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Research Application Summary

Sectorial appraisal of investor and consumer uptake potential for polychaete culture enterprises along the Kenyan coastline

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Abstract

Globally, wild harvesting of polychaetes (*Marphysa mossambica*) as mariculture feed and bait is unsustainable and hence artificial culture provides a viable alternative. However, adoption of culture techniques developed, and consumption of cultured end-products among stakeholders requires evaluation. This paper uses published and grey literature, and consultations with practitioners and personal observations to evaluate the existing and potential supply and demand characteristics of a polychaete driven enterprise. Results indicate that while conversion of the numerous artisanal fishers into polychaete growers and users may be the ideal target, their financial, cultural and technological capacity limits large-scale adoption. Other existing and potential users, such as entrepreneurial fish farmers, and recreational fishers, are possible alternatives. Polychaete annual demand of 298 tonnes may be absorbed by existing and upcoming stakeholders and could provide an important lucrative alternative livelihood venture, especially among the fish farmers. However, improving profitability will require rigorous examination of the supply chain and improving cost-effectiveness of culture protocols.

Key words: Artisanal fisheries, entrepreneurial fish farmers, *Marphysa mossambica*

Résumé

À l'échelle mondiale, la récolte à l'état sauvage de polychètes (*Marphysa mossambica*) en tant qu'aliments pour la mariculture et appâts n'est pas viable et, par conséquent, la culture artificielle constitue une alternative durable. Cependant, l'adoption de techniques de culture développées, et la consommation de produits finis cultivés au sein des bénéficiaires nécessite une évaluation. Cet article est basé sur la littérature existante, les consultations avec les praticiens et les observations personnelles, afin d'évaluer les caractéristiques existantes et potentielles de l'offre et de la demande d'une entreprise basée sur les polychètes. Les résultats indiquent que si la conversion des nombreux pêcheurs artisanaux en producteurs et utilisateurs des polychètes s'avère être une cible idéale, les capacités

financières, culturelles et technologiques limitent l'adoption à grande échelle. D'autres utilisateurs potentiels, comme les pêcheurs entrepreneurs et les pêcheurs récréatifs, sont des alternatives possibles. La demande annuelle en polychètes de 298 tonnes peut être satisfaite par les acteurs existants et à venir, et pourrait donc constituer une importante activité de subsistance lucrative, notamment pour les pêcheurs. Toutefois, l'amélioration de la profitabilité nécessitera un examen rigoureux de la chaîne d'approvisionnement et une amélioration de la rentabilité (par rapport au coût) des protocoles de culture.

Mots clés: Pêche artisanale, pêcheurs entrepreneurs, *Marphysa mossambica*

Introduction

Polychaetes *(Marphysa mossambica)* are segmented, marine annelids that apart from contributing to benthic structure and functioning, constitute major components of marine predator diets (Fauchald *et al.,* 1997). They are widely exploited as bait, in hook and line artisanal and recreation fishery, in both temperate and tropical shorelines (Brown, 1993). Additionally, their superior nutritional content is currently being exploited in high value finfish and invertebrate mariculture diets (Fidalgo *et al.,* 2006). In Europe, the value of baitworm harvesting, mainly for Nereid polychaetes, is estimated at US$210m (200m ECU), primarily from wild harvest and importation, to supply the lucrative recreational fishery (Olive, 1999). Unsustainable harvesting coupled with exotic introduction prompted implementation of a raft of legislation to regulate wild harvest (Kerr, 2012). Artificial polychaete culture is viewed as an important intervention to reduce overexploitation of wild populations (Olive, 1999). A European institution (Sea Bait ltd) is at the forefront in the development and innovation of artificial polychaete culture of temperate Nereid polychaete taxa (Olive, 1999).

