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Valuation of fishery among artisanal bait fishers that use non-commercialized intertidal bait at the Mida Creek, Kenya

Kihia C.M. [1], Muthumbi A.W. [2], Okondo J. [3], Njuguna V. [2], Nthiga A. [2] and Muchiri J.M. [4]

1 Department of Biological Sciences, Egerton University, Egerton, Kenya

2 Department of Biological Sciences, University of Nairobi, Nairobi, Kenya

3 Kenya Marine and Fisheries Research Institute, Mombasa, Kenya

4 Finance Department, Egerton University, Egerton, Kenya

Corresponding author email: charles.kihia@gmail.com

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Abstract Humanistic valuation of resources is critical to understanding drivers to patterns and impacts, however, value of non-traded intertidal tropical bait, such as polychaetes and hermit crabs, used by artisanal fishers, is unknown. Bait harvested from intertidal habitats and used for fishing at Mida Creek, were quantified, and variable and fixed cost incurred determined, income and profitability, were computed and compared. Fishers harvest and use 58 baits pieces, to land 2.4 kg of fish with an average earning of 3.8$.d-1. Bait values were similar among bait types and sites, but income (3.3$), earning (4.1$) and profitability (255%), were significantly higher for polychaete bait fishers. This was attributed to lower bait harvesting and fishing expenditure. Bait fishery is a labour intensive, and profitable enterprise, that is, however, comparable to semi-skilled wage livelihood options, in the region. Improvement in profits, may be achieved by increasing fishery yield, by adoption of alternative fishery and livelihoods.

Keywords *Marphysa value*; Harvesting; Bait fishing; Income; Wages; Profitability

1 Introduction

Imparting fiscal value to resources, has potential to improving the recognition, and hence, status of the resource to man. Additionally, allocating monetary value to resources provides a platform for ascertaining drivers influencing profitability, and subsequently, persistence of the enterprise. Such information, is crucial to policy makers, resource managers, and ultimately to the fisher. Bait, is an organism or object, used to attract fish and maximize fish landing, that is commonly used by tropical artisanal hook and trap fishers. Live bait organisms include a variety of invertebrates, small fish and also seaweeds, frequently exploited by tropical fishers (Samoilys et al., 2011; Elders of Atafu Atoll, 2012).

Although the value of intertidal habitats, such as coral reefs, marshes and mangrove are recognized for providing a variety of resources to tropical communities (Walters, 2003; Barbier et al., 2011; Kimberly et al., 2011), the exploitation of intertidal bait organisms is rarely acknowledged or evaluated. Literature on commercial fisheries valuation are replete with quotation of bait value, which is shown to influence profitability of fisheries in temperate (Kerr, 2012), as well as tropical fisheries (Anyanwu et al., 2009; Adewumi et al., 2012; Gbigbi & Taiwo, 2014). The sources of such information is rarely adequately described and is presumably for bait organisms, such as small fish (e.g. Sardine, Minnows) and crustaceans, such as (e,g. Shrimps), which are commercially exploited and marketed as bait (Kerr, 2012). It is however, doubtful whether, such estimates cover polychaete worms, hermit crabs, gastropods, and other intertidal invertebrate taxa, commonly exploited by tropical bait fishers, but are rarely commercially traded. Additionally, such non-marketable tropical intertidal invertebrate bait organisms are exploited exclusively as bait, and rarely consumed, as is the case for the marketable small fish and crustaceans.

In general terms, the profit of an enterprise is the difference between the cost of production and the market value of the resource (King, 1998). The cost of production on the other hand, is computed from the sum of both fixed and variable cost of inputs used in bait exploitation. In contrast to temperate fisheries, tropical artisanal fisheries have minimal capital expenditure on fixed assets, such as vessels and gear (Anene, 2010; Severin, 2012). Additionally, in tropical artisanal fisheries, variable costs, that include, labour, and other inputs, are the major determinants of profitability (Anene et al., 2010; Aheto et al., 2012). Compared to temperate bait exploitation, minimal mechanization and technology adoption, accompanies tropical bait exploitation (Brown, 1993; Branch et al., 2002). hence labour costs are expected to dominate variable costs.

