

Full Length Research Paper

Investigating changes in fish biodiversity in coastal villages of Zanzibar Island, Tanzania

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This study was conducted at the coastal villages of Zanzibar Island to investigate changes in fish biodiversity. The methodology mostly involved face-to-face interviews and structured questionnaires. Findings of this research paper revealed that there are twenty seven families of fish species of economically importance in the study area of which Scombridae is the most dominate species. This research study shows that there is no significant difference on the distribution of fish biodiversity in the coastal villages of Kizimkazki vs. Matemwe $p>0.86$; Matemwe vs. Nungwi $p>0.09$ and Nungwi vs Kizimkasi $p>0.06$. Findings of the research study revealed that out of twenty seven families of fish species of economic importance to the household's income of the fishermen; ten families of those fish species were reported by the highly experienced fishermen to have been depleted over the last four decades. The most devastated fish species perceived by the senior fishermen includes Green hump head parrot fish, Javelin grunter, Rosy dwaft monocle bream, Twinspot red snapper, Green job fish and bicour. T-test revealed that there is a significant difference on the perception of the fishermen on the changed in fish biodiversity between the three generation. Significant result were found between younger age vs middle age $p<0.002$; high significant results were found between middle age vs old age $p<0.002$ and high significant were found between old age vs younger age $p<0.000$. Findings of the research study revealed that the highly experienced fishermen perceived that the main reasons for the decline of fish biodiversity in the coastal villages of Zanzibar Island were (a) increasing number of fishermen, (b) the uses of destructive fishing gear has devastated marine ecosystem, (c) increasing development of tourism industry have created a new demand for fish market, (d) climate variability and seasonality has contributed negatively on the decline of fish biodiversity. The research study concluded that further decline on fish biodiversity are likely to increase in future unless appropriate enforcement of laws and regulation are established.

Key words: Biodiversity, marine fisheries, perception of fishermen changed, fish species.

INTRODUCTION

Human dependence on marine ecosystem is significant, both in terms of the nutritional value provided by fish and

other seafood to the population and in terms of the level of economic security the fishing industry provides for the

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coastal communities (Warui, 2014). Despite the importance of fishery resources to national food security and economy, there is evidence that the marine artisanal fishery is economically declining and faces the threat of stock collapse with negative community and economic implications (MLFD, 2012). The impact of this term artisanal fishery is not sufficiently assessed, and the environmental and economic implications of the fishing pressure are unclear (Gotesson, 2012). The change that occurs at marine ecosystem are aggravated by natural processes, making marine ecosystems more vulnerable to changes that previously could be absorbed. The recent documentary film under the titled 'End of the line1' (www.endoftheline.com) describes the uses of highly destructive fishing gears causing severe stock decline attempted to pointed that in future oceans may be left without fish. FAO (2012) report claimed that 57.4% of global fish stocks are fully exploited, of global fisheries 29.9% are overexploited and only 12.7% are underexploited and have the potential to sustain an increase in harvest. Tanzania is not an exception in this realm, trends in the landings of marine resources as evidenced by declining yields of fish and deteriorating conditions of coral reefs suggest that it may be approaching its maximum harvest potential (van der Elst et al., 2005). Fish community appears highly degraded, a situation made worse because the overall size is generally too small indicating high capture of immature fishes. The artisanal fishery along the coastal villages of Zanzibar Island is under high pressure from use of destructive fishing gears and this has contributed directly to the deterioration of coral reefs conditions in most part of Zanzibar Island (McClanahan et al., 2002; Jiddawi and Yahya 2003). To address long term sustainable fisheries management in the small island like Zanzibar, there is a need for the changes of a new regime policy that addresses issues related to environmental degradation, fisheries utilization. The institutional challenge becomes more common in most of the tropical countries as there is a fragmentation of decision making and management. Poor enforcement of laws and regulations have contributed greatly to the failure governmental institutions (De la Torre-Castro, 2006). There is no reliable information or research study that has been conducted in the past or at present to understand the extent on the changes in fish biodiversity in the coastal villages of Zanzibar Island. This research was designed to understand: (1) what are the economic importance fish species in the Coast of Zanzibar Island? (2) Do the fishermen perceive that there is change on the economic importance fish species? (3) How do the fishermen measure the changes on the fish biodiversity?

