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Fishery management for artisanal reef fisheries in developing countries: A holistic economic approach

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Abstract. Traditionally exploited renewable resources in developing countries, in particular artisanal coral reef fisheries, are often difficult or impossible to manage with classical fishery management tools. This paper argues that using the economic perspective to take a closer look at the special characteristics of these fisheries and the decisions that underlie the behavior of the fishing households, a different approach to management reveals itself. A set of feasible policy options, based on a broader economic scale, can be used to indirectly manage for sustainable fishing levels. We summarize some basic economic concepts for a non-economic audience, and apply them to the artisanal reef setting. The central policy implication of these models is that aligning actual incentives faced by fishers with the conservation objective is critical for success (though by no means sufficient). The central incentive "not to fish" is raising the opportunity cost of time of fishing households. Empowering fishers to pursue higher incomes beyond fishing will reduce the effective pressure on the resource. Hence any policy facilitating alternative livelihoods, increasing education or skills, or providing investment grants or credit should be considered conservation policy in and of itself. Further, long-term family planning policies are likely to have the greatest impact.

Key words: Economics, small-scale fisheries, resource management, alternative livelihood, labor supply

Introduction

Most coral reefs are located in developing countries and support a large number of rural fishing households. These labor-intense, small-scale, traditional, multi-species, coastal fisheries---in short artisanal fisheries---are the primary use of the reef. With population growth, development, and globalization these resources are facing tremendous pressures, and their fate rests, to a large degree, on the economic behavior of the fishing households. Unless policy makers intervene directly or indirectly in the decisions of these households, many of these resources will be depleted and possibly permanently damaged or destroyed.

Since the artisanal fishing households are often dependent on the resource and due to their large numbers, failure to sustainably manage these fisheries will have significant impacts beyond purely conservation and fishery concerns. A collapse will create unemployment, poverty, and possibly lead to large population movements. Because the human dimension is so dominant in these artisanal fisheries, it has been argued that they require a modified policy perspective (Tietze et al. 2000; Garcia et al. 2008).

A common characteristic of these resources is that they are being exploited on an open access basis. As bioeconomic theory and plenty of experience have shown, an open access resource will almost inevitably be depleted over time, unless policy makers intervene (McGoodwin 1990). Yet effective resource management is often neither feasible nor practical in a poor developing country setting.

For a variety of reasons, artisanal reef fisheries in poor developing countries are often difficult or impossible to manage with classical resource management tools. This paper is primarily concerned with these situations where successful management, i.e. access limitation of any sort, is not possible. We argue that by taking a more holistic economic approach to the behavior of the fishing households, a different set of policy options becomes apparent. These feasible policies would indirectly manage for a sustainable level of fishing effort. They could potentially conserve the biological health and potential of the resource in spite of it being exploited under an open access property rights regime. The paper is intended to make the case to a broad audience for more involvement of the science of economics when designing conservation policy for reef resources in developing countries. The economic perspective can offer an important understanding of the human actors in these settings.

Bioeconomics and Artisanal Reef Fisheries

Historically, the management of a fishery was treated as a biological exercise. Fishery economics, the bioeconomic approach to renewable resource extraction, began in the 1950s. Seasonal closures,

specific gear restrictions, and other regulations which did not account for human behavioral adaption often further exacerbated the "race for fish" (Homas and Wilen 1997). Economists point to the lack of private or common property rights (conferring the exclusive right to use a resource) as the fundamental culprit of this waste and to market-based tools, such as individual transferable quotas, as the solution. However, the practical importance of this work is limited for the management of artisanal reef fisheries in poor developing countries. First, in many such countries fishery management, in its narrow sense, is simply not feasible. And second, the settings and assumptions that drive the bioeconomic framework often do not apply.

The introduction of effective, modern management to artisanal reef fisheries in many poor developing countries faces many challenges. The first hurdle is a lack of recognition of the actual scarcity of the resource and no legal entity with clear management responsibility. Even if the need for management is recognized, few of the needed financial and administrative resources exist, and there are a plethora of more pressing problems (e.g. acute poverty, disease). The remoteness of locations, the lack of a property rights tradition, and minimal law enforcement make introducing most fishery management tools very difficult. Limited or non-existent data on catch, effort, and the resource status is a further problem. Finally, the costs of creating and running such a system would likely be prohibitive relative to the value of the fishery and the means of many poor developing countries.

Situations where successful management of artisanal reef fisheries is more likely to be feasible---not the primary concern of this paper---are richer developing countries where local marine tenure traditions exist and have government support. If access can be limited, protected areas are of particular promise because they can take account of many of the special characteristics of artisanal reef fisheries.

