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Extractive and Sustainable Development Reserves in Brazil: resilient alternatives to fisheries?

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This study uses the socio-ecological resilience concept to compare two categories of fisheries co-management in Brazil: Extractive and Sustainable Development Reserves. Ecological resilience was estimated by the indicators: reserve areas, human density and the existence of buffer zones around the reserves. Indicators for social-resilience were grouped in two categories: flexibility (assessed by livelihood diversification and resources exploited) and capacity to organize (assessed by local/governrnenta1 demand for reserve creation, existence of fishing management rules or management plans, participation in the decision-making process and existence of self-monitoring). Amazonian reserves are larger, have buffer zones and people depend on a broader range of natural resources compared to those on the coast. However, the inhabitants of coastal reserves can rely on ecotourism and jobs outside the reserves, which may reduce local fishing pressure. Both regions have reserves created using top-down initiatives as well as those created from local demands. Yet, participation in decision making is not necessarily related to the origin of demand and the level of local involvement can be limited in either case. Unless co-management is followed by adaptive management, increased local participation of people in management and the diversification of economic sources. its benefit to resilience is limited.

Keywords: Fisheries management; co-management; socio-ecological resilience; small scale fisheries; resource use; Amazon; Brazilian coast

1. Introduction

Co-management is a form of collective action in which decisions are made by local stakeholders in association with government agencies, non-governmental organisations (NGOs) and scientific institutions. In recent years, it has been suggested that co-management systems, especially adaptive co-management supported by local ecological knowledge (Johannes 2002), have the potential to enhance socio-ecological resilience (Olsson and Folke 2001, Tompkins and Adger 2004). In a

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socio-ecological context, resilience is the capacity of a system to absorb disturbance, such as change in the economic sources, without being destabilised and still able to adapt to changes by learning and self-organisation after disturbance (Folke *et al.* 2002).

During recent decades, Brazil has witnessed an unprecedented growth in the implementation of co-managed reserves, especially in fisheries management, where local people play an increasing role in the decision-making process (Goeschl and Igliori 2006). Some of these reserves originated from local demands, while others were created through top-down initiatives imposed by the government. The Amazon is the birthplace of co-managed initiatives in Brazil, but these initiatives have also been recently implemented on the coast following the same principles.

The goal of this paper was to review case studies of Brazilian co-managed reserves in the Amazon and on the coast with specific focus on the socio-ecological resilience attributes. Available indicators were used to evaluate the socio-ecological resilience of these reserves. We considered the ecological indicators as the reserve area, human density and buffer zones around reserves, and the socio-economic indicators as the socio-economic flexibility (resource-related economy and livelihood diversity) and the capacity to organise (community involvement in decision making, existence of rules and regulations, self-monitoring, demand for the reserve creation and the existence of management plans).

2. Fisheries co-management in the Brazilian Amazon and on the coast

Fisheries have been usually managed through a top-down approach in Brazil, without any prior consultation to the fishing communities involved (Castello *et al.* 2007). In this approach, the government (including several environmental institutions) decides on the rules that limit the catch, establish closed seasons and regulate the use of fishing gear (Silva 2004). As observed in other tropical fisheries, most top-down management measures have been based on poor generalisations, usually copying those in temperate countries, and have largely ignored the ecological and social aspects of the local fishing communities (Ruddle and Hickey 2008). Top-down management rarely takes into account small-scale ecological heterogeneity, such as spatial and temporal differences on fish reproduction or in habitat quality within the same geographical region (Bakun and Parrish 1991). There is also normally low compliance of the regulations by the fishers (Reis and D'Incao 2000), which can result in ineffective protection of the resource (Silva 2004).

The standardised top-down approach has not prevented the continued existence of informal local rules regarding fisheries management by users, in Brazil (McGrath *et al.* 1993) and elsewhere (Berkes *et al.* 2000, Johannes 2002, Ruddle and Hickey 2008). Informal rules based on fishers' knowledge and behaviour may often promote successful management, avoiding a de facto open access resource exploitation system (Begossi 1998a). In Brazil, one example of such informal rules is the fishing territories, which are designated to specific fishers, based on kinship ties (Cordell 1978, Begossi 1995). These territories can be maintained by respect and reciprocity (Cordell 1978). For example, a fisher does not need to actively defend his or her fishing area if the fishing community honours his or her claim to a given territory (Begossi 1998a).

The evolution of local rules requires time and effort from fishers, suggesting that self-organisation is probably triggered by important events, such as the perception of resource scarcity (Ostrom 2001). This is probably the case in the evolution of exclusive fishing areas and territories in the Amazon. The increase of commercial fisheries in some Amazonian rivers and lakes triggered a response by artisanal fishers, who tried to exclude outsiders and to assert control over their area. Conflicts between commercial and small-scale fishers became common in the Amazon, but some local fishers succeeded in closing their area to outsiders (McGrath *et al.* 1993, Castro and McGrath 2003). Through 'fishing agreements', several local small-scale Amazonian fishers established informal reserves where they controlled and managed the lakes closer to their villages (Castro and McGrath 2003, Furtado 2004). Besides the exclusion of outsiders, such lake reserves include fishing regulations, especially through catch or effort limits.

