Social, economic and trade characteristics of the elasmobranch fishery on Unguja Island, Zanzibar, East Africa.

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Abstract

Understanding the socio-economic drivers underpinning fishers' decisions to target elasmobranchs is considered vital in determining sustainable management objectives for these species, yet limited empirical data is collected. This study presents an overview of elasmobranch catch, trade and socio-economic characteristics of Zanzibar's small-scale, artisanal fishery. The value of applying this information to future elasmobranch fisheries policy is demonstrated. In August 2015, interviews were conducted with fishers (n=39) and merchants (n=16) at two landing sites, Kizimkazi-Dimbani and Mkokotoni, along with the main market site in Stone Town. Additionally, elasmobranch catches were recorded across the same locations between June and August 2015. Elasmobranchs were listed as target species by 49% of fishers interviewed. Whilst most fishers (n=30) stated that 76-100% of their household income came from fishing, there was variation in how elasmobranch catch and trade contributed. One-third of fishers (n=36) that caught and sold elasmobranchs reported that 41-60% of their income came from elasmobranch catch. However, for some fishers (n=8) elasmobranch catch represented 0-20% of their income, whilst for others (n=4) it represented 81-100%. Differences in fisheries income and elasmobranch price could be attributed to several interacting factors including season, weather, fishing effort, fishing gear, target catch and consumer demand. Further, elasmobranch price was influenced by size and species. The study revealed information on catch, trade, markets and socio-economy that is important for future research, conservation and management of elasmobranchs and fisheries in Zanzibar. The methods utilised have potential for broader application to understudied, artisanal elasmobranch fisheries in the western Indian Ocean.

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1. Introduction

The global decline of elasmobranch populations is both a species conservation and socio-economic concern. As apex and meso-predators, loss of elasmobranchs could have severe ecological impacts [1], [2] and [3], with wider implications for the health of marine ecosystems and the associated dependent livelihoods. Furthermore, elasmobranchs are of social and economic importance in many parts of the world, as a source of income and dietary protein through fisheries catch and trade [4], as well as income generated through tourism [5]. Elasmobranchs' k-selected life history (slow growth, late maturity and low fecundity) means they are particularly vulnerable to fisheries mortalities and typically have a lower chance of recovery from population decline, making sustainable harvest problematic [6], [7] and [8]. Fisheries are widely considered the primary driver of elasmobranch population decline worldwide, both through targeted and incidental catch [9], [10] and [11], but in many regions the data and understanding necessary to effectively manage them are lacking. Specifically, limited information exists on elasmobranch catch trends and the socio-economic drivers influencing these fishing practices; both of which are needed to design policy to support appropriate, context specific management measures

Given the anthropogenic impacts elasmobranchs face, the wider effects on marine ecosystem health and the socio-economic importance of this marine resource, it is difficult to both successfully protect and sustainably manage these species at the same time. Thus, appropriate management that is locally context specific is crucial for future sustainability of elasmobranch fisheries. By addressing gaps in the data and tailoring policy to account for socio-economic characteristics, elasmobranch fisheries could be better managed [12] and [13]. One approach is through interviewing fishers to collate their local knowledge of the fishery [14] and [15]. Fisheries management should balance the social dimensions of fisher behaviour with reliable catch and species composition information. Currently, ineffective management, poor enforcement and unregulated fishing mean elasmobranch populations are still declining [16].

Presently, elasmobranch catch trends are widely underreported making it difficult to accurately assess these fisheries [6] and [17]. Of the 1041 elasmobranch species assessed on the IUCN Red List, 18.1% are classified as critically endangered, endangered or vulnerable, whilst 43.1% are data deficient [18]. In some regions, such as the western Indian Ocean (WIO), where coastal communities are highly dependent on small-scale fisheries (SSF) for food security, nutrition, income generation and well-being, the extent to which elasmobranchs are targeted compared with incidental catches is unclear. Despite an estimated 137 million people worldwide involved in SSF [19], their importance in poverty alleviation and food security, as well as their likely significant contribution to catch, they are often overlooked compared to industrial fisheries [20], [21], [22] and [23].

Zanzibar is part of the United Republic of Tanzania and has jurisdiction over the fishing grounds located within its 12 nautical mile zone [21]. Zanzibar's fisheries are primarily artisanal, supporting approximately 27200 artisanal fishermen, a further 27200 subsistence fisherwomen and 2140 fish traders [24]. In 2010, the most recent year data are available for, there were a total of 212 fisheries landing sites and an estimated 8600 fishing vessels in Zanzibar. Fishing occurs throughout the year, with peak times relating to two monsoon seasons, generating an estimated annual yield of 31000 tons, mostly consumed locally. Fish is the most important source of dietary protein [25]. Zanzibar's fisheries are comprised mainly of traditional wooden fishing boats, typically powered by sails, but increasingly common are outboard engine powered fibreglass boats. Fishing gears commonly used include lines (longline, hand line and troll line), nets (drift gill, set gill, shark, scoop, cast and ring), seine (purse and beach), traps, fences and spears [24]. Target species include large pelagic fish such as tuna (*Thunnus* spp.); small pelagic fish such as sardines (*Sardinella* spp.); coral reef fish such as grouper (*Epinephelus* spp.); lobster (Nephropidae) and octopus (Octopodidae). Sharks are targeted for their fins, meat, liver, skin, cartilage, jaws and teeth [26] and [Temple, pers. obs.]. Batoids are targeted for their meat and liver, with fins also harvested from guitarfish (Rhinobatidae). The practice of finning where only fins are taken and the rest of the animal is discarded appears rare [26]. A market for mobulid ray gill plates [27] does not yet appear to have developed [Temple, pers. obs.]. Capture production of sharks, batoids and chimaeras for 2013 in Zanzibar was reported by the FAO as 1776mt but available data does not distinguish between species [28].

