RESEARCH ARTICLE

Ecosystem Restoration: Evaluating Local Knowledge and Management Systems of Fishermen in Fosu Lagoon, Ghana

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This article evaluates fishermen's knowledge about the value of mangrove to fish stock and discusses possible management practices to help restore fish stock within the Fosu Lagoon, Ghana. The lagoon was recently added to the list of water bodies with *dead zones*, raising concern for the people who depend on it for both sustenance and livelihood. The methodology includes in-depth interviews and surveys. Feedback was collected from 120 fishermen representing the different communities that fish the lagoon. Findings did include that fishermen indicated they have some knowledge about mangroves in general and specifically their value to fishing. However, they lack knowledge about the scientific information to manage these mangroves properly to derive the complete benefits that mangroves provide. With its importance to the livelihood of the fishermen and the traditional heritage of the Cape Coast (Ghana) community as a whole, Fosu Lagoon should be the object of more in-depth studies to help restore the fishery resources. This article provides baseline information for developing educational programs to educate the people about the economic, ecological value, and functions of mangroves. The report analyzes one of the obstacles—depletion of mangroves—leading to decline in fish resources in the lagoon. Based on the knowledge of the fishermen, the article provides some recommendations for better management of the lagoon to help reverse fish decline. This work is original, as no such analysis has been carried out before for this region.

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The Fosu Lagoon is an important environmental resource for the people of Cape Coast, Ghana. Located at 5° 7′ N, 1° 6′ W, it plays a significant role in the traditional heritage of the people, providing livelihood for fishermen living in and around the area. By the early 1980s, the Fosu Lagoon was classified as moderately polluted (Biney, 1982). Over the years, the Fosu Lagoon has faced a severe environmental crisis brought on by pollution. This deteriorating condition has led to a decline in the productivity of fish and other resources within the lagoon [Ghana Environmental Protection Agency (EPA), 2004]. In 2006, it was added to the list of the world's water bodies that contain *dead zones* as a result of an input of nutrients rich in phosphorus and nitrogen [United Nations Environment Program (UNEP), 2006]. Sources of the phosphorus- and nitrogen-rich nutrients have been linked to wastewater from surrounding residential areas and industrial activities that are carried out close to the lagoon (Kendie, 1998). High levels of phosphorus and nitrogen produce large populations of phytoplankton in the lagoon. Phytoplankton produced from high levels of phosphorus and nitrogen die and is eaten by bacteria that use up oxygen, reducing its availability and creating a biological oxygen demand (BOD) (UNEP, 2006).

The fishermen and the local communities in the Cape Coast municipality, who depend on the lagoon for fish, tend to face long-term health risks from eating fish from the lagoon. In recent research to characterize and assess heavy metals and polycyclic aromatic hydrocarbons (PAHs) in the sediments of the Fosu Lagoon, Ghana, Gilbert et al. (2006) reported that more than 50% of sediment samples taken from the lagoon contained cadmium (Cd) levels that exceeded established sediment Cd guidelines for the protection of aquatic life. Nickel was also found but to a lower extent. Gilbert et al. (2006) estimated an average of 359.4 mg/kg cadmium in the sediment from the Fosu Lagoon.

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Exposure to high concentrations of cadmium may cause long-term renal tubular dysfunction that leads to abnormalities in calcium metabolism and to osteoporosis and osteomalacia in both people and animals (Jarup et al., 1998). Adjei (1991) reported that zinc levels found in the Fosu Lagoon far outstrip levels recommended by the World Health Organization (WHO) and the Food and Agriculture Organization (FAO). High levels of zinc may damage the pancreas, disturb protein metabolism, and cause arteriosclerosis and other health problems, such as stomach cramps, skin irritations, vomiting, nausea, and anemia (Prasad, 2001). Some fish can accumulate zinc in their bodies when they live in zinc-contaminated waterways, leading to biomagnifications of zinc up the food chain.

The EPA in Cape Coast recently issued a warning to the public not to catch and eat fish from the lagoon because of the risk of it causing cancer and other severe nervous system–related illnesses (Buadu, 2008). The EPA has stated that all fishing activities in the lagoon must be stopped until the health of the lagoon has been restored (Buadu, 2008). The EPA has suggested that the polluters of the lagoon who reside in the surrounding communities such as Siwudu and Adisadel College be resettled, and that major drainage systems in the lagoon catchment area be constructed to divert runoff directly into the sea. Although infrastructure development may be a more effective way to reduce nutrient inputs to the lagoon and to restore water quality for fish and people, it will require millions of cedis (Ghanaian currency) to carry out and may be feasible only in the long term. In relation to this, the former Cape Coast Metropolitan Chief Executive, Ms. Mercy Arhin, indicated that the assembly will be seeking funds from different organizations for this purpose (Buadu, 2008).