Fishing agreements are a new initiative on the Brazilian coast, where management units are estuaries, coves and bays, instead of lakes and rivers, (Begossi *et al.* 2010). The first attempts towards coastal fishing agreements are taking place in the State of Rio de Janeiro, in the enclosed Ilha Grande Bay, where there are intense conflicts among artisanal fisheries, commercial fisheries and conservation units. Despite the government attempts to support co-management regimes here, the communities themselves are not fully aware of the meaning of a fishing agreement or a co-management regime. The historically over-restrictive conservation measures established by the Brazilian government (forbidding or restricting fisheries around many inhabited islands) may be a reason for the local suspicions of fishing agreements. Ironically, depending on how the fishing agreements will be established in Ilha Grande, they could result in a top-down initiative if some local communities are forced to accept these agreements (Begossi *et al.* 2010).

2.1. Extractive and Sustainable Development Reserves

Towards the end of the 1970s the Brazilian government provided strong incentives to develop the Amazon, resulting in the logging of trees traditionally used by local people, such as rubber trees (*Hevea brasiliensis* Mull. Arg.) and Brazil nut trees (*Bertholletia excelsa* Humb. and Bonpl.). Local people who were known as rubber tappers were violently displaced from their lands and they subsequently organised a struggle for their land rights (Begossi and Brown 2003). After more than a decade of political discussions, the Brazilian government authorised a new conservation category called Extractive Reserves (ER) (Law No. 7.804, 18 July 1989, Decree No. 98.863, 23 January 1990), which resulted in the Alto Juruá ER. This is the first formal and legally recognised co-management system held by local, but non-aboriginal people in Brazil. By 1989 the first marine ER (Pirajubaé) was also established on the southern Brazilian coast, aimed primarily at harvesting and farming the clam *Anomalocardia brasiliana*, but also allowed the taking of fish, shrimp and crab in designed areas (Cardoso 2003, Decree No. 553, 20 January 1992).

By definition, Extractive Reserves allow the presence of people within their limits. Moreover, the inhabitants are allowed to keep their traditional livelihood as long as this is considered sustainable. Such reserves have been designed to be managed collaboratively by both the government and the local people (Fearnside 1989). At present in Brazil there are 53 ERs in the Amazon (inland), at least 18[1] of which

include fishery management, plus 19 coastal fishery ERs (IBAMA 2008, Instituto SocioAmbiental 2008) (Table 1).

ERs have become widespread in Brazil, and have helped to solve a wide array of social and environmental conflicts. However, creating these reserves without information about the socio-economical background may fail to achieve sustainable use of the reserves' resources (Salafsky *et al*. 1993, Brown and Rosendo 2000). Sometimes, both the government and the fishers may lack the capacity to run a co-management regime, due to insufficient financial resources, training or experience (Silva 2004, Seixas *et al*. 2009). In addition, there are isolated cases of corruption and inadequate management by local groups (Macedo 2007).

Another category of natural resource co-management, which also originated in the Amazon, is the Sustainable Development Reserve (SDR). Similar to ERs, SDRs have mainly protected the fishing resources, probably due to the importance of fishing for the local economy of the Amazon region. At present, there are 19 SDRs which are legally recognised in Brazil, three of them on the coast (Table 1).

It is hard to draw the boundaries in theory and practice between the two categories of Brazilian reserves (ER and SDR). Among the few differences in the Federal Law that regulates both categories is the fact that local people must live in the SDRs, but they are not required to live in ERs, just to use them (Federal Law 9.985/00). Although private property within the reserve boundary is more tolerated in SDRs, it is not completely excluded from ERs either. According to a report prepared by WWF-Brazil (Vianna and Sales 2007), the two reserve categories differ mainly in the demand for their establishment, which is generated by scientists for SDRs as opposed to local groups for ERs. This implies that SDRs might have a higher biological diversity or important species of conservation concern.

3. Brazilian Amazon vs. the coast: different features, same fisheries management?

Although a range of management systems (fishing agreements, ERs and SDRs) are common to both the Amazon and the coast, ecological and social differences have resulted in a different evolution of management systems in these two regions. For example, local institutions are usually more prone to generate formal and organised management systems in the Amazon than on the coast, where new institutions will probably need to be built (Begossi 1998b, Begossi and Brown 2003). Regardless of institutional support and region, the effect of various ecological and social factors on the success or failure of different fisheries management initiatives is unknown.

Different case studies of ERs and SDRs in Brazil are presented here, which were chosen based on the existence of previous studies and available information both from the Amazon and the coast. These two reserve categories in the Brazilian Amazon and on the coast were compared in relation to some of their ecological and socio-economical aspects, which were used as indicators of socio-ecological resilience. The ecological indicators were the reserve area and existence of a buffer zone around the reserve. Human population density was also included as a measure of pressure over the resources. The socio-economic indicators were grouped into two general categories, which represent some of the resilience characteristics: flexibility (Gunderson 1999) and the capacity to organise (Carpenter *et al*. 2001). The indicators related to flexibility were the resource-based economy (all the main resources exploited in the reserve) and the livelihood diversity (alternative jobs or economic activities practiced by villagers other than fishing). The indicators related

Table 1. Main features of the studied Extractive (ER) and Sustainable Development (SDR) reserves in the Brazilian Amazon (inland) and on the coast (n = total number of reserves surveyed with available information), with the proportion (percentages) of reserves using each type of natural resource.

