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Fisheries Productivity and its Effects on the Consumption of Animal Protein and Food Sharing of Fishers' and Non-Fishers' Families

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Fisheries Productivity and its Effects on the Consumption of Animal Protein and Food Sharing of Fishers' and Non-Fishers' Families

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This study compared the consumption of animal protein and food sharing among fishers' and non-fishers' families of the north-eastern Brazilian coast. The diet of these families was registered through the 24-hour-recall method during 10 consecutive days in January (good fishing season) and June (bad fishing season) 2012. Fish consumption was not different between the fishers' and non–fishers' families, but varied according to fisheries productivity to both groups. Likewise, food sharing was not different between the two groups, but food was shared more often when fisheries were productive. Local availability of fish, more than a direct dependency on fisheries, determines local patterns of animal protein consumption, but a direct dependency on fisheries exposes families to a lower-quality diet in less-productive seasons. As such, fisheries could shape and affect the livelihoods of coastal villages, including fishers' and non-fishers' families.

KEYWORDS *animal protein, artisanal fisheries, diet, fisheries unpredictability, human ecology, risk*

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Human beings have always exposed themselves to the unpredictability and risks associated with fishing, hunting and gathering, investing energy when foraging for their own and/or their group subsistence due to the need to keep their homeostasis and their reproductive capacity (Betzig and Turke 1986; Bliege Bird et al. 2002). The high dependency on natural resources, especially in more isolated societies, leads humans to define strategies to obtain food that balance effectiveness, efficiency, and risk when determining their responses to environmental stresses. Such flexibility can be understood as an adaptive capacity to environmental fluctuations, and the more adapted a species is to its environment the higher the probability that its descendants will survive environmental hardships (Kormondy and Brown 2002; Moran 2010; Winterhalder 1986).

The last decades have witnessed a growth in studies that approach the strategies used by humans to assure a relatively steady food supply, especially in societies that depend directly on natural resources. These studies explore labor division (e.g., societies where women are responsible for food gathering and men for hunting and fishing) (Moran 2010), the cooperative acquisition of food and animal husbandry (Gurven, Hill, and Jakugi 2004) and also food-sharing patterns (Gurven and Hill 2009).

Food sharing, defined as the donation of food from one household to another (Feistner and McGrew 1989), can be seen as one of the physical and cultural ways to connect local people to their land, and in some instances, to their wildlife (Garibaldi and Turner 2004). According to many authors, food sharing favors community relationships by strengthening social and kin ties (Feenstra 1997; Loring and Gerlach 2009). Another point of view suggests yet that food sharing happens more commonly with foodstuff that is unpredictably acquired, such as game and fish, and that requires an intense energy investment (Gurven and Hill 2009). The exchange of resources that originate from hunting and fishing, for example, is seen by many authors as a way to decrease the risk of not having meat in the future (Bliege Bird et al. 2002). This brings up an especially interesting understanding of the evolution of cooperation among human beings, by allowing the test of hypotheses such as kin selection (the direct benefit of relatives) and reciprocal altruism (Allen-Arave, Gurven, and Hill 2008).

Moreover, in hunter-gatherer and fishing societies, not only are some foodstuff donated more often than others (e.g., the ones with variable return, such as meat), but there is also a direct relationship between the package size (how much food was hunted, gathered, or extracted in one event) and the donated amount (the bigger the food package, the larger the amount given) (Bliege Bird and Bird 1997; Hawkes, O'Connell, and Rogers 1997; Winterhalder 1986). Besides, some members of the group can be favored more or less not only because of their kin status or reciprocity history, but also due to their reproductive potential, in which younger individuals get more food (Allen-Arave et al. 2008). Another possibility is that donation could, in fact, be hiding the interest of getting back something other than food in the future (Bliege Bird and Bird 1997): there could be an exchange between different currencies, such as food for work or political allies (Koster 2011).

Environmental fluctuations can also indirectly affect the food-search behavior. Food sharing, stocking, and migration are seen as advantageous strategies to assure a steadier food supply in uncertain environments (Winterhalder 1986). Food sharing and stocking, for example, could partially mitigate the lack of a resource spatially or temporally unavailable (Andras, Lazarus, and Roberts 2007).