Indiscriminate cutting of mangrove trees in and around the lagoon, which would otherwise cycle nutrients and remove pollutants (Wilkie and Fortuna, 2003), has led to its deterioration. Mangrove nutrient processing has been exploited for water-quality improvement (Barbier, 1994; Spaninks and van Beukering, 1997). Mangrove trees are ideal habitat for a large variety of fish, crab, shrimp, and mollusk species (Manson et al., 2005) and serve as nurseries for many fish species (Mumby et al., 2004). Mangroves reduce excessive sediment and nutrient loading from runoff and thus protect habitats from excessive silt deposition (Wilkie and Fortuna, 2003). Basin mangrove forests may be particularly useful for transforming nutrients, particularly nitrogen, and immobilizing microbes and chemicals such as pesticides (Clough, Boto, and Attiwill, 1983). Mangrove trees will help remove cadmium, nickel, and other pollutants from the lagoon, minimizing harm to both aquatic and human life. Thus, in the short term, mangroves could be planted to help improve the health of the lagoon, restore fish productivity, and sustain the fishery. This will help protect jobs for over 1,000 fishermen who fish the lagoon (Buadu, 2008), as well as women who sell the fish.

Ayisi and Addo (1994) reported that the majority of rural dwellers in Ghana use mangrove trees mainly for firewood, charcoal, and fish smoking. Sackey, Laing, and Adomako (1993) revealed extensive commercial exploitation of mangroves for firewood in Ghana. Mangrove forest along the Fosu Lagoon has been used for similar purposes. Mangrove restoration projects are taking place in efforts to restore over exploited mangrove forests in Nsuekyir and Sankor villages, near Winneba in the Central region of Ghana (Rao, 2007). Nsuekyir has now conserved 90% of its mangrove forest, and Sankor is close to that, which has increased fish productivity in these regions (Rao, 2007).

Fish are an important local resource and provide both nutrition and economic opportunities for these fishermen and the local community. Fish are recognized as the most important source of animal protein in Ghana (Aggrey-Fynn, 2001). Thus, fish productivity and health must be protected. Currently, about 1,000 Fosu Lagoon fishermen have vowed to defy the EPA's warning against catching and eating fish from the lagoon for fear of becoming jobless (Buadu, 2008). Blay and Asabere-Ameyaw (1993) estimated the annual yield of the fishery in Fosu Lagoon to be 452–664 kg/ha. However, little research has been done on the productivity of the lagoon since then. A field survey of the employment structure of Cape Coast in 1996 ranked fishing and farming third (15.1%) among main occupation groups in Cape Coast (Kendie, 1998). Manufacturing came first (30%), followed by sales workers (29%). An effort to obtain recent information on the existing employment structure of Cape Coast has been difficult. At present, fishermen and farmers make up 60% of the total population of 118,106, of which 57,365 are males and 60,741 are females (Ghana Statistical Service, 2002). Introducing an alternative source of income for these fishermen may help reduce overexploitation of the fishery resources, as well as reduce the possibility of creating conflict between fishermen and the EPA.

Even though these fishermen and the Cape Coast community at large depend heavily on the Fosu Lagoon for fish and other fishery resources, little research has been conducted and documented in relation to investigating the reduction in fish productivity. To recognize and help restore the value of services provided by the lagoon, the dysfunction must be identified and the causes and potential solutions must be evaluated. *Environmental literacy* among the fishermen and the Cape Coast community can go a long way toward addressing some of the issues that bring about pollution in the lagoon. In this article, we will assess the level of exploitation of mangroves along the Fosu Lagoon by the local communities, evaluate fishermen's knowledge about the value of mangroves to fish productivity, and discuss possible management practices to help restore fish productivity in the lagoon.

Theoretical Background

As background, this section describes general characteristics and importance of mangroves, fishery management in the lagoon, and restorative strategies that could be adopted by the fishermen and people of Cape Coast to help restore the fishery in the lagoon. Mangroves play a critical role in the ecology and the economy of coastal communities (Ellison, 1997; Dahdouh-Guebas et al., 2000; Naylor and Drew, 1998). The total economic value of a natural resource such as a mangrove ecosystem comprises two main sources of revenue: the wealth from the direct valuation of its biological production and services habitat and nutrient cycling, water-quality maintenance, and coastal protection (Barbier, 1994; Spaninks and van Beukering, 1997). Fish management in the lagoon has always been by traditional means (system of beliefs), but this has not been able to sustain the fishery in recent times. The population of people fishing in the lagoon has increased, reflecting increased demand and possible overexploitation of fish from the lagoon. Socioeconomic conditions such as underemployment and lack of alternative employment opportunities for these fishermen compound the problem. Similar situations like the conflict between the EPA and the Fosu Lagoon fishermen have been stated earlier, and have been observed and dealt with in other regions. For instance, the World Wildlife Fund (WWF), a nongovernmental organization (NGO), provided some funding to support tribal management of the Kafue Flats grasslands along the Zambia River (Smardon, 2009).