	Extractive Reserves		Sustainable Development Reserves	
General features	Coastal	Amazon	Coastal	Amazon
Average size of the area (km^2) (±SD)	836.4 (±1493.4) n = 15	2600.4 (±3061.3) n = 40	79.9 (±71.1) n = 2	6146.3 (±8000.1) n = 16
Average population density (people per hectare) (±SD)	570.4 (±484.8) n = 10	26.7 (±45.7) n = 17	N/A	N/A
Main extracted resources (%)				
Açaí	5.3	6.5	0	7.1
Brazilian nuts	0	41.9	0	7.14
Ecotourism	5.3	0	0	0
Extracted oils	0	29.0	0	7.14
Fisheries/seafood	100	58.1	100	92.9
Fruit	0	9.7	0	0
Handicrafts	5.3	0	0	0
Rubber	0	51.6	0	7.14
Small-scale agriculture	10.5	12.9	0	14.29
Timber	0	19.4	0	14.29
Others	0	19.2	0	0
Number of reserves with available information on resource use	19	31	3	14

to the capacity to organise were: the degree of participation of local people in the decision-making process, the existence of local rules and regulations related to fisheries, the type of demand for the reserve creation (top-down or bottom-up), the existence of a self-monitoring system and the existence of a management plan. Indicators related to the capacity to learn (Carpenter *et al.* 2001) and assets (Adger 2000) were not used because there were no data to evaluate these characteristics. Most of the SDRs and ERs are new, created during the 1990s and 2000s, which explains the lack of follow-up studies and even the lack of formal management measures (Tables 2–4).

4. Extractive Reserves in the Amazon

4.1. Alto Juruá (Acre State, Western Amazon)

Alto Juruá was the first ER created in Brazil, soon after the murder of Chico Mendes, the leader of the Brazilian National Council of Rubber Tappers, in 1988. Mendes was organising the rubber tappers to fight against encroaching development and his murder brought about massive international attention, forcing the Brazilian government to discuss alternatives for resource management in the Amazon. Since its official creation in 1990, management of the Alto Juruá ER has been carried out by local families of rubber tappers, who work in a close alliance with NGOs and universities. In this case, scientific research was a demand from the rubber tappers themselves (Begossi and Brown 2003).

The traditional local economy, based on rubber tree exploitation, has been insufficient for meeting development goals. Thus, the ER economy eventually incorporated more productive activities. Due to new and diversified economic activities and better infrastructure near the riverbanks following the creation of the reserve, there were changes in the patterns of deforestation. Forest recovery increased in the hinterlands and levels of temporary and permanent deforestation of riverbanks increased (Ruiz-Pérez *et al.* 2005).

Even though the fishery is not an important commercial resource, it represents the main source of animal protein throughout the year. Yet, currently there is no clear evaluation of the fishery and its impacts (Begossi *et al.* 1999). The current Utilization Plan (a pre-management plan based on information gathered, usually through Rapid Assessment Surveys) limits the use of some fishing methods, but it is vague concerning additional fishing management measures (IBAMA 2008).

4.2. Ipaú-Anilzinho (Pará State, Eastern Amazon)

The Ipaú-Anilzinho ER was created in 2005 due to local demand. In 1986, fishers from the village of Joana Perez organised themselves and forced outsider commercial fishers to stop fishing in the lakes close to the village, accusing them of using unacceptable methods, such as large boats, gillnets and large amounts of ice (to keep the fish fresh). However, in the 1990s, fishers in Joana Perez were using ice and increasingly longer gillnets with smaller mesh sizes, selling the fish caught to large boats coming from nearby towns. This could have led to a shortage of fish supply for consumption and commerce. As such, the fishers decided to regulate their own fishing, without any government support. Following this, the Joana Perez community requested that the Brazilian government recognised their area as an ER. Through a top-down measure lobbied by the people of Joana Perez, an

Table 2. Available indicators of ecological resilience for the case studies of Extractive (ER) and Sustainable Development (SDR) reserves in the Brazilian Amazon and on the coast.

	Amazonian Extractive Reserves		Coastal Extractive Reserves		Amazonian Sustainable Development Reserves		Coastal Sustainable Development Reserves
	Alto Juruá	Ipaú-Anilzinho	Arraial do Cabo	Corumbau	Mamirauá	Piagaçu-Purus	Ponta do Tubarão
No. of people	3600	N/A (less than 1000)	~1200	800	6642	~4000	~4000
No. of villages	NA	5+4	4	9	60	56	11
Area (km^2)	506,186	318,817	56,769	89,500	1,124,000	1,008,167	13,023
Density (no. people/km^2)	0.71	0.31	2.1	0.88	0.59	0.40	30.72
Buffer zone around the reserve	Yes	Yes	No	No	Yes	Yes	No

additional five communities were included within the reserve to prevent over-fishing in these surrounding communities as well.

Among the five officially recognised communities that are in the Ipaú-Anilzinho ER (at least four more claim to be inside the reserve limits), two are *caboclo* communities (typical Amazonian riverine people), one is a *quilombola* (descendants of slave runaways) and two are formed by migrant peasants from northeastern Brazil (P.F.M. Lopes and R.A.M. Silvano, personal observations). Such cultural diversity results in different economic practices and land use in the Ipaú-Anilzinho ER, which are not always in agreement with each other or with the reserve goals.

By 2007 some fishing limits were established in the Ipaú-Anilzinho ER, such as a minimum mesh size for the fishing nets, a quota of 50 kg of fish per family per week (not for sale or transfer) and the prohibition of selling fish outside the community. Communities have been enforcing these regulations with sporadic support from the Brazilian Environmental Agency (IBAMA). There is some flexibility in the limits because some fishers may be allowed to exceed their fishing quota if they do not have another source of income (P.F.M. Lopes and R.A.M. Silvano, personal observations). A fisher who disregards one of the rules mentioned previously cannot fish for a month, and the same punishment can be applied up to five times. On the sixth time of infraction, the fisher is 'invited' to leave the reserve.