MATERIALS AND METHODS

The study was conducted in the three coastal villages of Zanzibar Island namely: Kizimkazi, Matemwe and Nungwi, the reasons for

the selected the three areas because of their suitability for touristic related activities.

Interviews

Participatory techniques were mainly used to collect qualitative data. Key informal interview were held with the senior government official at department of fisheries in Zanzibar. Face-to-face interview were mainly held with the three difference ages of fishermen namely: younger age fishermen (18 -29 years old, n=53), middle age fishermen (30-49 years old, n=79) and old age fishermen (50-80 years old, n=42). The questionnaire designed for the research study included both open-ended and closed ended questions aims to gain information on the extent to which the three generation of fishermen in the coastal village villages of Zanzibar Island perceived change in fish biodiversity. The fishermen were asked open questions to list all economically importance fish species that are native and familiar to them in the area and how the fishermen' do they perceived changes in fish biodiversity over the past 20 years since advent of tourism development along the coast of Zanzibar Island. The fishermen' were asked to compare quantity of fish they used to catch nowadays in contrast to the fish catches the fishermen used to catch over the past 20 years. In addition, respondents were asked to explain the reason for the decline of fish biodiversity in the area; and the experiences of fishermen were taken into consideration. A total of 170 fishermen households were interviewed from the period October 2011 – February 2012.

Data processing and analysis

Analysis of the data involved triangulation of the information from the field noted, transcribed interviews. Data were coded according to the themes and analysed using statistical packages for social science (SPSS) version (16.0).

RESULTS

Economic importance of fish species along the coast of Zanzibar Island

Findings of the research study revealed that there are twenty-seven (27) families of fish species of economic importance for the household's income of the fishermen, livelihoods and food security in the study area. The research study asserted that Nungwi is the richest fishing village in Zanzibar Island in terms of all families of fish species. For instance, the family Scombridae; (which comprises of Kibua 36%, Sehewa 46%, Nguru Kanadi 26%, Jodari 86%) represent the highest percentages, and followed by the family of Istiophoridae, (Mbasi 78%, Istiophoridae, Nduaro 74%); then followed by family Rhinobatidae 56%; and family Sphyniade 44%; Aterinidae, 38%; Coryphinidae 32%). Table 1 shows the percentage presentation of list of fish species of economic importance to the fishermen. Furthermore, findings of the research study revealed that Kizimikazi is the second richest village among the study sites (Figure 1) in terms of families of fish species. However, Matemwe is the richest village in terms of reef fishery and mollusk. For instance the families of Lethrinidae and 64.41%; Octopodidae 64.41% representing the highest percentages; then followed by Scaridae 40.68%,

Table 1. Shows the percentage presentation of list of fish species of economic importance to the fishermen households 'income (Multiple answers were possible).

