Traditional and modern management of natural resources: Evidence from Benin's inland fisheries[1]

Elena Briones Alonso[2] Romain Houssa[3] Marijke Verpoorten[4]

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Abstract

This paper investigates the functioning of two locally designed rules to manage the fishery stock. The rules apply to the use of fine meshed nets and stem from two distinct institutions: (i) a modern institution embodied in fishing committees, and (ii) a traditional institution embedded in Voodoo, an Animist religion that originated in Benin. We examine the effectiveness of these rules relying on individual-level data on weekly revenue and the use of fishing gear by fishermen. We find that the two types of rules co-exist, and have a statistically significant effect on fishing activity. However, the quantitative effect of these rules on fishing activities is small and, unless reinforced, the existing rules may not be sufficient to prevent the collapse of the ecosystem.

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[2] University of Leuven (KU Leuven) – Centre for Institutions and Economic Performance (LICOS)
[3] CRED & CeReFiM, University of Namur. Tel: +32(0)81 724947. Email: romain.roussa@fundp.ac.be
[4] University of Antwerp (UA) - Institute for Development policy and Management (IOB) and University of Leuven (KU Leuven) – Centre for Institutions and Economic Performance (LICOS)

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1. INTRODUCTION

Around the globe, marine and inland fishery stocks are being overexploited (Allan et al., 2005; Food and Agriculture Organization, 2012). According to Hardin (1986), overexploitation of common pool resources such as fisheries is inevitable unless the resource is converted to state or private property. As Hardin theorizes, this inexorable 'tragedy of the commons' rises from the fact that all common pool resources are characterized by non-trivial exclusion and rivalry in consumption. These properties create short term individual incentives for unlimited exploitation that conflict with the long-run interest of the group to restrain exploitation and preserve the resource. The argument that this conflicting situation will inevitably lead to overexploitation of the resource hinges on the assumption that resource users are unable to collectively restrain exploitation without the intervention of an external force.

An extensive body of theoretical and case study literature has shown that this assumption does not always hold: communities of resource users often succeed in collectively regulating exploitation and sustainably managing common pool resources (Baland & Platteau, 1996; Berkes, 1989; Berkes et al, 1989; Bromley, 1992; Feeny et al., 1990; Feeny, Hannah & McEvoy, 1996; Gibson et al., 2000; Pinkerton & Weinstein, 1995; McCay & Acheson, 1987; National Research Council [NRC], 2002; Ostrom, 1990; Wade, 1994). The success of community-level governance is shown to crucially depend on the existence of effective governance institutions, which has led to the formulation of design principles for effective institutions (Agrawal, 2001; Cox, Arnold & Villamayor Tomás, 2010;; NRC, 2002; Ostrom, 1990; 1999; Wade, 1994).

Several design principles tend to be met when resource governance institutions are embedded in traditional culture and religion, and the historical success of this type of institutions supported the notion that traditional religion can serve as an adequate framework for

governance institutions (Barua, 2009; Berkes, Colding & Folk, 2000; Dorm-Adzobu, Ampadu-Agyei & Veil, 1991; Eneji et al., 2012; Kajembe, Luoga, Kijazi & Mwaipopo, 2003; Rusinga & Maposa, 2010; Sharma, Rikhari & Palni, 2010). However, it was also shown that traditional institutions are often vulnerable to changes in the environment, in particular when these changes take the form of the arrival of new, competing governance institutions (Baland & Platteau, 1996; Dorm-Adzobu, Ampadu-Agyei & Veil, 1991; Eneji et al., 2012). Adaptability to a changing environment thus emerged as a crucial principle in the design of effective governance institutions (Dietz, Ostrom & Stern 2003; NRC, 2002). In this context an important question arises: to what extent can traditional religion continue to serve as a framework for effective governance institutions in an increasingly globalized and modernized world?

We examine this issue in the context of the coastal fisheries of Southern Benin, which provide a livelihood to several communities of artisanal fishers. More specifically, we study the effectiveness of two institutions designed to manage the fishery stock. One is a traditional pre-colonial institution integrated in Voodoo, an Animist religion originated in Benin. The second is a post-colonial institution in the form of rules issued by fishing committees (*comités de pêche*), a relatively new structure. Both institutions formulate rules about the use of damaging fishing gear, but the rules differ. We are thus presented with a case in which two competing institutions exist side by side, one originating from pre-colonial times and one created in recent years. However, in contrast to many other cases of competing institutions, the modern institution was not created and imposed by an external force, such as the central government, but created by the fishing communities themselves.

Using qualitative and quantitative data from several weeks of fieldwork in the months March-July 2009 and data from the 2006 fishery census in Southern Benin, we provide

evidence that both the traditional and the modern institution affect fishing activities nowadays, but that both are malfunctioning as their impact is limited.

The coastal fisheries of Benin provide a textbook example of *a tragedy of the commons*. Intensive fishing by individuals pursuing their self-interest has compromised the sustainability of the fishery stock, which has dramatically declined in the last decades (Amoussou, 2004; FAO, 2008; Gnohossou, 2006; USAID, 2007). This overexploitation is in part a consequence of socio-economic changes, such as the explosion of the number of fishers and a rapidly rising demand for fishery products. Another important cause is the erosion of the traditional fishery governance system embedded in Voodoo under the changing circumstances of post-colonial Benin (Bourgoignie, 1972; Dangbégnon, 2000; Pliya, 1980). Attempts by the state to mitigate the problem of overfishing by creating alternative governance institutions were unsuccessful, as the government institutions altogether failed to regulate the fishing activity (Dangbégnon, 2000).

