

Assessment of Catch Composition and Fishing Effort (CPUE) in the Small-Scale Fisheries of Hawks Bay, in the northern Arabian Sea

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Abstract

The study determines catch composition of the small-scale fisheries from Hawks Bay in the northern Arabian Sea by means of catch per unit effort (CPUE). Seasonal data collection from February to December 2024 using a 2.5 cm mesh gill net deployed for one hour from a small commercial fishing boat. The total catch was 31.82 kg, comprising 26 families and 49 species. The target species consisted of 1.87 kg with 4 species, while the bycatch contained 29.95 kg composed of 45 species from 25 different families. The study revealed that the seasonal CPUE of the target catch (Ponyfish) varied and differed significantly in weight and length. The most abundant target species was *Karalla daura* found in all seasons, but the remaining species were found in a specific time period. Although Banded Ilisha, *Ilisha striatula*, is predominant on the coast of Hawk's Bay. The Anderson-Darling test was applied to test seasonal variations in CPUE statistics, which showed the highest mean value in SIM (110.1), 74.47 in AIM, and the Lowest mean value in SWM (61.76). This disparity suggests that bycatch variability was most pronounced in SIM, reflecting the greatest seasonal fluctuations. However, the target species, including ecologically critical families crucial for the food web and fisheries production, remained unstable. Therefore, implementing effective management strategies is essential to ensure sustainable harvesting of these species.

Introduction

The Northern Arabian Sea (NAS) is a semi-enclosed sea located in the northwestern part of the Indian Ocean. It is bordered by the Arabian Peninsula to the west, Iran and Pakistan to the north, India to the east, and the rest of the Indian Ocean to the south. This unique geographical setting, coupled with the strong influence of the monsoon wind, makes the NAS a highly dynamic and biologically significant ecosystem.

Hawks Bay, situated in the northern Arabian Sea, is a vital nursery ground, characterized by a unique and diverse ecosystem encompassing rocky shores, sandy beaches, and intertidal mudflats interspersed with mangrove swamps. This area holds significant ecological value, with its coastal wetlands, tidal lagoons, salt marshes, and estuaries providing crucial habitats for a wide array of the fisheries community. The mangrove swamps are particularly important, functioning as essential feeding, sheltering, and breeding grounds for numerous epipelagic species. However, the adjacent Lyari River Estuary has suffered severe degradation due to pollution, leading to drastically reduced biodiversity and posing a substantial threat to the marine ecosystem.

The northernmost reaches of the Arabian Sea, heavily influenced by the monsoon inversion, constitute a critical maritime zone experiencing pronounced seasonal fluctuations in oceanographic conditions (Kashani et al. 2025 a). This dynamic environment makes Hawks Bay an ideal location for investigating the complex relationships between climate oscillations and the structure of both micro- and macrofaunal communities. The area's rich genetic diversity, coupled with its diverse ecosystems, habitats, and biological communities, underscores its importance as a vital source of marine resources. Consequently, regular monitoring of the ecological health and status of Hawks Bay is essential to ensure the long-term preservation and sustainable management of these valuable resources.

Ponyfish (Order Perciformes; Family Leiognathidae) play a vital role in marine food web, serving as a crucial food source for a variety of predators, including larger fish (e.g., barracuda, mackerel, tuna), seabirds (e.g., gulls, terns), and marine mammals (e.g., dolphins, seals). Their high abundance and availability make them a key component of the diet for these diverse predators (Ahmadi and Ghanem, 2024). Furthermore, ponyfish can act as indicator species for the overall health of marine ecosystems. Changes in their populations, distribution, or condition can reflect broader environmental shifts, such as alterations in water quality, habitat loss, or the impacts of overfishing (Kashani et al. 2025 a). Despite the recognized ecological and biological significance of the Leiognathidae family, stock assessments for this group remain limited, particularly in the NAS. Data on ecologically important fish in this region are scarce, even though large trawlers operating in the NAS frequently capture these species as bycatch, often discarding them at minimal value, sometimes for use in low-cost pet food. This lack of data hinders effective management and conservation efforts.

