Supporting Information

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SI Published Literature

Rönnbäck et al. (1) found high structural complexity and penaeid shrimp density in 5- to 6-y-old replanted habitat. Mangrove plantations studied in Gazi Bay, Kenya, were found to exhibit similar, and in certain instances, greater species richness, abundance, and biomass in sediment-infauna, macrobenthic fauna, epibiotic flora and fauna, postlarval and juvenile shrimp, and juvenile and adult fish populations to natural stands 5 to 8 y after planting (2–6) (Table S1). However, mangrove replanting does not always result in the same level of fish and benthic macrobiota species diversity found in natural cover as a result of lower accretion rates of fine and organically rich sediments and differences in the types of habitat abutting natural versus replanted sites (7). Therefore, when possible, emphasis should be placed on protecting natural mangrove habitat.

SI Survey

The survey collected information on all income categories and on major categories for productive and consumable assets. Income categories include agriculture, fishing, shrimping, aquaculture, firewood and charcoal, livestock, self-used businesses not covered in other sections, wage jobs, pensions, remittances from relatives or others, assistance/support from nongovernmental organizations or other institutions (not credit), and other (specified by the respondent). Productive assets include farming and fishing equipment, livestock, and transportation vehicles. Land was not included as part of productive assets as there is no well functioning land rental market. Consumable assets include furniture, electronics, mosquito nets, mobile phone, and current value of housing.

The study relies on information for 1990, 2000, 2004, and 2009 that was collected in 2010. We acknowledge the potential problems inherent in recall data, especially regarding the pre-SANAPA period. Unfortunately, government agencies in Tanzania did not collect information from the local communities before the park was established. We addressed concerns about recall bias through the design of the survey, for example, by reminding the respondent that 2004 refers to the pre-SANAPA period. We also trained the enumerators to ensure that respondents produced their best recollections of past amounts and activities. At the same time, if all the households have the same degree of recall bias, at least a part of it is captured through the first-differenced model (a version with constant terms, which absorbs the time effect). In addition, to the extent that the degree of recall bias is correlated with wealth (e.g., the poor may have more diverse income sources and hence have a more severe recall bias), we also partly controlled for these differences through the wealth categories we included in the full model.

In addition to recall bias, we were concerned about the potential bias in the data regarding mangrove firewood collection because of the perceived risk of reporting an illegal behavior. To solicit information that is as accurate as possible, we did explain to the respondents at the outset of the survey that any information we collect will remain confidential, that it will not be shared with any other entities, and that they may refuse to respond to any question. Based on information from focus groups we conducted after the survey, we have some indication that there could have been cases of underreporting among households who live in or adjacent to the park. However, our data show that there are few households who switched from mangrove to other types of firewood from 1990 to 2004 among households who live in or adjacent to the park. Therefore, although the absolute level of proportion of those who use mangrove firewood may be biased downward, the switch information contains less bias.

In this study, we linked household survey data with mangrove cover data within a 5-km-radius circle around each subvillage. Because all households are georeferenced, we could technically create the same variable at the household level. However, as most households are clustered within each subvillage, there is little variation in the location of the circular 5-km-radius land cover analysis zone (and hence mangrove area). We therefore use the subvillage-level variable.

SI Materials and Methods

Geospatial Data and Methods. Landsat Thematic Mapper scenes acquired between 1988 and 1990 and Landsat-7 Enhanced Thematic Mapper Plus (ETM+) scenes acquired in 2005 and 2010 (path/row numbers of P166/R164) were used to extract the mangrove forest area and quantify changes in mangrove area cover. The data selection was dictated by available cloud-free coverages, and variations in the tidal range are a potential source of error. Both the Landsat Thematic Mapper and ETM+ images have a spatial resolution of 30 m. The frame and fill program (version 1) created and distributed by NASA in 2009 was used to fill the gaps in the 2005 and 2010 Landsat ETM+ imagery caused by the Landsat 7 Scan Line Corrector-Off malfunction in 2003. The Landsat images were manually interpreted and delineated within ArcGIS (ESRI) at a scale of 1:17,000, and manual interpretation was selected instead of supervised classification because the former enables more precise extraction of the mangrove vegetation boundary. One researcher conducted all image interpretation for the three time periods to minimize inconsistencies in the image interpretation process. The classification of mangrove cover area focused on dense stands and those that changed over time from a scattered pattern associated with colonization to denser growth, but did not delineate new scattered growth.