Family Name	Local Name	Kizimkazi % (n=61)	Matemwe % (n=59)	Nungwi % (n=50)
Acanthuridae	Kangaja	3.28	18.64	0
Carangidae	Kolekole	31.15	18.64	30
Chanidae	Mwatiko	1.64	0	2
Coryphanidae	Dorodo/Panje	22.25	11.86	32
Gymnuridae	Tenga	14.75	1.69	8
Haemulidae	Karamamba	3.28	0	0
Haemulidae	Kui	4.92	1.69	0
Istiophoridae	Mbasi	42.62	22.03	78
Istiophoridae	Nduwaro	18.03	3.28	74
Lethrinidae	Changu	32.78	64.41	18.03
Lobridae	Gumbasi	18.03	0	0
Loliginidae	Ngasi	34.43	27.12	36
Lutjanidae	Janja	1.69	3.28	2
Lutjanidae	Futundu	3.28	1.69	2
Lutjanidae	Mrongo	1.64	5.08	2
Lutjanidae	Molelis	0	3.39	2
Lutjanidae	Kungu	1.64	3.39	6
Mobulidae	Pungu	13.12	5.08	22
Mugilidae	Mkizi	6.56	11.86	18
Mullidae	Goat fish	13.11	28.81	4
Nemipteridae	Koana	4.92	15.25	4
Nephropidae	Kamba	37.71	20.34	34
Octopodidae	Pweza	34.43	64.41	34
Rachycentridae	Songoro	8.19	5.08	16
Rhinobatidae	Papa fuwanda	31.15	6.78	56
Siganidae	Tasi	59.01	57.63	28
Serranidae	Chewa	6.56	35.59	6
Scaridae	Chore	3.28	0	2
Scaridae	Kangaguruwe	0	6.77	2
Scaridae	Pono	18.03	40.68	30
Scombridae	Kibua	14.75	28.81	36
Scombridae	Sehewa	16.39	3.28	46
Scombridae	Nguru (Kanadi)	11.47	3.28	26
Scombridae	Nguru	70.49	15.25	42
Scombridae	Zanuba	0	11.86	22
Scombridae	Jodari	44.26	11.86	86
Rna lewini	Papa pingusi	22.95	11.86	44
Sardinella	Dagaa	27.87	15.25	38
Sphyraenidae	Mzia	26.33	38.98	38
Xiphidae	Nduaro	13.11	1.69	26

Sphyraenidae 38.98%; Serranidae 35.59%; Mullidae 28.81%, and Acanthuridae, 18.64%. In conducting statistical test on the distribution of fish biodiversity in the coastal villages of Zanzibar Island. T-test analysis shows that there is significant difference in fish biodiversity between the Kizimkazi vs Matamwe t-value =0.594, df=80, p=0.553 and p>0.86; Matemwe vs Nungwi t-

value=-1.776, df=80, p=0.079 and p>0.09; while Nungwi vs Kizimkazi t-value=-1.283, df=80, p=0.202 and p>0.006.

Perceptions of fishermen on changed in fish biodiversity in Zanzibar Island

Findings of the research study indicated that the majority



Figure 1. Study area.

(80%) of the interviewed fishermen perceived that they have witnessed a changes in fish biodiversity along the coastal villages of Zanzibar Island. For instance out of the twenty seven families of fish species of economic importance to the households 'income of fishermen in Zanzibar Island, 10 families of fish species were reported by the fishermen' to have been depleted over the four decades. Discussion with the highly experienced fishermen perceived that the most devastated fish species of economic importance such as Chanidae (Milk fish), Haemulidae (*Javelin grunter*, *Saddle fish*), Nemipteridae (*Rosy dwaft monocle bream*), Rhinobatidae

(*Giant guitarfish*) and Scaridae (*Green humphead parrot fish*, *bicolour fish*). However, the families of fish species such as Lobridae (*Humphead wrasse*), Lutjanidae (*Emperor snapper*, *Green job fish*, *Twinspot red snapper*, and *Ruby snapper*), Molulidae (*Montar ray*), Serranidae (groupers in general), and Sphymidae (*Scallop hammerhead*) were reported by the three generation of fishermen to have been declining nowadays see Table 2 below. The perceptions of fishermen' from the three generation in the coastal villages vary considerable, the mean average of fish species claimed by the young aged fishers to have have been declined nowadays 1.57 ± 2.18

Table 2. Fish biodiversity cited by the three generations of fishermen' to have been declining over the past 20 years based on the traditional knowledge and experience of fishermen.