Subsistence and small-scale fisheries are characterized by natural environmental unpredictability that can subject fishers to an unstable economy. Due to that, fishers are sometimes denied basic rights, such as access to health benefits and education, which might worsen their poverty (Allison et al. 2012). However, small-scale fisheries could also prevent fishers from getting into deeper deprivation by helping them maintain their livelihoods through an easy access to fishing grounds and to their free common property or, in some cases, open-access resources (Béné, MacFadyen, and Allison 2005). The environmental unpredictability, on its turn, can be made even worse by anthropogenic effects, such as overfishing (Burbridge et al. 2001). In coastal communities, fishing resources are essential as food and income sources, and, as such, impacts on these resources have consequences to food security and to the local socioeconomics (Chatterjee, Fernandes, and Hernandez 2012; Mulyila, Matsuoka, and Anraku 2012). Such impacts reflect on the livelihood of the fishers' families by leading them, for example, to look for more stable economic alternatives, resulting in groups with different levels of fisheries dependency in the community (Capellesso and Cazella 2011). If, on the one hand, this situation can imply in local socioeconomic changes, on the other hand it shows itself as a unique chance to understand how these changes would affect food-consumption patterns and food sharing, especially of fish.

Based on that, this study investigated the animal protein consumption by two distinct households groups (fisheries and non-fisheries dependent), being expected that fishers' families would ingest fish more often and in higher amounts than the non-fishers' families, and that this pattern would be affected by seasonal fisheries productivity. The origin of the food consumed by these same groups was also analyzed, being expected a higher prevalence of externally acquired food in the diet of non-fishers' families. Some food-sharing hypotheses were also tested: (1) food sharing among the fishers' families should be directly related to the frequency and amount of food caught, varying with the fishing period; and (2) food sharing should be more frequent and the amount of shared food larger among fishers' families than among non-fishers' families, as the first ones directly depend on an unpredictable resource (fish) and are more likely to be poor, hence sharing could reduce such variation and add to food security.

Understanding such aspects can help clarify the understanding of livelihood strategies of human groups with distinct dependencies on a natural resource used for food, who are subjected to stochastic factors but who need to keep a steady supply of animal protein in the family. Moreover, this study can also shed some light, although indirectly, in the understanding of food-sharing patterns, considering the direct or indirect relevance of an important but unpredictable natural resource.

STUDY AREA

Perobas is a coastal fishing village belonging to Touros municipality (5° 11′ 56" S and 35° 27′ 39" W), on the northern coast of Rio Grande do Norte State, Brazil (figure 1). The climate in the region is tropical rainy, with dry summers (Instituto de Desenvolvimento Sustentavel e Meio Ambiente [IDEMA] 2008).

About 130 families live in Perobas and most of them have a direct or indirect dependency on fisheries, using fish resources for consumption or commerce. This village was chosen for offering ideal conditions to compare food intake and food sharing between families who still directly depend on fisheries and the ones that do not, but who are both spatially concentrated on a clearly defined area. Such arrangement allowed following the food in

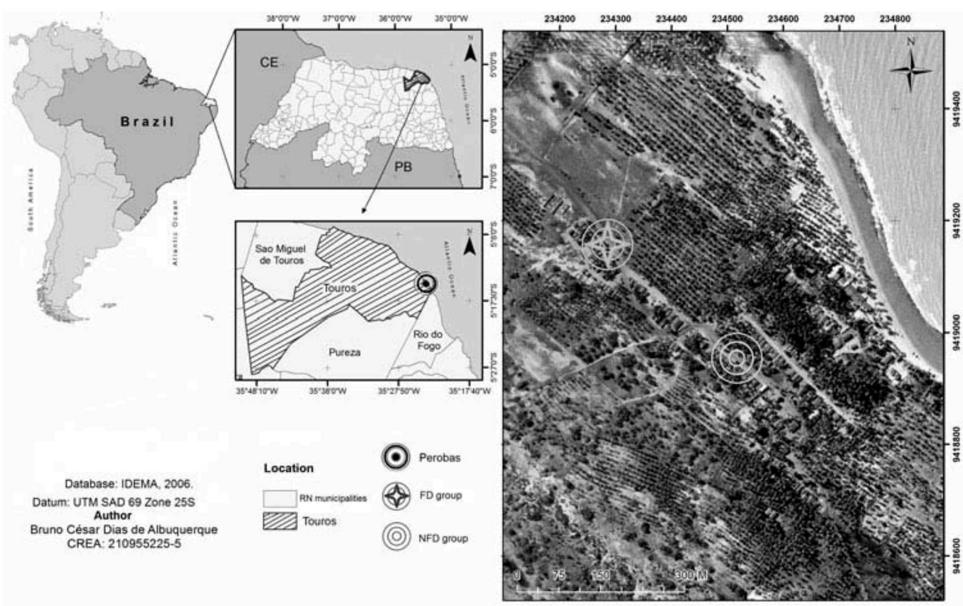

FIGURE 1 Map showing the study area, the coastal village of Perobas (Rio Grande do Norte state, Brazil), highlighting the two groups considered in this study. FD = fisheries dependent; NFD = non-fisheries dependent.

the village with some relatively certainty, from the time it was acquired to its distribution.