Econometric Method. In identifying a causal linkage between the establishment of SANAPA and mangrove-related incomes, we use econometric methods to address concerns that changes in mangrove-related incomes could have been caused by factors other than the establishment of SANAPA and stronger enforcement of regulations on mangrove harvest. For example, households may be shrimping and fishing more in 2009 in response to increasing demand for shrimp and fish. Alternatively, stocks of shrimp and fish could have increased between 2004 and 2009 all along the coast of the study area because of more favorable weather or ecological conditions. Changes in mangrove-related incomes could also have resulted from changes in mangrove areas outside SANAPA areas. Moreover, they also could have been caused by unobservable factors that affect both mangroves and mangrove-related income (e.g., a community's ability in managing mangroves, shrimp, and fish) and location-specific factors that affect productivity of mangroves. We also needed to control for selection bias in income activities.

To address these challenges, we used the Heckman sample selection model for panel data (8). In general, a key advantage of the selection model is to control for sample selection biases that could otherwise arise from the existence of unobservable variables that determine the discrete and continuous choices pertaining to income generation. Such biases may emerge from the possibility that the determinants of income activities are not random. The sample selection model for panel data allowed us to control for time trends (e.g., the trawling ban or changes in output prices, to the extent that they do not vary across households in the study area), time-invariant unobservable factors (e.g., biophysical factors that affect the productivity of shrimp and fish that do not change over time), and sample selection (i.e., factors that are inherently different about those households who engage in shrimping and those who do not). We acknowledge the shortcoming, however, that this approach does not allow us to control for time-varying factors that could affect fishing and shrimping income such as prices and fish stock. Unfortunately, we do not have the data to control for these time-variant factors.

To implement the Heckman's sample selection model for panel data, we used the data from pre-SANAPA (2004) and post-SANAPA (2009) to form a panel data set in a two-step estimation procedure. Here this is explained in the context of fishing income; we repeated the same procedure for shrimping income. The first step is to estimate the selection model for whether the household earns income from shrimping in each year (2004, 2009). Let the equation that determines the sample selection be:

$$z_{it}* = w_{it}'\gamma_t + u_{it}, t = 2004, 2009 \quad \textbf{[S1]}$$

where t is the year, z_{it}^* is a latent variable for fishing income in year t for household i, z_{it} is 1 if $z_{it}^* > 0$ and 0 otherwise, w_{it} denotes the determinant of this status, γ_t is associated parameter estimates, and u_{it} is an error term. The canonical specification for this relationship is a probit regression of the following form:

$$\text{Prob}(z_{it} = 1|w) = \Phi(w_{it}'\gamma_t) \quad \textbf{[S2]}$$

where Φ is the cumulative distribution function of the standard normal distribution. In our specification, the explanatory variables in Z_{it} are all time-invariant variables, including household size, household head's age, sex, education, whether the household can borrow from a commercial bank in times of need, and productive and consumable asset per capita in 2004. We estimate two probits on selection into fishing income in each year (2004 and 2009). As an example, the selection into fishing in 2004 is shown in Table S3. From the probit model estimates, we compute the IMRs for each year, defined as follows:

$$\widehat{\lambda}_{it} = \varphi(w_{it}'\widehat{\gamma}_t)/\Phi(w_{it}'\widehat{\gamma}_t) \quad \textbf{[S3]}$$

where φ denotes the standard normal density function.

The second step is to use the IMRs to estimate the equation of primary interest (outcome equation):

$$y_{it} = x_{it}'\beta + \varepsilon_{it} \quad \textbf{[S4]}$$

where y_{it} is income from fishing, x_{it} is a determinant of fishing income including mangrove cover, β is an associated parameter estimate, and ε_{it} is an error term. In estimating this equation, we use the first-differenced model with IMRs, which is equivalent to fixed effects for two periods. Under assumptions explained by Wooldridge (8), we can control for the sample selection by including the IMRs in estimating this outcome equation. The advantage of the first-differenced model is that we are able to control for all time-invariant, unobserved variables at the household level, which can potentially bias the coefficient estimates. To do so, we took the difference of the time-variant variables and measured the changes between pre- and post-SANAPA, including changes in mangrove cover in the 5-km radius within the SANAPA boundaries and outside the boundaries, and the IMRs. We then include interaction terms between these variables and the distance to boat ramp, as well as the income categories. We report the robust t statistics in Table 4.