From the 1960s onwards, the institutional weakness and rising value of fishery products resulted in the introduction and proliferation of high-yielding but damaging fishing instruments, which exacerbated the problem of overfishing (Amoussou, 2004; Dangbégnon, 2000; FAO, 2008; Gnohoussou, 2006; USAID, 2007). The *konou* (also known as *medokpokonou)* is one such instrument and forms the object of this study. In response to the problems of overfishing and resource degradation, local fishing committees were formed in recent years with the task of regulating the use of harmful fishing gear. The committees decided upon a new rule for the *konou*. This rule applies throughout the fishing season and allows the use of the konou for four consecutive weeks, then bans it for the following two weeks.

In pre-colonial times, a traditional Voodoo governance system regulated the fishing activity on the lakes, preventing overfishing and preserving the collective character of the

resource (Pliya, 1980). A wide array of concrete rules integrated in Voodoo beliefs regulated fishing intensity and the use of fishing gear (Bourgoignie, 1972; Dangbégnon, 2000; Clédjo, 2006; Pliya, 1980). Since the *konou* is a relatively new fishing instrument (initiated in 1986), the traditional Voodoo system does not stipulate any specific rules about its use. There are, however, traditional rules about the use of fine mesh fishing gear, and these differ from the modern rule. Instead of allowing the use of fine mesh nets in some periods and abolishing it in others, the Voodoo system bans the use of fine mesh gear at all times (Dangbégnon, 2000; Clédjo, 2006; Pliya, 1980).

In this study, we seek to address two specific questions. First, does Voodoo – which in its heydays successfully banned the use of fine mesh nets – still induce fishermen to refrain from using fine mesh fishing gear? And second, is the modern rule effective in regulating the use of the *konou*? Answering these questions allows us to assess whether traditional religion-based institutions can continue to influence behaviour in rapidly changing circumstances, and whether new locally devised institutions can be effective in this setting.

Benin provides an ideal testing ground for the first question, because of its unique setting of religious pluralism, with considerable variation in reported religion between and within villages, and even within the same household (Barbier & Dorier-Apprill, 2002). This not only increases the probability that reported religion in Benin reflects individual beliefs, but also allows us to measure the impact of religion on fishing after controlling for other relevant individual and community characteristics. In contrast, most studies so far have studied homogeneous religious groups and therefore faced the difficulty of perfect correlation in these variables.

If Voodoo still influences fishing behavior, we should find that Voodoo followers use fine meshed gear significantly less and hence have a lower probability of using the *konou*. We explore the correlation between Voodoo and the use of the *konou* in two different

samples. The first is a sample of 392 fishermen questioned in our survey for which we have observations across several weeks in 2009. The second is the 2006 fishery census, which contains one single observation for 18,683 fishermen from all 9 communes surrounding Lake Nokoué and Lake Porto Novo. Using the large census dataset allows us to better control for environmental factors – by means of village fixed effects – that may confound the relationship between Voodoo and the choice of fishing gear.

To investigate the second question, we rely on a detailed dataset of the self-reported use of fishing gear and fishing revenue over time, for a period of 14 weeks. If fishers respect the modern rule, we should find a corresponding periodical variation in the use of the *konou* across weeks. Fishermen may, however, lie about their use of the *konou*. If they do, the variation we pick up could merely reflect clever but untruthful answering by the respondents. To check if our results are driven by untruthful answering, we examine the fluctuations in fishing revenue reported by fishers. Since the *konou* is a highly productive instrument, periodical changes in its use should be reflected in changes in the revenue of fishers. If fishers respect the modern rule, we should find fishing revenue to be lower in closed weeks. Moreover, if the use of the *konou* is abandoned during the closed weeks, the resulting fall in fishing intensity should allow the fishery stock to increase. Fishing revenue should then be highest in the first week of re-opening, and gradually decline in the following open weeks as intensive fishing with the *konou* again reduces the fishery stock. Finding such a trend across open weeks would provide additional evidence that the modern rule is respected.

We find that both the modern rule and adherence to Voodoo affect the use of the *konou*. For both our sample of fishermen and the fishery census of 2006, we find a negative relation between adherence to Voodoo and the use of the *konou*, suggesting that the traditional Voodoo rules are still respected by at least some fishermen. The variation in the use of the *konou* and in fishing revenue across weeks suggests that the *konou* is less used

when the lakes are closed, but that compliance to the modern rule is far from perfect. We explore a number of competing explanations for these results and find that our qualitative conclusions hold.

The next section gives an overview of the coastal fisheries of Benin and the problem of overfishing, and discusses the evolution of the fishery governance institutions. In section 3 we set out the empirical framework used to address our research questions. Section 4 discusses the data used in the analysis and section 5 presents the results. Section 6 concludes.