Family Name	Local Name	Young % (n=50)	Middle % (n=78)	Old % (n=32)
Carangidae	Kolekole	4	3.85	12.5
Chanidae	Mwatiko	0	21.79	56.25
Coryphanidae	Panje	0	2.56	0
Gymnuridae	Tenga	4	2.56	9.37
Haemulidae	Kui	0	1.28	25
Haemulidae	Karamamba	0	0	15.63
Istiophoridae	Nduwaro	4	5.13	6.25
Istiophoridae	Mbasi	6	2.56	0
Lobridae	Gumbasi	0	3.85	15.63
Lutjanidae	Molelis	0	2.56	3.13
Lutjanidae	Fatundu	0	5.13	50
Lutjanidae	Mrongo	0	2.56	9.37
Lutjanidae	Kungu	0	2.56	25
Lutjanidae	Changu	4	1.28	3.13
Mobulidae	Pungu	0	2.56	6.25
Nemipteridae	Sorobika	0	0	18.75
Nemiperidae	Sasare	6	3.85	18.75
Rachycentridae	Songoro	6	5.13	3.13
Rhinobatidae	Papa fuwanda	2	38.46	81.25
Serranidae	Chewa	2	5.13	6.25
Scaridae	Kangaguruwe	0	14.10	37.5
Scaridae	Chore	0	1.28	18.75
Scombridae	Nguru (Kanadi)	20	12.82	9.37
Scombridae	Kibua	6	1.28	0
Scombridae	Sehewa	2	2.56	0
Sphymidae	Papa Pingusi	10	28.21	50
Xiphidae	Nduwaro	6	2.56	6.25

(Mean±SD) in contrast to the average mean of fish species cited by the middle aged fishers 'was 4.89±7.08 (Mean±SD) and the average mean for the old aged fishers was 5.57±6.48 (Mean±SD).

Statistical analysis of T-Test shows that there is a significant difference between the younger age fishermen verse middle age fishermen where t-value =-1.642, df=54, p=0.106 and p<0.002. Furthermore, the statistical analysis of T-Test shows that there is a high significant difference between the middle age fishermen and old age fishermen where t-value =-2.654, df=54, p=0.010 and p<0.008. In conducting T-Test analysis between the old age fishermen and the younger age fishermen indicates that there is a highly significant difference between these generation, t-value =-3.642, df=54, p=0.006 and p<0.000.

Perceptions of fishermen on the current fish catch in the coastal villages

Findings of research study revealed that that the majority of fishermen (80%) in the coastal villages of Kizimkazi

(80%); (50%) in Matemwe and (90%) in the coastal village of Nungwi respectively stated that there was a serious decline of fish stock. However, (24.59%) of fishermen in the coastal village of Kizimkazi perceived there is more fish stock in the area. Secondary data collected from the Department of Fisheries on fish catches in metric tons (MT) and the number of fishermen along the coastal villages of Zanzibar from 1990 – 2011 show trends of fish catches in Zanzibar supported by the government statistician in the Department of Fisheries (Figure 2).

Beginning from period between 2003 – 2011 the Department of Fisheries in Zanzibar had witnessed serious increased by 50% of local communities in the coastal villages got recruited in the fishing business (Department of Fisheries, 2010).