Catch per unit effort (CPUE) is a valuable fisheries management tool, providing insights into localized areas of concern based on topography, ecological characteristics, and fish density (Owiredu et al. 2024). CPUE serves as a crucial metric for assessing fish stock abundance and informing management decisions (Hoyle et al. 2024). Various methods based on long-term catch data, are increasingly employed for stock assessments globally (Kindong et al. 2022; Pons et al. 2020). This is often the case in fisheries for pelagic or lower-value species, where surveys are too costly or impractical (Hoyle et al. 2024). CPUE analysis specifically for bycatch small-scale fisheries species including ponyfishes remains limited in the NAS. This is a critical gap, given the high proportion of ponyfish in bycatch and their potential vulnerability.

CPUE is a crucial index of abundance for stock assessments, particularly in the absence of fishery-independent surveys. This research addresses the gap by providing updated information on the catch rates and stock density of these ecologically important pelagic fish in the Hawks Bay, northern Arabian Sea. Utilizing a CPUE-based approach, the study emphasizes the urgent need for conservation efforts to protect these vital species and highlights the importance of incorporating bycatch data into fisheries management strategies.

Materials and Methods

Study area

Hawks Bay is located at 24° 51' 36.73" N, 66° 51' 49.15" E in the northern Arabian Sea. It is a popular recreational beach and vital small-scale fishery. The eastern Bay features scattered mangroves, while its western expanse transitions from sandy to rocky beach, creating a complex and vulnerable coastal ecosystem.

Estimation of Catch-Per-Unit-Effort (CPUE)

To estimate the CPUE, we used the total catch and harvesting time. The catch was divided by the number of hours (time) of fishing ($CPUE = \text{catch number} / \text{time}$).

Statistically

$$\text{CPUE} = \sum C / \sum f$$

where C is the catch (in kg), and f is a fishing effort (time duration)

Fishing gear and time

Only one type of fish gear was used for the CPUE estimation. A 100 m long and 60 m wide gill net with a mesh size of 2.5 cm was used. The capacity of the boat was not greater than 100–350 m in depth. The netting duration was 1 h.

Data and sample processing

The collected ichthyofaunas were preserved in an ice box and deposited in the CEMB Fisheries Laboratory for identification and meristic counting (length and weight). The samples were classified into targeted species, and bycatch. The samples were measured precisely to the nearest unit of total length (TL) and the data from the length frequency distribution were analysed. The composition of the catch and the percentage of each species relative to the total catch were recorded. The seasonal CPUE was calculated as described by Sparre and Venema (1998).

Statistical analysis

The primary statistical tools utilized for data analysis included IBM SPSS Statistics version 27 and Microsoft Excel 365 version. 2502. And Minitab ver. 21.4.3 utilized for Anderson-Darling (AD) test to assess statistically significant differences depending on the sampling season.

Results

In this study, an effort was made to estimate the CPUE of the ecological fishes in Hawks Bay, northern Arabian Sea. The catch was sorted into target (ponyfishes), and bycatch. The study revealed significant seasonal variations in catch composition within the NAS. The total catch fluctuated throughout the seasons, exceeding 25 kg during the South Inter Monsoon (SIM), bycatch consistently comprised over 89% of the total, highlighting its dominant presence. Surprisingly, the target species (ponyfish) only represented a small fraction, less than 11% exclusively with the highest contribution in SIM (Table 1). Furthermore, the total catch reveals a diverse fish community with 26 families and 49 identified species. The catch composition varies significantly across seasons. *Karalla daura* (target species) dominated by 10.64% and *Ilisha striatula* (43.97%), *Restrelliger kanagurta* (4.02%) and *Scomber austerlasics* (3.07%) appeared in the SIM. The highest total catch was recorded during the SIM (3.86 kg) and autumn inter-monsoon (AIM) (25.1 kg), 79.41% and 12.32%, respectively, of the total biomass catch. The lowest total catch was recorded in the southwest monsoon season (SWM) (8.27%) (Table 1).