2. THE COASTAL FISHERIES OF BENIN

2.1. Natural resources and overfishing

We study fishing communities that live at two of the largest lakes in Southern Benin: Lake Nokoué and Lake Porto Novo. Both lakes are indicated on the map in Figure 1. Lake Nokoué is by far the largest water body, with a surface of 150 km^2, while Lake Porto Novo is considerably smaller (35 km^2) and shallower (Gnohoussou, 2006). The two lakes are part of the largest and most productive water basin in Benin – responsible for 65 to 70 percent of the total inland fisheries production – and are connected via the Totché channel (Gnohoussou, 2006; Clédjo, 2006). Lake Nokoué is also connected to the Atlantic Ocean through the Cotonou channel, which is an important element in the lake ecosystem: the periodical inflow of marine water creates seasonal variations in the salinity and temperature of the lakes, which promotes the diversity, reproduction and growth of aquatic fauna and flora (Amoussou, 2004; Gnohoussou, 2006; see Cummings (1961) and Williams (1958) for the case of southern pink shrimp).

In the course of history different ethnic groups settled around the lakes and engaged in fishing activities (Bourgoignie, 1972; Pliya, 1980; 1989). The lakes gradually became

surrounded by fishing villages, located on the lake shores or on the water in the form of pile villages (Bourgoignie, 1972; Pliya, 1980; 1989). To this day, only artisanal fishers are active on the lakes; industrial fishing is absent. The livelihoods of the local households are highly dependent on the lake fisheries: there are few alternative economic activities available to them, which is reflected in a very low degree of income diversification (Stoop et. al, 2012).

The lakes suffer from severe environmental degradation and overfishing (Amoussou, 2004; FAO, 2008; Gnohoussou, 2006; USAID, 2007). The main causes are strong population pressure, commercialization and monetization of the economy, pollution from industrial and household waste and the erosion of the traditional Voodoo governance system (Amoussou, 2004; FAO, 2008; Gnohoussou, 2006; USAID, 2007). The increasing value of fish led to a rise in fishing intensity and triggered the search for more powerful fishing technologies (Dangbégnon, 2000). The most important innovations in fishing techniques were the *acadja*, introduced around the 1960s, and the *konou*, introduced around the 1980s[5].

The *konou* is a fixed fishing installation consisting of a central rectangular fine mesh net (20 to 5 mm) with pouches at its extremities (USAID, 2007; PNE, 2010). Animals that hit the central net are guided into the pouches, from which they cannot escape. In this way the *konou* catches large quantities of fish and shrimp, especially when placed in narrow channels or strong currents. Although the *konou* is not designed exclusively for catching shrimp, it is one of the main instruments used for shrimp fishing and the most productive by far. Aside from being a highly productive instrument, the *konou* is also an expensive fishing instrument.

The *acadja* is a type of tropical brush park fishery that was developed around the end of the 19th century and modernized by the government in the 20th century. It is constructed by placing wooden branches in the bottom of the lake and fencing these branches with a fishing

[5] Other fishing gear used on the lakes include cast nets, trawl nets, pots, longlines, hooks and lines, landing nets and fish traps.

net. The branches, which resemble the natural mangrove habitat of several fish species, protect spawning areas and provide fish with shelter and abundant food supply (de Kimpe, 1968; Lalèyè, 2000; Niyonkuru & Lalèyè, 2010; Gnohoussou, 2006). These features attract fish to the *acadja* and stimulate fish reproduction and growth within the *acadja*, making this a highly productive fishing instrument (de Kimpe, 1968; Clédjo, 2006; Lalèyè, 2000; Niyonkuru & Lalèyè, 2010).

The proliferation of *acadja*s is a major cause of the disappearance of mangrove vegetation on the lake shores, which has aggravated the problems of siltation and habitat degradation (Lalèyè, 2000; Gnohossou, 2006; USAID, 2007). Today, the net environmental impact of the proliferation of *acadja*s is debated. There is general agreement that it increases the amount of organic biomass in the water, thereby lowering oxygen levels and leading to eutrophication (Gnohossou, 2006; Clédjo, 2006). Some authors argue that the presence of *acadja*s itself leads to siltation, though others claim that this effect is negligible (see Ammoussou, 2006; Gnohoussou, 2006; Clédjo, 2006). Clédjo (2006) and Niyonkuru and Lalèyè (2010) argue that the *acadja*, when properly managed, could provide a viable and sustainable fishing practice by promoting fishery reproduction and growth.

The negative impact of the *konou*, in contrast, is widely agreed upon. The damaging nature of the *konou* lies in the use of fine mesh nets. These nets also catch non-mature animals and eggs, which reduces the reproduction capacity of the fishery stock and thus endangers the sustainability of the resource (PNE, 2010; USAID, 2007). In this manner the intensive use of the *konou* has contributed to the problem of overfishing and resource degradation (FAO, 2008; Niyonkuru & Lalèyè, 2010; PNE, 2010; USAID, 2007).

Aside from environmental concerns, the *acadja* and the *konou* create social tensions as well. In the past years, the use of these instruments has provoked severe conflicts between fishers, and the *konou* in particular continues to be a source of conflicts today (Pliya, 1980;

Dangbégnon, 2000; PNE, 2010). Conflicts arise from the use of the *acadja* because of the first come, first serve principle that has ruled the allocation and installment of *acadja*s and because *acadja* owners are de facto privatizing an ever-growing portion of the fishing grounds (Pliya, 1980; PNE, 2010). The use of the *konou* creates conflicts because of the negative impact on fishery stocks, and because the *konou*s are set in such ways that they leave few catches to those fishing in the neighborhood (PNE, 2010).