5. Extractive Reserves on the coast

5.1. Arraial do Cabo (Rio de Janeiro State, Southeastern Brazil)

The marine ER of Arraial do Cabo was created in 1997 as a response to the constant invasion of the artisan fishers' area by industrial fishing fleets. However, the creation of this reserve was not a demand from the local communities. It was suggested and implemented by IBAMA, with the intention of giving user-rights to local people while still conserving important fish nursery sites (Seixas *et al.* 2009). The fact that the communities were already organised before IBAMA arrived probably facilitated the establishment of a co-managed reserve. On the other hand, the top-down implementation meant that artisanal fishers were not seriously considered in the management design of this ER (Silva 2004). The fishing methods used by artisanal fishers were considered sustainable and were allowed. Some areas were designated for biological conservation, where fishing would not be allowed. However, according to the fishers, such areas would need to be restored in order to become effective for biological conservation purposes (Silva 2004).

Since 1921, a set of complex fishing rules including restrictions on gear, vessel, number of crew and access rights have been practised in Arraial do Cabo. Back then, the main artisanal fishing method was beach seining. With the creation of the ER, the previously existing regulations were absorbed and expanded to include the new fishing methods used by recent migrants, such as hook and line (Silva 2004).

The Arraial do Cabo ER gave fishing rights to fishers who did not have their own gear and worked as crew for the beach seiners. This threatened the majority of seine owners and discouraged their participation, which led to them boycotting the reserve. In addition, the limited local involvement in reserve management is also associated with the abundance of alternative jobs unrelated to the reserve, providing relative economic independence from the fishery (Silva 2004).

For the reasons mentioned above, plus the lack of governmental support to run monitoring programmes, the Arraial do Cabo ER has a weak role in achieving

sustainable exploitation and conservation of fishing resources. The enforcement of the Utilization Plan (a pre-management plan) constrained the industrial fishery and increased the catch of artisanal fishers in this reserve, but it is unknown whether this trend is due to a real increase of the fish stocks or due to a re-allocation of fishing effort from industrial to artisanal fisheries (Seixas *et al*. 2009). Therefore, detailed assessments of fish abundance are required to properly assert the efficacy of the Arraial do Cabo ER and its contribution to sustainable fishery management.

5.2. Corumbau Extractive Reserve (Bahia State, Northeastern Brazil)

The Corumbau reserve was created in 2000 and it was the first ER aimed at protecting coral reef fisheries, although beaches and mangroves were also included in the reserve area (Moura *et al*. 2007). Local fishers organised themselves after perceiving that they were clearly disadvantaged compared to better equipped outside fishers, who were using methods such as trawling, and depleting important local fishing resources, including shrimp (Di Ciommo 2007). In 1998 three fishing villages started the movement to create the reserve. At present, nine communities take part in the reserve and participate in the decision-making process for regulating access and the user-rights within it.

However, the lack of guidelines and a clear definition of the co-management arrangements have recently been causing internal conflicts at the household and community levels (Di Ciommo 2007). Users were expecting high returns in the short term, but after nine years they still have not seen improvements in their catch or income. A recent survey shows an increase in fish populations over time within the reserve limits for at least some exploited species. Yet, such positive trends are unlikely to be maintained for all species, because no-fishing areas were not established in the higher quality habitats (Francini-Filho and Moura 2008).

The current measures adopted in the Corumbau ER have the potential to achieve marine resource conservation after some adjustments in the location of no-take areas (Francini-Filho and Moura 2008). However, the exclusion of inland areas from the reserve restricts the effectiveness in attaining the conservation and sustainable use of resources due to unplanned tourism development, which does not necessarily benefit local communities (Seixas *et al*. 2009).

6. Sustainable Development Reserves in the Amazon

6.1. Mamirauá (Amazonas State, Central Amazon)

Mamirauá is the first and most important SDR in Brazil and started from a typical top-down approach. In 1985, Brazilian researchers demanded the creation of an Ecological Station to protect the endangered primate species 'Uacari-Branco' (*Cacajao calvus calvus*) (Ayres *et al*. 1996). However, ecological stations are conservation units that, according to the Brazilian law, do not allow people within their limits. This was unacceptable for an area occupied and used by over 5300 people (Viana *et al*. 2004). As such, in 1996, the State of Amazonas created the SDR as a new conservation category that allows the sustainable use of resources by local people within the reserve limits. This category was later included in the Brazilian federal conservation legislation.

Fishing in the highly productive floodplain is the main economic resource for people in the Mamiraúa SDR, which is currently managed in a participatory way by

local people, researchers and the Brazilian Environmental Agency (IBAMA). Fishing management was inspired by a system of lake rotations established by the Catholic Church in the 1970s (Queiroz 2005). The lakes of the Mamiraúa SDR floodplain were assigned to three main categories: preservation (no fishing allowed), subsistence (allows only fishing for food) and commercialisation (allows commercial fishing by local fishers) (Queiroz 1999). Economically relevant fish species, such as *pirarucu* (*Arapaima gigas*) and *tambaqui* (*Colossoma macropomum*) are managed based primarily on fishers' knowledge (Castello 2004). Fishers also suggested the rotation of 31 of the 133 lakes and are responsible for counting *pirarucu* in the lakes to establish the harvesting quota for the following year (Viana *et al*. 2004, Castello *et al*. 2009). *Pirarucu* is harvested under a licence system and therefore mostly commercialised without a middleman (Viana *et al*. 2004). Mamirauá is one of the few Brazilian reserves that has follow-up fishing studies. These studies show that *pirarucu* and *tambaqui* have increased in the preservation lakes (Costa *et al*. 1999, MacCord *et al*. 2007, Castello *et al*. 2009, Silvano *et al*. 2009).