As stated earlier in the introduction, Ayisi and Addo (1994) discussed multiple reasons that account for the deforestation of mangrove ecosystems. To help control mangrove deforestation, it is important to identify the real causes of this activity and its associated socioeconomic relationships. Most of the mangrove trees along the Fosu Lagoon have been cut down and sold or used as fuel by the community. The potential of mangroves functioning as good habitat for fish production is well documented in literature (Barbier, 1994; Spaninks and van Beukering, 1997), yet many societies destroy this valuable resource but witnessed sustainable harvesting of mangrove in St. Lucia's Mankote Mangrove for charcoal production (Smardon, 2003, 2009).

Odum (1971) identified that leaf detritus from mangroves contributes a major energy input into fisheries. Tropical mangrove habitats are an important part of estuarine food webs, producing algal or bacterial conglomerates, and forming detritus that serves as food for fish, shrimp, and crabs (Manson et al., 2005; Sheridan and Hays, 2003). Yet, less than 50% of these mangrove habitats remain (Wilkie and Fortuna, 2003). Earlier studies by Daniel and Robertson (1990) state that comparisons of the densities of fish and Old World mangrove sites have generally supported the contention of a nursery ground function for mangrove habitat, but the fish nursery value of mangrove habitats often varies greatly in any one region. Wilkie and Fortuna (2003) examined mangrove habitat functions in south Florida, finding that an estimated 75% of the game fish and 90% of the commercial species in south Florida depend on the mangrove system during at least part of their life cycles. Also insects, reptiles, amphibians, birds, and mammals thrive in the mangrove habitat and contribute to its unique character. The mangrove roots and shallow waters offer shelter from predators until the juveniles reach a size large enough to avoid most predators (Wilkie and Fortuna, 2003).

Six main species of red and white mangroves grow in Ghana (FAO, 2003): *Rhizophora racemosa*, *Rhizophora mangle*, and *Rhizophora Harrison I* (all red); and *Avicenia germinans*, *Avicenia africana*, and *Laguncularia racemosa* (all white). However, the red mangrove *R. racemosa* and the white mangrove *A. africana* are the two main species found along the Fosu Lagoon. Of the mangroves and significant wetlands around the Greater Accra area, 55% have been decimated through pollution and overcutting (Interim Guinea Current Commission, 2007). The consequences of urbanization include high levels of pollution and persistent stench (Sackey, Laing, and Adomako, 1993) and the permanent destruction of mangrove forests and their inhabitants (Lacerda, Machado, and Moscatelli, 2000).

Fishery management tools like legally limiting harvest by size and number, closing seasons, limiting entry, and stocking from hatcheries have often been used where worldwide declines in harvests of fish from lagoons have been attributed to overharvesting, water pollution, and habitat loss (Royce, 1987; Stroud, 1983). These management tools, though effective, are not easily adopted by poor, developing countries. For example, stocking from hatcheries is expensive, considering the resources required to implement and sustain it. Recently, restoration of degraded or lost coastal wetland habitats has been recognized as having great potential as a cost-effective fishery maintenance and restoration strategy (Benaka, 1999; Lewis, 1992).

Methodology

The *mental model approach* comprising both interviews and surveys was employed for this study (Morgan et al., 2002). This methodology was designed to record and document information on what the fishermen knew about mangroves and what guided their use of the resources provided by the lagoon. The study population was drawn from six communities close to the Fosu Lagoon and consisted of fishermen who fished from the Fosu Lagoon (Figure 1): Siwudu, Adisadel village, Adisadel estate, Esikafoambantem, Antem village, and Zongo. Of the six communities, Siwudu was selected as the site for administering the survey to the fishermen because it is the community closest to the lagoon and the place where fishermen from other communities gather prior to fishing. The mental model approach, which is a risk communication tool that provides quantitative information, can be used to provide knowledge and information that people need to make informed decisions about risks to health, safety, and the environment (Morgan et al., 2002). It also enables researchers to identify any new facts that they may observe while conducting research (Morgan et al., 2002).