2.2. Governance of fishery resources

In pre-colonial times, the traditional Voodoo governance system regulated the fishing activity on the lakes, preventing overfishing and preserving the collective character of the resource (Pliya, 1980). A wide array of concrete rules integrated in Voodoo beliefs regulated fishing intensity and the use of fishing gear (Bourgoignie, 1972; Dangbégnon, 2000; Clédjo, 2006; Pliya, 1980). Fishing was for instance banned during market days and days of Voodoo worship (in practice two days per week), and was prohibited in the vicinity of sacred locations, which often coincided with spawning grounds for fish. Regarding fishing gear, the rules prohibited the use of fine mesh nets, the use of multiple hooks and the use of tree branches to attract fish (Dangbégnon, 2000; Clédjo, 2006; Pliya, 1980). Sanctions were severe, ranging from fines to public flagellation or the confiscation of fishing gear. The worst offenses were sanctioned by the death sentence, which was depicted as a punishment by the offended Voodoo spirit and executed by Voodoo priests (Pliya, 1980).

In the Voodoo religion, Voodoo spirits each have their own task in ruling the world and control those elements in the physical world to which they are connected (Bourgoignie, 1972). For instance, the Voodoo spirits that govern the lakes are believed to control the movements of water and fish (Bourgoignie, 1972). Voodoo spirits can thus protect and help mankind, but can also do evil when angered or offended (Bourgoignie, 1972; Tall, 1995).

Phenomena such as flooding or the accumulation of silt are believed to be punishments from an angered Voodoo spirit (Ammoussou, 2004; Tall, 1995). Fishers thus submitted themselves to the rules because of a fear of punishment and an awe for the Voodoo gods (Pliya, 1980).

The rules were organized and enforced by local spiritual leaders who gained legitimacy, authority and trustworthiness from their religious status (Bourgoignie, 1972; Dangbégnon, 2000; Clédjo, 2006; Pliya, 1980). As the leading religious and political class merged together, religious leaders became very powerful (Dangbégnon, 2000; Pliya, 1980; Tall, 1995). Besides exercising power over all aspects of fishing, religious leaders also controlled social and moral life and designed rules about general conduct, such as the prohibition to whistle or fight on the lake (Clédjo, 2006). Feared and respected by people because of their alleged witchcraft and connectedness to the spirits, Voodoo priests played a crucial role in the organization, monitoring and enforcement of the traditional rules (Dangbégnon, 2000; Pliya, 1980).

According to Pliya (1980), the Voodoo rules managed to keep resource exploitation in check, even in the face of population growth. The system started to fail, however, when Voodoo received competition from monotheistic religions and the politico-religious leaders were challenged by new colonial and post-colonial powers (Dangbégnon, 2000; Pliya, 1980). Fast population growth, internal migration and an increased monetization and commercialization of the economy further contributed to the erosion of the traditional governance system (Dangbégnon, 2000; Pliya, 1980).

As a result, the deterring effect of sanctions decreased. At the same time the benefits of shirking increased following the monetization of the economy and access to new markets in the form of supply to urban centers or exports to Europe. New settlements of agricultural communities started exploiting the lake resources as well, engaging in a competition with the communities who had been full-time fishers since pre-colonial times. These new part-time

fishers showed little respect for the traditional Voodoo system, fishing whenever and wherever they chose, openly disobeying rules and mocking the authority of Voodoo priests. These outsiders thus further undermined the power of the Voodoo system and reduced the incentives for locally born fishers to obey the rules (Pliya 1980).

The waning power of the traditional Voodoo institution and the problems of overfishing and resource degradation induced the government to create new institutions to take over the role of the Voodoo system. Yet, these institutions generally failed to effectively regulate fishing activities (Dangbégnon, 2000; Maarleveld & Dangbégnon, 1999; Pliya, 1980). Either rules were left unmonitored, sanctions were not severe, or punishments not implemented. For instance, during our interviews of civil servants designated to inspect the use of fishing gear, we were told that monitoring and certainly sanctioning is halted when elections approach in order for the incumbent officials to gain the votes of the fishers (see also Dangbégnon, 2000). Besides failing to effectively regulate the fishing activity, the governmentally created institutions also contributed to undermining the authority of Voodoo priests and their rules (Pliya, 1980). For example, by enforcing the individual property claim of *acadja* owners, the government broke with the long-established Voodoo principle that regarded and preserved the lake resources as common property (Pliya, 1980).

In spite of all these undermining forces and the considerable loss in power, the traditional Voodoo governance system did not completely disappear. In fact, during the seventeen years of Marxist-Leninist policies in Benin, 1972-1989, with its anti-religious campaigns and witch-hunts, the importance and influence of Voodoo was greatly reduced, but with the coming of democratic renewal since 1990, Voodoo regained vitality (Tall, 1995). The Voodoo religion became more and more organized and structured as a traditional religion, with a national feast (10 January) and a national hierarchy (Pliya, 1980; Tall, 1995). Maybe partly thanks to this rather unique revival, Voodoo continues to influence day-to-day

life and Voodoo priests continue to be involved in the fishing activity. Though not all taboos and sanctions have survived, concrete rules and sanctions still exist today (Amoussou, 2004; Clédjo, 2006; Dangbégnon, 2000). For instance, Voodoo continues to prohibit fishing in the neighborhood of shrines and sacred locations (Clédjo, 2006).