This study aimed to assess the dependence of local communities on Zanzibar's artisanal elasmobranch fishery by investigating catch, trade and socio-economic characteristics. Further, the socio-economic importance of the elasmobranch fishery, relative to fishers' and merchants' occupations in general was also assessed. The objectives were to explore how this was affected by the seasonality of catch availability in Zanzibar's fisheries, fishing practices and variation in elasmobranch price. The way in which this information can be utilised for future elasmobranch fisheries policy is also demonstrated.

2. Methods

2.1. Study area

Zanzibar is located in the western Indian Ocean off the coast of Tanzania and consists of two islands: Pemba and Unguja. The majority of fishing vessels and fisheries landing sites are located in Unguja (Fig. 1) [24]. The tropical climate of the islands is defined by two monsoon seasons and a longer rainy season in April/May. The Southeast monsoon season ('Kusi') occurs from June to September and is characterised by strong winds, whilst the Northeast monsoon season ('Kaskazi') between November and March is characterised by lighter winds and short rains [29].

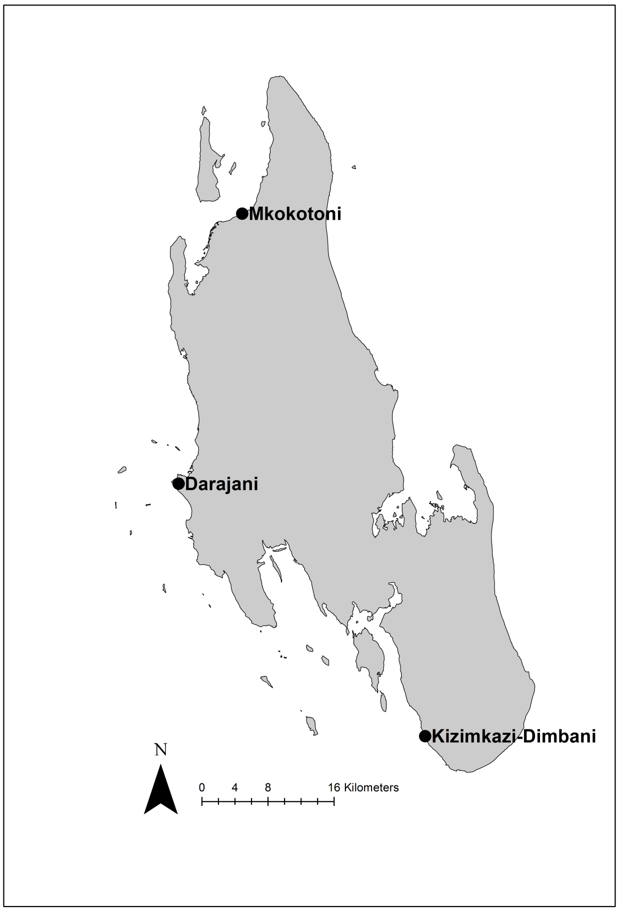

Fig. 1 Locations of the study sites (Kizimkazi-Dimbani: 6°16′12"S, 39°27′12"E; Darajani market, Stone Town: 6°9′44"S, 39°11′36"E; and Mkokotoni: 5°52′30"S, 39°15′18"E) on Unguja Island, Zanzibar, East Africa, where sampling took place between 28 June and 22 August 2015.

Data were collected using face-to-face questionnaire-based interviews between 7 and 21 August 2015 in Unguja. Interviews were carried out with both fishers and merchants and included questions that covered both the Kusi and Kaskazi seasons. Fishers' (n = 39) and merchants interviews (n = 2) were undertaken in Kizimkazi-Dimbani (6°16′12"S, 39°27′12"E), with merchants' interviews also conducted in Mkokotoni (n = 10) (5°52′30"S, 39°15′18"E) and the Darajani market in Stone Town (n = 4) (6°9′44"S, 39°11′36"E) (Fig. 1).

In addition to interview data, elasmobranch catch was sampled between 28 June and 22 August 2015 during the Kusi season. This included elasmobranchs sold at the Darajani market and those landed in Kizimkazi-Dimbani and Mkokotoni.

2.2. Survey design

Fishers and merchants were asked for verbal consent to participate in the survey and anonymity was guaranteed before undertaking the face-to-face interview. Interviews were carried out in private with only the interviewee, translator and interviewer present. Main interview questions recorded qualitative and quantitative data on fishers' target catch and fishing gear; the primary fish species sold and fish landing sites used to source elasmobranchs for sale by merchants; and income and historic changes in the abundance and value of elasmobranchs. Fishers and merchants were asked to list the elasmobranchs they commonly caught or bought by their local Swahili name. Local names were matched with the elasmobranch species by direct identification of catch to record the correct scientific name. Interviews were conducted in Swahili, directly translated and recorded in English. Interviews lasted 15 - 20 minutes and were arranged at the convenience of the fishers and merchants.

2.3. Elasmobranch catches data and trade information

Elasmobranch catches data were collected during daylight hours at the two landing sites, Kizimkazi-Dimbani and Mkokotoni. The data recorded included: species, local common name, fishing gear, weight in kg, size in cm (shark and guitarfish total length; batoid disc width) and sale price in Tanzanian Shillings (TZS; 1TZS = 0.7 British pounds or 0.9 US dollars). Data were collected with permission and assistance from local fishers. A total of 480 elasmobranchs were sampled (Kizimkazi-Dimbani, n = 225; Mkokotoni, n = 146; Darajani market, n = 109). Sale prices were recorded for 153 of the elasmobranchs sampled in TZS (Kizimkazi-Dimbani, n = 78; Mkokotoni, n = 36; Darajani market, n = 39). The trade of two thirds (n = 150) of the elasmobranchs landed at Kizimkazi-Dimbani (n = 225) was also recorded.

2.4. Data analysis

Maximum income for the Kusi (June to September) and Kaskazi (November to March) seasons stated during fishers' interviews in Kizimkazi-Dimbani was used to investigate if there was a significant difference in income between the two seasons for fishers interviewed. Elasmobranchs used for subsistence purposes had no monetary value and were excluded from price data analyses. Guitarfish were excluded from ray price data analysis because their body form is more similar to that of sharks, which affects their monetary value and could skew the results. Price per unit weight (TZS/kg) was calculated for a total of 86 elasmobranchs sold from landings in Kizimkazi-Dimbani and Mkokotoni. Price at first sale (TZS/kg) and weight (kg) data of elasmobranchs were used to investigate if there was a significant correlation for sharks or rays. Elasmobranch species with less than four sale values recorded were excluded from species comparisons due to the low sample size. Price at first sale data was also used to investigate if there was a significant difference in median price among four shark species and among five ray species.