The CPUE is statistically represented in (Table 2). When measuring CPUE per hour, target species are non-existent (0.00 kg/hour), highlighting their lowest abundance. In contrast, bycatch boasts a substantial CPUE of 0.47 kg/hour. Similarly, per haul, target species consist of a low 1.25 kg, while bycatch reaches 18.89 kg. This trend continues when analysing catch per kilogram of total target species (T.kg/T.T.species). While bycatch captures 1.12 kg for every total kg of target species, the target species capture only 16.99 kg, indicating comparatively a much lower catch rate (Table 2). The study underscored the prominent influence of variables such as month, fishing season, and environmental changes on the nominal CPUE during the examined year scenario. The CPUE of the target (Ponyfish) per sample trip was 35-1200 g (average 0.38 kg) with 8–15 cm (mean length), the bycatch an average of 5 kg. The most dominant species was *Ilisha striatula* found in Hawks Bay NAS. Although a substantial variation comes in all seasons. While *Megalaspis cordyla* and *Gaza minuta* are abundant in SWM, *Karalla daura* is AIM and *Ilisha striatula* in SIM (Fig. 1).

The maximum weight in catch occurs in SIM while minimum in AIM and SWM is moderate (Fig. 2). Across all seasons, the mean values represent the central tendency of the catch distribution, with SWM holding the highest average (61.76) followed by SIM (110.1) and AIM (74.47) (Fig. 3). However, the accompanying standard deviations show a different scenario, revealing substantial spread within each season. Notably, AIM exhibits the most significant variability (60.43) compared to SWM (112.4) and SIM (89.65), suggesting a wider range of catch values during AIM.

The Anderson-Darling (AD) test, a non-parametric alternative, was used to determine the statistical significance of observed differences, as the data did not meet the assumptions of normality. Most importantly the AD statistic, its corresponding p-values offer valuable clues about the underlying data distribution. While low p-values (< 0.005) for SWM and AIM indicate a strong rejection of normality, SIM's p-value of 0.006 suggests a potential departure from normality as well. This implies that the catch (or percentage) data for each season might not perfectly follow a normal distribution, potentially exhibiting skewed or multimodal patterns. This is because of the maximum different families and species catches, thus resulting in a high value AD in SWM and AIM. These observations raise several questions for further exploration. Understanding the factors contributing to the observed variability within each season, particularly during AIM, could be crucial.

Discussion

A study of fisheries resources in the Northern Arabian Sea (NAS), using catch-per-unit-effort (CPUE) as an indicator of biomass and population, revealed a significant level of species richness. The catch composition was heavily dominated by bycatch (94.2%), with target species representing only 5.8% of the total catch. This contrasts with data reported by the FAO (2020), which indicates Pakistan's total annual fish production is 1403 metric tons, encompassing nearly 80 species (representing 34% of known species). In the present study, a one-hour netting with a 60m width, 100m length, and a 2.5 mesh size, yielded a biodiversity index of 30%. These discrepancies likely arise from differences in geographical distribution, species abundance, fishing techniques, fishing fleet size, and netting duration. Akyol et al. (2024) reported a total of 37 bycatch species (target and non-target) and a more diverse overall catch

composition of 61 species using four different fishing gears. Our study, using a single gear, identified 49 species, including bycatch, and showed some alignment with their bycatch findings. Further, the study identified four primary target species. Among these, the goldstrip ponyfish, *Karalla daura*, was the most abundant (14.18%), followed by the ornate ponyfish, *Equulites lineolatus* (2.6%), the tooth-ponyfish, *Gaza minuta* (1.18%), and *Deveximentum ruconius* (1.18%). These species typically returned to the ocean without being recorded, resulting in a lack of information regarding their ecological importance.