Rouse and Morris (1986) reported the use of mental models in diverse domains, ranging from acquiring knowledge in engineering systems to typologies of indigenous peoples of the natural world. The mental model approach in this study gave the fishermen the opportunity to express, in their own terms, their beliefs about the degradation and pollution within the lagoon and its impact on fish and their well-being. Likewise, it helped us (the researchers) to capture the current knowledge about the processes that determine the nature and magnitude of the risk of loss in

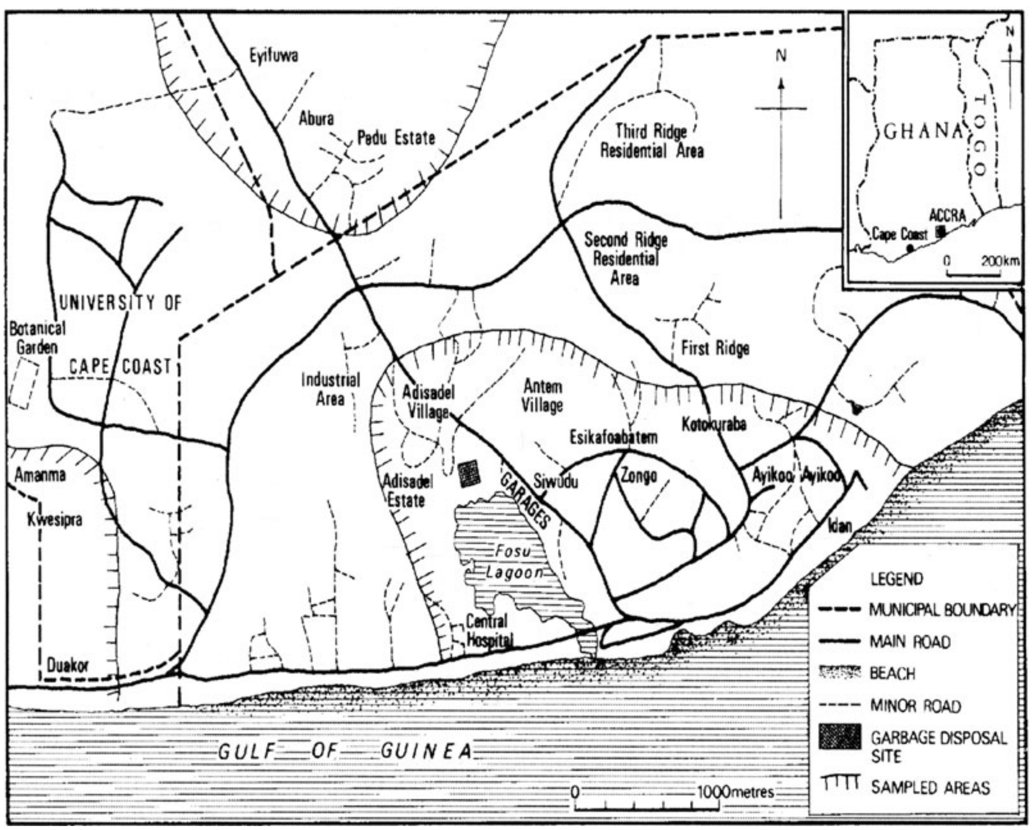

Figure 1. Cape Coast Municipal area showing the Fosu Lagoon and surrounding communities. Source: Survey of Ghana (Kendie, 1998).

fish productivity and the health risks of eating polluted fish from the lagoon.

Data Collection

Data collection consisted of two phases: an interview and a survey. A questionnaire administered verbally face to face (qualitative research) using mostly open-ended questions was employed to increase participation from 20 fishermen who had fished in the lagoon for longer than 15 years and knew much about its fishing patterns and history. These fishermen were selected with the help of the linguist from the clan that takes care of the lagoon and were representative of the six communities selected. After interviewing the 20 fishermen, the recorded interviews were transcribed manually. Detailed notes from the transcription were typed, and grounded theory was used for analysis. The typed notes were used for coding by reading through them several times line by line. Meanings (codes) were assigned to the different aspects of information provided. This was followed by focused coding in which repeating ideas and larger underlying themes that connected codes were identified, as well as patterns and variations. Different features, general categories, and concepts were compared, and themes were developed from the comparisons. Themes were selected based on topics that had considerable amounts of data collected and reflected causal patterns of behavior under study. The frequency of certain items and responses was also useful to identify patterns.