The Kolmogorov-Smirnov test was used to test for normality and Levene's test was used to test for equality of variance. If the assumptions for a parametric test were not met and data could not be transformed, then an alternative non-parametric test was utilised. Where post hoc analysis was required, Bonferroni adjustment was used to control for type 1 error. Statistical tests were conducted using SPSS Statistics 22. A significance level of 5% was used.

3. Results

3.1. Interview data

All fishers (n = 39) interviewed in Kizimkazi-Dimbani stated that fishing was their primary occupation, with the majority (n = 38) fishing for both subsistence and sale purposes, and only one fisher stating he fished solely for subsistence purposes. The majority of fishers (n = 30) stated that 76 - 100% of their household income came from fishing illustrating a high level of dependence on this activity for income generation. The household income of some fishers (n = 7) was 100% dependent on their fishing occupation as the sole income for their household, whilst others reported they had additional income from supplementary occupations (n = 20) or their wives' occupation (n = 8). Supplementary occupations included agriculture, tourism and maintenance of boat engines, whilst wives' occupations included tailoring, agriculture and beachcombing. There was no statistically significant difference in mean annual income of fishers in Kizimkazi-Dimbani between the Kusi (mean = 577077 ± 662218 TZS S.D.) and the Kaskazi seasons (mean = 764513 ± 1085776 TZS S.D.) (t-test, t = -0.885, df = 76, $P > 0.05$). Nevertheless on an individual basis, fishers stated different reasons for earning more in a particular season (Table 1). The reasons that were given covered weather, fishing effort, gear, target catch and consumer demand. The majority of merchants interviewed at the three locations stated that trading fish was their primary occupation (n = 15) and that 76-100% of their household income came from this occupation (n = 11). Merchants reported supplementary occupations (n = 7) such as agriculture and auctioneering, whilst one merchant also reported that his wife's occupation of baking and agriculture supported their household income. Those that did not have supplementary incomes or additional income from their wives stated that their household income was 100% dependent on their occupation as a merchant (n = 9). Like the fishers, there was variation in whether merchants earned more during the Kusi or Kaskazi seasons (Table 1). Of the fishers (n = 36) that caught and sold elasmobranchs, one third reported that 41-60% of their income came from elasmobranch catch. Of the merchants (n = 16) that sold elasmobranchs, 31% reported that 61-80% of their income came from selling elasmobranchs. However, for some fishers (n = 8) and merchants (n = 1) elasmobranch sale represented 0-20%, whilst for other fishers (n = 4) and merchants (n = 2) it represented 81-100% of their income. This was supported by variation in the reported number of elasmobranchs caught by fishers in the past year. For example, 36% of fishers that stated they caught sharks (n = 36), reported they had caught between 1 - 10 sharks in the past year, whilst 19% reported they had caught over 50 sharks. Similarly, 34% of fishers that stated they caught rays (n = 35), reported they had caught between 1 - 10 rays in the past year, whilst 17% reported they had caught over 50 rays.

Table 1.

Reasons stated by fishers (n = 27) and merchants (n = 14) for earning more during the 'Kusi' or 'Kaskazi' monsoon season during questionnaire surveys conducted between 7 and 21 August 2015 in Kizimkazi-Dimbani, Mkokotoni and Stone Town, Unguja Island, Zanzibar. The number of fishers that stated each reason is given in parentheses.

Higher Income in Kusi		Higher Income in Kaskazi	
Fishers	**Merchants**	**Fishers**	**Merchants**
Higher elasmobranch price/demand: earns more from elasmobranchs (5)	Fish less abundant so higher value (1)	Calmer seas: increased fishing effort and higher catch (7)	Fish more abundant & larger (5)
Calmer seas: increased fishing effort (3)	Elasmobranchs targeted have a higher sale price than other fish species caught, generating a higher income (1)	Fish more abundant (4)	Calmer seas: higher fish catch (3)
Cooler seas: greater abundance of fish (3)	Calmer weather: increased number of fishing vessels active (1)	Fish species caught have a higher sale price (2)	More boats/fishers: higher fish catch (2)
Increased fishing effort (3)		More bait (1)	Season where fish are more abundant (2)
Gear used catches more fish (1)		Increased demand & abundance of fish (1)	
Gear used & greater abundance of fish (1)			
Strong winds: fewer fish caught so increased sale price (1)			
Fish species caught have a higher sale price (1)			

Of fishers (n=39) surveyed, 69% and 84% considered shark and batoid numbers respectively to have decreased in their fishing grounds, whilst 69% and 87% considered the sale value of sharks and batoids respectively to have increased since they had first started fishing, which ranged from 3 - 51 years. Fishers offered reasons such as overfishing (n = 5) for the stated decrease in elasmobranch numbers and reasons such as lower catch (n = 3) and increased demand (n = 8) for the stated increase in elasmobranch value (Table 2). It was also reported that price fluctuated with supply and demand. For example, throughout the holy month of Ramadan (17 June-18 July 2015; the majority of Zanzibar's population follow Islam) and during periods of bad weather, lower fishing effort and catch increased the sale value of fish caught. Some fishers commented that they took advantage of this to obtain higher prices for their catch when there was lower fishing effort or poorer sea state. Despite the fluctuating price of elasmobranch catch, fishers had consistent costs, including vessel fuel, public transport and bait. Salaries for those who helped transport elasmobranchs, either from the vessel to the landing site or to the Darajani market in Stone Town (the main location where fish was sold) were an additional cost. It was also reported that money was put aside for vessel and gear repairs. All fishers stated that the remaining profit from the sale of catch was split equally between all boat crew including the captain.

Table 2.