Ponyfish are a globally distributed group, inhabiting nearly all marine environments. While considerable data exists on ponyfish biodiversity, Kashani et al. (2025 c) reported fifteen species in the NAS and numerous studies documenting over thirteen species in the Indian Ocean (Abraham et al. 2011; Sharifuzzaman et al. 2011; Chakrabarty et al. 2010, 2008), challenges remain in understanding their population dynamics. Ponyfish have shown promise as bioindicators of coastal ecosystem health due to their sensitivity to environmental changes (Kashani and Panhwar, 2023). Factors like species-specific growth rates and ecological stress influence these dynamics (Kachhi et al. 2022; Kashani et al. 2022). While some species, like *Karalla daura*, are widespread in the NAS, others, such as *Deviximentum indicum*, have more limited distributions. These distributional differences suggest varying degrees of sensitivity to environmental stressors, with widespread species potentially possessing enhanced resilience to global changes (Xu et al. 2023). It's critical to acknowledge the significant and ongoing impact of climate change and anthropogenic activities are demonstrably altering fish communities and the overall health of the marine ecosystem (Kachhi et al. 2024; Kashani et al. 2025b).

Indices of abundance derived from CPUE play a significant role in stock assessments, particularly when fishery-independent data sources, such as research surveys, are lacking (Hoyle et al. 2024). CPUE is frequently used as a proxy for fish abundance, its application rests on the often-unrealistic assumption of uniform fish behavior across a given area. In reality, CPUE data rarely reflects true abundance across an entire geographic region. Oceanographic variability, driven by factors like sea surface temperature, currents, depth profiles, and thermocline depth, creates diverse conditions that differentially influence marine life. Consequently, CPUE should be interpreted as a relative abundance index, valid only within the specific spatial and temporal boundaries from which the data were collected. Öndes and Unal (2023) using CPUE, emphasized the importance of monitoring and managing non-indigenous species in small-scale fisheries to ensure sustainability and protect native species and ecosystems. Furthermore, Radinger et al. (2023) advocate for ecosystem-based management as a more effective approach to fisheries management. Furthermore, CPUE is influenced by a complex interplay of factors, including temporal variables (e.g., year, month), spatial variables (fishing area), and environmental variables (e.g., sea surface temperature (SST), sea surface salinity (SSS), and chlorophyll a (Chlor_a)) (Sarr et al. 2023; Li et al. 2013). These variables can significantly affect fish abundance and consequently impact CPUE. Local fishermen often possess valuable knowledge of productive fishing grounds within their operational range. In the Hawks Bay fishery, for example, fishing effort concentrates in relatively small areas within the target species' overall range. However, extrapolating CPUE data from these fishing areas to larger management zones, including unfished regions, can lead to overestimates of stock abundance, a phenomenon known as hyperstability (Harley et al. 2001). This extrapolation fails to account for the non-uniform distribution of

individuals across the species' geographic range. In addition to localized environmental conditions, catchability is influenced by the type of fishing gear employed and its method of deployment. Furthermore, the effectiveness of a given gear in capturing target species is dependent upon a range of factors under the control of the fisher (Campbell et al., 2017).

Ecosystem-based fishery management, which considers the impacts of fishing on both target and non-target species (bycatch), is crucial (Gilman et al. 2014). Despite its importance, bycatch data remains scarce (Komoroske and Lewison, 2015). In addition, ecosystem-based management offers a more comprehensive and sustainable approach compared to traditional single-species management, its widespread adoption in conservation remains limited. The holistic consideration of species interactions, environmental factors, and human influences inherent in ecosystem-based habitat management makes it demonstrably more effective. Therefore, it is essential to prioritize the study, continuous monitoring, and regular updating of the ecological needs of fish populations to achieve conservation goals and ensure sustainable fisheries management. The Hawks Bay groundfish fishery, with its observer or catch monitoring system, offers a valuable opportunity to study bycatch dynamics. By considering the broader ecosystem context and interspecies interactions, this strategy aimed to promote the long-term health and resilience of both fish populations and the ecosystems they inhabit.