A number of studies have demonstrated that tropical artisanal fisheries are moderately profitable with regional variation related to ecosystem productivity and gears (Branch et al., 2002). In general, bait fishers using handlines, are considered more profitable than other gears, due to lower capital outlay (Turay & Verstralen, 1997). Comparison of artisanal fisheries monthly earnings with other sectors in West (Anene et al, 2010) and south Africa (Branch et al., 2010), reveal that the fishery is more profitable than farming, but lower than public sector employment. Napier et al. (2009) estimate that the value of subsistence fishing using mainly sand prawn bait in South Africa at between 0.07 and 0.11 M $ annually and this is accompanied by legislation governing bag limits and gear used in bait harvesting. Similar comparison are not available for the Kenyan coastline, however, Cinner et al., (2008) and also Branch et al., (2002) among others regard artisanal fishers as the poorest of the poor.

2 Materials and methods

2.1 Study area

This study was carried out at the Mida Creek (03o 21'S; 39o 59'E), which is a Marine National Park and World Biosphere Reserve, situated 88 km North of Mombasa town, that has been in existence since 1968 (Figure 1). The creek covers an area of 31.6 km^2, consisting of mangrove forests, sea grass beds, sandy-mud flats, rocky outcrops and subtidal habitats.

The Mijikenda tribal group, most of whom are fishers and farmers, dominate the population at Mida (Mwaipopo et al., 2011). Additionally, migrant fishers from Pemba (Tanzania) also participate in the fishery at Mida, during the Northeast monsoon (October to March) season (Hoorweg et al., 2006). It is estimated that at least half of the estimated 300 bait fishers at Mida, use intertidal bait for hook and basket trap fishing (Frame survey, 2012; Muthumbi et al, 2015).

Three sites; Dabaso, Kirepwe and Mayonda, differing in levels of bait exploitation were used in the current study. Dabaso is a small village center with several homesteads adjacent to a well-developed mangrove forest. Moderate levels of mudflat excavation for polychaetes and hermit crabs occur at the beach. Kirepwe is a recently inhabited island to the east of Dabaso, with moderate to low levels of polychaete excavation and hermit crab exploitation, and a thin band of mangrove along the shoreline. Mayonda lies due north of Dabaso and has extensive mudflats, which are regularly exploited for polychaete excavation but no hermit crab exploitation. Fishers from the adjacent villages walk to the beach to acquire bait prior to undertaking fishing.

2.2 Determination of intertidal bait value

Polychaete (*Marphysa sp*) and hermit crab (*Clibanarius spp*) bait fishers, were followed during their normal bait harvesting activities. The duration of each bait harvesting activity that involves; travel to and from the bait harvest site, harvesting and processing bait (H_b), and the quantity of bait obtained (Q_b), was monitored and recorded. Cost of bait harvesting gears and tools include: digging stick (chulo), 3-5 liter plastic container for polychaete, shell crushing implement, 10 liter plastic container for hermit crab. In most instances, these tools are: rudimentary, minimal value, and easily available local material. These items are frequently not bought, but obtained from the surroundings and were given an estimated total value of 2$US (~200 Ksh). It was assumed that these tools were replaced at least thrice per year, giving a daily cost of 0.016 $ d^{-1} (64 Ksh. d^{-1}).

Hence cost of bait harvesting per day was calculated using;

$$C_b = Bait\ labor_{\ l} + Bait\ gear_{\ g} + Profit_{\ p}$$

Where Cb = cost of bait; bait labour =Hb * 0.13 $ per hour where Hb is the duration of bait harvest (travel, search, processing) per day, Bait gear= cost of gears (0.016 $. d^{-1}), Profit= bait profit (0 $ per day), but since harvested bait were not sold or bought, it was given a value of nil (i.e. 0 $.$d^{-1}$)..

Hence, cost per unit of bait was derived using.

Cost per bait = C_b / Q_b

Where; Q_b- quantity of bait.

Data obtained were compared among the sites and bait types.