Moreover, by adding a constant term to the first-differenced model, we can control for time-variant, unobservable variables that are common across households, such as the trawling ban that took place between 2004 and 2009. This type of effect gets absorbed in the constant term along with all other time effects. We ran all six models with a constant term and found that the difference in the magnitude and the significance of the coefficients of interest were negligible.

What we cannot control for through this approach are time-variant, unobservable, potentially confounding variables that vary across households. For example, output prices of fish and shrimp changed over time in the region, and this price effect could be different across households depending on which species the fishermen harvested in each year. Moreover, the effects may also be confounded by improvements in the harvesting technology, for which we also do not have household-specific data (although we are not too concerned based on our field observation). Unfortunately, as we have information on net earnings from fishing only as a lump sum and not for specific species, we cannot control for these effects. We note that, for this reason, most fisheries analysis will look for fishery-independent estimates of abundance change [e.g., a series of standardized stock surveys (9)]. However, a critical advantage for this study of using income data is that we can directly observe the changes in households' welfare.

Unfortunately, our survey did not include direct questions about the reasons behind the behavioral change in effort allocation. The information we do have are qualitative information on the respondents' perceptions of the positive and negative effects of SANAPA. We do not attempt to identify causality by using the answers to these questions partly because of lack of observations, lack of a convincing strategy, and high collinearity among questions. However, based on simple correlation coefficients, we find that those who lost land to crops as a result of the establishment of SANAPA were associated with larger gains in fishing income between 2004 and 2009. We know through our focus groups that fishing and shrimping are some of the few (in some cases, the only) income-generating activities available in the area. This suggests that households could be changing effort allocation partly out of necessity when there are changes in other income sources, which could be driven by the establishment of a protected area. However, because we cannot convincingly demonstrate this causality, we refrained from speculating this in the main text.

SI Fisheries

Commercial and Artisanal Fisheries in Tanzania. The shrimp and fish species typically caught by the commercial trawlers and the artisanal fishermen varied as a result of the types of fishing gear used. Double-rigged side trawlers were used in the commercial fishery, and the preferred fish species harvested included grunters, groupers, kingfish, catfish, cobia, and spiny turbots (10). The most common shrimp species harvested by the trawlers included *Fenneropenaeus indicus* (74.8%), *Metapenaeus monoceros* (17.2%), *Penaeus monodon* (3.8%), *Penaeus semisulcatus* (3.8%), and *Metapenaeus stebbingi* (0.4%) (10).

Artisanal fishermen with access to boats use dhows, dugout canoes, outrigger canoes, and small boats propelled by sails or oars. Those who use hook and line catch barracuda, bream, emperor, kingfish, and needle fish. Kingfish, queen fish, rays, sharks, and tuna are typically caught with shark nets and gillnets, whereas marlin and sailfish are targeted with long lines and drift nets. Fishermen purse seining at night with pressure lamps typically harvest anchovies, mackerels, and sardines (10, 11). However, the majority of fishermen in our study area rely on seine nets (which are dragged off the beach at low tide), cast nets, mesh nets, mosquito nets, and fish traps. The seine-net fishery typically yields emperor, mackerel, parrotfish, rabbit fish, and sardines (10). Research by Jiddawi et al. (12) found coral reef fishes such as emperors, goatfish, groupers, parrotfish, rabbit fish, snappers, surgeonfish, and sweetlips particularly important to the artisanal fishermen as they can access and harvest these species with their traditional fishing gear and crafts. The most common shrimp species harvested by the artisanal fishermen are *P. monodon, P. semisulcatus*, and *F. indicus*, with the latter most prevalent when mesh nets are used near river mouths or within the intertidal zone (10, 13).

Ecosystem Impacts of Commercial Shrimping. Before the outright ban in January 2008, a series of regulations were created by the Tanzanian government in an attempt to reduce the impact of commercial shrimp trawling on the ecosystem: (*i*) limitations on commercial vessels (i.e., a maximum of 500 HP engine power, 150 gross registered tonnage, two nets, and a minimum cod-end mesh of 50 mm); (*ii*) a minimum depth requirement of 5 m and a closed season extending from December 1 through February 28 to help protect juvenile shrimp populations; (*iii*) prohibition of night trawling to minimize conflicts with artisanal fishermen setting their nets or fishing in the same grounds at night; (*iv*) creation of three zones and rotation of commercial vessels throughout them to try to evenly disperse fishing effort; and (*v*) a bycatch policy mandating the retention of all bycatch species for marketing and processing at the landing sites (14–16). In addition, Tanzania Fisheries Research Institute put forth maximum sustainable yield recommendations, but harvesting levels were twice the recommended amounts (17).