Conclusion

This study sheds light on the significance of ponyfishes in the NAS ecosystem. While CPUE identified the goldstripe ponyfish (*Karalla daura*) as the most abundant species, this method likely overestimates true diversity due to factors like gear selectivity and non-uniform fish distribution. The high percentage of bycatch (80.86%) compared to target catch (19.14%) further emphasizes the need for alternative methods to assess fish populations.

CPUE assumes homogenous fish distribution within a geographical range, which is rarely the case due to variations in physical and biological factors. This highlights the limitations of CPUE as a sole indicator of abundance. Ecosystem-based fishery management offers a more holistic approach, considering bycatch, environmental factors, and interactions between species. Future efforts should focus on continuous monitoring and data collection to gain a deeper understanding of the ecological needs of fish populations, particularly those often discarded as bycatch. Studying the growth rates and habitat preferences of ponyfishes can provide valuable insights for population management.

This study underscores the importance of reevaluating abundance estimates and incorporating ponyfishes as a frequently overlooked ecological player, into future assessments. By acknowledging the limitations of CPUE and adopting ecosystem-based fishery management principles, we can promote the long-term sustainability of fisheries and the health of the NAS ecosystem. Continuous monitoring and data collection remain crucial for informing effective conservation and management strategies in the NAS. This comprehensive approach will ensure the continued health and resilience of this vital marine environment for generations to come.

Declarations

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Tables

Table 1. Total catch composition and seasonal variation in percentage (%)

S.No.	Family	Species	Season			
			Autumn inter-monsoon%	South-inter monsoon %	Southwest monsoon %	Grand total
1	Alpheidae	<i>Alpheus bellulus</i>	0.24	-	-	0.24
2	Carangidae	<i>Alectis indica</i>	0.24	-	-	0.24
		<i>Alepes djedaba</i>	-	-	0.47	0.47
		<i>Alepes melanoptera</i>	-	0.47	-	0.47
		<i>Carangoides praeustus</i>	1.42	-	-	1.42
		<i>Decapterus macrosoma</i>	-	0.24	-	0.24
		<i>Megalaspis cordyla</i>	-	-	1.65	1.65
		<i>Scomberoides commersonianus</i>	0.47	0.24	-	0.71
3	Chirocentridae	<i>Chirocentrus nudus</i>	0.24	-	-	0.24
4	Clupeidae	<i>Hilsa kelee</i>	-	0.7	-	0.7
		<i>Nematalosa nesus</i>	-	0.24	-	0.24
		<i>Sardinella gibbosa</i>	-	0.24	-	0.24
		<i>Sardinella longiceps</i>	-	5.91	-	5.91
		<i>Spratelloides delicatulus</i>	-	-	0.24	0.24
5	Drepaneidae	<i>Drepane punctata</i>	0.24	-	-	0.24
6	Engraulidae	<i>Thryssa mystax</i>	-	1.18	-	1.18
		<i>Thryssa setirostris</i>	-	1.65	-	1.65
7	Gerreidae	<i>Gerres filamentous</i>	0.24	-	-	0.24
8	Haemulidae	<i>Pomadasys furcatus</i>	-	0.24	-	0.24
9	Lactariidae	<i>lactarius lactarius</i>	-	0.47	0.71	1.18
10	Leiognathidae	<i>Equulites lineolatus</i>	2.6	-	-	2.6
		<i>Gaza minuta</i>	-	-	1.18	1.18
		<i>Karalla daura</i>	3.07	10.64	0.47	14.18