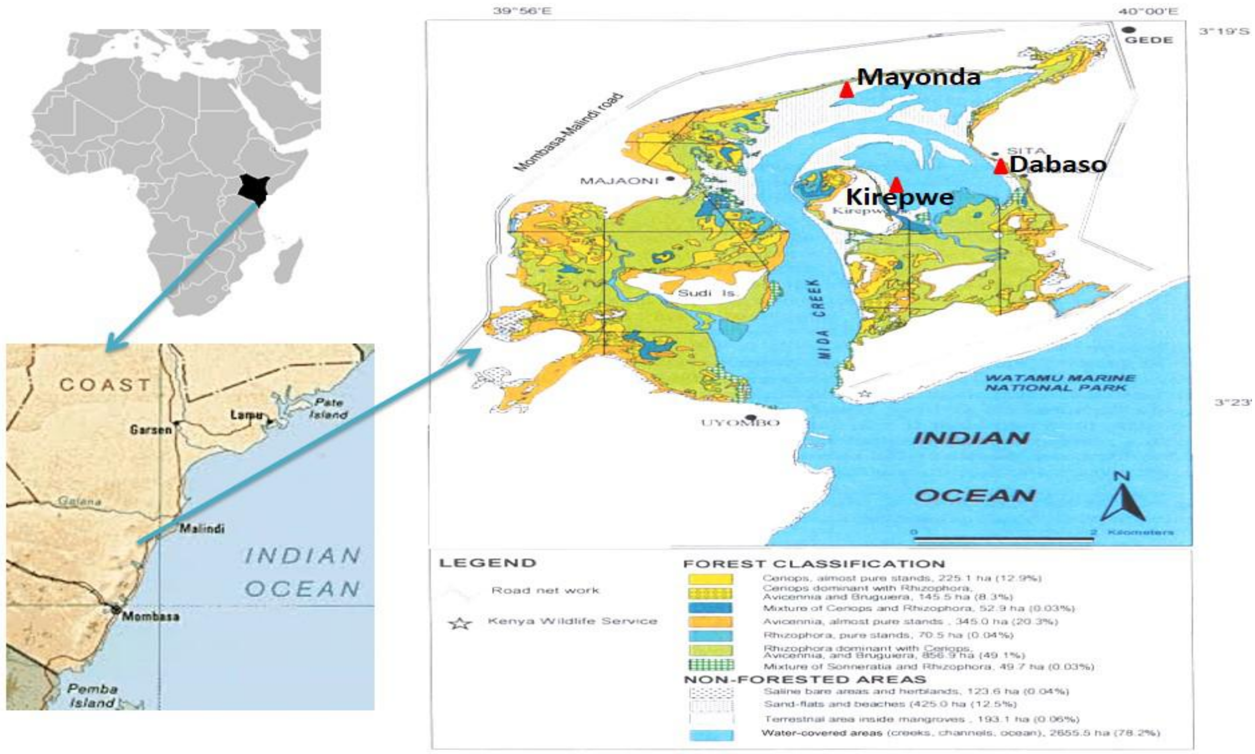

Figure 1 Map of Africa showing location Kenya, the Kenyan coastline and a detailed sketch of the Creek indicating the sampling sites at Mayonda, Dabaso and Kirepwe

2.3 Determination of bait fishery profitability

Fishers identified as above, were followed during their normal bait fishing activity, and the quantity of fish landed (Qf) and duration of fishing activity (Hf) was determined and recorded. Items and gears used in the fishing activity (canoe, hooks, line, and fish container) were recorded and valued.

Net income from fishery was computed as in Aheto et al., (2012) using;

Net Income = *Total Fish Value* - *Total fishery cost*

Where Total fish value = Q_f * sale price of fish at landing beach (1.8 $ per kg) (Malleret-King et al., n.d.), while Total fishery cost was computed as:

Total fishery cost=cost of fishing gears + *cost of bait* + *Fees* + *Overheads*

Where; Cost of fishing gears = Purchase price of fishing gears was taken as 2.5 $ for the hook and line, while the boat was estimated at 50 $, with a useful life of 5 years (Versleijen & Hoorweg, 2008). Depreciation value for fishing gears was thus calculated as 10.50 $ per year equivalent to 0.03 $.d^{-1}. Cost of bait was obtained as outlined above. Landing fee of 0.01 $ per Kg fish, payable to the BMU (USAID, 2008) was added. Overhead costs was taken as cost of any food, water or emergency and gear maintenance undertaken during the fishing activity and was given an estimated nominal value of 0.5 $ d^{-1} (50 Ksh)..

Profitability (Return on Investment) of bait fishery was estimated as in Severin (2012), by computing:

*Profitability = (Net Income) / (Total Cost) * 100……………………(3)*

Fisher earnings were calculated using;

Total fisher earning =Wages + Net Income

Where: Wages = Duration of bait harvest and fishing * 0.13 $ per hour.

Computed income, profitability, earning and expenses data were compared among the bait types and sites using ANOVA.

3 Results

3.1 Bait value

On average fishers at Mida Creek harvest 58 bait pieces.d-1, weighing about 0.12 kg. These bait were obtained from harvesting activity in intertidal mudflats over a period of 0.8 hrs. d^{-1}, incurring an average bait harvesting cost of 0.11$ d^{-1} (11.40 Ksh). The average cost of bait at Mida Creek was therefore $0.0022 per individual, equivalent to 2.20 $.kg-1.