6.2. Piagaçu-Purus (Amazonas State, Central Amazon)

The Piagaçu-Purus SDR, which was created in 2003, also originated from a scientific (rather than local) demand, with the goal of protecting natural resources, especially fish. The initial discussion for the creation of Piagaçu-Purus reserve was conducted by the same group that implemented Mamirauá SDR in 1996. It is estimated that more than 50% of the fish consumed in Manaus, one of the biggest cities in the Brazilian Amazon, is caught in the Purus River (Pereira de Deus *et al*. 2002).

The local economy of the Piagaçu-Purus SDR is based on slash and burn agriculture, fisheries and hunting (mainly the illegal caiman hunting). Forest logging and gathering of non-timber forest resources play a secondary role (Marcano *et al*. 2002). The fishery is not yet managed, and according to researchers working on this SDR, fishing agreements similar to the ones already occurring in other Amazonian regions (Castro and McGrath 2003) are currently being discussed (Pantoja Lima, personal communication).

7. Sustainable Development Reserves on the coast

7.1. Ponta do Tubarão (Rio Grande do Norte State, Northeastern Brazil)

Ponta do Tubarão was one of the first SDRs created outside the Amazonian region. One of the unique qualities of this SDR is that it encompasses a range of northeastern ecosystems, such as small estuaries, 'caatinga' (xeric shrub land and thorn forest), and 'restinga' (tropical and subtropical dry broadleaf forest). The local organisation for the creation of this reserve began in 1995, due to the news that a foreign company was about to buy part of the beach for the construction of a resort. Demand for the reserve was further reinforced by a fire that occurred in a locally important mangrove area, which was started by a group operating an aquaculture project (Nobre 2005).

Ponta do Tubarão was officially established as a reserve in 2003. The limits of the reserve were established to protect the estuarine habitats and the various types of fishing resources up to 2 km offshore. The communities that were not initially consulted about their interest in taking part in the reserve were later included during the reserve establishment (Nobre 2005). The lack of financial resources currently

prevents effective action and has proven to be the major problem preventing the effectiveness of management actions (Vianna and Sales 2007).

8. Discussion

8.1. The resilience of different Brazilian co-management systems

Brazilian socio-ecological systems are undergoing striking changes. Such changes can be at the environmental level, such as the increasing deforestation and unregulated harvest of natural resources, or at the social level, such as population displacement and increasing competition or conflicts over natural resources. If a socio-ecological system is able to deal with changes and can remain in operation, this system is considered to be resilient (Folke *et al.* 2002). Management actions can either contribute to increase resilience or erode it, depending on how the socio-ecological system organises itself in response to the adopted management measures (Holling 2001).

The case studies analysed focus on fisheries management, and as such, show just part of a general situation. Fisheries management measures, such as fishing gear or effort restrictions, fishing quotas and no-fishing areas, can potentially increase the ecological resilience of the system (Table 4), but how it will affect the social resilience depends on other factors. For example, constraining fishing effort can lead to a new social organisation on which fishing may not be as relevant as before, and do so without disrupting the system. On the other hand, socio-ecological systems with lower resilience can collapse when subjected to highly restrictive measures (Folke 2000). Therefore, the final ecological and social outcomes of fisheries management measures will depend on the pre-existent ecological and social conditions, including those that control the capacity of the system to adapt.

Despite the geographic differences among them, the Brazilian Amazon and the coast share many similar ecological and social features. Both regions have a high biodiversity (terrestrial and aquatic) and a high degree of endemism (Brooks *et al.* 2002). Both are still inhabited by local people, the *caboclos* (Amazon) and the *caiçaras* (coast), who make a living primarily from natural resources (Adams 2000, Brondízio *et al.* 1994). Both groups were subjected to European miscegenation and have contact with the external world through commerce, media and formal education. Finally, in both regions there are communities who chose, and those that were forced, to live in conservation units that allow the sustainable use of natural resources (ERs and SDRs).

8.2. Ecological resilience

Coastal and estuarine systems have been regarded as being highly resilient to changes. For example, Constanza *et al.* (1995) suggest that the diversity of functions performed by these ecological systems, such as rapid self-regulation and regeneration after severe impacts, continually surprise ecologists. Even though there is a lack of detailed knowledge on the resilience of the Brazilian coast, if coastal systems had a higher ecological resilience in general, this could be an advantage to the coastal reserves. On the other hand, the resilience of the Amazon is highly affected by human pressures. Increasing deforestation increases the size of forest edges, making the forest more vulnerable to desiccation, increases tree mortality and fire impacts, which is expected to get worse as climate change progresses (Malhi *et al.* 2008).

Table 3. Available indicators of social resilience (flexibility and capacity to organize) for the case studies of Extractive (ER) and Sustainable Development (SDR) reserves in the Brazilian Amazon and on the coast (HD = high diversification; D = diversified; LD = low diversification, FD = fisheries dependent).