S.No.	Family	Species	Season			
			Autumn inter-monsoon%	South-inter monsoon %	Southwest monsoon %	Grand total
		<i>Deveximentum ruconius</i>	1.18	-	-	1.18
11	Lethrinidae	<i>Lethrinus nebulosius</i>	-	0.7	0.24	0.94
12	Loliginidae	<i>Uroteuthis duvaucelii</i>	0.47	-	-	0.47
13	Matutidae	<i>Matuta planipes</i>	0.24	-	-	0.24
14	Muraenidae	<i>Gymnothorax pseudothrysosoidus</i>	0.24	-	-	0.24
15	Octopodidae	<i>octopus vulgaris</i>	0.47	-	-	0.47
16	Penaeidae	<i>Parapenaeopsis sculptilis</i>	0.24	-	-	0.24
17	Plotosidae	<i>Plotosus limbatus</i>	0.24	-	-	0.24
18	Pristigasteridae	<i>Ilisha striatula</i>	-	43.97	-	43.97
19	Pseudotricanthidae	<i>Pseudotriacanthus strigilifae</i>	0.24	-	-	0.24
20	Scatophagidae	<i>Scatophagus argus</i>	-	-	0.47	0.47
21	Sciaenidae	<i>Johnius amblycephalus</i>	-	0.24	-	0.24
		<i>Johnius macrorhynchus</i>	-	-	0.47	0.47
		<i>Nibea maculata</i>	-	0.24	0.24	0.48
		<i>Otolithes ruber</i>	-	1.18	0.24	1.42
22	Scombridae	<i>Auxis richiei</i>	-	1.65	-	1.65
		<i>Restrelliger kanagurta</i>	-	4.02	-	4.02
		<i>Scomber austerlasics</i>	-	3.07	-	3.07
23	Serrianidae	<i>Epinephelus erythrurus</i>	-	0.24	-	0.24
24	Siganidae	<i>Siganus canaliculatus</i>	-	0.7	-	0.7

S.No.	Family	Species	Season			
			Autumn inter-monsoon%	South-inter monsoon %	Southwest monsoon %	Grand total
		<i>Siganus luridus</i>	-	-	0.7	0.7
25	Sparidae	<i>Acanthopagrus berda</i>	-	0.24	-	0.24
		<i>Rhabdosargus sarba</i>	-	0.24	0.24	0.48
26	Triacanthidae	<i>Triacanthus biaculeatus</i>	-	0.7	-	0.7
		<i>Trichiurus lepturus</i>	0.24	-	0.71	0.95
		<i>Triacanthus nieuhofii</i>	-	-	0.24	0.24
		Total	12.32	79.41	8.27	100

Table 2. Categorical CPUE Estimation of Total Catch

	Categories	
	Target (kg)	Bycatch (kg)
Range	1.87	28.34
Percentage	19.39	80.61
CPUE (kg/hour)	0.00	0.47
CPUE (kg/haul)	1.25	18.89
CPUE (T.kg/T.T.species)	16.99	1.12