Although there were significant differences in the quantities of the different bait types harvested, the cost of the baits, were similar (Table 1). Polychaete (*Marphysa sp*) value was 0.23 * 10-2 $ per bait, while hermit crab (*Clibanarius sp*) was 0.18*10-2 $ per bait), but fewer quantities of polychaete (50 ind. d-1) were used, compared to hermit crabs (Table 1).

Table 1 Bait value ($) of hermit crab and polychaetes harvested by fishers at the Mida Creek

Parameter	Hermit	Polychaete	F	P
Bait used (#)	81	50	64.20	0.0001
Duration (hr.)	0.85	0.76	0.39	0.2 ns
Total Cost Bait ($)	0.128	0.11	0.39	0.5 ns
Cost per bait ($*10^{-2})	0.15	0.22	1.7	0.2 ns

Comparison of the value of bait among the site reveals that, although quantity of bait used was significantly lower at Mayonda (50 ind.d-1), compared to Dabaso and Kirepwe (74 and 81 ind.d-1, respectively), the duration of bait harvesting and cost per bait, were similar (Table 2).

Table 2 Comparison of estimated bait value ($) harvested by fishers among sites at the Mida Creek

Parameter	Dabaso	Kirepwe	Mayonda	F Significance
bait used (#)	81	74	50	32.9 ****
Duration (hr.)	0.93	0.92	0.72	1.1 ns
Cost per bait ($ *10^{-2})	0.16	0.18	0.22	0.09 ns

3.2 Bait fishery profitability

Valuation of the bait fishing operation showed that the bait harvested, was used to land 2.4 kg of fish d^{-1} valued at 4.33 $. During the fishing operation, average variable and fixed costs of 0.62 $ and 0.03 $ d^{-1} respectively, were incurred. Thus the total cost of fishing was 0.65 $ d^{-1}. This corresponded to an estimated gross margin (net income-valuable cost) and net profit (gross margin-fixed cost) of 3.73 and 3.68 $ d^{-1}, respectively (Table 3). These levels of income corresponded to net earnings of 3.79 $ d^{-1} and a profitability of 222% for the fisher.

Table 3 Estimated commercial characteristics of the bait fishery at Mida Creek

Parameter	Dabaso	Kirepwe	Mayonda	F Significance
bait used (#)	81	74	50	32.9 ****
Duration (hr.)	0.93	0.92	0.72	1.1 ns
Cost per bait ($ *10^{-2})	0.16	0.18	0.22	0.09 ns

Comparison of bait fishery income and profitability among the bait types revealed significantly higher income (3.3 $ d^{-1}) and profit (255%) when using polychaete bait, compared to hermit crab (Table 4). Daily wages from hermit fishery (1.02 $ d^{-1}) were however, higher than from polychaete fishery (0.77 $ d^{-1}).

Table 4 Comparison of bait fishery profitability among the baits types used at Mida creek

Parameter	Hermit crabs	Polychaete	F Significance
Fish value ($)	3.48	4.61	4.82 *
Gross margin ($)	2.86	4.00	4.93 ***
Net Income ($)	1.92	3.29	7.27 **
Wages ($)	1.02	0.77	21.21 ***
Net Earnings ($)	2.94	4.07	4.8 *
Profitability (%)	117	255	11.58 **

Comparison of bait fishery profitability among the sites revealed that, income, total earning and profitability were statistically similar (Table 5). Daily wages were however significantly lower at Mayonda (0.77 $ d^{-1}), compared to either Dabaso (1.04 $ d^{-1}) or Kirepwe (0.97 $ d^{-1}).

Table 5 Variation in bait fishery earnings and profitability among site at the Mida creek

Parameter	Dabaso	Kirepwe	Mayonda	F Significance
Fish value ($)	3.57	4.74	4.46	1.34 ns
Gross margin ($)	2.94	4.11	3.86	1.4 ns
Net Income ($)	2.06	3.16	3.16	1.8 ns
Wages ($)	0.97	1.04	0.77	10.6 ***
Net Earnings ($)	3.03	4.20	3.92	1.4 ns
Profitability (%)	156	195	242	1.7 ns

4 Discussion

Results presented, indicate that artisanal bait fishers at Mida creek spend less than 1 hour d^{-1} to harvest about 58 baits, worth 0.13 $ per day. Bait value presented here is the first estimate in the region. Fidalgo et al. (2006) report a bait cost range of between 0.01 and 0.5 $ per bait, for temperate polychaete taxa exported from Asia and USA, into the European market. This is higher than values reported here. The difference may arise due to higher bait gear investment cost in temperate regions, where metal implements and also pumps, may be employed for excavation (Cretchley, 1996). Additionally, temperate bait harvesting is of a commercial nature, with excavated bait being sold to anglers at a profit (Brown, 1993).