Although the prohibition of night trawling was meant to reduce conflict with artisanal fishermen, an unintended consequence of this policy was exacerbated damage to the bottom habitats, as trawlers conducted heavier sweeps with tickler chains to dig up *Penaeus semisulcatus*, a nocturnal shrimp species (18). Regulations did not require turtle exclusion devices and bycatch reduction devices. The net result was the harvesting of many unintended marine and estuarine species, as well as increased turbidity and habitat damage (14, 16, 18, 19). To address these issues and concerns related to overfishing of the shrimp stock, trawling was banned outright in 2008 (20).

Bycatch species included seagrasses, sponges, sea cucumbers, starfish, crabs, fish, squid, sharks, rays, and sea turtles. Common bycatch fish species include *Arius* spp. (catfish), *Chirocentrus* spp. (wolf herring), *Gazza minuta* (toothpony), *Hilsa kelee* (kelee shad), numerous *Leiognathidae* spp. (pony fish), *Mugil* spp. (mullet), *Pellona ditchela* (Indian pellona), *Trichiurus lepturus* (largehead hairtail), *Thryssa vitrirostris* (orangemouth anchovy), and immature valuable commercial species such as *Gerres filamentosus* (whipfin silver-biddy), *Johnieops sina* and *Otolithes ruber* (croakers), *Sphyraena obtusata* (barracuda), and *Terapon theraps* (largescale grunter) (10, 14, 16, 21). Clearly, one would expect trophic interactions among the species. It is entirely possible that removal of a key species by one fishery could have significant effects in the other. However, we have no empirical evidence or data that would allow us to identify such interactions.

Artisanal Catch Levels Within Bagamoyo District. In Tanzania, all artisanal catch is supposed to be recorded at the district level. However, data collection is not always systematic as a result of budgetary and logistical constraints. In the case of Bagamoyo District, only two of the eight landing stations (i.e., Nchi Pana and Custom) systematically record landings (10). Based on a very limited data set provided by the Bagamoyo District Natural Resource Office, the total artisanal catch in the district decreased from a high point of approximately 4,200 tons in 1995 to approximately 1,250 tons in 2005, but then increased to 3,875 tons by 2009 (Fig. S1). The data also reveal that the number of licensed fishermen within Bagamoyo District increased from approximately 900 to 1,751 individuals from 1994 to 2010, with the largest increase occurring between 2004 and 2005 (Fig. S1). These data, however, should be interpreted with caution. Semesi et al. (1) found that many of the district's official records underestimated the actual quantities of shrimp and fish harvested, as fishermen often do not take their catch to the landing sites to avoid paying taxes. Furthermore, the number of licensed fishermen may not reflect the actual number of fishermen because they may have been encouraged to register in certain years. Moreover, there is no information on the maximum sustainable yield with which we can compare the harvest data. We therefore cannot infer any conclusions about the sustainability of the current rate of harvest.

To understand how the artisanal catch levels reported by the district compare with the national trends, we plotted the total artisanal catch for Bagamoyo District with the national-level total shrimp and marine fish capture statistics compiled and submitted by the government of Tanzania to the Food and Agricultural Organization of the United Nations. The countrywide total catch decreased and then leveled off from 2004 to 2008, whereas the total artisanal catch within Bagamoyo District has increased since 2005 (Fig. S2). The nationwide ban on commercial bottom trawling in 2008 could be a large contributor to the fisheries resources and their availability to the subsistence and artisanal fisheries, as evidenced by the increase in Bagamoyo District catch in 2008 and 2009 (Figs. S1 and S2). Further, the increase observed within Bagamoyo District may be caused in part by the establishment of SANAPA and the subsequent protection of important nursery habitats; however, we cannot draw any firm conclusions from the available fisheries data.

Future Monitoring. Given the lack of fisheries-independent monitoring data, we could only infer the relationship between mangrove protection and increased fisheries production. Therefore, we recommend the implementation of a series of standardized surveys to monitor changes in fish and shrimp abundance in the riverine and coastal mangrove habitat protected along the Wami River and Estuary over time so that future studies can base analyses on empirical evidence. Precise details will be site-specific, but important components to consider when designing and executing a fisheries monitoring program include a sound experimental and statistical design that is pragmatic (e.g., costs, sustainable funding, logistics) and encourages improvements in local assessment capacity.