Experiences of the fishermen in the coastal village of Zanzibar Island

The interviewed fishermen in the research study areas

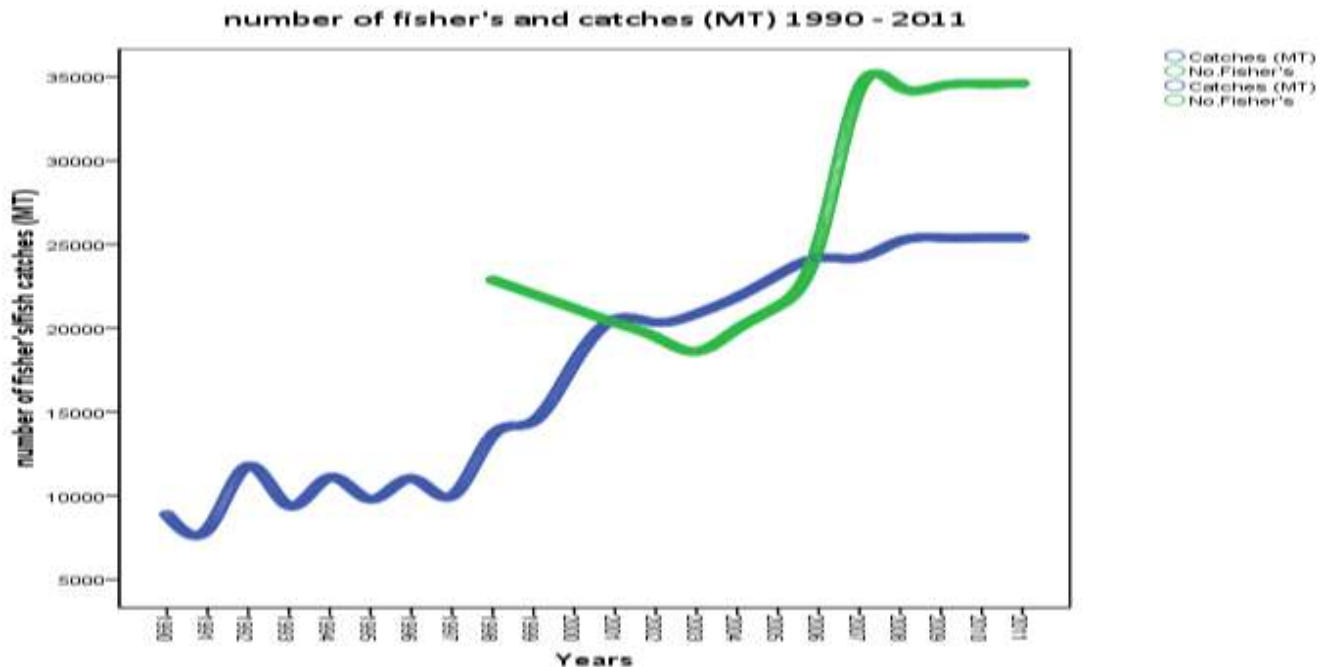


Figure 2. Fish catches (MT) and the number of local fisher's in Zanzibar Island. Source: Zanzibar Fisheries Department.

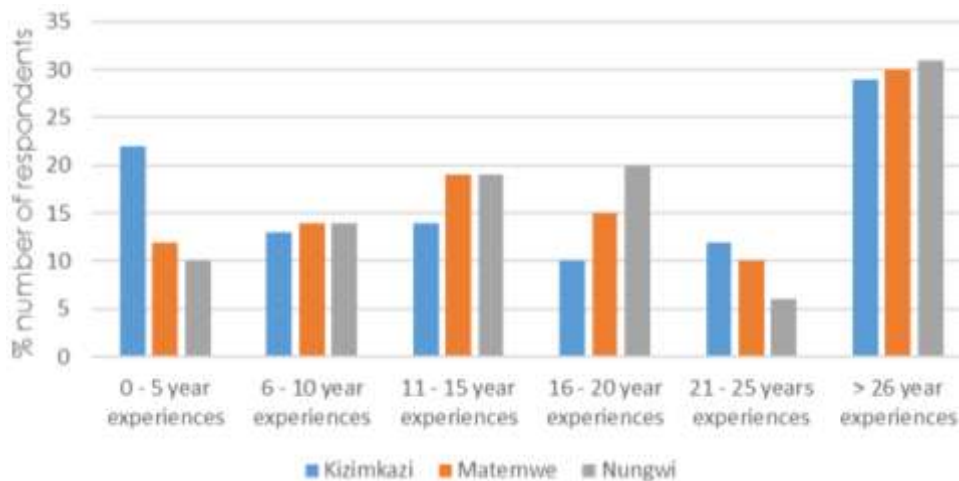


Figure 3. Shows the experience of the fishermen in research area of study.

revealed that the majority (31%) in the coastal village of Kizimkazi, (30%) in Matemwe and (29%) in Nungwi were highly experienced fishermen with more than 26 years old actively engaged in fishing activity along the coastal villages of Zanzibar Island. However, the experience of middle age fishermen ranging from 16 – 20 years old fully participating in fisheries related activity represent (10%) in Kizimkazi, (15%) in Matemwe and (20%) in the coastal village of Nungwi. Then followed by the fishermen with experience ranging from 11 – 15 year experiences 14, 14 and 19% respectively in the coastal village of Kizimkazi,

Matemwe and Nungwi presented in Figure 3.