Although hermit crab fishers, use higher quantities of bait, the value of the bait obtained, is similar to that of polychaete. This study has utilized similar cost estimates for bait harvesting gear, this may imply more elaborate evaluation of these items are needed in order to authenticate the findings. Since the bait types considered here, are exclusively used as bait as compared to other bait types such as octopus, squid, shrimp, and small fish, which are also consumed and available on the market (Kihia et al., 2015), the primary driver for harvesting the intertidal bait is solely to land fish (0 profit), and hence the bait value is governed by the bait harvesting process.

Findings also showed that although quantities of bait used among the site differed, the value of bait were similar. Bait harvesting duration were also similar among the sites. It was expected that sites with lower bait harvesting duration, such as Mayonda, would consequently record lower bait value. It is possible that bait yield per unit of effort may be lower at Mayonda and hence counteracting the observed valuation. These aspects requires further evaluation.

Bait fishers at Mida land approximately 2.4 kg d^{-1} of fish valued at over 4.3 \$. 32% (1.4 \$) of earning from sale of landing is incurred as daily cost during the fishery, corresponding to daily profit of 2.96 \$ d^{-1}. The fishers spend about 5.9 hours daily during the fishing and together with the time spent in bait harvesting, earn an average daily wage of 0.83 \$ d^{-1}. Total income for the fishers is estimated at 3.8 \$.

Monthly income from bait fishery can be estimated at between 76 and 114 \$ per month, for 20 and 30 fishing days, respectively. The World Bank (2013) defines Kenyans earning less than 29 and 54 \$ per month, in rural and urban centers, respectively, as living below the poverty line. Bait fishery income is also higher than values of between 40 and 50 \$ per month, reported by Dose (2007) among rural small scale farmers in Kenya. It is therefore apparent that contrary to observations of Cinner et al., (2010), bait fisher earnings are substantially above poverty line. However, the daily earning of bait fishers, lies within the range of 2 to 4 \$ d^{-1} for unskilled and semiskilled wage laborer in Kenya, but lower than skilled wage earners (Thornton, 2013).

Cinner et al., (2010) characterizes artisanal subsistence fisher households at the Kenyan coast, as the poorest of the poor, lacking common indicators of wealth, such as; permanent dwelling, access to water, electricity and amenities, and this drives their participation in illegal and unsustainable resource exploitation. Additionally, Dose (2007) demonstrated that rural farm households monthly expenditure, were over 150% higher than total income, and these propels such households into perpetual penury. It is speculated that similar scenario obtains in the artisanal bait fishery. Additionally, as has been reported here, Tuda et al., (2008) reports that fishers spend a limited time of less than 10 hours daily during fishing operations, but also avoid inclement conditions and rough weather. This may substantially reduce monthly and yearly participation in the fishery, and hence the potential working days, to 20 to 25 days per month, concentrated in the main calm NEM fishing season. Similar variability is also observed in the West African artisanal fishery (IDAF, 1997).

Hervis et al., (2014) report that fishery enterprises with profitability of above 10% are considered as ideal for investors. Results also indicate that bait fishery is a highly profitable enterprise involving minimal expenditure on fixed cost. In comparison to other livelihood options, bait fishery, will remain attractive to unskilled and semi-skilled individuals, especially unemployed youth. However, McClanahan & Mangi (2004) among others, have continually reported evidence of overfishing in nearshore habitats of the region, and recommended a raft of legislations, such as banning of unselective gears (beach seine) and protection of vulnerable sites (coral gardens, turtle breeding sites). Prospects of limiting participation of bait fishers however, remain elusive. It can be speculated, that inculcation of a saving culture among the bait fishers, where a small percent of daily income (10%), would substantially improve the outlook of the community in the long run (EcoAfrica, 2014). Exploration of non-conventional banking instruments, such as mobile banking and cooperatives (USAID, 2009), may be ideal for such a value chain.