Reasons stated by fishers (n = 30) for changes in elasmobranch abundance and sale value since they started fishing (range 3 - 51 years) during questionnaire interviews conducted between 7 and 21 August 2015 in Kizimkazi-Dimbani, Unguja Island, Zanzibar. The number of fishers that stated each reason is given in parentheses.

Elasmobranch	**Reported change in abundance**			**Reported change in sale value**	
	Increased	**Decreased**	**No change**	**Increased**	**Decreased**
Sharks	Low fishing pressure: not highly targeted (1)	Highly fished (4) Increased technology, numbers of vessels and improved gears (3) Decrease of larger sharks (2) Climatic change (2) Large foreign vessels (2) Fishers from northern Zanzibar extending their fishing grounds (1) Poor technology: decreased catch (1) Less bait to target fish: decreased catch (1)	No change in smaller sharks (2) Catch has always fluctuated but no overall change (1) Still abundant in known areas (1)	Lower catch so higher price (3) Higher cost of living: natural increase in price (3) Increased demand for fins so higher sale price (2) Increased demand (2) Increased price of meat (2) Seasonal fluctuation in sale value but overall increase (1) Increased tourism (1) Increased consumption and therefore demand (1)	Reduced demand for fins so lower price (4) Reduced consumption and therefore demand (2) Reduced demand (2) Restrictions on exporting fins (1)

Batoids	Climatic change (2) Increased numbers due to pup release (1) Highly fished (1) Gears used more efficient at catching rays so increased catch (1)	Highly fished (5) Increased technology & improved gears (2) Fishers from northern Zanzibar use bottom-trawl so overfished (2) Decrease in all fish (1) Climatic change (1) No longer use fence traps so lower catch (1) Not targeted as much so lower catch (1)	Increased consumption and therefore demand (6) Increased tourism (3) Higher cost of living: natural increase in price (3) Fewer caught so higher price (3) Overall increase but still seasonal fluctuation (2) Increased demand and decreased catch (2)

Of fishers (n = 39) interviewed in Kizimkazi-Dimbani, 69% stated that they used their main gear 6 - 7 days per week as a yearly average. Some fishers commented that poor weather conditions (n = 2) and lack of bait (n = 4) were reasons why they might fish less, with many also reporting that they did not fish on Fridays and that there was less fishing during the holy month of Ramadan. Longline was used by 59% of the fishers interviewed but responses indicated that fishers' main gear altered at different times of the year depending on the season, weather constraints and target preferences. Top targets were mainly large pelagic fish such as tuna as well as coral reef fish including grouper. Elasmobranchs were listed by 49% of fishers as target species; these fishers mostly used longline as their main gear. Handline, bottom-set gillnets and drift gillnets were reported as additional gear that sometimes caught elasmobranchs, despite not targeting them.

The majority of the 39 fishers caught batoids (n = 35) and sharks (n = 36), with 38 fishers reporting that they sold the majority of the catch. The price range stated in interviews for shark or guitarfish fins was 10-35,000TZS/kg with bottlenose wedgefish (*Rhynchobatus australiae*) fins considered the most valuable and highest quality for consumption. The fins of small sharks were discarded. The value of meat also varied for different species depending on the perceived quality. For example, the meat of hammerhead sharks (*Spyrna* spp.) was considered of high quality whilst tiger sharks (*Galeocerdo cuvier*) and blotched stingrays (*Taeniurops meyeni*) were viewed as lower quality, due to their 'consumption of anything' and 'watery flesh', respectively. The mean price of two smooth hammerhead sharks (*Sphyrna zygaena*) recorded in this study was 2995TZS/kg compared to 2778TZS/kg recorded for two tiger sharks and 562TZS/kg for four blotched stingrays (Table 3).

Table 3.

Mean weight (kg) and price (TZS/kg) of elasmobranch species (n = 13) recorded in Kizimkazi-Dimbani (KI), Mkokotoni (MK) and the Darajani market (DA) on Unguja Island, Zanzibar between 28 June and 22 August 2015. Local swahili names in bold were reported in fisher and merchant interviews as the primary elasmobranchs caught and sold. The number of specimens used to calculate mean values are reported in parentheses. An additional 15 species were recorded with a sample size < 10 specimens. ND = no data.

Elasmobranchs: scientific name (common name), local Swahili name	**Mean weight (kg)**			**Mean price (TZS/kg)**		
	KI	**MK**	**DA**	**KI**	**MK**	**DA**
Neotrygon caeruleopunctata (Bluespotted maskray), Katwe mweupe	1.0 (28)	1.5 (32)	1.5 (1)	471 (8)	ND	ND
Himantura uarnak (Coach whipray), **Taa chui**	44 (17)	26 (14)	31.25 (4)	1401 (10)	2169 (6)	1299 (2)
Taeniura lymma (Bluespotted fantail ray), Katwe bluu	1.5 (19)	1.5 (26)	1.0 (2)	0 (1)	1333 (2)	1600 (1)
Maculabatis ambigua (Baraka's whipray), **Taa mweupe,** Nyenga	ND	10 (40)	18 (7)	ND	2681 (15)	1579 (1)
Mustelus spp. (Smoothhound shark), Papa kinengwe (sg.)	5.0 (36)	ND	ND	143 (7)	ND	ND
Rhizoprionodon acutus (Milk shark), **Papa vinengwe (pl.)**	4.0 (14)	2.0 (3)	4.0 (10)	1321 (7)	ND	4167 (4)
Squalus spp. (Spurdog shark), Papa kinengwe (sg)	20 (8)	ND	3.0 (18)	0 (1)	ND	ND
Hemipristis elongata (Snaggletooth shark), Papa manyu	33 (9)	29 (1)	8.0 (11)	2598 (4)	2655 (1)	3625 (3)
Carcharhinus leucas (Bull shark), **Papa Sumbwe**	95 (13)	ND	80 (1)	3677 (5)	ND	2475 (1)
Dasyatis thetidis (Thorntail stingray), **Taa mweupe**	72.5 (11)	ND	ND	1577 (6)	ND	ND
Acroteriobatus zanzibarensis (Zanzibar guitarfish), Barrobarro	2.0 (3)	1.0 (3)	2.0 (5)	0 (2)	4000 (1)	2000 (1)
Aetobatus ocellatus (Spotted eagle ray), **Pungu**	ND	23.69 (8)	21.75 (2)	ND	23.69 (8)	2000 (2)
Taeniurops meyeni (Blotched stingray), **Taa maji**	40 (7)	21 (1)	22.5 (2)	543 (2)	581 (1)	581 (1)