	Extractive Reserves				Sustainable Development Reserves		
	Amazon		Coast		Amazon		Coast
Indicators	Alto Juruá	Ipaú-Anilzinho	Arraial do Cabo	Corumbau	Mamiraua	Piagaçu-Purus	Ponta do Tubarão
Flexibility							
Level of resource diversification	HD	D	FD	FD	LD	D	FD
(Resource-related economy)	(Rubber, small-scale agriculture, cattle ranching, logging and fisheries)	(Fisheries, Brazilian nut, black pepper)	(Fisheries)	(Fisheries)	(Fisheries, small-scale agriculture)	(Fisheries, hunting, small-scale agriculture)	(Fisheries)
Livelihood diversity[a]	None	None	External jobs	Tourism	Jobs at the reserve	None	None[b]
Capacity to organize							
Participation in reserve decision making	High	High	Medium[c]	Medium[d]	High	Medium[e]	Low
Rules and regulations related to fisheries[f]	Low	High	Medium	High	High	High	Medium
Demand for the reserve creation	Local	Local (Joana Perez)/ Top-down (other villages)	Top-down	Local	Top-down	Top-down	Local

(*continued*)

Table 3. (*Continued*).

	Extractive Reserves				Sustainable Development Reserves		
	Amazon		Coast		Amazon		Coast
Indicators	Alto Juruá	Ipaú-Anilzinho	Arraial do Cabo	Corumbau	Mamiraua	Piagaçu-Purus	Ponta do Tubarão
Self-monitoring	Yes	Yes	Yes	Yes	Yes	NA	No
Management Plan	Utilization Plan	None	Utilization Plan	Utilization Plan, (Management Plan being prepared)	Adaptive Management Plan	Utilization Plan	None

Notes: [a]It refers to other economic activities, such as external jobs.
[b]Nobre (2005) highlights the potential for ecotourism in the area, but nothing related to it was being done.
[c]There is a democratic decision-making forum concerning fishing activities, but such forum has not been accessible to most fishers (Silva 2004).
[d]Di Ciommo (2007) highlights that participation in decision making is especially low for women.
[e]Painter *et al.* (2008) show that villagers are getting continually involved in the decision-making process related to the management of this reserve, but this process is at the beginning.
[f]Low = the existence of one or no fisheries management measures in place or under development; Medium = two to three regulations; High = the existence of four or more fisheries management measures in place or under development.

At the regional scales considered here, Amazonian reserves are, on average, at least twice as large as coastal ones, and most of the Amazonian reserves still have a buffer zone with at least some relatively intact forest. There is evidence that intact Amazonian forest could be resilient to climatic drying (Malhi *et al.* 2008), which can be an advantage of having large, protected and well-managed forest areas. Furthermore, there is evidence that biodiversity at larger spatial scales ensures the maintenance of key species for ecosystem functioning, even after major disturbances (Peterson *et al.* 1998, Bengtsson *et al.* 2003). On the other hand, even in high diversity ecological systems, such as tropical coral reefs, the loss of a single key species due to human pressure (fishing) may lead to an ecosystem's disruption and loss of coral diversity (Bellwood *et al.* 2003). Coastal reserves, besides being smaller than Amazonian ones, are surrounded by cities and threatened by the advance of unplanned tourism, which may reduce their ecological resilience.

Human population density is another attribute that differs between the Amazon and the coast, and can be a function of the reserve's size and surrounding development. In the case studies considered here, all the Amazon reserves had less than 0.8 person/km^2, while this varied from 0.9 person/km^2 to 31 people/km^2 in the coastal reserves (Table 2). The impacts of human population density on biological conservation efforts have been controversial in the scientific literature; for example, carnivores were first thought to be highly negatively affected by a human presence (Woodroffe 2000), but other studies have shown that such impacts can be minimised by adequate management measures (Linnell *et al.* 2001). However, for the case studies considered here, we can reasonably assume that more people would imply more resource use, especially if people rely on a low variety of resources or if there is a lack of sufficient alternative jobs, as discussed below.

Considering the above general discussion and the overall ecological characteristics of the two Brazilian regions, coastal areas may be more resilient, but the reserve areas designated for them may be too small to assure significant resource conservation or to take advantage of the naturally high coastal ecological resilience. Conversely, the Amazon reserves are usually much larger and have a lower human population density than coastal reserves, which is probably the only way of assuring sustainable resource use in this region, given the susceptibility of this socio-ecological system to external changes and disturbance.

8.3. Social resilience

Social resilience has been described as the ability of communities to absorb changes and adversity, while still maintaining the sustainability of their livelihoods (Adger *et al.* 2002). Marshall and Marshall (2007) illustrate social resilience in a very intuitive way, using fishers as a hypothetical example. According to this example, fishers could maintain social resilience if they changed their economic activity due to policy changes in their working life, as long as they could have similar incomes and lifestyle rewards and pay similar taxes. As such, it is possible for a system to achieve social resilience while not necessarily showing socio-ecological resilience (Marshall and Marshall 2007). Similarly, ecological sustainability of a socio-ecological system will not be necessarily linked to the economic or social sustainability of people within that system (Glaser and Diele 2004). Thus, ecological and social resilience are mutually exclusive and one does not require the other.

At the local level, four key aspects have been used to examine social resilience: flexibility, assets, the capacity to learn and the capacity to organise, which can all be linked to regional and national scales (Cinner *et al*. 2009a). For each of these key aspects, several indicators can be measured, such as livelihood diversity, the strength and stability of institutions (flexibility), migration (capacity to organise), monitoring of resources (capacity to learn) and infrastructure (assets), among many others (Adger 2000, Cinner *et al*. 2009a).