Generally, increase in profitability of an enterprise may be achieved by reduction in expenses and/or concurrent increase in fish landings coupled with improved selling prices. Reduction in expense in artisanal fishery reported here, is well-nigh impossible, since most of the items used for bait harvesting and fishing, are available at rock bottom prices or scavenged from the ecosystem at minimal cost. It therefore implies that increase in profit in this fishery can only be achieved by significant increase in fish landing. Increase in either fishing effort or utilizing fishing areas that are rarely exploited may therefore provide respite for overcapacity in the nearshore. Most of the fishers barely spend more than 10 hours at sea, stemming from their aversion to rough seas. Equipping the fishers with suitable skills and superior vessels, may increase their ability to venture into more profitable, and less exploited offshore fishery resources (Maina, 2012). Evidence form Uyombo, an adjacent fish landing beach, frequented by both contract and migrant fishers from Pemba, suggests that, higher fish yields (over 20 kg.d^{-1}), are obtained using similar bait, by fishing in deeper waters.

Exploitation of artisanal fishers by middlemen and other fish traders is commonly reported, for instance, Yang & McClanahan (2013) and others, reports marine fish fryers and dealers earning 3 to 7 \$ d^{-1}, which is higher than that obtained by the fisher. Value chain improvement as well as strengthening BMU, is seen as a means of ameliorating such condition.

This study has shown that income and profitability, when using polychaete bait, was higher than that obtained using hermit crabs. This higher value is brought about by higher fish landing and lower bait cost, while using polychaete bait. It was expected that hermit crabs, which are only found within mangrove forest, and require more expertise to search and process (Kihia et al., 2015), would correspond to higher fish landing and hence higher profitability. Findings presented here do not support such a position, and indicate that hermit crabs, are both more expensive and land less fish. More investigations are therefore called for, to discern drivers to bait choice among the fishers.

Among the bait harvesters, investment on rudimentary tools, such as a polychaete excavating stick locally known as a *chulo*, or a hermit shell crushing (metal rod) and cutting implement (knife or *panga*) implements, were paramount to participation in harvesting activity. The excavating stick is obtained from the adjacent mangrove forest and can be described as a 1-1.5m long stick, with a diameter of 3-5cm. Such sticks, may occur in abundance in regenerating and healthy mangrove forests and are called *fito*, when used for roof filling (Dahdouh-Guebas et al., 2000). In temperate mudflats, metallic forks, blades and pumping implements, are used to excavate sediments and expose the polychaete (Brown, 1993; Cretchley, 1996). Although, these large scale polychaete abstraction to supply the lucrative angler fishery trade, are absent from the local scene, resource managers are well advised to be on the look-out for such developments, due to their documented impact on habitats.

Apart from differences in daily wages, most other aspects of bait fishery profitability were similar among the sites. Wages earned in the fishery may therefore be more dependent on other factors, such as bait and fish productivity at the sites.

As was expected, artisanal fishery using harvested bait, is a labour intensive activity with minimal expenditures on fixed cost. The most important fixed costs incurred by the fisher are the cost of vessels, and fishing gears. Ownership of vessels was not ascertained during this study, however, previous studies (Hoorweg et al., 2006; Malleret-King et al, n.d.) have established that, although many fisher do not directly own vessels, they may access to such vessels through kinship and social bonds. Instances of payment for the vessels are largely restricted to commercial fishing operations e.g. net fishing, where the boat owner gets a proportion of the catch in return. Indications of similar arrangement for the subsistence bait fishery, were however lacking.

In Kenya, a practicing fisher is required to register and pay an annual fee of 1 $, which is levied on the vessel used, but no fee is currently levied on bait harvested (Kenya Fisheries Policy, 2005). Anecdotal evidence, however suggests that most of the bait fishers are neither registered by requisite statutory body, nor pay annual fees. It is suggested that such fees should be incorporated into future valuations.

5 Conclusions

Artisanal fishery using harvested intertidal hermit crab and polychaete is a labour intensive highly profitable enterprise, with an estimated profit of nearly 3 $ d^{-1} after incurring a total expenditure of about 1.4 $ d^{-1}. Profitability was more dependent on type of bait than on the site, with fishers utilizing polychaete worth 0.48 $.d-1, earning higher profits of over 250% than those employing 0.15 $.d-1 of hermit crabs. In the absence of concerted legislation, bait harvesting, and consequent bait fishery, will remain an attractive and profitable livelihood option for unskilled locals. Improvement in income flow management, may improve living standards of the community, but consequently encourage overexploitation, in the absence of alternative livelihoods.

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