The information gleaned from the interviews was employed to develop the questionnaire used in the second phase of the study. The questionnaire was given to 12 fishermen to respond as a way of pretesting to determine whether the items in the questionnaire were well structured, clear, and easy to understand. After pretesting the questionnaire and getting good responses, it was given to 132 fishermen selected at random. This was done to verify the information obtained from the face-to-face interviews. Sampling was done each day at the study site (Siwudu) by interviewing the first fisherman who agreed to participate in the study, and subsequent participants were selected by counting five fishermen and picking the sixth one. The questionnaire used in phase 2 included both closed and open-ended questions designed to ascertain the respondents' knowledge of the role of mangroves for fishing; their knowledge of the environmental effects of degrading the mangroves; the number of times they fished in the lagoon; the number of times they and their family ate fish caught from the lagoon; their perceptions, beliefs, and knowledge about the risk of eating contaminated fish; their risk-reduction behaviors; and their awareness and knowledge about the state of pollution in the lagoon. Information on the demographic characteristics of the anglers was also collected. Several open-ended questions allowed participants to express their personal beliefs about fish and lagoon pollution, and their attitudes and concerns about the loss of fish and the risks of eating fish caught in Fosu Lagoon. Women were not interviewed or surveyed because women are not allowed to fish the lagoon and, although they may know the value of mangroves to fish productivity, the study was more interested in those who do the fishing. Failure to sample women may have its own limitations for the study since women are involved in harvesting mangroves and using the wood for fish smoking. Perhaps future studies can look at the influence of gender on the knowledge and behavior of the fishermen and the women who use these resources.

The survey was conducted from December 2006 to January 2007. Of 132 fishermen selected, 120 completed the questionnaire for the survey. The questionnaire was verbally administered face to face to increase respondents' participation and likelihood of questionnaire completion, since most of the fishermen were under time constraints. The questions were read to participants, and their responses were written down by the interviewer. The time required to complete each questionnaire ranged from 30 to 40 min.

Data Analyses

Survey responses were compiled, coded, and analyzed using the Statistical Package for Social Scientists [SPSS version 12 (Pallant, 2005)]. For coding, the raw data were translated into meaningful categories and coded numerically to facilitate further data analysis by SPSS. Descriptive statistics such as frequencies and percentages for various variables were determined from the analysis. The frequency distribution helped us summarize and compress the data by grouping it into classes. These classes showed how many observations of each variable had a particular characteristic. The percentages provided a more useful description of the data and provided more contexts. Interviews and survey results were used to identify gaps in fishermen's knowledge of mangroves. A few quotes from the interviews have also been included to support the discussion.

Results

Of the 132 questionnaires given out to the fishermen, 120 were completed and collected and 12 were discarded because they were incomplete. The response rate was 91%.

Age ranged from 21 to 68 years, with a mean age of 48 (Table 1). Of the fishermen, 104 (86%) were Fante (indigenous people of Cape Coast) and 16 (14%) were Hausa/Frafra from Northern Ghana (Table 1). All fishermen were residents of communities surrounding the lagoon: Siwudu, Adisadel Village, Adisadel estate, Esikafoambantem, Antem village, and Zongo. Percentage of fish consumption changed with age as shown in Table 1. All fishermen reported that fish consumption depends on availability and, the more often these fishermen fish, the more fish they get to consume. The age bracket 41–50 consumed the most fish daily, followed by those between 31–40 and 21–30.

Mangrove Coverage Assessment

The current population density of mangrove trees was estimated by counting the number of trees per 50 m along the bank of the Siwudu side of the lagoon. A cluster of about 12 trees covered an area of about 5 m^2 within the 50 m. The area described is shown in Figure 2. Most of the other parts of the lagoon have no mangroves but are covered with grasses and other weeds. The total surface area covered by the lagoon is 61 ha (Blay and Asabere-Ameyaw, 1993). After an extensive review of the literature, barely any documented information was found on the past mangrove coverage for Fosu Lagoon. Personal communications with some professors at the University of Cape Coast who had studied the lagoon and the fishermen was the only information that could be collected on the past mangrove coverage. Based on that information, mangrove trees covered most of the area along the lagoon in the past, but currently there are only few mangroves along certain areas of the lagoon.

Table 1. Selected demographics of the fishermen ($N = 120$)

	No. of fishermen	%	% Consuming fish daily
Age (years)			
21–30	21	17.5	17
31–40	36	30	31
41–50	49	40.8	41
51–60	9	7.5	5
61–70	5	4.2	6
Ethnicity			
Fante	104	87	94.2
Hausa/Frafra	16	13	100
Education			
No formal education	22	18	100
Basic/primary	62	52	90.3
Middle/trade shool	36	30	100

One explanation provided by respondents for cutting these mangroves is that they harbor dangerous reptiles such as snakes. Others explained that they have used these mangrove trees as an important source of firewood and charcoal in response to the increase in domestic needs for energy by urban populations in Ghana (Sackey, Laing, and Adomako, 1993). The Cape Coast municipality also has a large fish-smoking sector and a host of palm kernel oil producers who depend on wood fuel for their activities (Kendie and De-Graft Johnson, 1999). Although 90% of the fishermen mentioned that the mangroves serve as good habitat for the fish, they still are cutting them down. Some respondents reported that other individuals come from the community to harvest these mangrove trees for burning as charcoal fuel. Some respondents believed that the young fish feed on the propagules and breathing roots of these mangroves, and so when the roots were abundant they used to catch big fish, but this does not happen now that most of the mangroves are gone. Some of the fishermen also recounted that fish used this habitat as a spawning ground. Despite this knowledge, some of the fishermen still cut down these mangroves.