The bioeconomic framework and the associated management tools are primarily developed for an "industrial" fleet fishing a large single species stock, with a focus on capital investment in vessels and equipment. Fishers are modeled as profit maximizing firms active in perfect markets for capital, labor, and fish. Total fishing "effort" is usually dominated by vessel and gear capacity, with labor playing a secondary roll. All of these assumptions are in stark contrast to the settings found in artisanal reef fisheries in developing countries.

Artisanal fishers are usually small operations in a local, seasonal, multi-species, multi-gear fishery, where single species management is impossible. They use predominantly small wooden boats and basic gear (lines, nets, spears, etc.). Human labor is the dominant input, with capital playing a secondary role. The artisanal fishing households often live in poverty and consume the less-marketable portion of their catch. Further, market failures plague these fisheries. Product markets exhibit high transaction costs due to the remoteness of small fishing communities and the perishable nature of fish, while labor markets often do not exist (Polunin and Roberts 1996).

It should be noted that semi-subsistence, agricultural households, including fishing households, are often characterized as stagnant entities. This is usually far from the truth as they engage in occupational multiplicity and respond strongly to changes in prices and costs. They behave as economic agents, suggesting that fishing is best understood as one productive activity among many (Tietze et al. 2000; Allison and Ellis 2001; Liese et al. 2007).

More recently outboard motors have extended the range of the typical fisher, while monofilament nets have increased the intensity of exploitation. As a result, the effective fishing capacity has increased, but the overall fishing effort in most artisanal reef fisheries is still primarily a function of the labor supplied by the households. Given the predominance of the human dimension, preferences, market aspects, and socio-economic and demographic variables must be taken into account when designing policy. While the bioeconomic approach offers little practical guidance, the economic approach in general can be very helpful.

Effort in an Artisanal Reef Fishery

Given a level of technology, the total effort in a traditional setting can be decomposed into individual and population elements (Kalland 1995). Both are determined by household behavior, yet the relevant decisions are particular to each level. Fig. 1 is a

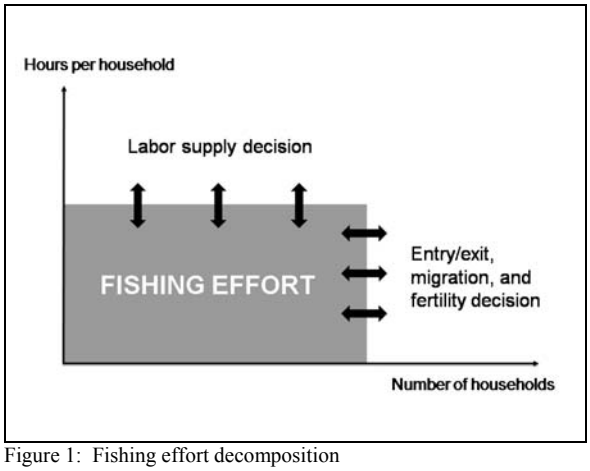

Figure 1: Fishing effort decomposition

stylized illustration of this decomposition of total fishing effort. The representative household's fishing

effort times the number of fishing households leads to the total fishing effort, which is depicted as the shaded area. The individual element is the fishing effort decision by each household, i.e. the intensity of use or hours spent fishing. The population element comprises occupational entry/exit, migration, and fertility decisions. Another way to look at Fig. 1 is as a split along temporal lines. Since traditional fishers usually are independent entrepreneurs, in the short run, the total effort changes due to changes in fishing intensity by existing fishers. Over a longer time horizon, entry/exit into the population of fishers becomes the dominant determinant of the total effort.

Economic Modeling of Labor Supply

The effort decision by a fisher can be modeled in the utility-theoretic framework of micro-economic theory. At the most basic, an individual's utility depends on the consumption of two normal goods, one leisure and one a catch-all for purchased consumption (see any microeconomic text for a more thorough discussion). The individual maximizes his utility by selling part of his fixed endowment of time (i.e. giving up leisure) at a fixed wage rate in order to generate an income with which to buy the consumption good. The amount of labor sold---the labor supply---depends on the wage rate. The wage rate influences the supply through two channels: 1) as the price at which consumption can be substituted for leisure, leading to a substitution effect, and 2) as a determinant of the total wealth (time endowment valued at the wage rate), leading to an income effect. The substitution and income effects have countervailing effects on the labor supply. If this analysis is expanded to include a minimum subsistence requirement it gives rise to the inverted "S"-shaped labor supply function depicted in Fig. 2.