Fisheries monitoring methods need to be reliable, repeatable, and conducted consistently over time for intra- and interannual temporal comparisons (22). To make these efforts comparable to other studies carried out in the Western Indian Ocean region, sampling regimes should be linked to life histories and habits of the species of interest during neap spring tides with stake nets (23–25). In addition, appropriate sample sizes for stock assessments and the inclusion of spatial and temporal controls are important considerations. The collection of other important physiochemical aquatic variables and mangrove characteristics such as structural complexity of the root system to track the extent of nursery habitat over time are also recommended.

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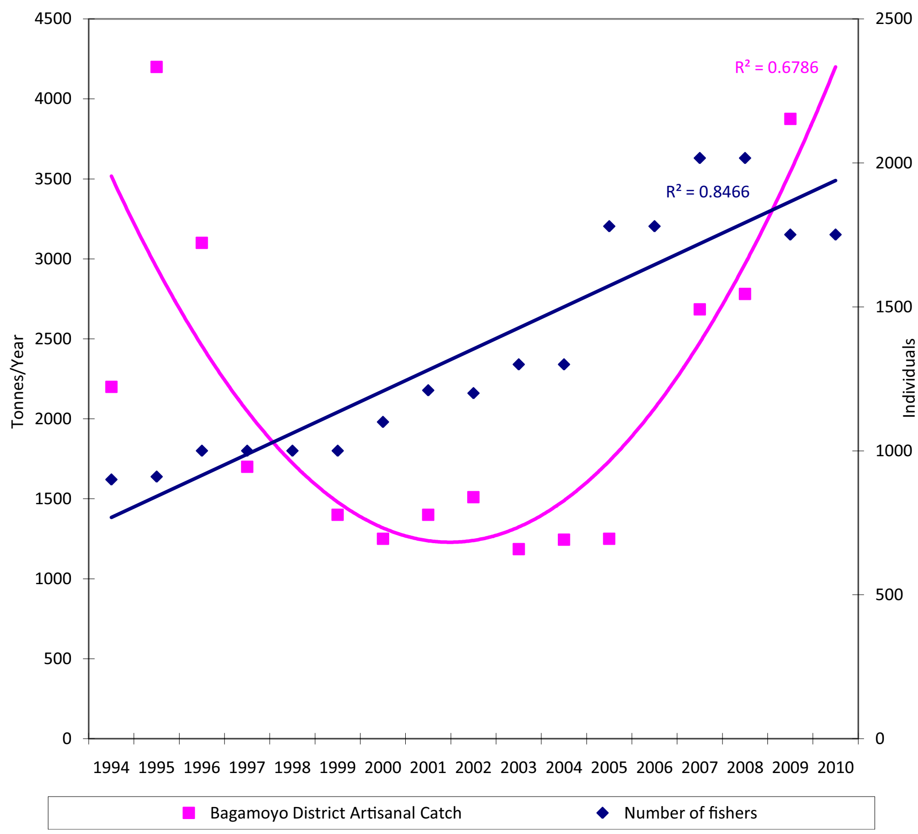

Fig. S1. Multispecies artisanal catch and number of licensed artisanal fishers in Bagamoyo District from 1994 to 2010. Source of data: Bagamoyo District Natural Resource Office.