Taboos, Cultural Practices, and Knowledge Related to Fishing in the Lagoon

Taboos and cultural practices may in a way enhance the conservation of the fishery because they limit fishing pressure on the lagoon resources. Open-ended in-depth interviews were conducted to elicit fishermen's beliefs about pollution in the Fosu Lagoon, their knowledge about the causes of decline in fish productivity, and their perceptions of the risk of eating contaminated fish from the lagoon. Information collected was mostly related to cultural practices and values of the people: 88% of the interview respondents and 78% of questionnaire respondents believed that cultural practices, values, and beliefs influenced their perception and behavior. The beliefs and practices of these fishermen are usually portrayed in proverbs, myths, legends, names, and attributes of the Supreme Being, among others. The Fosu Lagoon is said to be occupied by a god called Nana Fosu, who is regarded as a father with attributes of a loving mother, and the crabs and fish in the lagoon are his. He caters to the economic and nutritional needs of the people by providing them with plenty of fish and offering protection, as well.

Non-taboo-observing fishermen (15%) were between 21 and 41 years of age. The different beliefs/taboos and percentage adherence to these beliefs are listed in Table 2.

Figure 2. A photograph showing the Mangrove distribution in the Fosu Lagoon. The cluster of mangroves is to the left of the *black line*.

Table 2. Beliefs, taboos, and knowledge of fishermen ($N = 120$)

Belief/taboo	Effect on lagoon/mangroves	% Adherence to belief	Reason for not adhering to belief
Fishing is prohibited on Tuesdays	Prevents overexploitation of fish	85	Christian beliefs
Women are not allowed to cross the lagoon when in their menstrual period	Against the gods of the lagoon	100	No reason; they all adhere
Canoes are prohibited in the lagoon.	Disturbs the water and fish because the lagoon is shallow, which leads to fish decline	90	Can cover more fishing grounds and carry more catch with a canoe
Night fishing is prohibited	Disturbs the gods at night and encourages pilfering of fish from other people's nets, so fish decline	85	Some work other jobs during the day and can fish only at night
Knowledge	**Information source**	**Response/action as a result of the knowledge**	
Fishing	From parents/other family members	Use nets of the right size; some fishermen avoid night fishing	
Habitat destruction	Personal observation, radio	Not much action has been taken	
Mangroves as good habitat for fish	Personal observation or experience	Not much action has been taken	
Pollution	Personal observation, radio	Not much action has been taken	

Table 3 lists the percentage of respondents receiving information about the pollution in the lagoon from various sources. FM programs on the radio were the main source of information, followed by personal observation. Government institutions are significantly less often a source of information compared to radio and personal observation.

Some taboos and practices are more observed than others. Women in their menstrual period never cross the lagoon or associate themselves with it. Some fishermen, however, fish the lagoon on Tuesdays. Fishermen are supposed to use only nets and baskets for fishing, casting them as they wade, yet some fishermen (10%) were seen using canoes for fishing during the period of the study. Some respondents reported that some people (15%) do fish at night, although that is not an acceptable cultural practice. The local people believe that the god Nana Fosu and his family come out only during the night and therefore fishing the lagoon at night infringes on their privacy and rights. Some fishermen reported cases of others stealing fish from nets cast by others and left overnight in the lagoon to trap more fish.

Culture and Management Practices

Fishermen over age 50 held strong beliefs, values, and assumptions that they had learned in early childhood. They stated that when fishermen adopted these cultural practices in the past, they achieved high performance and all the fishermen caught enough fish. They blamed the present predicament partly on Christianity: they said the younger generation tends to ignore the community's traditional practices because Christianity teaches them not to believe in them. One of the elderly men interviewed had this to say:

> Children of today have no respect for their ancestors; they do not believe in anything traditional and so do not listen to advice. This is why we are all suffering; our children wrong our ancestors a lot. Before Christianity, there were our traditional beliefs and values, and so churches must not forget that. People must treat the lagoon with respect and observe its rules. It is only by doing this that the god will give us more fish.

Table 3. Sources of information about pollution among fishermen

Source of information	No. of respondents*	% Respondents
Newspaper	0	0
Radio	104	87
Government institution	2	2
Personal observation	100	83

*Most respondents selected more than one source.