DISCUSSION

Economic importance fish species in the coast of Zanzibar Island

The marine ecosystem of Zanzibar Island is very rich in fish biodiversity. It is interesting that fish biodiversity varies from one coastal village to another based on the

traditional knowledge of the fishermen in the research area of study. For instance it was observed that Scombridae is the most dominate fish species along the coastal villages Zanzibar Island during the season of south east trade wind. Although the coastal villages of Zanzibar Island shared the environment, the abundance of fish biodiversity varies from one coastal village to another. The lead author noted that *Nugwi and Kizimakzi* were the richest fishing villages with the majority of large predatory fish species. However, the coastal village of Matemwe is dominated by the coral reef fisheries. Key informant interview with the senior official at the department of fisheries in Zanzibar revealed that there is 19 families of fish species of economic importance which are used in collection of government fish statistics within the Zanzibar Department of Fisheries. The new recorded families of economic importance species of fish that were not found in the record of the Department of Fisheries were Haemulidae (*Javelin Grunter and Saddle fish*), Lobridae (*Humphead Wrasse*), Nemipteridae (*Rosy dwarf monocle breams*), Scaridae (*Bicolour parrot fish and Green humphead parrot fish*).

Perceptions of fishermen on change in fish biodiversity in Zanzibar Island

The senior experienced fishermen in the research area of study perceived that changed in fish biodiversity along the coastal villages of Zanzibar Island have been categories into four different reasons. (a) the fishermen perceived that coastal population growth, has increased the number of fishermen along the coastal villages (b) the uses of destructive fishing gears has devastated marine ecosystem (c) increasing development of tourism industry along the coastal villages of Zanzibar Island has created a new demand for fish market (d) climate variability and seasonality has contributed negatively for the decline of fish biodiversity. The highly experienced fishermen perceived that families of fish species such species such as Lutjanidae (*Emperor snapper*), Rhinobatidae (*Giant guitarfish*), Scaridae (*Green humphead parrot fish*), Scombridae (*Kanadi-kingfish*) and Sphyrnidae (*Scallop hammerhead*) are the most threatened fish species in the study area. For instance the fishermen that fish species such as *Green humphead parrot fish, Javelin grunter, Twinspot red snapper, Rosy dwarf monocle bream, and Green job fish* started to disappeared systemically over the last four decades. The observed results are in line with the study conducted by Katikiro (2014); Division of Fisheries (2013) and van der Elst et al. (2005) whom lamented that decline of fish stock in the western Indian ocean of Tanzania was considered back to 1960s, but it is likely some depletion might have occurred prior to this since even low-level artisanal fishing from ancient times. Robert (2003) concluded that the fishing communities at the coastal villages of Zanzibar Island stated that the fish

catch rate of demersal fish species and other fishery resources such as octopus, squid, snail (for shell), sea cucumber and other intertidal organisms are declining. It is interesting that most of the fish species mentioned by the highly experienced fishermen to have been depleted are native and familiar to the fishermen in the respective fishing villages in Zanzibar Island. The lead author noted that the name of fish species mentioned by the highly experienced fishermen in the coastal villages were not found in the record of the Department of Fisheries in Zanzibar. Realistic information pertaining to fish catches was difficult to be obtained due to the daily and seasonal variability. The fish species and biodiversity found in the recorded data of the Ministry of Livestock and Fisheries, Department of Fisheries in Zanzibar Island were categorized into a group. However, the fishermen in the coastal villages reported the individual fish species. For instance the lead author observed capture of groupers only twice during the period of data collection in the research areas of study. Informal discussion with the highly experienced fishermen revealed that groupers were the most common species and at the same time many Zanzibar is preferred to consume this species. The highly experienced fishermen described that although groupers can be caught on seasonal basis, it is very difficult to capture groupers nowadays. The lead author was not familiar with the species, generic information on 'groupers' was sought, followed by a discussion of which fish species in particular is becoming rarer. There is no reliable or sufficient data on these resources that can really support such perception despite their importance to fishermen. Katikiro (2009) stated that fishermen reported fish species of less commercial importance have decline without the knowledge of fishermen.