The traditional portion of the labor supply curve is upward sloping, where an individual substitutes consumption for leisure as the wage increases, i.e. as the opportunity cost of consuming leisure increases. In this area, the substitution effect dominates. At higher wage rates the income effect starts to dominate the substitution effect. Starting at this point the labor supply curve becomes backward bending, which is characteristic of richer individuals or economies. If an individual is secure in his subsistence requirement, i.e. income beyond labor income, then his labor supply curve begins with the upward sloping segment. The wage that corresponds to the lowest point is referred to the reservation wage and at wages below this level, the individual will choose not to participate in the labor market.

The "distress sale" portion of the curve would only be observed in a traditional sector of a developing country in the absence of any type of social insurance programs (Sharif 2000; Dessing 2002). This portion of the labor supply curve results if individuals face serious poverty where their only income is through labor, and the wage is less than a living wage. Along this section of the curve an individual only sells his labor due to acute distress. As the wage rises, the individual reduces his supply of labor, as less is necessary to generate the minimum subsistence income. In the fishery context this might reflect a Malthusian overfishing scenario (McManus 1996).

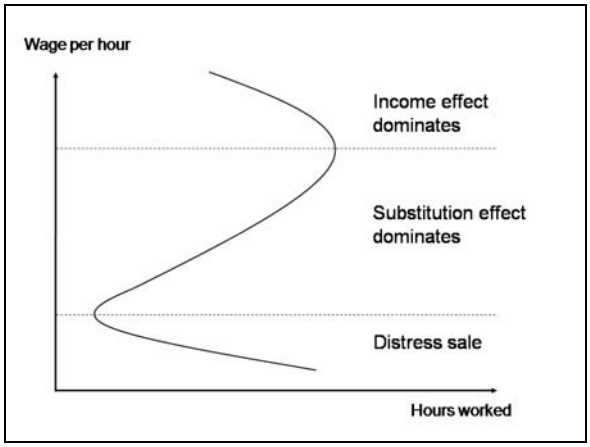

Figure 2: Complete neo-classical labor supply function

In a rural setting of a developing country, few individuals work for a fixed wage as most are self-employed. It seems reasonable that the above neo-classical labor supply relation still explains behavior if one reinterprets the wage as the effective return to labor of a productive activity (net of non-labor costs). For example, the amount of time a person would spend fishing would depend on the implicit wage of the activity, i.e. the productivity of fishing times the price of fish. Differing implicit wages would give rise to a schedule of labor supply roughly corresponding to Fig. 2. The key idea is that developing country households are surrounded by opportunities and challenges in their daily struggle to make a living. In the informal village economies of most artisanal reef fishers, psychic, physical, and material benefits and costs play the same role as financial benefits and costs do in a more formal economy. These incentives drive behavior.

An important disincentive for spending time on any one activity is the opportunity cost of time, which is the value of the time in its next best use. Regardless of whether labor markets exist or not, each individual (or household) faces an opportunity cost of time, be it an implicit wage, an actual wage, or a value for leisure. The possibility of engaging in multiple activities, as is very common in developing countries, can be economically modeled with the help of the time allocation or home production frameworks (Gronau 1977).

Finally, the population of fishers is partly determined by occupational entry/exit decisions. Households enter the fishing enterprise when economic incentives are right and exit when more income (or utility) can be generated in a different profession (Cinner et al. 2008). Entry/exit decisions can be modeled with approaches similar to the ones mentioned above for labor supply and time allocation.

Migration and Fertility

In the long run, migration and population growth are driving forces behind the exploitation of renewable resources (Kramer et al. 2002). These are complex phenomena, and it is a multi-disciplinary undertaking to define, measure, and explain reasons for and consequences of demographic change. In spite of this, population growth must at least be considered, especially since resource conservation is about this long run. Migration among fishers is especially important since it re-allocates fishing effort over space. An important and successful approach to understand and explain population movements is the economic one by framing migration as the outcome of a utility maximizing decision by individuals. At the end of the 19th century E.G. Ravenstein developed six "laws" of migration which have stood the test of time. One of them is "the dominance of the economic motive" for migration (Todaro 1976).

Fertility and mortality are additional forces changing the fishers population level. In the past, fertility has often been the dominant force of change. Population growth without economic development leads to pressure on the natural resources. Even if access is limited, population pressure in such settings has a high potential to undermine any management institutions. Artisanal fisheries are particularly prone to this, as it is ethically questionable to exclude people living at the existence minimum from a potential food source. Examining the fertility decision by households and linking it to economic development is a major topic in demographics and population economics (Becker 1960).