The local fishers use small bottom trawl and gillnets, and go out for fishing in small paddled boats or non-motorized rafts. The main species caught in the area are white shrimp and fish, which are divided into two categories: high priced—the ones that grow more than 20 cm long (e.g., Silver mojarra – *Eucinostomus argenteus,* Seabream – *Archosargus rhomboidalis,* pampo – *Trachinotus carolinus,* Grunt – *Genyatremus luteus,* and Littlescale threadfin – *Polydactylus oligodon),* and low priced species (e.g., Sardines – *Harengula clupeola* and *Opisthonema oglinum*, Little croaker – *Stellifer stellifer* and Roughneck grunt – *Pomadasys corvinaeformis)*. These species were identified on site by an ichthyologist (G. A Alves) and some specimens were brought to the laboratory to have their identification confirmed with the support of fish identification keys (Figueiredo and Menezes 1978, 1980, 2000).

METHODS

The households were chosen based on the identification of natural spatial sub-groups in the village, each with one or a few streets, in order to facilitate the register of the daily food sharing and diet of the families. Two groups with 16 families each were chosen: the fisheries dependent (FD) and the non-fisheries dependent (NFD). In fact, the NFD implies in a non-direct dependency on fisheries: although they can eventually fish and/or sell their catch, fisheries are not their main economic activity. These two groups represent approximately 25% of the total number of families living in Perobas, and although they can have different economic activities, there can be kin ties between families of both groups.

A pre-questionnaire was applied to all these selected households to identify its socioeconomic features and to gather information about fisheries, in order to characterize the homogeneity of the group. After that, these households were coded and had their diet and food sharing registered through a standard protocol. The data was put on observational matrixes, according to a methodology adapted from Hames (2000). All the procedures were approved in January 2012 by the Ethics Committee of the University of Rio Grande do Norte (CAAE-0232.0.051.000-11).

This protocol was defined after a pilot test in August 2011, applied with the FD group. After that, the sampling was done along 10 consecutive days in January and June 2012, chosen for being locally considered a good (GM – dry period) and a bad month (BM – rainy period) for fishing, respectively, by the FD group during the pre-questionnaire phase. Good and bad months were then defined according to fishers' local perception, who see dry months as less productive than rainy ones.

The protocols were filled in after lunch, with the support of the household women, as they are responsible for the food preparation in the village. The 24-h recall method was used to gather information on the three main meals of the day (dinner, breakfast and lunch), registering the types of food consumed, the approximate amounts eaten (in kg), as well as the amount of fish caught in the previous day, if any. Any animal protein that was donated or received (in number of events and amounts in kg) within and between groups was also registered. The animal protein was classified in beef, chicken, egg, processed meat (sausages, cold cuts, and canned beef/tuna), high and low-priced fish and others. Animal protein was chosen as the item to be followed in the food exchanging analysis for being considered an unpredictable resource, thus, more likely to be subjected to food sharing (Hawkes, O'Connell, and Jones 2001).

Fish landings were also directly observed whenever possible to confirm the estimates given by the fishers, as well as food-sharing events. In these cases, the researcher would take note of the amounts of fish landed or the amounts of food shared and compare them with the estimates provided by fishers or household members.

Characterization of the Groups

The average number of individuals per household was of 5.4 (FD) and 5.2 (NFD). In the FD group, bottom-trawl nets were the main fishing gear ($n = 13$ households), while in the NFD only five families had fishing gear or equipment (beach seine net = 2; rafts = 3), although such equipment was never used to provide the main source of income. In the NFD group, income comes mainly from commerce ($n = 6$), retirement funding ($n = 5$) and domestic services ($n = 5$), such as working as maids or housekeepers. The income of the two groups varied between the two periods, GM (FD = R\$ 562 ± 213; NFD = R\$ 655 ± 264) and BM (FD = R\$ 402 ± 304; NFD = R\$ 485 ± 970), with the NFD group always showing a higher average income (Mann-Whitney test: GM: U = 70.5; $p = 0.0302$; BM: U = 48.0; $p = 0.0026$).