In this study, it was possible to show differences between the two Brazilian regions (Amazon and the coast) by using social resilience indicators of flexibility and the capacity to organise. The reliance on a narrow range of resources can lead to social and economic stress. Relying on fewer economic resources makes people more susceptible to market variations (boom and bust cycles), which increases the variance of income. This also increases sensitivity to natural variations, such as ecological change, which may affect the distribution and abundance of a given resource (Adger 2000). Moreover, having alternative sources of income is essential if fishing is to be restricted in order to achieve management goals (Johannes 2002).

One striking difference between Amazonian and coastal reserves is the variety of resource-related economic activities (Table 1 and 3). Local people in Amazonian reserves seem to depend on a broader array of economic resources, while coastal dwellers depend mostly on fisheries. Hence, a failure in fisheries would probably result in a failure of the economic stability of coastal communities. Moreover, these people would be less willing to restrict their fishing effort if fish and seafood are their only source of income. Considering this, Amazonian communities could potentially do better in managing fisheries, because they also rely on other economic resource based activities, such as small-scale agriculture and, less often, on cattle ranching (McGrath *et al*. 2008). In the past, Brazilian coastal communities also used to rely on different sources of income, such as small-scale agriculture, but different economic cycles, associated with the growth of coastal cities and tourism, forced coastal people to abandon some of these former economic activities (Adams 2000, Begossi 2006).

However, being on the coast and thus closer to larger urban areas allows diversification of people's livelihoods, such as the development of ecotourism, which can decrease the pressure on fishing resources. As such, even if coastal reserves rely on fewer natural resources than Amazonian ones, people in coastal reserves have the potential alternative to diversify jobs, which contributes to enhancing their flexibility (Table 3) (Berkes and Seixas 2006). Thus, urbanisation and tourism can be both a threat and an opportunity for flexibility and the diversification of the resource base.

The second characteristic related to socio-economic resilience addressed here is the capacity to organise. However, some of the indicators used in the current study may not fit into a strict definition of capacity to organise. This applies to indicators such as the existence and types of fishery management measures, self-monitoring, the fishing rules and of a general management plan. Given that the management actions are relatively new, and that more time is needed before their effects are observed, these indicators may be more useful to measure the capacity to learn in the future.

The first indicator of the capacity to organise used here was the degree of participation by local people in the decision-making process within the reserve, and this is considered an important factor in achieving local resilience (Tompkins and Adger 2004). Although this is a qualitative measure, Amazonian reserves seem to incorporate a stronger involvement of local people in the decision-making process

(Table 3). One way to improve this measure would be to interview different families about their actual involvement in the decision-making processes, exemplified by reserves in Madagascar and Kenya (Cinner *et al.* 2009a, 2009b). In Madagascar, more than 50% of the survey respondents were actively involved in decision making (Cinner *et al.* 2009a), while the figure was approximately 36% in Kenya (Cinner *et al.* 2009b).

The second indicator, self-monitoring, has been done in almost all the reserves studied here, although it is not known whether local people are learning from resource monitoring and using this information to change and adapt their management measures (Table 3). Mamirauá is an exception: they have been adapting their management according to what they learn from different sources, including self-monitoring. It is probably too early for most of the reserves studied to have meaningful feedback from self-monitoring, since most were created less than 10 years ago. Although it is considered here to be an indicator of capacity to organise, self-monitoring may be an indicator of capacity to learn in the future.

As most of the reserves studied here (both in the Amazon and on the coast) aim at managing fisheries, they already have (or are on the way to having) clearly defined local fishing rules, the third indicator considered here (Table 4). The Amazonian Alto Juruá is an exception, probably because most people in this reserve make a living from other forest products, such as the Brazil nut. Since the most effective fishery management rules are not static and they are re-evaluated regularly based on monitoring data (such as every five years), the existence of fishing rules can be considered as an indicator for the capacity to learn, especially in the long term. Indeed, the success or failure of these fishing management measures will depend on the ability of local people to evaluate and adapt the rules as necessary (Tompkins and Adger 2004).

Despite having fishing management rules, most reserves (except for Mamirauá) do not have an official management plan. Instead, these reserves either have a utilisation plan (a pre-management plan) or they are progressing towards developing a management plan (Table 3). Adaptive management plans are an important tool to increase socio-ecological resilience. They enable local people to deal with new information and unpredictable social and environmental changes (internal or external), including increased or decreased dependency on a given resource and even climate change, which could affect resource distribution or availability (Tompkins and Adger 2004).

Regardless of the indicators used here, both in the Brazilian Amazon and on the coast, there are examples of top-down approaches imposing a co-managed system. In such cases, it is not always clear to local people why they need to change their resource use practices, sometimes restraining their effort and even incurring short-term economic loss. Top-down approaches generally do not assure community participation and require an extra effort to build trust among participants in management action, one of the key components of social resilience (Gunderson 2000). Building trust among distinct stakeholders requires time and willingness, as shown by successful co-management systems elsewhere (Pretty and Ward 2001, Olsson *et al.* 2004). Although they do implement co-management systems, top-down initiatives will usually imply more effort and probably higher management costs. Nevertheless, the Brazilian case studies analysed here show that even such initiatives can turn into participatory fisheries co-management regimes, as evidenced by the Mamirauá example (Castello *et al.* 2009).

Table 4. Fishing management measures applied to the considered case studies of Extractive (ER) and Sustainable Development (SDR) reserves in the Brazilian Amazon and on the coast.