Along tropical shorelines, including in Kenya sharelines, a variety of polychaete taxa, dominated by large eunicids, are harvested as bait for use by artisanal fishers (Mbaru, 2012; Kihia *et al.,* 2015a). Along the Kenyan coastline, *Marphysa mossambica* (*eunicidae*) is harvested by excavation in mudflats adjacent to mangrove forests, and used by 50 to 60% of hook and line fishers (Kihia *et al.,* 2015 b). Overexploitation and attendant harvesting damage raise the spectre of unsustainability, requiring immediate intervention, such as regulating harvesting, coupled with alternate bait sources and livelihoods (Kihia, 2015b).

The stagnation of mariculture in Kenya and elsewhere, is primarily blamed on inadequate mariculture technology, infrastructure and poor uptake of change among local community (Brycesson and Beymer-Farris, 2011). Poverty driven factors, such as, lack of adequate funds and access to resources and markets, limit uptake of technological innovation among resource limited communities (ESPRC, 2009). Apart from seaweed ranching by women groups (at Gazi in Kenya and Zanzibar in Tanzania) and pen culture of crabs by youth groups (at Mida creek), the potential for mariculture to uplift livelihoods of fisher communities remains largely untapped (see Brycesson and Beymer-Harris, 2011; Mirera, 2011). Although, techniques for the culture of a variety of tropical finfish

and crustaceans have been and continue to be investigated, uptake is limited (Bostock *et al.,* 2012). The lack of adequate juvenile stock and suitable feeds, hampers growth in tropical mariculture (Tacon *et al.,* 2011). Currently, mariculture of high value marine carnivore consumes 60 to 70% of global fishmeal and oils and hence the need for identifying sustainable alternatives (Allsops *et al.,* 2008).

High essential protein and fatty acid content of polychaete based diets utilised in current marine finfish and crustacean culture has improved seedling supply and consequently yields, in Asian countries (Tacon, 2011). Additionally, use of polychaete based diets reduces dependence on expensive, valuable and unsustainable marine fish and fish oils, in mariculture feed formulation. Allsopp *et al.* (2008) and Olsen (2011) indicated that high value mariculture taxa require at least 20% fish oil and protein in their diet. However, ideal mariculture feed should contain at least 30% protein and should be rich in Poly Unsaturated Fatty Acids such as 3 and 6 series. These are commonly derived from fish and fish oils, further exacerbating current unsustainability of global fisheries.

This study is evaluating the suitability of cultured local polychaetes as alternative fishery bait and fish feed, with a view to encouraging uptake of developed technology in Kenya, and elsewhere. This paper reports on the potential for investor and consumer uptake of culture protocols developed, and explores impediments and their solution. It is based on available published as well as observation data to derive working estimates. Where estimates are not locally available, data and outcomes from similar enterprises in the region are used.

Results and discussions

Three categories of potential stakeholders are recognised, namely, artisanal fishers, mariculture fish farmers and recreational fishers (anglers) (Table 1). Among these, artisanal fishers have the lowest purchasing power, earning at or close to the minimum daily wage of 1$ per day (Hoorweg *et al.,* 2009; Kihia *et al.,* in press). In addition, these fishers have limited access to either credit or formal banking instruments.

Artisanal fishers also have the lowest level of formal educational skills (Table 1), since they frequently have less than eight years of formal learning (Branch *et al.*, 2002; Hoorweg *et al.,* 2009). Anglers and professional fishers, however, are more educated. Anglers are frequently local or foreign tourists (Branch *et al.,* 2002; Le Menach *et al.,* 2015).

Polychaete culture techniques developed for temperate species use recirculating system (Olive, 1999), which apart from involving high tech equipment, requires reliable access to electricity. These systems stock 2000 to 3000 polychaetes m^{-2} and achieve high yield (Fidalgo *et al.,* 2006). High cost and lack of suitable infrastructure may prohibit uptake of such techniques among local populace. For instance, there is poor uptake of high

yielding recirculating systems among freshwater aquaculture enterprises, which are low intensity and require low technology but with concurrent low yields (Brummet and Noble, 1995; FAO, 2012). Thus polychaete culture techniques developed for local taxa must be adapted to fit local conditions and needs, in order to enhance uptake.