In the beach-seine fishery, six fishers (household heads) who own their boats and nets hire other fishers to work together with them. The outcome of this fishery is separated: high priced fish and shrimp are usually destined to commerce, while the rest can be consumed by the fishers' families or donated. The money made from each fishing event (if any) is shared in six parts, as the owner of the net has the right to keep two parts for himself for the maintenance of the gear. The net owner is also responsible for selling and dividing the money. The sale is done on the beach to middlemen or regular people, usually based on an auction. The fishers' wives also fish, especially the low-priced species as they can be caught from the shore or very close to it. These fish, especially for being the low-priced kind, are usually consumed by their families. The women are also responsible for storing the fish, by freezing or mostly salting it.

Fishers that use rafts work in pairs and they set apart a little part of the money made (defined according to the need) to maintain the boat and buy gas to cook their food while fishing. The remaining of the profit is shared equally in two.

Statistical Analyses

To analyze the food sharing and intake within and between groups (FD and NFD) in the different periods (GM and BM), all kinds of animal protein were considered, although a more detailed focus was given to fish protein, through specific and separate analyses.

To verify if the *number of times* the households consumed animal protein was different between the groups (FD and NFD) in the two periods (GM and BM), a contingency Chi-square was performed (one for each period). After observing a significant Chi-square, a partitioning chi-square was used to identify differences between the categories, when a visual inspection of the frequency distribution was not sufficient for that (Goodman 1971).

A two-way ANOVA was performed to analyze if the average *amount* of low priced and high priced fish consumed by the households would vary according to the dependency level on fisheries and according to the period of the year. Another two-way ANOVA was performed to investigate whether there was any difference on the average amount of food shared between the groups (FD and NFD) and between the two considered periods (GM and BM).

A Spearman correlation was used to investigate if there was any positive correlation between the *amount of caught fish* (kg) and the *number of food-sharing event*s in the two groups (FD and NFD) and in the two considered periods (GM and BM).

Finally, both groups (FD and NFD) were compared (frequency) in relation to their main food origin (commerce, donation, stored fish, fresh fish, other stored food—mainly chicken, canned beef and canned tuna) and if these sources would change according to the period of the year (GM and BM), through a chi-square test, followed by a Partitioning chi-square.

The software R (Team 2009) and Bioestat 5.0 (Ayres et al. 2007) were used for the statistical analyses and figures.

RESULTS

Diet

A total of 993 events of animal protein consumption (459 meals with fish) were registered during the study. Both groups, fisheries dependent and non-dependent, consumed animal protein more frequently in January, the more productive month for fisheries (table 1).

TABLE 1 Frequency of Protein Consumed by the Groups

Periods	Events of protein consumed		Average of fish (Kg) consumed per families		Frequency
	FD	NFD	FD	NFD	For groups
GM	294	266	3,0	3,0	1
BM	229	204	2,7	1,7	0

Note. Data were obtained using the 24-hour recall method on the Brazilian northeastern coast. FD = fisheries dependent; NFD = Non-fisheries dependent) in a good month (GM) and in a bad month (BM) for fishery; and average of kilogram of fish consumed per family in a good and bad month for fishery.

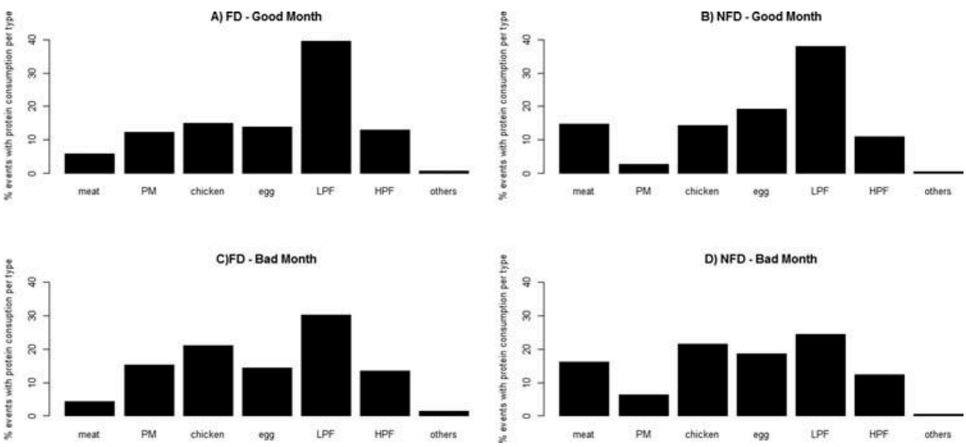

FIGURE 2 Percentage (%) of events with protein consumption per type: A) fisheries dependent (FD) in a good month for fishery (GM); B) non-fisheries dependent (NFD) in a good month for fishery (GM); C) Fisheries dependent (FD) in a bad month for fishery (BM); D) non-fisheries dependent (NFD) in a bad month for fishery (BM). Data were obtained using the 24-hour recall method on the Brazilian northeastern coast. PM = processed meat; LPF = low-priced fish; HPF = high-priced fish.