3.2. Elasmobranch landings and trade data

The trade of 150 elasmobranchs landed at Kizimkazi-Dimbani was documented; 86% were sold whilst the remainder were used for subsistence purposes (food or bait) (Fig. 2). This equated to 98.7% of the total weight landed being sold. One third of those used for subsistence purposes were smooth-hound sharks (*Mustelus* spp.), whilst another third were bluespotted maskrays (*Neotrygon caeruleopunctata*) and all were ≤ 7kg. Although 43% of elasmobranch landings were sold locally in Kizimkazi-Dimbani, this only equated to 4.3% of the total weight sold. This was compared to 92.1% of the total weight landed (50% of total landings) being sold at the Darajani market in Stone Town. Of those sold at the Darajani Market (n = 65), 62% (50.5% of the total weight sold) were traded through a local merchant who bought elasmobranchs at Kizimkazi-Dimbani landing site and transported them to the Darajani market for sale. Some elasmobranchs (n = 9) were also traded through a second merchant who sold them in a nearby town, Makunduchi (Fig. 2). Generally, elasmobranchs taken for sale outside the village were bought whole. At the Darajani market, large elasmobranchs were finned, with the remainder auctioned whole or in parts, typically quartered for sharks and halved for batoids. For example, a quarter of a bull shark (*Carcharhinus leucas*), approximately 2.5m in length (based on two specimen: 242cm and 252cm total length) ranged from 100 - 160,000TZS, whilst its fins sold for 105,000TZS (17 - 19% of the total price). Merchants with stalls at the Darajani market would sell slices of meat or smaller whole specimens.

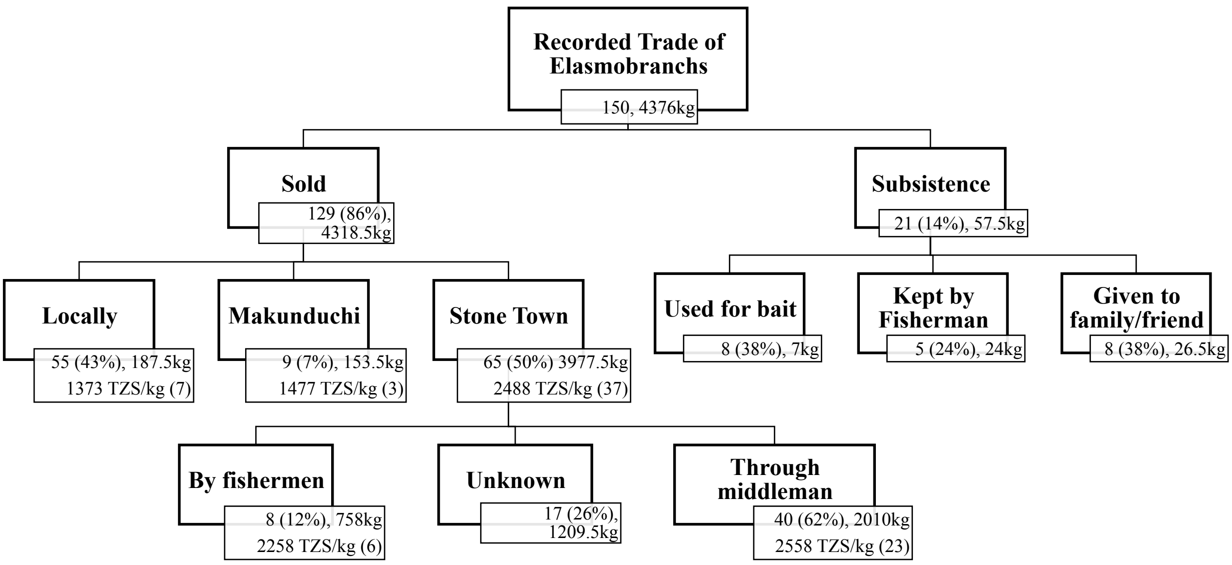

Fig. 2 Recorded trade of elasmobranchs (n = 150) from Kizimkazi-Dimbani, Unguja Island, Zanzibar between 28 June and 22 August 2015 utilised for subsistence or sale purposes**.** The number of elasmobranchs is stated with the percentage of total number recorded in parentheses, followed by total weight (kg). Mean sale prices (TZS/kg) are also indicated with the number of recorded specimens' values are based on given in parentheses.

Of elasmobranchs (n = 208) landed in Kizimkazi-Dimbani with recorded weights, 57.7% were caught by longline, making it the predominant fishing gear for catching elasmobranchs during the sampling period (Table 4). The prices at first sale (TZS/kg) of elasmobranchs from the two landing sites were analysed to indicate whether the weight of elasmobranchs influenced their price. There was a statistically significant positive correlation between the first sale price/kg and weight of sharks (Spearman Rank Correlation Coefficient, $r_s = 0.705$, n = 29, $P < 0.05$) and a statistically significant negative correlation between the first sale price/kg and weight of rays (Spearman Rank Correlation Coefficient, $r_s = -0.652$, n = 57, $P < 0.05$) (Fig. 3). Three specimens of shark ray (*Rhina ancylostoma*) [total lengths (cm) = 167, 194, 196; total weights (kg) = 60, 69, 55; first sale price (TZS/kg) = 1417, 1159, 1455] and two specimens of bottlenose wedgefish [total lengths (cm) = 276, 301; total weights (kg) = 147, 169; first sale price (TZS/kg) = 4286, 3728] were also recorded at Kizimkazi-Dimbani landing site.