Figures

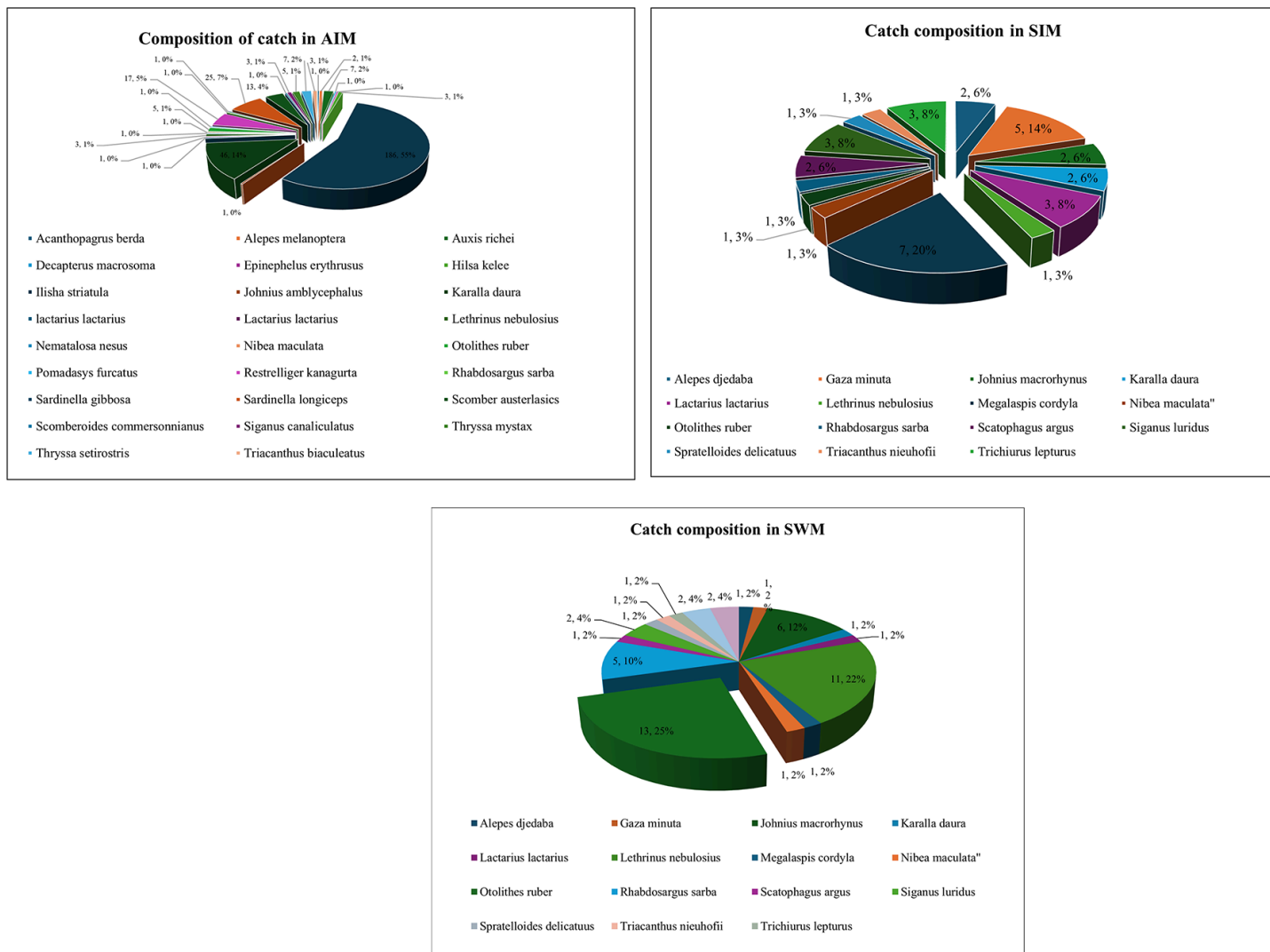


Figure 1

Composition of the catch by different seasons with an abundance of biomass.