There was no difference between the households of the two groups in terms of frequency of animal protein consumption ($\chi^2 = 0.022$; $p = 0.8827$; $df = 1$; $n = 32$). However, the groups slightly differed in relation to the kind of animal protein they consumed ($\chi^2 = 11.127$; $p = .0845$; $df = 6$; $n = 32$). The difference between the groups was due to more events of consumption of processed meat by the FD families (Processed meat: FD = 13.6%; NFD = 4.25%; $\chi^2_{\text{Processed meat}} = 9.8794$; $p = .0017$; $df = 1$; $n = 32$) (figure 2). Fish was consumed slightly more often by the FD group (Low-priced fish: FD = 35.4%; NFD = 32.1%; High-priced fish: FD = 13.2%; NFD = 11.5%), but this was a non-significant difference.

Regarding the amounts of fish ingested, approximately 272.59 kg of fish was estimated to be consumed by the studied households, from which 69%

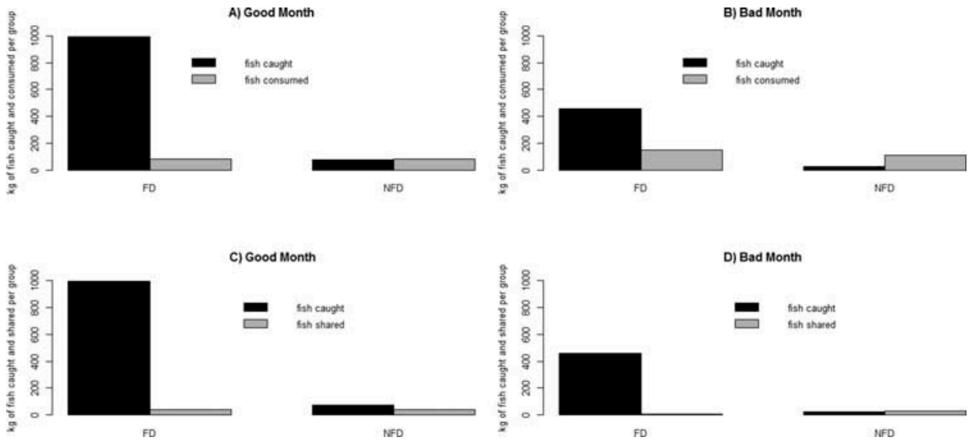

FIGURE 3 A and B) Kilogram of fish caught and kilogram of fish consumed for fisheries dependent (FD) and non-fisheries dependent (NFD) families in a good and in a bad month for fishery, respectively; C and D) Kilogram of fish caught and amount (kg) of food shared among fisheries dependent (FD) and non-fisheries dependent (NFD) families in a good and in bad month for fishery, respectively. Data were obtained using the 24-hour recall method on the Brazilian northeastern coast.

(n = 189.19 kg) were classified as low-priced species and the remaining as high-priced species. On average, the families consumed 2.63 kg of fish per family per day, considering all the diet events sampled in the study. Although families that depend directly on fisheries consumed slightly higher amounts of fish than the ones that do not (Low-priced: FD = 58%; NFD = 42%; High-priced fish: FD = 51%; NFD = 49%, n = 189.19 kg), there was no significant difference in the consumption of low and high priced fish between these two groups, neither were these fish consumed in different proportions in the two sampled seasons ($F = 4.3844$; $df = 1.4$; $p = .1038$; $n = 8$).

Even though the diet did not vary between the groups or across periods, fisheries varied between the periods. For example, in January, the productive month, 1069.20 kg of fish were caught by these families, an average of 33.41 kg of fish per fishing event (± 102.58 kg), but in June, the least productive month of the year, 482.80 kg of fish were caught by these same families, representing an average of 15.08 kg per fishing event (± 37.74 kg) (figure 3).