Implications for Conservation Management

Fisheries management is foremost about managing people rather than fish (McManus 1996). As a result, the economic approach---the utility theoretic framework---is central to evaluating the design of any policy aimed at conservation in an artisanal reef fishery. The most important economic contribution to management of reef resources is focusing the discussion on incentives---the factors encouraging, motivating, and inducing behavior.

For any policy to be successful it must align the incentives the fishers face with the conservation objective. Any policy that changes the incentives faced by the fishers by changing relative prices and costs within the fishery will impact the resource status. Since these incentives can be influenced by a variety of non-fishery policies, indirectly managing for a sustainable fishing effort level can be possible. Non-fishery policy instruments in areas such as development, employment, population, and social policy could be tried. Unlike with standard bioeconomic prescriptions, removing the open access nature of the fishery is not necessary. McGoodwin (1990) refers to such policies as "passive indigenous regulation," though he also includes anthropological concepts, such as customs and beliefs.

The central incentive "not to fish" is a high opportunity cost of time among the resource users. In particular, helping fishers find better paying livelihoods raises their opportunity cost of time and will reduce the pressure on the resource. The scope and scale of the labor market can be expanded by creating alternative employment or income diversification opportunities. Other interventions include increasing the education level, providing skills, or raising productivity in non-fishing industries or agricultural (intensification).

The above is related to the alternative livelihood approach, but with the emphasis on fishers being "pulled" out of their profession by better opportunities elsewhere rather than being pushed out of fishing and needing to find other employment. Creating alternative income opportunities should be seen as a conservation policy in itself, rather than just as an add-on to mitigate unwanted side effects of a conservation policy. Policies that empower households and enable them to pursue alternative livelihoods, rather than prescribing specific ones, are likely to be more effective. In addition to education and skills mentioned above, market liberalization, land reform, and providing credit or grants for investment beyond fishing are policies of this nature.

Other policies likely to increase the opportunity cost of time include general development and poverty reduction. With increasing wealth, households will value leisure time more. New entertainment options might also increase the value of leisure time directly. Reducing poverty through income redistribution would probably have similar effects. But caution is warranted. Policies that promote general development will likely also create incentives for households to fish more. For example, improved infrastructure or exposure of artisanal fishers to regional and global product markets can increase fish demand, raise its price, and hence lead to more exploitation (Cinner 2006; Liese et al. 2007). Anticipating the various incentives and disincentives created by a policy and the resulting impact on the resource might be called a holistic economic approach to resource management.

Demographic phenomena are always very context dependent, so general insights for conservation policy are limited. We might risk speculating that policies that set the incentives for households to discourage fishing are likely to have similar effects on migrants' fishing decisions and by extension on the migration decision (if it is motivated by fishing income, as it often is). On the other hand, family- or refugee-based migration is clearly beyond simple economic analysis. Over time, fertility is the central determinant of fishing effort in a poor developing country setting. Three general policy implications suggest themselves: 1. Family planning policies are among the most powerful conservation measures available; 2. any policy with the aim to conserve the reef resource over time must anticipate and be able to withstand demographic developments; and 3. if population growth and in-migration cannot be stopped, access must be limited or the resource will be depleted.

Conclusion

This paper sets out to make the case for more involvement of the science of economics when designing conservation policy aimed at coral reef fisheries in developing countries. This brief paper is in no way a comprehensive or exhaustive review or discussion of this topic. Instead it summarizes some basic economic concepts for a non-economic audience, and applies them to the coral reef setting.

We describe the science of fisheries economics and its serious limitations when applied to a developing country artisanal reef fishery. Instead, we propose that more basic and usually simpler economic models can be more helpful---and in fact critical---for understanding effort in these fisheries. Labor supply and time allocation models can be employed to help explain households' fishing behavior. The determinants of the household's fishing decision can sometimes be influenced by policies, thereby providing possible avenues to indirectly manage for conservation of the resource, even if classical fisheries tool are impossible to implement (which is often the case).

The central implication of these conceptual economic models is that aligning the actual incentives faced by fishers with the conservation objective is a necessary condition for success (though by no means sufficient). In many cases the only feasible incentive "not to fish" is raising the opportunity cost of time of the fishing households. Empowering fishers to pursue higher incomes outside of fishing will reduce the fishing pressure on the resource. Hence promotion of alternative livelihoods, education, skills, and others mentioned should be considered conservation policy in and of itself.

Finally this paper argues that conservation policies that aim for sustainability must take into account the very long run. Over time, demographic developments will usually be the dominant force determining fishing effort in a developing country setting. Conservation policies that ignore demographic pressures are doomed to failure by (lack of) design unless access can be effectively limited.

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