The Voodoo governance system is not the only institution regulating fishing activity nowadays. As was highlighted in the introduction, fishers recently created a new rule to regulate the use of the *konou*, which is unrelated to the traditional Voodoo institutions. This modern rule is implemented throughout the fishing season, which coincides with high spawning activities of targeted species (Pliya, 1980). In this period, the size of the sexually mature stock has an important impact on the reproduction rate and, in addition, larvae and young specimen have high growth rates (see Cummings, 1961; Williams, 1958). By periodically closing the lakes to the use of the *konou*, the rule intends to promote fishery reproduction and growth and reduce the damaging impact of the *konou*. . The committees impose a number of sanctions when the rule is violated, such as the confiscation of fishing gear, but the effectiveness of the sanctioning mechanism is undermined by corruption and inertia (Dangbégnon, 2000; Pliya, 1980).

3. EMPIRICAL SETUP

We investigate the functioning of two institutions regulating the fishing activity. The first is the modern rule, which periodically prohibits the use of the *konou* across weeks. The second is the traditional Voodoo rule, which prohibits the use of fine mesh nets at all times. To identify compliance to the modern rule, we exploit variation in the use of the *konou* across

weeks. To analyze the functioning of the traditional rule we exploit variation in Voodoo adherence across and within villages. Our first equation to be estimated is the following:

$$Konou_{it} = \alpha_0 + \alpha_1 Closed_t + \alpha_2 Voodoo_i + \tau_t + X'_{it}\Omega + \lambda_a + \varepsilon_{ita} \quad (1)$$

$Konou_{it}$ is an indicator variable taking value 1 if individual *i* reports to use the *konou* for fishing in week *t*, and 0 otherwise; $Closed_t$ is an indicator variable that equals 1 if the lakes are closed in week *t*; $Voodoo_i$ is an indicator variable that equals 1 if individual *i* reports his religion to be $Voodoo_t$; τ_t is a time trend; X'_{it} is a vector of the following control variables for individual *i* in week *t*: the logarithm of age, an indicator variable for literacy, an interaction effect between literacy and $Closed_t$ and the logarithm of the total value of assets; λ_a indicates fixed effects at the *arrondissement* level [6]; ε_{ita} denotes the usual error term.

The time trend is included to capture temporal variation in the use of the *konou* generated by unobserved environmental variables. We control for age because the use of the *konou* requires a considerable amount of physical strength. Literacy and the total value of assets are included as indicators of income, to capture the effect of the expensiveness of the *konou*. We leave aside any concern for potential endogeneity as their inclusion has only a small effect on the estimation results. The interaction term between literacy and the closed variable is included to capture differences in compliance between fishermen of high and low education levels.

If α_1 is estimated significantly negative, it suggests that the use of the *konou* is on average lower for weeks in which the modern rule prohibits its use, i.e. for weeks in which the lakes are closed. If α_2 is estimated significantly negative, it suggests that Voodoo fishermen respect the traditional rule of not using fine meshed nets. However, in both cases

[6] The arrondissement is an administrative unit between the village level and the commune level. Each of the four arrondissements included in our sample comprises three samples villages.

there is a competing hypothesis. Regarding the effect of the modern rule, the alternative is that fishers lie about the use of the *konou* in closed weeks. This scenario will cause the estimate of α_1 to be negative without there being actual compliance to the modern rule. Regarding the impact of Voodoo, there may be unobserved factors that are correlated with both adherence to Voodoo and the use of fine mesh nets. Such factors would bias the estimate for α_2. For instance, the Voodoo variable might absorb the effect of village level variables if Voodoo fishermen are concentrated in villages where the use of the *konou* is affected by village-level environmental factors. In the above specification we control for arrondissement fixed effects, but we do not include village fixed effects because of the small number and proximity of the villages in the sample.

To deal with the first of these caveats, we examine the fluctuation of fishing revenue for shrimp across weeks. As was mentioned before, the *konou* is one of the main instruments used for shrimp fishing, and the most productive instrument by far. Hence, any periodical variation in its use should be reflected in fishing revenue for shrimp. Total fishing revenue on the other hand is generated by a larger variety of fishing gear and will be considerably less affected by changes in the use of the *konou*. If fishers respect the modern rule and refrain from using the *konou* when the lakes are closed, we should find that shrimp fishing revenue is lower in closed weeks. Moreover, the resulting decline of fishing intensity should allow the fishery stock to increase in the closed period. Fishing revenue should then be highest in the first week of re-opening, and gradually decline over the following open weeks as intensive fishing with the *konou* again decreases the fishery stock.