Food Sharing

A total of 81 events of food sharing was observed (GM = 47; BM = 34). Of these, fish was donated 28 times in the productive month for fisheries and 14 times in the less productive month (table 2). The average number of food-sharing events, calculated across families, that included meat was relatively low, both in the productive month for fisheries (FD: 3.1 and NFD:

TABLE 2 Spearman Correlation between 1) The Number of Fishing Events and the Number of Food-sharing Events and 2) Between the Amount (kg) of Fish Caught by Local Fishers Included in the Study and the Number of Food-sharing Events for the Two Groups Considered in This Study

Spearman correlation

		No. fishing events and food-sharing events				Amount of fish (kg) and of food-sharing events			
Month	Dependency	r_s	p	Fishing	Food sharing	r_s	p	Fishing	Food sharing
GM	FD	0.4605	.0726	50	26	0.4428	.0858	995	26
GM	NFD	0.3082	.2455	11	21	0.4753	.0627	75	21
BM	FD	−0.0847	.7552	34	22	−0.1489	.5820	457	22
BM	NFD	−0.0157	.9538	8	12	−0.1134	.658	26	12

Note. Data were obtained using the 24-hour recall method on the Brazilian northeastern coast. FD = fisheries dependent; NFD = non-fisheries dependent, in the two periods sampled, which represent high and low fisheries productivity; GM = good month – January; BM = bad month – June.

1.7), and in the month considered least productive (FD: 2.75; NFD: 2.0). The amounts donated were not different between the households that were dependent and not dependent on fisheries ($F = .090$; $p = .766$; $df = 1$; $n = 32$). Also, no difference was observed between the amounts donated in the most and least productive fisheries periods ($F = 0.266$; $p = .610$; $df = 1$; $n = 32$).

Even though no significant correlation was observed between the number of times the fishers of the studied households went fishing and caught something ($n = 103$) and the number of food-sharing events ($n = 81$), there was a slight tendency of increase in these events in January, the good month for fisheries, among the households that depend on fisheries (table 2). Such slight increase was also observed when the correlation was performed between the total biomass of fish caught and the number of food-sharing events, in this case, for both groups (fish biomass: January – FD = 993.7 kg; NFD = 75 kg; June - FD = 456.8 kg; NFD = 26 kg) (table 2). Although incipient, the success of fisheries could slightly affect food sharing in the village, with a few more food-sharing events among the households that directly depend on fisheries when there is more fish.

Food Origin

Households that directly depend on fisheries obtain their animal protein from different sources than the households that do not, considering the number of events ($\chi^2 = 23.712$; $df = 4$; $p < .0001$; $n = 10$).

Such difference was mostly due to the fact that households that depend directly on fisheries got more of their animal protein from their daily fisheries, a free but uncertain source of protein (January FD: 10.8%; NFD: 1.8%; June

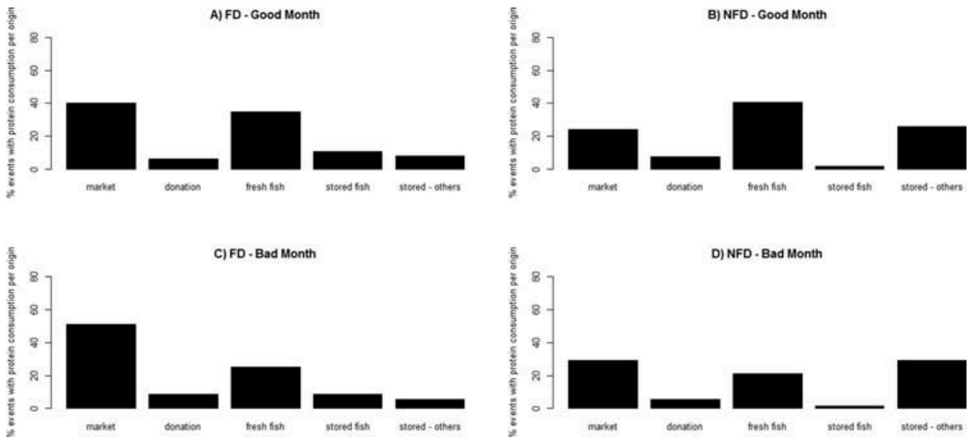

FIGURE 4 Percentage (%) of events with protein consumption per origin: A) fisheries dependent (FD) in a good month for fishery (GM); B) non-fisheries dependent (NFD) in a good month for fishery (GM); C) fisheries dependent (DF) in a bad month for fishery (BM); D) non-fisheries dependent (NFD) in a bad month for fishery (BM). Data were obtained using the 24-hour recall method on the Brazilian northeastern coast.