A total of 72% of the interview respondents and 50% of the questionnaire respondents believed that people fishing at night, on Tuesdays, and using canoes affect the decline in fish stock. This idea was expressed in a respondent's answer to a question about why some anglers fish at night:

> I feel the people who come to fish the lagoon in the night have bad intentions. They come to steal fish rather than work hard to catch their own. Only thieves fish at night, and it is not surprising that such thieves often die miserably. The god of the lagoon sometimes curses them and they die, yet people continue to do that [fish at night], especially the young ones; they do not know and understand our tradition, which is unfortunate.

Discussion

Fishing constitutes one of the major economic activities of the people in Cape Coast and, although the fisheries of almost all lagoons in Ghana are artisanal, they play an important role in the economy of some coastal inhabitants, especially during the off-season for marine fishing (Mensah, 1979). The report by Blay and Asabere-Ameyaw (1993) the exploitation rate (E) for the dominant fish stock in the Fosu Lagoon (*Sarotherodon melanotheron* E = 0.62) is indicative of its overexploitation. Although all the fishermen reported that there has been some reduction in productivity of fish in the lagoon, they are still catching fish. Most probably, the population of fish (mostly tilapia) has the ability to maintain a reasonably high yield despite the high pollution in the lagoon. Fryer and Iles (1972), Iles (1973), and Payne (1975) reported a high reproductive resilience of tilapia. We observed that the lagoon fish were rather stunted. Chimits (1955) observed that the young of stunted tilapia are capable of high independent activity from birth. Comparable breeding habits might occur in the Fosu Lagoon population, and this characteristic might warrant year-round fish production. Thus, though fish productivity has reduced, the size is more affected than the numbers. Blay and Asabere-Ameyaw (1993) reported that the exploitation level of fish from the Fosu Lagoon appeared adequate for maximal utilization of the stock. However, with the recent increase in the population of the communities that fish the lagoon, coupled with the related increased demand for fish, there is a probability of overexploitation, which has likely caused a decline in fish yield.

During the study, we observed that most of the mangroves around the lagoon have been exploited. As reported in the introduction, Ayisi and Addo (1994) observed a similar pattern among rural dwellers in the Tema district of Ghana. Koranteng, Ofori-Danso, and Entsua-Mensah (2000) in a study of fish and fisheries of the Muni Lagoon in Ghana observed similar mangrove exploitation. Destruction of mangroves has affected the fish habitats of other lagoons in West Africa. Din et al. (2008) recently studied logging activities in mangrove forests in Douala, Cameroon, and stressed the importance of the economic value of mangroves especially as fishing resources. In addition, they stated that mangroves have the potential to be a valuable resource to people, provided the mangroves are managed through sustainable practices. Din et al. (2008) suggested that the future of mangroves requires a balance between various anthropogenic activities and regeneration processes. As stated earlier, Smardon (2003, 2009) witnessed sustainable harvesting of mangrove in St. Lucia's Mankote Mangrove for charcoal production.

Various studies have tended to link small scale enterprises to the pollution of Fosu Lagoon (Adjei, 1991; Hagan, 1986; Tay, 1998). Kendie (1998) reported that the 189 workshops at Siwudu that contributed most of the pollutants to the Fosu Lagoon included automechanics, blacksmiths, electricians, welders, sprayers, vulcanizers and scrap-metal dealers. Pollutants generated from anthropogenic activities need to be properly disposed off to avoid having them end up in the lagoon. Providing more knowledge of the ecology and regenerative capacity of mangrove in the Fosu Lagoon can lead to better understanding, management, and conservation practices. An earlier personal conversation with one of the professors at the University of Cape Coast indicated that the community had received some education about the value of preserving mangroves. However, neither the interviews nor the survey revealed such information. Rather, the main type of information these fishermen received concerning the lagoon was about pollution.

One of the taboos identified by the fishermen is "no fishing" from the lagoon on Tuesdays. The Cape Coast community has a tradition where the gods in the ocean and Fosu Lagoon are honored each Tuesday. Fishermen can fish on any other day in the week except from early August to early September in connection with the celebration of their annual festival. Thus, the anglers can fish approximately 286 fishing days a year (Blay and Asabere-Ameyaw, 1993). To honor the gods, mashed yam mixed with palm oil and eggs is sprinkled into the lagoon for the god and his children to eat. Occasionally, the people of Cape Coast will slaughter cows, sheep, and fowl as sacrifices to Nana Fosu as a way to ask for more fish and water, especially to pacify him when the lagoon has dried up.