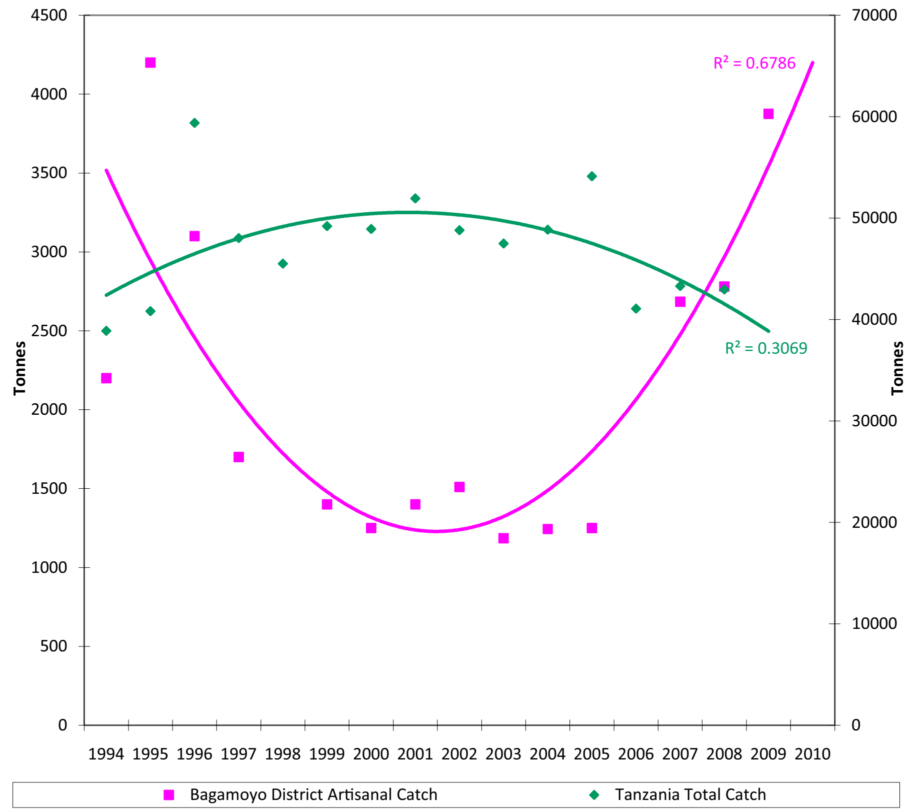

Fig. S2. Total shrimp and marine fish catch in Tanzania (1994–2008) compared with the total artisanal catch in Bagamoyo District (1994–2009). Source of data: FAO Capture Production Statistics and Bagamoyo District Natural Resource Office.

Table S1. Summaries of research articles pertinent to the study

Al-Khayat and Jones, 1999. A comparison of the macrofauna of natural and replanted mangroves in Qatar
Study Location: Qatar. Date of Study: June 1993-June 1994. Purpose: To quantify decapod and fish biodiversity in a natural *Avicenna marina* mangrove, a ten-year old *A. marina* mangrove plantation, and a salt marsh to ascertain if pelagic biota recolonize replanted mangroves. Methods: Hand net fishing to capture juvenile and small fish, gill net (20m x 1.5m with 7cm mesh) and seine net (15m x 1.5 m with 5cm mesh) fishing to capture adults. Main relevant findings: 1) Natural mangrove areas had smaller sediment grain size and higher levels of organic material and substrate moisture in comparison to the planted mangrove areas 2) Overall species diversity ranged from 33-34 spp. among the natural sites, 27-33 spp. among the replanted sites, and 24 spp. in the salt marsh sites. 3) 26-30 spp. of juvenile fish and 17 spp. of adult fish were captured in the natural sites versus 13-22 spp. of juvenile fish and 9-14 spp. of adult fish in the replanted sites. 4) *P. semisulcatus* was present in both the natural and replanted sites. 5) The natural and replanted sites demonstrated 61% similarity. Relevant study conclusions: Difference in species diversity and abundance between the natural and replanted sites was due to the slow accretion rates of organically rich, fine sediment and differences in bordering vegetation types.

Rönnbäck et al., 1999. Distribution pattern of shrimps and fish among *Avicennia* and *Rhizophora* microhabitats in the Pagbilao Mangroves, Philippines
Study location: Pagbilao Bay, Philippines. Date of study: 1996. Purpose: To determine the shrimp and fish species composition and distribution in natural stands of *Avicennia officinalis, A. marina* and *Rhizophora opiculata* and 5-6 year old restored *R. opiculata*. Methods: Stake netting (2-3mm mesh) to capture post larvae penaeid shrimp and fish. Main relevant findings: 1) The most abundant shrimp were Palaemonidae (53.5%) followed by *Acetes spp.* (31.7%). 2) Fish from 37 taxa were caught with *Ambassis urotaenia, A. kopsi* and *Atherinomorus balabacensis* comprising more than 92% of the total abundance. 3) The replanted *Rhizophora* site, which had the greatest structural complexity, exhibited the highest shrimp density whereas the highest small-sized fish density and biomass were observed in *Avicennia* sites located furthest inland. Relevant study conclusions: The successful shrimp and fish recolonization of the replanted *Rhizophora* habitat suggests that mangrove restoration can help to restore depleted fisheries (p. 233).