	Amazonian ER		Coastal ER		Amazonian SDR		Coastal SDR
	Alto Juruá	Ipaú-Anilzinho	Arraial do Cabo	Corumbau	Mamirauá	Piagaçu-Purus	Ponta do Tubarão
Restrictions on fishing gear (gillnets)	No	Minimum mesh size (6 mm knot to knot)	No	Restricted in some areas, limited in others (net and mesh size)	Minimum mesh size, place restriction, season restriction	No	Minimum mesh size
Restrictions on fishing methods	Batição,[a] explosives, poison	Poison, closure of river mouths	Trawling	Methods are allowed or forbidden according to zoning of the area	Purse-seine, beach seine fishing	Purse-seine fishing	Diving
No-fishing areas	No	Yes	Yes	Yes	Yes	Fishing accords being developed	No
Catch restrictions (quota)	No	50 kg per family/ per week	No	Trawling (300 kg/ day or 1500 kg/month)	Annual quota to pirarucu *(Arapaimas gigas)*. Tambaqui (*Colossoma macropomum)* secondarily controlled	Fishing accords being developed	No
Periodic closures (species or areas)	Federal and State law (not known if observed or not)	No	Federal law	Federal law	Local and State law	State law, locally enforced	Federal and State law (not known if observed or not)

(*continued*)

Table 4. (*Continued*).

	Amazonian ER		Coastal ER		Amazonian SDR		Coastal SDR
	Alto Juruá	Ipaú-Anilzinho	Arraial do Cabo	Corumbau	Mamirauá	Piagaçu-Purus	Ponta do Tubarão
Fish-size restrictions	Federal law	Federal law poorly observed	Federal law	Federal law; locally defined to crabs (more restricted than federal law)	Locally controlled; applied to commercial species	Locally controlled; applied to commercial species	Federal law poorly observed
Pre-existent regulations	Not known	Yes	Yes	Not known	Yes	No	No

[a]Fishers hit a piece of wood on the water to scare the fish towards a cast-net.

9. Conclusions

Starting in the Amazon and spreading along the coast, similar fishery management strategies represented mainly by the Extractive and Sustainable Development Reserves discussed here have been adopted throughout Brazil. The conservation category chosen (ER or SDR) does not imply any meaningful difference in resource use. The conservation category of these reserves has apparently been defined based on local feasibility (such as the existence of private properties in the area to be preserved), instead of being specifically designed to achieve major conservation or resource use goals.

In general, the success of ERs and SDRs in different environments are more likely to be affected by environmental differences, such as the size (area) of the reserves, whether or not they are surrounded by forests and variation in human density inside reserves, as well as social differences, such as having diversified sources of income (Ruiz-Pérez *et al.* 2005).

Fishery management in the Amazonian reserves is expected to be in a better position to achieve ecological resilience (compared to coastal reserves), mostly due to their larger size. However, increasing Amazonian deforestation may represent a threat to local resources (Nepstad *et al.* 2001), which may have negative consequences for the fishery. Coastal reserves may be naturally more resilient ecologically (see above), which can partially compensate for the smaller (and thus more vulnerable) protected areas on the Brazilian coast.

Social resilience, described here by the indicators of flexibility and capacity to organise, may drive Amazonian and coastal reserves to similar outcomes (successful fishery management), but through different ways. On the one hand, there is a higher diversity of natural resources being exploited by local people in Amazonian reserves, while local people on coastal reserves concentrate more on fisheries. On the other hand, people living on coastal reserves can take advantage of their proximity to major urban centres to work in tourism related activities, including ecotourism. This may offset to some extent the almost exclusive dependence of coastal people on a single resource (fish), as well as potentially contributing to decrease fishing pressure.

The level of participation of local people in the decision-making process should be increased in both of the regions studied, especially because the two types of reserves analysed (ER and SDR) are most effective when co-managed with intensive participation of local communities. The reserves studied already have or are developing mechanisms that can be considered indicators of the capacity to learn, such as self-monitoring schemes and adaptive management plans. However, using such mechanisms to significantly improve the capacity to learn will probably depend on additional investments from the government in formal and informal education for communities involved, and the development of institutions capable of conjugating scientific and local knowledge (Berkes and Seixas 2006).

The creation of a reserve, regardless of where it is, does not seal the fate of local people or guarantee the biodiversity and resource conservation of an area. Abandoning communities living in reserves and excluding them from development of management plans may lead to social and ecological failure (Pomeroy *et al.* 2001). Therefore, neither Amazonian reserves nor coastal ones can be regarded as conservation or sustainability models, because most of them (with the exception of SDR Mamirauá and its adaptive management plan) have not yet developed management plans. Furthermore, despite the fact that all the reserves have some

degree of fishing rules and regulations, most of the fishery management measures adopted have so far been vague.

Co-management regimes have the potential to contribute to improve the socio-ecological resilience (Olsson *et al.* 2004), but only if managers consider more carefully the general and local characteristics of distinct regions before establishing reserves. Good conservation models will probably spread, but creating co-managed reserves should be regarded as a continuous process towards a desired conservation state that incorporates and facilitates socio-ecological resilience. This can be achieved following the establishment of the reserve by the establishment of specific management measures, including an adaptive management plan, the increased participation of local people and developing economic alternatives.

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Note

1. There is no available information on resource exploitation for 22 Extractive Reserves, 17 of them in Rondônia State, where many small reserves were created in 1995. Such reserves have been considered as not fulfilling their role of social and environmental protection due to the lack of governmental support and competing interests between local people and supporting NGOs (Brown and Rosendo 2000).

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