FD: 8.5%; NFD: 1.3%; $\chi^2_{\text{Fresh Fish}} = 4.060$; $p = .0439$; $df = 1$; $n = 10$), while the households that do not depend on fisheries consumed more stored protein, externally acquired and usually more expensive meat, such as chicken, canned tuna, and canned beef (January FD: 8%; NFD: 26%; June FD: 5.4%; NFD: 29%; $\chi^2_{\text{Stored protein}} = 16.835$; $p = .0001$; $df = 1$; $n = 32$) (figure 4).

The consumption of animal protein acquired outside the village was more common to the FD group, when both periods were considered (FD: 45.2%; NFD: 28.1%), while 5% and 11% corresponded to the purchase of some sort of fish, in the fisheries-dependent and in the non-fisheries dependent group, respectively. From the animal protein coming from some food-sharing event (FD: 7.3%; NFD: 7.1%), 70% were fish or fish part for both groups.

DISCUSSION

Diet

The occurrence of fisheries in a coastal community, as shown in this study, goes beyond its immediate relevance for the subsistence and source of income to families that depend directly on this activity: fisheries play a role on the food security of the whole village, understood as access to food that fulfill not only nutritional needs but also diet preferences (FSN Forum 2007). For example, the local diet of both groups is affected by the fish seasonal availability. In January for example, a productive month for fisheries, households with and without active fishers (regardless of being FD or NFD) increased their fish consumption. A previous study had already suggested that fisheries productivity would play a role in the diet of fishers' families, but it did not investigate the effects of this activity on the diet of non-fishers' families (MacCord and Begossi 2006). Fish is a central source of calories to millions of poor people, meaning the ones who are vulnerable to environmental, health, or educational risks (Béné et al. 2005). The studied families are indeed subjected to environmental fluctuations that threaten their diet and income (health and education were not considered), so fish could potentially be supplying part of both groups' needs, slightly more, but not significantly, to the FD families, who also happened to be poorer.

However, Béné and colleagues (2005) suggest that many fishers' families do not necessarily consume the protein they obtain from fish, as this would preferentially be redirected to commerce. Instead, such families would acquire cheaper but lower-quality protein for their diet. This could explain partially what was observed in this study: although fish consumption varies with the availability of fish gathered from fisheries, the ingestion of processed meat is higher among fishers' families. Still, higher-priced fish are also consumed by these same families, counting against this hypothesis. In this case, the fishers' families could be ingesting lower-quality protein, especially when they cannot fish. Fisheries unpredictability, associated with the lack of alternative sources of income, would direct these families to buy whatever they can afford to supply their protein needs in harsher times. This hypothesis would be supported by the fact that families that do not depend on fisheries have a higher average income and perform other economic activities, consumed less processed meat, which is usually cheaper, than the fishers' families.

Another point to consider is the fact that it is possible that fish availability affects the price of other locally available types of protein: when fish is abundant, the search for other types of protein might decrease, decreasing their price as well. This hypothesis deserves to be investigated, as it could confirm an even stronger link between fisheries and food security, with fish availability affecting the market price for alternative sources of protein.

The widespread dependency on fisheries observed in this study should be positively interpreted, especially in rural areas where other nutritious food and employment alternatives may not be easily available. Fish could be the means to achieve what has been called "subsistence affluence" in rural areas (Bell et al. 2009), by helping to support food security and local livelihoods. This dependency is likely to happen in hundreds of small-scale fishing communities along the Brazilian coast and also inland, which are usually underdeveloped and marginalized areas, counting on a great degree on the direct exploitation of fishing resources (Diegues 2008). In such villages, as the studied one, fish provides important and essential nutrients, while sometimes it also represents the main source of income, representing the means to acquire other foods (Garcia and Rosenberg 2010).

Food Sharing

The sharing of animal protein was relatively low in both groups, probably because households store some fish by freezing and salting it. Also, sharing did not differ between the months with different fisheries productivity, which could also be attributed to the low number of observed sharing events ($n = 81$). Qualitative information gathered on fisheries suggests that fisheries in general are not that productive, compared to other similar villages in the same region, where larger amounts of fish are landed daily (Silva 2010). The average amount of fish separated for consumption was very similar between groups and between periods, which was also observed when the frequency of food-sharing events was compared. However, the fish consumption decreased slightly among the non-fisheries dependent households when fisheries were worse, followed by an increase in the number of food-sharing events.

Food sharing, especially of fish, was slightly more common in the productive month for fisheries and such trend between fishing and donation could be suggesting that families tended to donate food when they exceeded their household needs. However, this must be carefully investigated, ideally with a larger sample size, as the correlations between fishing and food sharing were only marginally significant (table 2; $p < .1$).