Perceptions of fishermen on the current fish catch in the coastal villages

The perceptions of fishermen in the research area on the current fish catches in the coastal villages of Zanzibar Island varies considerably from one fishermen to another. For instance the majority of younger fishermen in the coastal villages of Kizimkazi perceived that there is abundance of fish catches in area due to the fact that Menai Bay is Marine Protected Area where fishermen are restricted to open season and closed fishing seasons. The lead author noted that the majority of the younger-star generation in the coastal village of Kizimkazi were actively involved in ecotourism related income generating activities such as dolphin tour, game fishing, tour guides, and taxi driver which supported the household's income of the younger fishermen. However, the fishermen in the coastal villages of Matemwe and Nungwi expressed that there is a rapid increase in the number of the coastal communities venturing into fisheries related activities nowadays, this has contributed negatively on the decline

of fish biodiversity in the area. The senior fishermen perceived that the increasing number of the younger fisher's in the coastal villages as a results of rapids development of tourism industry that have created a new demand of fish market in the coastal villages. The observed results are in line with the study conducted by Jiddawi and Öhman (2002) who revealed that the advent of tourism development in the 1990s along the coastal villages of Zanzibar Island have motivated fishermen to concentrate highly on demersal fish species such as snappers, groupers, emperors, parrotfish and this has greatly contributed to the decline of catch per unit effort as well as reduction in fish sizes. Department of Fisheries (2010) describe that the number of fishermen has increased by 50% from 2003 – 2011, the increased in the number of coastal communities into fishing activity may lead to further degradation of marine fisheries resources along the coastal villages of Zanzibar Island. The lead author noted that sometimes the fishermen were returning back from their respective fishing ground without a single fish in their fishing craft/boats.

Experiences of the fishermen in the coastal village of Zanzibar Island

The experiences of fishermen is considered as important because it allowed social scientist to understand specific information of the area based on the traditional knowledge and experience of local community within that specified geographical location. It is interesting that there was a gradual difference at the level of experience among the fishermen in the coastal villages of Zanzibar Island. For the instance the highly experience fishermen with more than 26 years of experience in the coastal villages of Zanzibar Island represent the smallest percentage in the fishing communities in contrast to experienced middle aged fishermen. The experience of local communities is an advantage of connected the researchers with the nature and what happened over the last decades. Lotze et al. (2006) describes that enhanced the past knowledge of the local communities are needed to support our recent data in conducting research. For instance if scientists will devoid past experience then evidences such as extirpation of large vertebrates around the Mediterranean which are said to extend far beyond Christian will be vague. Sáenz-Arroyo and Roberts (2008) revealed that people always view the environment simply by inclining to how they found it.

Conclusion

The serious decline on the economic important fish species and biodiversity was attributed to factors such as increases in the number of fishermen, the uses of destructive fishing gears has devastated marine fisheries resources, increasing development of tourism industry

has created a new demand for fish market and climate variability and seasonality has contributed negatively on the decline of fish species and biodiversity. The highly experienced fishermen perceived that changed in the abundance of fish biodiversity returned back in 1960-1970s is the period where they started to observe dramatic changed in certain type of fish species. Secondary data collection from the ministry of livestock and fisheries, department of fisheries described that there is a systematic increases by 50% in the number of new recruits fishermen from 2003 – 2011 which shows the real threat to marine resources, not only fisheries only. The advent of tourism industry along the coastal villages of Zanzibar Island has created a new demand of fish market which is an incentive for the fishermen. To date fishermen in the coastal villages of Zanzibar Island were targeting high value fish such as King fish, Yellowfin tuna, skipjack tuna, kawakawa, snappers and groupers, sail fish, octopus, lobsters and squid because of it high demands in the tourist resorts and hotel. The research study concluded that further decline on fish biodiversity are likely to increase in future unless appropriate regulation and enforcement of laws and regulation are established.

Conflict of Interests

The authors have not declared any conflict of interests.

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