The potential for growth of polychaete culture and use of end products is highest among fish farmers and recreational fishers (Table 1). Fish farmers and recreational fishers will immediately realise benefits from the venture, through acquisition of quality and reliable supply for their needs. On the other hand, although artisanal fishers are more numerous, their rigid cultural and monetary handicap, limits growth potential.

Fish farmers in developing countries have been shown to adopt technologies that are integrated into their normal activity patterns (Brummet and Noble, 1995). For instance, agri-pisciculture models are attractive to local communities due to their integration, which allow multiple harvests (Brummet and Noble, 1995). Exception do occur, for example, Kamuthanga Fish farm in Machakos county, apart from adopting high yielding recirculating aquaculture system, also rears manure worms (*oligochaete*), as a high value fattening dietary supplement (Mr. Tony Ndilinge, Proprietor Kamuthanga fish farm Pers. Comm.). Such exceptions are ideal targets for adoption of culture by investors. Mariculture of high value finfish and crustaceans, such as eels, prawns and crabs is highly profitable in South Africa and Asia, but expensive feed demands limit productivity (Brycesson and Beymer-Farris, 2011). Hence, combining highly profitable and marketable mariculture taxa with polychaete culture may be an ideal way for integration.

T**able 1:** Evaluation of stakeholder characteristics and uptake potential for technology and marketed end product

Stakeholder	**Educational levels**	**Purchasing power**	**Growth potential**
Artisanal fishers	Low	Low	Moderate
Fish farmers	Moderate	High	High
Recreational fishers	High	High	High

There are about 5,846 hook and line fishers along the Kenyan coastline (MAFFS, 2014). Of these, 60% use polychaete worms as bait (Kihia *et al.,* 2015a, b). The fishers use 0.22 kg (50 pieces) per fishing expedition, whose value is estimated at 0.11$ (Kihia *et al.,* in press). Total annual polychaete demand for 220 days of fishing is hence estimated at 771,672 kg, worth about 18,600$ (Table 2). Assuming only 10% of the fishers adopt purchasing of bait, potential demand may be estimated at 1,800 $ annually (Table 2).

Mirera (2009) estimates current mariculture production in Kenya at 2.3t of crabs, milkfish, mullet and shrimp, worth about 6,000$. However, an additional 25-30 registered community groups comprising 15 to 40 members, practice Mariculture

(milkfish and prawns) in Kilifi and Mombasa counties. The total demand for fish and prawn feeds among five of these groups, during the on-going FAO-BGI project is estimated at 39,840$ (Mr B. Muli, Mariculture consultant to FAO-BGI project, Pers Comm.). Hence total demand for all the fish farms can conservatively be estimated at 195,000$ annually. Assuming other counties such as Kwale and Lamu may also participate in mariculture, current mariculture fish feed demand along the coastline is estimated at 200,000$ annually. Further, assuming protein and lipid requirement of mariculture feeds normally constitute 50% of costs (Allsopps *et al.,* 2008), potential protein demand is estimated at 100,000$ annually (Table 2). Also assuming that polychaete culture can supply at least 50% of this dietary protein demand would give a potential supply of 100,000 kg worth about 50,000$.

The potential demand for mariculture fish feed could also increase substantially with the entry of new mariculture entrepreneurs. For example there is the proposed prawn hatchery at Kuruwitu, Kilifi County by Mtoni Ltd, a project funded by Australian Government Department of Foreign Affairs and Trade (Mr B. Muli, Mariculture consultant to FAO-BGI project, Pers Comm.). The company has approached partners in the current project (Kwetu training centre) for the possibility of supplying cultured polychaetes for maturation diet for brood stock and spawner. In order to achieve profitable yields, potential conservative estimated of total fish feed needs is 200,000$ annually. Plans are also underway for the possible revival of the Ngomeni prawn farm by the Fisheries department (in partnership with KMFRI, a partner in the current project). This would see demand for polychaetes increase tenfold due to the expansive nature of the farm. Factoring in the massive Kenyan government incentive to support aquaculture, it is predicted that mariculture production may double in the current decade (Dr. J. Munguti, Aquaculture expert, KMRI, Pers Comm.). Assuming there is doubling in mariculture feed demands in Kenya and polychaete potential demand for aquaculture, it is estimated that an additional 50,000$ will be generated annually. Hence total mariculture feed polychaete sales is estimated at 200,000 kg, worth about 100,000 $ annually (Table 2).

