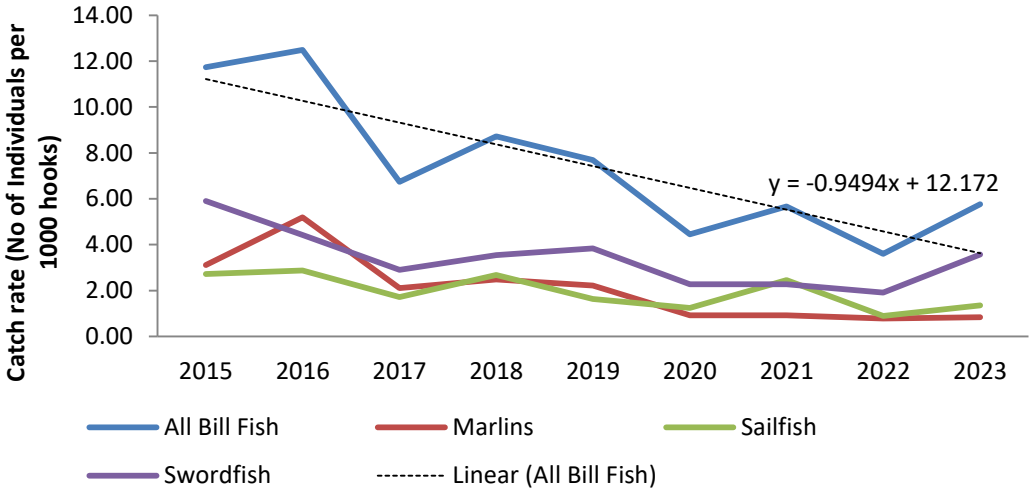


Figure 5. Variations of catch rate of bill fish (number of fish in 1000 hooks) during the recent years (Source: PELAGOS database)

Diel variations of billfish catch rates

The average longline catch rates of billfish in recent years (2017-2023) during daytime and nighttime were 3.4 ±0.84 and 6.6 ±1.33 individuals per 1,000 hooks, respectively. The results reveal that billfish catch rates are approximately two times higher during nighttime. Although billfish species are highly migratory species with a wide range of horizontal distribution (Brill & Lutcavage., 2001), many studies have shown that their habitat preference are related to physical factors such as water temperature and dissolved oxygen (Wormet al., 2005; Boyce et al., 2008), and biological factors such as food availability, feeding and reproductive activities (Shimose et al., 2008; Shimose et al., 2009; Blondin et al., 2023).

Swordfish are typically associated with deeper layers during the daytime compared to other billfishes but remain at surface layers during the night (Carrey, 1990). In addition, a detailed depth and temperature time-series data obtained from a recovered tag show clear diel differences in the depth use of blue marlin, involving consistent use of the surface at night and deeper diving activity during the day, predominately to depths greater than 50 m (Freitas et al., 2022). Ambient light levels play a key role in billfish vertical foraging habits, as they are anatomically equipped with large eyes. Their thermoregulatory abilities facilitate foraging below the warm surface layers (Braun et al., 2015).

Additionally, evidence suggests that they avoid regions with low dissolved oxygen, which is becoming a concern due to human-induced climate change (Barun et al., 2015). As Rohner et al. (2022) pointed out, some species of billfish move about 14 km per day in vertical dives and prefer dusk & dawn for deeper dives.

MANAGEMENT MEASURES IN THE NATIONAL CONTEXT

Understanding the importance of fisheries data collection, Sri Lanka is in the practice of recording catch and effort data using a logbook prepared according to the standards set in the Resolution 15/02 in the IOTC area. Species identification cards for billfish are being used to ensure accurate identification, particularly for the three marlin species (Hewapathirana et al., 2022).

Moreover, in compliance with the Resolution 15/02 on Mandatory Statistical Reporting Requirements for IOTC Contracting Parties and Cooperating Non-Contracting Parties (CPCS) (IOTC Compendium, 2024), catch and effort data of billfish species are submitted separately for surface fisheries (1° grid area and month strata), longline fisheries (5° grid area and month strata), and coastal fisheries (as per the defined geographic area). However, size frequency data often do not comply with the resolution (i.e., sampling coverage shall be set to at least one fish measured per ton caught by species and type of fishery) due to the infrequent presence of whole billfish at landing sites.

In compliance with the Resolution 18/05 on Management Measures for the Conservation of Billfishes of striped marlin, black marlin, blue marlin and Indo-Pacific sailfish (IOTC Compendium, 2024), the following condition has been included in the High Seas fishing operation license in Sri Lanka: *"Catch, retain on board, trans-ship, land of bill fish (Striped Marlin, Black Marlin, Blue Marlin, Indo Pacific Sailfish) smaller than 60 cm Lower Jaw Fork Length is prohibited in High Seas"* (Hewapathirana et al., 2021).

RESEARCH CHALLENGES: IS IT POSSIBLE TO OVERCOME?

Billfish studies in Sri Lanka have been mostly focused on their environmental preferences (Rathnasuriya et al., 2016; Bandaranayake et al., 2018; Bandaranayake et al., 2019) and gear-vessel, and bait efficiencies (Haputhantri, 2012; Bandaranayake et al., 2023). However, unlike other species, billfish are unique in terms of their nature of landings. Most of the harvested billfish, especially those caught on longlines, are cut open at sea into two or three pieces for the purpose of storage. Consequently, obtaining length frequency data and other biological data has become a challenge (Haputhantri and Perera, 2015).