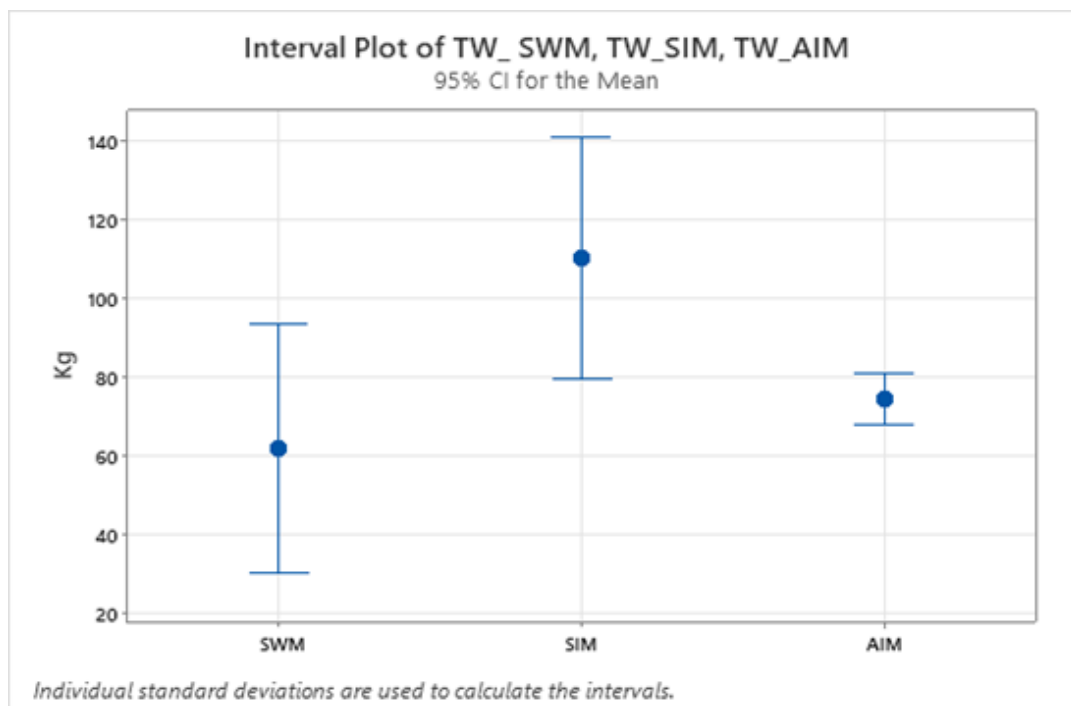


Figure 2

Conventional presentation of different season catches in kg (TW=Total weight, SWM=Southwest monsoon, SIM=South inter monsoon, and AIM=Autumn inter monsoon).

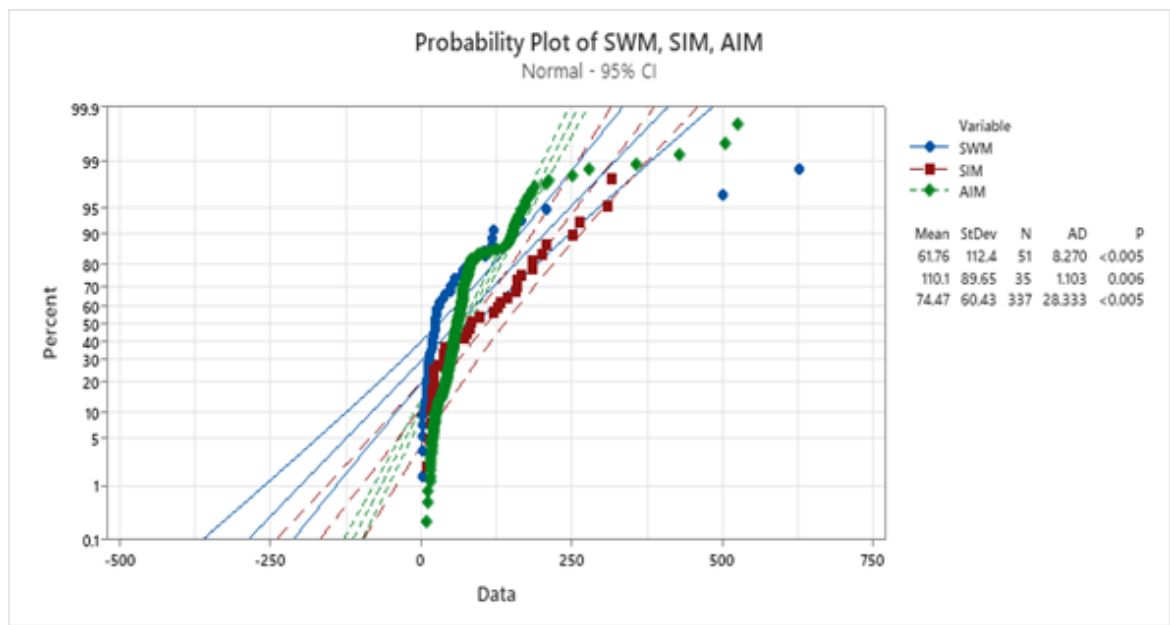


Figure 3

Probability plot of all seasons catch and percentage with the Anderson-Darling (AD) and p value. N = number of individuals, AD=Anderson-Darling, SWM= South winter monsoon, SIM= South inter monsoon, AIM= Autum inter monsoon.