Bosire et al., 2004. Spatial variations in the macrobenthic fauna recolonisation in a tropical mangrove bay
Study location: Gazi Bay, Kenya. Date of study: Not specified, but the research was conducted five years after mangrove replanting. Purpose: To study the recolonization of macrobenthic fauna in replanted *Avicennia marina*, *Rhizophora mucronata*, and *Sonneratia alba* mangrove plantations. Methods: Crabs and sediment infauna were collected from randomly placed quadrats, identified, and counted. Main relevant findings: 1) Natural sites had the highest sediment infauna density with the exception of the reforested *A. marina* site. 2) The *R. mucronata* and *A. marina* reforested sites had higher crab densities than the natural forests, but the reverse pattern was observed within *S. alba* sites. Relevant study conclusions: Similarities in the number of taxa between natural and reforested sites suggests a recovery in habitat provisioning ecosystem services (p.1069).

Huxham et al., 2004. Mangrove fish: a comparison of community structure between forested and cleared habitats
Study location: Gazi Bay, Kenya. Date of study: 2002. Purpose: To compare the fish communities among natural, reforested, and cleared sites of *Sonneratia alba*, and *Rhizophora mucronata*. Methods: Stake netting with single (100m with 1mm mesh) and paired (24m with 1mm mesh) nets to capture fish. Main relevant findings: 1) Site 1, a *S. alba* plantation planted years before the study, had the highest mean abundance, biomass, and species richness of all mangrove sites, the second highest total number of species, and supported several species found only in mangroves. Relevant study conclusions: The findings suggest that reforested sites are capable of providing "suitable (or possibly superior) habitat for fish" (p.644).

Crona and Rönnbäck, 2005. Use of replanted mangroves as nursery grounds by shrimp communities in Gazi Bay, Kenya
Study location: Gazi Bay, Kenya. Date of study: 2002-2003. Purpose: To assess the distribution of post larval and juvenile shrimps in two different 8 year old reforested *Sonneratia alba* stands (IP and MP) and compare these findings to natural and clear cut sites. Methods: Stake netting (2mm mesh enclosing $9m^2$ of intertidal microhabitat). Main relevant findings: 1) A total of 615 individuals from 19 spp/taxa were caught with Penaeids comprising 66% of the catch. 2) ANOSIM (analysis of similarities) found the natural and reforested IP site to have similar shrimp species composition and abundance values. 3) Macrobrachium spp., Acetes spp., and *P. semisulcatus* were mainly found in the natural and reforested IP sites, *P. indicus* was found mainly in the reforested MP site, *M. monoceros* was found in the natural and both reforested sites, and *P. japonicus* was found predominantly in the clear cut site. Relevant study conclusions: The higher diversity of penaeid spp. in the natural and reforested IP sites are likely due to longer periods of inundation and greater heterogeneity in structural complexity (p.543).

Crona et al., 2006. Re-establishment of epibiotic communities in reforested mangroves of Gazi Bay, Kenya
Study location: Gazi Bay, Kenya. Date of study: 2002. Purpose: To examine epibiotic flora and fauna recolonization in 8 year old replanted *Sonneratia alba* pneumatophores and trunks and compare these findings to natural and clear cut sites. Methods: Sampling of all epibiota within randomly placed 0.5m x 0.5m wood frames. Main relevant findings: 1) There were 18 species of algae in the natural site, 23 spp. in the reforested IP site, 10 in the reforested MP site, and 1 in the clear cut site; 2) the highest total algae and sessile fauna biomass occurred in the natural and reforested IP sites.

Crona and Rönnbäck, 2007. Community structure and temporal variability of juvenile fish assemblages in natural and replanted mangroves, *Sonneratia alba* Sm., of Gazi Bay, Kenya
Study location: Gazi Bay, Kenya. Date of study: 2002. Purpose: To determine the abundance and species composition of juvenile fish within two different 8 year old replanted *Sonneratia alba* sites and compare these findings to natural and clear cut sites. Methods: Stake netting (2mm mesh enclosing $9m^2$ of intertidal microhabitat). Main relevant findings: 1) A total of 1800 individuals from 49 taxa and 34 families were caught with five spp/taxa comprising ~70% of the total fish abundance. 2) Margalef's index of species richness ranged from 1.07 at restored site MP to 1.43 at restored site IP, and Shannon-Wiener diversity ranged from 0.66 at the natural site to 1.00 at the clear cut site. There were no statistically significant differences between any of the sites. 3) The clear cut site had the highest fish abundances while restored site MP had the lowest abundance, but highest fish biomass. Relevant study conclusions: 1) The insignificant differences between diversity values suggest that at this spatial scale, temporal patterns play a larger role in juvenile fish assemblages than the presence and type of mangrove (p.50). 2) Similarities in fish density, diversity, and community composition between the natural and replanted sites suggest that the refuge and foraging areas for juvenile fish has been restored in the replanted mangroves (p. 50). 3) Higher fish densities in the clear cut site may be explained by its small size and enclosure by mangrove habitat at a larger spatial scale (p. 50).