Table 4.
Number and weight (kg) of elasmobranchs landed by different gears in Kizimkazi-Dimbani, Unguja Island, Zanzibar between 28 June and 22 August 2015 including the percentage of total number of elasmobranchs landed (n = 208) and percentage of total weight (5243kg) landed by all gears.

Gear	No. elasmobranchs landed	% of total no. landed	Weight landed (kg)	% of total weight landed
Longline, big hooks	36	17.30	2175	41.50
Longline, small hooks	30	14.40	575	10.95
Longline, unspecified	54	26.0	2069	39.45
Bottom-set gillnet	38	18.30	83	1.60
Unspecified net	2	0.95	5	0.10
Handline	2	0.95	47	0.90
Spear	12	5.70	16	0.30
Unspecified gear	34	16.40	273	5.20
Total	**208**	**100**	**5243**	**100**

Elasmobranchs were further analysed to investigate if there were any species differences in the price at first sale among sharks and rays landed. There was a statistically significant difference in the median price of bull sharks (median = 2500 ± 2575 TZS/kg range), grey reef sharks (*C. amblyrhynchos*) (median = 2628 ± 2259 TZS/kg range), snaggletooth sharks (*Hemipristis elongata*) (median = 2655 ± 1036 TZS/kg range) and milk sharks (*Rhizoprionodon acutus*) (median = 1250 ± 667 TZS/kg range) (Kruskal-Wallis test, K =

13.7, df = 3, $P < 0.05$) (Fig. 4). Bull sharks, grey reef sharks and snaggletooth sharks all had a significantly greater median price/kg compared to milk sharks (Mann-Whitney *U*-test, $P < 0.008$) but were not significantly different in median price/kg from each other (Mann-Whitney *U*-test, $P > 0.008$). There was a statistically significant difference in the median price of thorntail stingrays (*Dasyatis thetidis*) (median = 1408 ± 1088 TZS/kg range), coach whiprays (*Himantura uarnak*) (median = 1656 ± 3574 TZS/kg range), Javan cownose rays (*Rhinoptera javanica*) (median = 2000 ± 2935 TZS/kg range), Baraka's whiprays (*Maculabatis ambigua*) (median = 3000 ± 5703 TZS/kg range) and spotted eagle rays (*Aetobatus ocellatus*) (median = 3556 ± 2711 TZS/kg range) (Kruskal-Wallis test, K = 16.6, df = 4, $P < 0.05$) (Fig. 4). Baraka's whiprays were significantly greater in price/kg than thorntail stingrays and coach whiprays (Mann-Whitney *U*-test, $P < 0.005$) but were not significantly different in price/kg to Javan cownose rays or spotted eagle rays (Mann-Whitney *U*-test, $P > 0.005$). Thorntail stingrays, coach whiprays, Javan cownose rays and spotted eagle rays were not significantly different in price/kg from each other (Mann-Whitney *U*-test, $P > 0.005$).