To improve fish productivity in the lagoon, local communities need to be encouraged and assisted in replanting mangroves while receiving appropriate technical advice and under supervision. This requires adequate budgetary support. Woodlots that use fast-growing trees like *Cassia* species could be established to ease the pressure on the mangroves. The local communities need to be actively involved for any management plan to succeed.

Mangrove restoration can be adopted as a viable strategy to help restore the fish habitat and improve fish productivity. The case studies of Gazi Bay in Kenya and Tanga in Tanzania, mentioned earlier, are typical success stories of such restoration. Gazi Bay had more than 300,000 propagules of mangroves planted with the involvement of the local community.

Studies conducted on other lagoons in Ghana, such as the Muni Lagoon and Songor Lagoon, indicate the use of similar taboos and cultural practices in the management of the lagoon. In both Muni and Fosu Lagoons, women in their menstrual period are not allowed to cross the lagoon (Koranteng, Ofori-Danso, and Entsua-Mensah, 2000). Despite the taboos and cultural practices at these lagoons, gross environmental degradation, mangrove loss, and reduction in fish productivity persist. As observed for these other fishery resources in Ghana, proper management is necessary if they are to make significant improvements in the socioeconomic life of the fishing communities in the coastal regions. The lagoon could be desilted to enhance water flow and mangroves replanted to achieve all of the important benefits discussed earlier. Although these fishermen reported that they know the value of mangroves to fish productivity, further stressing the importance of these mangroves to fish productivity, as well as the effects of irresponsible fishing and indiscriminate cutting of mangroves, is still be worthwhile.

NGOs in many countries have helped in dissemination of information especially through creating public awareness and funding. Smardon (2003, 2009) reported the efforts of Friends of the Wadden Sea, an NGO based in the Netherlands, which pushed the governments of the Wadden Sea Wetland Management in the Netherlands, Germany, and Denmark toward an innovative trilateral agreement for managing and monitoring of their wetlands. The International Crane Foundation (ICF) worked with local leaders in the Mekong Delta to develop a management plan and to reestablish the hydrologic cycle through flooding structures and reestablish vegetation to bring back crane, waterfowl, and the fisheries in the Tran Chim Nature Reserve (Smardon, 2003, 2009). NGOs also work effectively with government, schools, and colleges, and the general public through campaigns and media events.

Laws to promote mangrove replanting and protection could be enacted by government bodies such as the District Assembly, which oversees administrative matters in the Cape Coast Municipality. Existing taboos and cultural practices of conservation value could be woven into these laws. Sanctions should be strictly applied to defaulters as a means of enforcing these laws. The national mangrove management project in Tanga, northern Tanzania, in collaboration with the Tanga Coastal Zone Conservation Program, has been replanting mangroves since 1997 and had 107.4 ha of mangroves actively rehabilitated by 2004 (Bosire et al., 2003). In Tanga, gaining the support of local chiefs was crucial because they could pass laws and ban activities such as mangrove cutting as taboo. Community leaders planted woodlots so people would no longer depend on the mangroves for fuelwood. As stated earlier, in addition to replanting mangroves to improve fish productivity in the lagoon, the long-term plans for developing infrastructure that will reduce pollution into the lagoon should still be pursued.

Some studies have suggested that small, local, citizen-based restorations have educational value and can play a supplementary role, especially in regard to reestablishing species and community diversity (Layman and Arrington, 2005). An example is the Kiunga mangrove establishment in northern Kenya. As stated earlier, the local community has been involved in developing larger-scale mangroves in Gazi Bay, Kenya (Bosire et al., 2003). These mangrove restoration efforts have proven to be inexpensive but labor intensive and may require some donor assistance. The Ada-Azizakpe women's group in Ghana restored degraded mangrove forests with support from Heifer International (Macintosh and Ashton, 2003). Ellison (2000) in an earlier study concluded that the ecological restoration of mangrove forests is feasible, can be done cost effectively, has been done on a large scale in various parts of the world.

Conclusions

Findings indicate that more research needs to be carried out on the Fosu Lagoon to update information on fish productivity. This can help develop more appropriate and specific management plans aimed at restoring fish productivity in the lagoon. Fishermen did show that they have some knowledge about mangroves in general and specifically their value for fish productivity but probably need more in-depth information to help change behavior and derive the complete benefits that mangroves provide. Highlighting the impact of mangrove destruction on fish productivity could also encourage the fishermen to protect the mangroves when restored. Involving the people at the grassroots level in the protection of these mangroves is vital. Although education alone may not always change behavior, providing the necessary scientific information about the value of mangroves to fish stock, as well as the value of restoration programs to the fishermen and the Cape Coast community as a whole, may go a long way toward helping to restore the fishery in the lagoon and improving the health of the lagoon.

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