Since the early 1990s, Sri Lanka has been engaged in national-level data collection program for large pelagic fish landings, based on port sampling, which also includes billfish species (Dissanayake, 2005). This program has contributed to the improvement of the reporting of billfish landings, including species-level data for marlins (Hewapathirana et al., 2023). The accuracy of species identification by field enumerators has been enhanced with the use of species identification cards produced by the IOTC. Additionally, skippers have been trained in species identification and catch data reporting in the logbook (Hewapathirana, 2022). Despite these efforts, difficulties in species identification continue to be observed in the field.

Considering the realism in the nature of landings (often billfish are unloaded dressed), it is noted that identification keys based solely on whole specimens are insufficient to address the challenges of misidentification of billfish species. For example, finned, de-headed, and cut blue marlin and black marlin show a high degree of similarity at landing sites. To differentiate them by species, attention must be given to more specific features such as the nature of the pectoral fin cut, the appearance of scales, and the positions of second dorsal and second anal fins (Plate 1,2,3 and 4). Therefore, identification guides should be updated with the specific features to enable accurate identification of billfish species at landing sites based on macroscopically observable characteristics of particular billfish pieces. Further, more training programs for enumerators and skippers will be valuable in ensuring accurate species identification.

Reporting size frequencies as required by IOTC Resolution 15/2 remains challenging under current circumstances, as a significant portion of billfish are cut open at sea and landed in pieces. Several attempts are underway to derive the length-length conversions to address this issue. Haputhantri and Perera (2015) derived length-length relationships for *I. platypterus* (Indo-Pacific sailfish), for various length types; upper jaw-total length, upper jaw-fork length, lower jaw-total length, lower jaw-fork length, pectoral-dorsal length and pectoral-anal length. Also, they have considered girth measurements (girth via beginning of pectoral fin and girth via the beginning of 1st anal fin) in their analysis.

Currently, the National Aquatic Resources Research and Development Agency (NARA), Sri Lanka is making preliminary attempts to develop an application to explore the possibility of estimating the full length of sailfish using available relationships. Similar work is being attempted for other billfish species as well. However, certain difficulties remain, such as defining lengths in the finned billfish when they are landed mainly in more pieces. Further, it is crucial to explore the potential of advanced image processing techniques to accurately identify billfish species from partial images and estimate fish size from images of cut pieces.

Since the internal organs, especially the gut and gonads are removed, research on the biological aspects of billfish species has been limited using commercial catches. Strengthening this research requires regional collaboration, standardized maturity keys, capacity building and financial assistance. Maintaining a regional database for biological information on billfish would be a powerful tool for conducting research for fisheries management, helping to ensure the sustainability of billfish resources in the region.

		
(a)Round shaped body with smooth skin texture with no scales	(b)Round shaped body with rough skin embedded with scales	(c)Laterally compressed body with distinct body band pattern

Plate 1. Characters which can be used to distinguish three major billfish groups; (a) swordfish, (b) marlins and (c) Indo-Pacific sailfish

		
(a) Dark blue above, silvery white below; sometimes with light blue vertical stripes, body densely covered with scales	(b)Body blue-black above and silvery white below, with pale cobalt-colored stripes	(c) Blue-black above and silvery white below, with cobalt-colored stripes, Round body shape, smooth skin

Plate 2. Identification of three marlin species based on their external appearance (a) *Istiompax indica* (black marlin) (b) *Makaira nigricans* (blue marlin) (c) *Kajikia audax* (striped marlin)

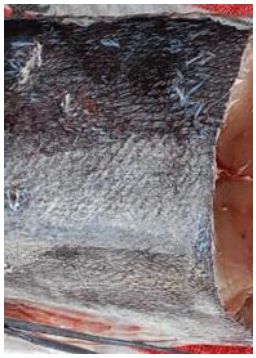
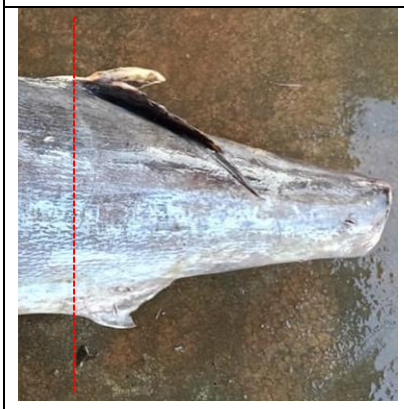
 (a)Scales are not conspicuous, small, embedded scales with 1 or 2 sharp points	 (b) elongate, thick, bony scales, each often with 1 or 2, , posterior points	 (c) body completely covered with embedded scales with 1 or 2 bluntish points

Plate 3. Close up veiw of skin of three marlin species (a) *Istiompax indica* (black marlin) (b) *Makaira nigricans* (blue marlin) (c) *Kajikia audax* (striped marlin)

 Pectoral fin cut is bulge out in black marlin	 Pectoral fin cut is comparatively flattened in blue marlin
 Second dorsal fin is slightly infront of/ align with second anal fin in black marlin	 Second dorsal fin is slightly behind second anal fin in blue marlin

Pectoral fin folding flat on the body in blue marlin

Plate 4. Characters which can be used to easily distinguish *Istiompax indica* (black marlin) and *Makaira nigricans* (blue marlin)[1]

Furthermore, research on early life histories, trophic relationships, migratory patterns, population dynamics, climate impacts and mitigating postharvest loss of billfish needs to be urgently addressed in the Indian Ocean through collaborative efforts.

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[1] Please note: Species confirmation should be based on overall of all the observable features

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