To analyze the fluctuation of fishing revenue across weeks, we estimate two regression specifications. In the first specification we examine weeks in which the lakes are closed, taking the open period as the baseline category. In the second specification, we look

at weeks in which the lakes are open, taking the closed period as the baseline category. These two specifications can be written as follows:

$$F_{it} = \omega_0 + \omega_1 closed_t^1 + \omega_2 closed_t^2 + \tau_t + \text{K}'_i\ \Theta + \varphi_i + \varepsilon_{it} \quad (2)$$

$$F_{it} = \omega'_0 + \omega_3 open_t^1 + \omega_4 open_t^2 + \omega_5 open_t^3 + \omega_6 open_t^4 + \tau_t + \text{K}'_i\ \Theta' + \varphi_i + \varepsilon_{it} \quad (3)$$

where F_{it} denotes shrimp fishing revenue for fisherman i in week t; $closed_t^w$ and $open_t^w$ are dummy variables that take value 1 if the lake is closed, respectively open in week t for the w-th consecutive week; τ_t denotes a time trend; K'_i is a vector consisting of the following set of control variables for individual i in week t: the logarithms of the number of fishing days, the number of persons fishing and the total value of fishing instruments used; φ_i captures individual fixed effects; ε_{it} denotes a classical random error term clustered at the individual level. The time trend is again included to capture temporal variation caused by environmental variables. The control variables in K'_i reflect the production function of the fishing activity and capture the effect of time spent fishing, the use of labour and the use of capital.

If ω_1 and ω_2 are estimated significantly negative, it suggests that fishermen respect the modern rule and use the *konou* less when the lakes are closed. Significantly positive estimates for ω_3, ω_4, ω_5 and ω_6 that decrease in magnitude would provide additional evidence that fishermen respect the modern rule.

To deal with the second caveat, we make use of a larger dataset taken from the 2006 fishery census, which contains 18 683 observations for 121 villages in all 9 communes surrounding Lake Nokoué and Lake Porto Novo. The census contains cross-sectional data on religion and the use of fishing gear. This extended dataset allows us to examine the

relationship between Voodoo and the use of the *konou* while controlling for village fixed effects. We estimate the following regression specification:

$$Konou_i = \gamma_0 + \gamma_1 Voodoo_i + \Phi_i' \Upsilon + \varphi_v + \varepsilon_{iv} \quad (4)$$

$Konou_i$ is an indicator variable taking value 1 if individual *i* reports to use the *konou* for fishing, and 0 otherwise; $Voodoo_i$ is an indicator variable taking value 1 if individual *i* reports his religion to be Voodoo, and 0 otherwise; Φ_i' is a set of control variables consisting of the logarithm of age and the level of education reported by individual *i*; φ_v indicates fixed effects at the village level; ε_{iv} is a classical random error term. The control variables are included for the same reasons as mentioned before. If the estimate of γ_1 is statistically insignificant when village fixed effects are included, it would suggest that any relationship between adhering to Voodoo and the use of the *konou* is mainly driven by village-level variables.

Finally, it can be argued that the individual choice of religion is correlated with several (unobserved) individual characteristics, which would bias the results if in turn correlated to the use of the *konou*. We therefore replace the individual measure of Voodoo used so far with a measure of the proportion of Voodoo followers in the village. We estimate the following specification:

$$Konou_i = \gamma'_0 + \gamma'_1 Voodoo_v^{share} + \Phi_i' \Upsilon' + \lambda_a + \varepsilon_{iv} \quad (5)$$

where $Voodoo_v^{share}$ measures the number of Voodoo followers relative to the total number of individuals in the village, and λ_a again denotes arrondissement fixed effects (instead of village fixed effects). If the estimate for γ_1' is not statistically different from zero, it would suggest that any negative relationship between individual adherence to Voodoo and the use of

the *konou* is mainly driven by unobserved individual characteristics. On the other hand, if we find that the proportion of Voodoo followers in the village significantly affects the use of the *konou*, an additional question arises. Do Voodoo fishermen use the *konou* less because of a true individual respect for the rules dictated by Voodoo, or do they comply to the rules solely because their peers do so? To address this question, we estimate a last specification in which we include both the individual measure of Voodoo and the proportion of Voodoo followers in the village. The specification can be written as follows:

$$Konou_i = \gamma''_0 + \gamma''_1 Voodoo_i + \gamma_2 Voodoo^{share}_v + \Phi_i' \Upsilon'' + \lambda_a + \varepsilon_{iv} \quad (6)$$

If γ_2 is estimated significantly negative while the estimate for γ''_1 is insignificant, it seems more plausible that the Voodoo effect is driven by peer behaviour, rather than an inherent respect for Voodoo rules. The reverse would give support to the notion that the decision to comply with Voodoo rules is made individually, rather than driven by the behaviour of peers.

4. DATA AND SUMMARY STATISTICS

We make use of data from a household survey implemented in 2009 among fishing communities at Lake Nokoué and Lake Porto Novo. The survey collected detailed information for the members of 360 households. The households were selected by taking a stratified random sample from the 2006 fishery census in 12 villages, which are located in four different arrondissements that form part of two communes. The two communes – So-Ava and Aguesgues – are located in the vicinity of Lake Nokoué and Lake Porto Novo, as is illustrated in Figure 1.