Table S2. Perceptions of the effect of SANAPA on livelihood, 2010

Perception	Mean of households in subvillages: Some mangrove cover within SANAPA in 5-km radius	Mean of households in subvillages: No mangrove cover within SANAPA in 5-km radius
Lost access to mangroves used for cooking fuel	−2.38	−3.33
Lost access to mangroves for income (e.g., charcoal)	−3.54	−2.93
Lost access to land to grow crops	−4.08	−3.90
Lost access to fishing grounds	−1.58	−2.31
Has been increase in mangroves	3.36*	2.17
Has been increase in fish stock	0.26	0.49
Has been increase in shrimp stock	−0.35	−0.23
Has been increase in coastal buffer against storms	−0.24	0.46
Better water quality	0.86	0.17
More tourism-related jobs	−0.06	−0.06
Any negative impact of SANAPA on livelihood, %†	44‡	17
Any positive impact of SANAPA on livelihood, %†	24‡	5

Respondents were asked whether they agree or disagree with each statement and to rate the response on an 11-point Likert scale. Original numbers were rescaled so that +5 indicated "strongly agree" and −5 indicated "strongly disagree." Numbers shown are means.
*Significant difference between groups at 5% level.
†Assessed on a per-household basis.
‡Significant difference between groups at 1% level.

Table S3. Probit model for the presence or absence of fishing income in 2004

Explanatory variable	Dependent variable: Fishing income in 2004 (1 if yes, 0 if no)
Household size	0.02 (1.21)
Household head's age	0.00 (0.07)
Sex (1 if household head is female, 0 otherwise)	−0.29* (−4.17)
Household head education dummy variable (1 if 3 y)	0.14 (0.57)
Household head education dummy variable (1 if 4 y)	0.28 (0.58)
Household head education dummy variable (1 if 5 y)	0.35 (0.92)
Household head education dummy variable (1 if 6 y)	0.00 (0.01)
Household head education dummy variable (1 if 10 y)	0.55† (2.20)
Credit market access (1 if cannot borrow from commercial bank in times of need)	0.14 (1.58)
Credit market access (1 if do not know whether they can borrow from commercial bank in times of need)	−0.08 (−0.39)
Productive and consumable asset per capita in 2004	0.00 (0.12)
Observations	127
Pseudo-R^2	0.11

z-statistics are listed in parentheses. Significant at *$P < 0.01$ or †$P < 0.05$.

Table S4. Descriptive Statistics

Variable	Observations	Mean	SD
Fishing income in 2004 (1,000 Tanzanian shillings)	65	370.78	641.50
Fishing income in 2009 (1,000 Tanzanian shillings)	65	599.21	851.35
Shrimping income in 2004 (1,000 Tanzanian shillings)	34	659.54	956.86
Shrimping income in 2009 (1,000 Tanzanian shillings)	34	674.03	930.90
Household size	150	4.68	2.42
Household head age	146	42.32	12.07
Household head sex (1 if female)	150	0.13	0.33
Household head education, y	150	5.41	2.35
Credit market access (1 if can borrow from commercial bank in times of need, 0 if cannot borrow)	143	0.26	0.52
Asset per capita in 2004 (1,000 Tanzanian shillings)	150	421.85	735.40
Asset per capita in 2009 (1,000 Tanzanian shillings)	150	441.67	618.35
Mangrove cover in 5-km radius circle within SANAPA boundaries, km^2			
2005	150	0.71	1.75
2010	150	0.73	1.79
Mangrove cover in 5-km radius circle outside SANAPA boundaries, km^2			
2005	150	2.35	1.89
2010	150	2.42	1.93
Distance to SANAPA boat ramp, km	150	39.04	21.59