Even though the reasons for food sharing in this study can only be speculated, as it was not designed to investigate its underlying causes, it is worth noticing that about 70% of all the animal protein donated to the households came from fisheries, suggesting that the most unpredictable resource is the main one being shared. In the future, it will be worth investigating though a larger database if fish is indeed being donated more often to the FD families. Studies have shown that sharing, when there is available surplus, can increase the chances of receiving protein back in the future, thus potentially alleviating the natural fluctuation in animal protein acquisition (Bliege Bird et al. 2002; Gurven 2004). A study done with the Achuar, Quichua, and Zapara speakers in Conambo, indigenous communities of horticultural foragers in the Ecuadorian Amazon, showed that meat sharing is more common at times of surplus to alleviate the failure differences in hunting success among foragers (Patton 2005).

Food Origin

The animal protein ingested by the studied families had multiple origins and varied according to the level of fisheries dependency. The fisheries dependent households, as expected, consumed fresh fish more frequently than the non-dependent ones, which reinforces the role still played by fish on the food security of these families. However, both groups depended mainly on the local market for their protein supply (except for NFD in GM). Another study done on the Brazilian coast showed that fishing communities were undergoing a process of substituting locally acquired food, mostly fish, for external products, namely canned tuna due to its low price. The authors concluded that such diet changes are correlated to urban development and the arrival of a better established commerce (Hanazaki and Begossi 2003).

In this study, households that did not depend exclusively on fisheries and had better incomes could afford market-purchased food significantly more often than the other households. Acquiring food through commerce, if the family has the means for it, could be an alternative to reduce the local unpredictability in food gathering. Among the Huaorani, in the Ecuadorian Amazon, commercialization of their food surplus is a strategy to reduce risk: families that commercialize their meat surplus can afford food that can be stocked (e.g., rice and canned tuna). In this case, the families first separate what they need, share part of the meat with other families of the same village and then sell the remaining, making sure that the purchased food remains in the household (Franzen and Eaves 2007).

Increasing inclusion of market products in the local diet could also suggest changes in resource availability. In another study done with fishers' families in Brazil, the inclusion of meat from commerce in the local diet was, at the time, a relatively new strategy representing a shift from a higher to a low dependency on natural resources (MacCord and Begossi 2006). In this mentioned study, the diet of these fishers' families went through a sharp transition along one decade, mostly because there was a decrease in fisheries productivity probably due to industrial overfishing in the region. The lack of alternatives to obtain free and healthy protein seemed to have forced families to increase their dependency on food acquired externally. In the studied region, so far no long-term study has been done to show overfishing effects on small-scale fisheries. However, one study that considered all the commercial fisheries in the Brazilian Northeast suggested that this is one of the few areas in Brazil (Rio Grande do Norte state) where fisheries are still focused on top predators, which could suggest a relatively healthy system (Freire, Christensen, and Pauly 2008).

CONCLUSIONS

This study showed how the level of dependency on a source of animal protein (fisheries) could affect local strategies used by coastal artisanal fishing communities to assure such supply. Fisheries as a main economic activity, in opposition to activities not related to the direct extraction of natural resources, did not affect much of the strategies used by the studied households. For example, both groups had their diets and sharing subjected to the environmental fluctuation in the local fish availability. Also, non-fishers families, despite consuming fish regularly, ingested a lower amount of fish in the period, and such fish was mostly from donation. Finally, food sharing was not different between groups that depended and that did not depend on fisheries.

Although shedding light on some aspects, other questions remain unanswered and deserve further investigation, such as if there is a preference for locally produced protein, if households are indeed abandoning fisheries towards other economic activities that can provide a more stable income, if fisheries are undergoing some changes with likely consequences on fishers' families diets, and the possible effects on health and local economy of the insertion of external food products in the daily lives of coastal fishing villages. Moreover, the reasons for sharing food in this case is not clear, although there are studies suggesting an array of explanations, such as kin selection (Kaplan and Hill 1985), tolerated theft (Winterhalder 1996), and reciprocal altruism (Allen-Arave et al. 2008). Future studies could fulfill some of these gaps in the understanding of the relationship among economic shifts, resource extraction, human behavior and diet and health of communities undergoing such changes. However, this study reinforces the relevance of fisheries to the food security and livelihood of coastal villages in tropical developing countries, going beyond its effects on families that directly depend on this activity. The pattern observed here is likely to repeat in many other places where fish not only feeds people, but, by being a main source of income, also provides the means for acquiring other types of food.

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