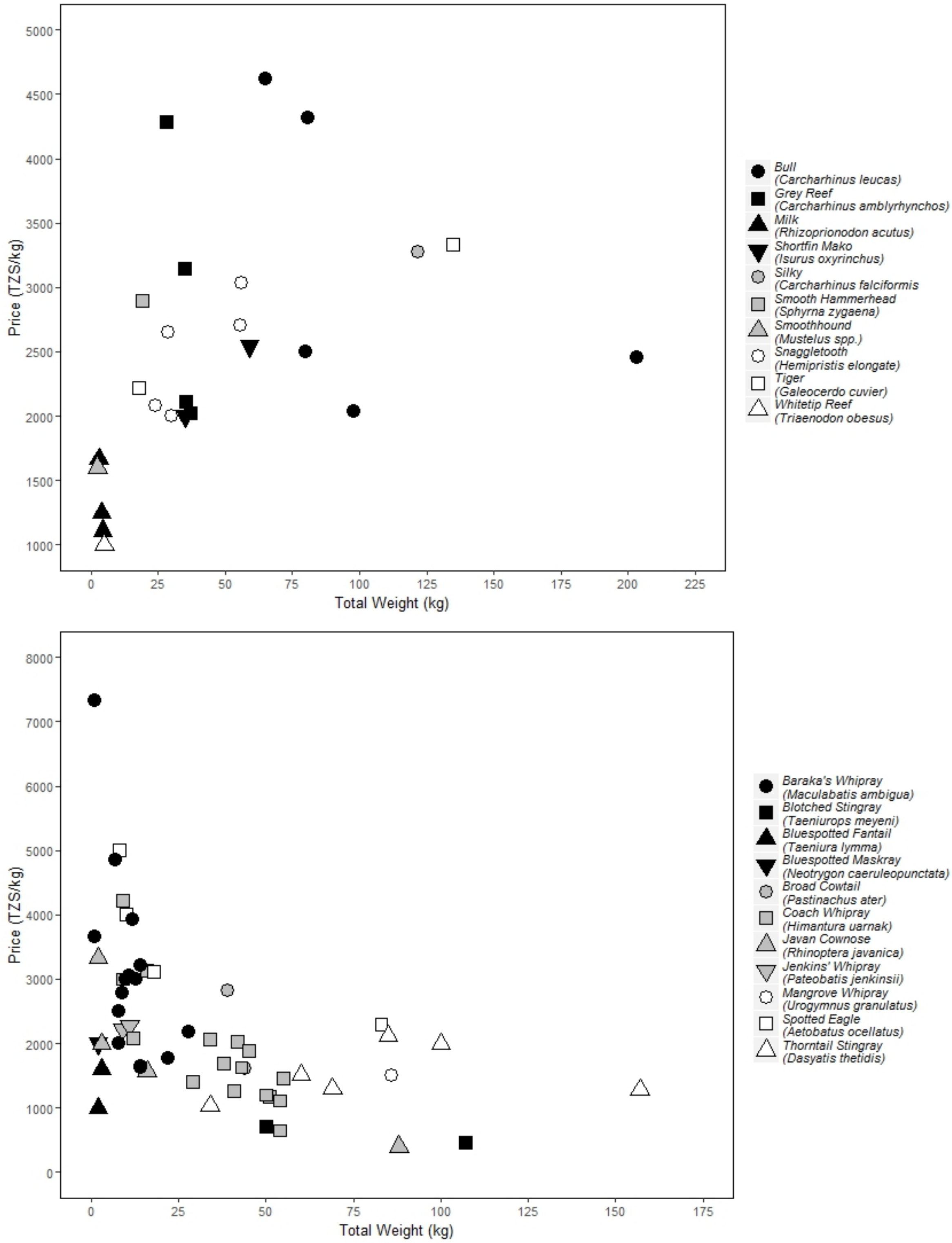

Fig. 3 First sale price (TZS/kg) and total weight (kg) of **a)** ten species of sharks (n = 29) and **b)** eleven species of rays (n = 57) landed in Kizimkazi-Dimbani and Mkokotoni, Unguja Island, Zanzibar between 28 June and 22 August 2015.

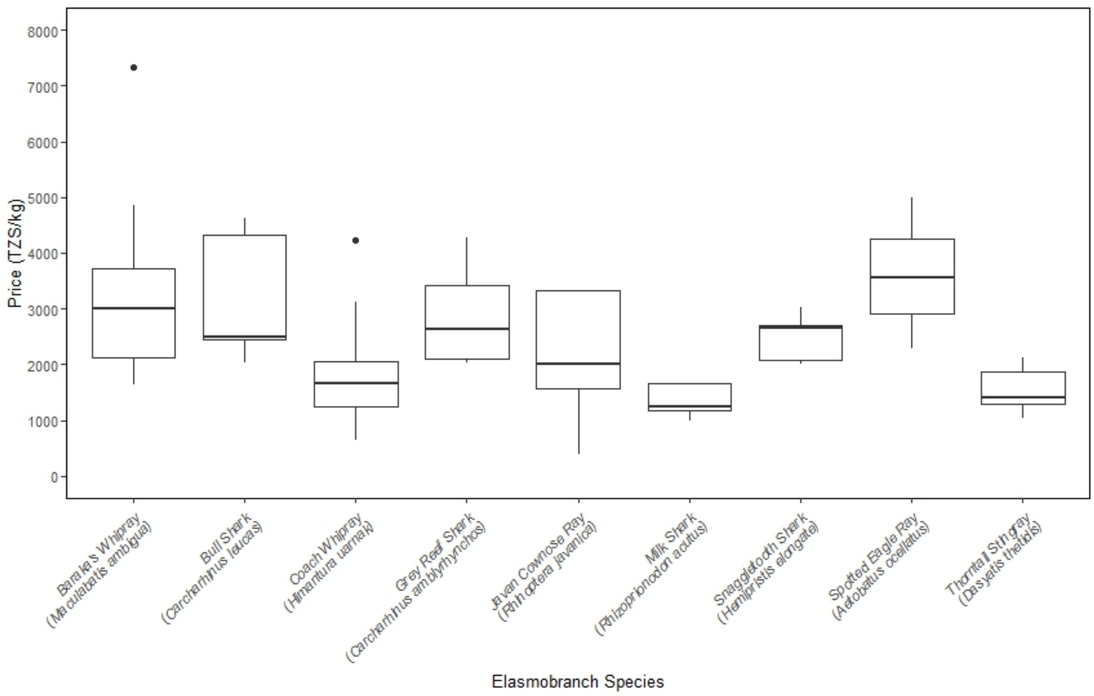

Fig. 4 Median (± lower and upper quartiles, ± range) price at first sale (TZS/kg) of four species of sharks (n = 21) and five species of rays (n = 47) landed in Kizimkazi-Dimbani and Mkokotoni, Unguja Island, Zanzibar between 28 June and 22 August 2015. Baraka's whiprays (*Maculabatis ambigua*) were significantly more expensive than thorntail stingrays (*Dasyatis thetidis)* and coach whiprays (*Himantura uarnak*). Milk sharks (*Rhizoprionodon acutus*) were significantly cheaper than the other three shark species.

4. Discussion

This study investigated the dependence of local communities in Zanzibar on elasmobranch catches and trade, as a source of income and subsistence. This represents the first initiative to assess empirical data for determining the socio-economic value of an artisanal elasmobranch fishery in the western Indian Ocean. This information is useful for understanding the broader implications of fisheries management measures on fishers and their communities especially in a livelihood dependence and policy development context. The household incomes' of fishers and merchants interviewed were highly dependent on fishing as their primary occupation, with 77% of fishers (n = 39) and 69% of merchants (n = 16) stating that 76 - 100% of their income came from this activity. The relative importance of elasmobranch catch and trade to the income generated by being a fisher and merchant was influenced by a combination of interacting factors including season, weather, fishing effort, fishing gear, target catch and consumer demand. These factors, along with size and species, caused variation in elasmobranch price per kilo.

Often, seasonal differences were cited as main reasons for variation in the sale value of fisheries catch and income generated. However, the situation was much more complex than comparing the two monsoon seasons, with fluctuations in catch and price on smaller temporal scales, as well as individual differences in gear use and target catch preferences. This may account for contradicting reasons given by different fishers and merchants for which season their income was higher (Table 1). Whilst this can make it difficult to interpret results, it also highlights the importance of fishers' knowledge in understanding the complex drivers influencing their fishing practices. Some fishers reported that seasonal differences in elasmobranch catch and price influenced in which season their income was higher (Table 2). For example, five fishers reported that they earned more in the Kusi season due to a higher demand and therefore higher price for elasmobranchs. Fluctuation in elasmobranch price, and income generally, was evident over smaller temporal scales due to factors including weather, fishing effort, bait availability and cultural reasons. Findings from this study suggested that fishers interviewed utilised different fishing gears and altered their target catch with these temporal fluctuations. Engaging in multiple fisheries provides social and economic resilience by adapting to temporal changes in climate and available catch, and should be accounted for in fisheries management [30].