The data used for the empirical analysis cover the household members whose main occupation is fishing; it includes weekly information on fishing activities and information on

individual and household characteristics for 392 individuals[7]. The fishermen were visited bi-weekly during a period of 14 weeks, but for part of the respondents (24 percent) information is lacking for one or more weeks as they were unavailable for one or more of the interviews. We also make use of data from the 2006 fishery census, as was discusses in the previous section.

Religious affiliation

Table 1 presents the distribution of religious affiliation across the two lakes, both for the sample of fishermen and the 2006 fishery census. The overall distribution is quite similar for the two datasets. Panel B shows that there are some differences with respect to the ranking of the religions within the lakes. At Lake Nokoué the three main religions are Voodoo, Catholicism and Christianisme Céleste (a particularly popular form of Protestantism). At Lake Porto Novo, the main religions are Catholicism, Protestantism and other forms of Christianity, while Voodoo is only of minor importance. The large heterogeneity in religious affiliation can be partly explained by the historical migration patterns of different ethnic groups, as well as the religious pluralism and high tolerance towards individual religious choice in Benin(Barbier & Dorier-Apprill, 2002;). In our sample we find within-household variation in reported religion for about 31percent of the households.

Use of the konou

Table 2 and Figure 2 present information on the use of the *konou* across weeks. Table 2 shows only a small difference between the 23.6 percent use of the *konou* in open weeks and the 18.5 percent use of the *konou* in closed weeks. Figure 2 reveals similar information: although the use of the *konou* drops when the lakes are closed, the drop is very modest.

[7] The fishing activity in this region is dominated by men: less than 3 percent of the individuals in the dataset are women. In the remainder of the paper we will therefore simply refer to the individuals as fishermen.

Figure 2 also shows that the use of the *konou* starts to increase already in the second week of closure, before the lakes are re-opened.

Figure 3 depicts the fluctuation of fishing revenue for shrimp across open and closed weeks, showing that average revenue drops when the lakes are closed, but starts to increase again before the lakes are re-opened. Similar to Figure 2, this pattern suggests that fishermen may be shirking when the benefits increase, that is when the quantity of fish has increased in the first week of closure. Alternatively, those fishermen who do not respect the rule at all may start to benefit from the compliance of other fishermen and experience an increase in revenue when the lake has been closed for a week.

Control variables

Table 3 presents summary statistics of characteristics of fishermen and of weekly fishing activities. It is worth noting that the literacy rate of 14.4 percent lies far below the estimated national average of 55.2 percent for male adults[8]. Another noteworthy feature is the strong dependency of income on fishing: about 92 percent of yearly household income consists of income from the fishery sector.

5. RESULTS

Regarding the first specification for the use of the *konou*, the two hypotheses imply that α_1 and α_2 are negative: the *konou* should be used less in weeks in which the lakes are closed, and should be used less by Voodoo followers. Table 4 presents the OLS estimation results for equation (1). The dependent variable $Konou_{it}$ equals 1 if the *konou* is among the self-reported

[8] 2010 estimate of the Unesco Institute for Statistics (UIS).

fishing instruments used in week t. If we redefine the dependent variable such that it takes value 1 only if the *konou* is the most important instrument used in week t, the results are qualitatively the same.

As Table 4 shows, the estimate of α_1 is negative and statistically significant in all columns. This result confirms the first hypothesis: the use of the *konou* is on average lower in weeks in which the lakes are closed (compared to open weeks). The estimates of α_2 are also negative and statistically significant in all columns, suggesting a negative relationship between Voodoo adherence and the use of the *konou*. The results in column (6) suggest that the probability of using the *konou* is on average 8.5 percent lower for Voodoo fishermen, compared to fishermen who adhere to other religions (all else equal). With respect to the modern rule, the results suggest that the probability of using the *konou* in closed weeks is on average 23.6 percent lower for illiterate fishermen and 14 percent lower for literate fishermen, compared to open weeks (all else equal). These findings lead to a third observation: literate fishermen seem to be more likely to break the modern rule.

With respect to the specifications for fishing revenue across weeks, our hypotheses state that ω_1 and ω_2 are negative, while ω_3, ω_4, ω_5 and ω_6 are positive and decreasing in size. Table 5 presents the fixed effects estimates for specification (2) and Table 6 presents the fixed effects estimates for specification (3).

In all columns of Table 5 the estimates of ω_1 and ω_2 are negative and statistically significant: fishing revenue for shrimp is on average lower in closed weeks compared to open weeks. Another observation emerging from the final column is that the coefficient for the first week of closure is roughly twice as large as the coefficient for the second week of closure. In other words, the drop in fishing revenue for shrimp is on average twice as large in the first week of closure compared to the second week of closure (all else equal).

The results presented by Table 6 support the hypotheses as well. In all columns the estimates of ω_3, ω_4, ω_5 and ω_6 are positive and statistically significant, suggesting that fishing revenue for shrimp is on average higher in open weeks compared to the closed period. Moreover, the coefficient estimates gradually decline in magnitude from the first week of opening to the fourth week of opening. The gap is largest between the coefficients of the second and third week.