FAO (2012) defines coastal recreational fishers or anglers, as a fishery, where the primary driver, is pleasure and entertainment, as opposed to subsistence needs. Globally, 54 million anglers earn over 40B$ annually, and provide employment to nearly one million persons (FAO, 2012; Wood *et al.,* 2013). While subsistence and commercial fishery are expected to decline globally, recreational fishery is projected to increase linearly with economic development (FAO, 2012; Le Menach *et al.,* 2015). Mackenzie (2005) reports that recreational fishers form over 91% of the bait fishers in South Africa and these use both purchased and harvested polychaete, sandprawn, fish and prawns as bait. The anglers spend 2.1$ per day on bait purchase (cost 0.01-0.05$) and hence 996,594$ annually (Mackenzie, 2005). There are about 850 documented recreational fishers along the Kenyan coastline, especially during the NEM season (McMillan, 1987; MAFFS, 2012). This value takes into consideration game fisher numbers but rarely incorporates local or other informal fishers that periodically participate in the fishery

within inshore waters. However, although an unknown number use polychaete the rest use either artificial lure or other bait types. Hence a working estimate of 50% (500) of the recreational fishers is taken as a fair estimate of reported and unreported annual recreational fisher numbers using polychaete (this requires further investigation). Using the bait expenditure data from South Africa (2$ per day) and a fishing season of four months (during NEM), annual recreational fishery bait demand is estimated at 240,000$. Anecdotal evidence suggest that bait supply shops exist in Malindi, supplied by polychaete harvesters from Mida creek and other sites (Mr. C. Van De Geer, Manager, Local Ocean Conservation, *Pers. Comm*.), but the characteristics of this trade have not beenstudied. However, assuming that 10% of recreational fishers will purchase cultured polychaete bait, potential sales are estimated at 24,000$.

It is estimated that total polychaete demand may be in the region of 677, 268 kg worth about 339,000$ annually. Taking into consideration existing and potential impediments to uptake of cultured bait, it is estimated that over 114,000 $ worth of cultured polychaete may be absorbed among the key stakeholders evaluated (Table 2). This corresponds to a cultured polychaete supply of 228,000 kg that could be absorbed into the market, which corresponds to supplying about 33% of existing demand.

Table 2: Potential cultured polychaete demand and market potential among stakeholders along the Kenyan coastline

Market	**Estimated number**	**Estimated current Demand ($.yr^{-1})**	**Estimated potential sale ($.yr^{-1})**
Artisanal fishers	3500	18,634	1,863
Fish farmers	12-50	200,000	100,000
Anglers	500	120,000	12,000
Total	--	338,634	113,863

Conclusions and recommendation

Wild polychaetes are currently harvested and used by a large number of artisanal hook and line fishers, compared to fewer fish farmers and recreational fishers. Uptake of innovation in artificial culture techniques and products among artisanal fishers, may be hampered by limited financial and technical capacity. However, entrepreneurial and financially secure fish farmers may integrate fish feed provision with the sale of extra polychaete yield to both artisanal and recreational fishers. Local markets can potentially absorb 228 tonnes of cultured polychaete annually, which may enhance productivity and profitability and hence livelihoods and sustainability. Building the capacity of local fish farmers is therefore critical to ensuring uptake and expansion of polychaete culture, in order to supply suitable quality fish feed and bait. In the long run, refinement and innovation of novel low cost culture techniques are needed in order to entice artisanal harvesters and fishers and the sustainability of resources and livelihoods.

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