Fluctuation in elasmobranch price was evident historically, seasonally and over smaller temporal scales. The majority of fishers interviewed in this study reported that elasmobranch numbers had decreased in their fishing grounds, whilst value had increased since they first began fishing (Table 2). Fishers perceived changes in elasmobranch catch as the result of a range of factors such as overfishing, with an increased number of vessels and more efficient gear. Changes in value were perceived due to combined factors of lower catch and increased demand as well as a higher cost of living. However, some of the reasons cited by different fishers were contradictory, for example, some thought the demand for elasmobranch products had increased, whilst others thought it had decreased along with the sale value (Table 2). This could result from the large variation in the number of years fishers had been fishing and requires further investigation. Some fishers commented that larger sharks had decreased in number whilst smaller sharks had remained the same (Table 2). This may be a result of the typically greater vulnerability of larger elasmobranch species and corroborates the likely overexploitation and partial collapse of Zanzibar's elasmobranch fishery [31]. Further research is needed to increase understanding of these temporal changes in Zanzibar, the adaptive approach fishers and merchants employ, and the influence it has on their livelihoods, in order to aid future fisheries management.

The recorded trade of elasmobranchs from landings in Kizimkazi-Dimbani indicated that size influenced the market for elasmobranchs. Smaller specimens were kept for subsistence or sold locally, whilst larger specimens were generally sold at the Darajani market in the capital city, Stone Town (Fig. 2). Whilst there was a domestic market for elasmobranch meat in Zanzibar, the high price of fins was driven by an international export market with reports of fin traders operating from the Darajani market. Analysis of the landings data showed that first sale price/kg had a significant positive correlation with weight of sharks but a significant negative correlation with weight of rays (Fig. 3). In global markets, fins are disproportionately higher in value than meat [32]. Interview responses from this study indicated that the price of sharks and guitarfish increased with size due to large, valuable fins. For example, the fins of two bull shark specimens recorded in this study were worth nearly 20% of the total shark price. Whilst sale price is likely to vary depending on the season and availability, our findings suggest that the high fin value offsets any reduction in meat value per kilo. Any management measures would need to account for the disproportionately higher value of large sharks compared to small sharks and provide incentives to replace the market for highly valued, large fins.

Results showed that there was variation in the first sale price/kg amongst different elasmobranch species (Fig. 4). In some cases, this was likely due to inherent size differences between species, given price/kg was found to increase with weight (Table 1) (Fig. 3). For example, milk sharks were significantly cheaper per kilo compared to other shark species analysed, which could be due to their typically smaller size. Similarly, one longline fisher reported only fishing elasmobranchs for consumption due to only catching bluespotted fantail rays (*Taeniura lymma*), which were typically low in value due to their small size. However, in other cases, the 'quality' of the meat and fins for consumption was reported to vary among species and therefore to influence the price. For example, the meat of hammerhead sharks and the fins of guitarfish were considered of high quality. The lower caudal fins of hammerhead sharks and guitarfish have been reported by traders in China as a source of high quality fin needles for consumption [33], which could drive a high export value for these species in Zanzibar. Understanding the drivers of demand for elasmobranch products and the factors that influence price through methods utilised in this study is important to inform the management of elasmobranch fisheries and markets. For example, recording fin values once they are removed from specimens at the Darajani market in Stone Town would give the proportion of the total sale value that fins account for. Further, following their trade would provide insight into the influence of the international market for different products on domestic elasmobranch catch.

Understanding the variation in price among elasmobranch size classes or species could help inform a more tailored approach to fisheries management to meet both conservation and socio-economic requirements. For example, limiting fishing to particular juvenile age classes, as oppose to targeting all age classes, is a more strategic approach to addressing recruitment issues and has been shown as a potential management strategy to improve the sustainability of elasmobranch fisheries [34]. This was shown to be effective for species with lower productivity and lower natural mortality rates. This would require appropriate fisheries management, adapting fishing practices to protect adult elasmobranchs, for example through gear modification, but also appropriate knowledge of elasmobranch behaviour, for example habitat utilisation. Given that the first sale price/kg was found to decrease with increasing ray weight, fisheries may be more economically resilient to catch restrictions on larger rays since price/kg did not increase with size. It is also important to understand any variation in price between different elasmobranch species, how this influences fishers' target catch and how this could contribute to protecting more vulnerable species. However, the current lack of species-specific information on elasmobranch biology and catch composition of Zanzibar's elasmobranch fishery needs to be addressed in order to assess elasmobranch population status and recommend sustainable fishing practices.

5. Conclusions

The socio-economic importance of Zanzibar's elasmobranch fishery to local communities has not previously been determined. This is the case for the majority of countries worldwide despite wide recognition that this information can inform development of more tailored fisheries management strategies. Here, findings show that elasmobranchs caught provide a source of income, as well as subsistence. The importance of elasmobranch catch and trade in supporting fishers' and merchants' livelihoods varied according to a number of key interacting factors including season, weather constraints, fishing effort, fishing gear, target catch preferences and consumer demand. These factors contributed to fluctuation in elasmobranch catch biomass and price historically, seasonally and over shorter temporal scales. The price at first sale was also shown to vary among different elasmobranch species and size classes. This information could be utilised in tailoring locally context specific, elasmobranch fisheries management.

As a first initiative to assess the socio-economic value of an artisanal elasmobranch fishery in the western Indian Ocean, this study highlights how social, economic and trade characteristics can help inform the structure of future elasmobranch fisheries policy. However, it is important to recognise the limited spatial and temporal coverage; a larger more comprehensive study is required to accurately assess Zanzibar's elasmobranch fishery and to regionally assess elasmobranch populations. The vulnerability of many of the elasmobranch species recorded, according to their IUCN red list classification, emphasise the need for species-specific catch and biological data to be examined within the socio-economic context, so as to better understand drivers influencing catch and effort. This study has highlighted how future socio-economic research combined with population dynamic studies can identify the actions needed to better understand understudied elasmobranch fisheries locally, regionally and globally. This broader knowledge can then be used to ensure that any fisheries management methods employed will more likely have a positive impact on the health of elasmobranch stocks and the sustainability of the fisheries that target them.

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