Regarding the specifications for the 2006 fishery census, our hypotheses are that γ_1 and γ'_1 are significantly negative. Table 7 presents the OLS estimation results for equation (4) in columns (1) to (3). Column (4) presents the OLS estimates for equation (5) and column (6) shows the OLS estimates for equation (5). A comparison of Table 4 and Table 7 reveals that the estimation results for the 2006 fishery census are in line with the results for the 2009 household survey sample. The estimates of γ_1 are negative and statistically significant in all columns. When controlling for village fixed effects in column (2), the coefficient for Voodoo remains significantly negative. Controlling for arrondissement fixed effects in column (3) does not change the significance of the coefficient for Voodoo (and barely changes the magnitude). These estimates basically rule out that the negative coefficient of Voodoo is driven by village level variables. In column (4), where the individual measure of Voodoo is replaced by the share of Voodoo followers in the village, the estimate of γ''_1 is significantly negative as well. This finding suggests that the negative relationship between Voodoo and the use of the *konou* is not reflecting the impact of (unobserved) individual characteristics. Finally, in column (5), where both the individual measure and the village share of Voodoo are included, the coefficients for both the individual measure of Voodoo and the village share of Voodoo are significantly negative. These estimates suggest that the negative effect of adherence to Voodoo on the use of the *konou* is driven by both an individual respect for

Voodoo rules and peer behaviour. The sizes of the coefficients suggest that peer behaviour is slightly more influential than individual considerations.

6. ROBUSTNESS CHECKS

The first robustness checks concerns the results for the use of the *konou* across weeks. We test whether the results obtained with the OLS model hold under alternative regression models. Since it is intuitive to interpret the dependent variable as a probability, we start by estimating equation (1) using a probit model. The probit estimation results for specification (1) are presented in Table 8.

When comparing Table 8 with Table 4, it is apparent that the results are qualitatively the same. The coefficient for the closing of the lake is negative and statistically significant in all columns, suggesting that the probability of using the *konou* is on average lower when the lakes are closed, compared to open weeks. The coefficient for Voodoo is also negative and statistically significant in all columns, suggesting that Voodoo fishermen on average have a lower probability of using the *konou* compared to other fishermen. The average marginal effects for Voodoo and the closed variable have roughly the same magnitude as the corresponding OLS estimates (results not reported).

The results for the closed variable also hold when we estimate specification (1) using a conditional fixed effects logit model (results not reported).

We additionally perform a falsification test for the results for fishing revenue across weeks. More specifically, we attempt to verify whether the coefficients for the week dummies are picking up the impact of some other variable than the opening and closing of the lakes. To do so, we estimate specifications (2) and (3) using data for Lake Ahémé instead of Lake Nokoué and Lake Porto Novo. Lake Ahémé is another important water body in Southern Benin and offers an interesting case for comparison. Lake Ahémé is rather similar

to Lake Nokoué and Lake Porto Novo with respect to the nature of fishing activities, but – for our purpose – the key difference is that the *konou* is not used at Lake Ahémé. Hence, the modern rule does not exist at this lake. If we repeat the estimation of equations (2) and (3) using data for Lake Ahémé, we should not find a particular pattern for the coefficients ω_1, ω_2, ω_3, ω_4, ω_5 and ω_6. If we do find such a pattern, it may indicate that our results for Lake Nokoué and Lake Porto Novo are not due to the existence of the modern rule, but rather to a natural phenomenon that characterizes the fishing activity at the lakes in Southern Benin.

Figure 5 shows the evolution of average weekly fishing revenue for shrimp at lake Ahémé and gives a first indication that there are no systematic fluctuations of fishing revenue at this lake. Average revenue does not seem to drop in weeks in which Lake Nokoué and Lake Porto Novo are closed, nor does it seem to rise again in weeks in which these lakes are reopened. Table 9 presents the fixed effects estimation results for equation (2) and Table 10 presents the fixed effects estimation results for equation (3) for the Lake Ahémé sample. The estimates that show most similarity to the results for the Nokoué-Porto Novo sample are the estimates for the first week of closure (ω_1) and the second week of opening (ω_4). However, when looking at all the estimates simultaneously, the pattern of fishing revenue falling in closed weeks and gradually increasing again in open weeks does not emerge as clearly as for the Nokoué-Porto Novo sample[9].

7. DISCUSSION AND CONCLUSION

[9] As Table 9 shows, the estimates for ω_1 are negative, but significance varies with the specification. The estimates for ω_2 are positive, but significance goes down as the specification is extended. Table 10 presents positive estimates for ω_3, ω_4, and ω_5, but the estimates for ω_3 and ω_5 are insignificant in (nearly) all specifications. The estimates for ω_6 are negative and only significant in the first two columns.

For the case of the coastal lakes of Benin, we have shown that Voodoo-based traditional institutions survived a rapidly changing environment and still play a role in regulating the fishing activity. One aspect that may have contributed to its resilience is the strong integration of Voodoo in Beninese culture. For instance, Voodoo deities are born to each clan and tribe, and are central to maintaining the moral, social and political order of the village. The deep roots of Voodoo are also materialized by its enlistment in the constitution as an official religion in Benin and the existence of a public holiday to celebrate Voodoo.

Although we have found a strong correlation between refraining from using of the *konou* and being a Voodoo follower – and this correlation is robust to the use of different samples, the inclusion of village fixed effects, and the use of village-level rather than individual-level Voodoo adherence – there are competing explanations. For instance, the observed correlation may be caused by conservatism among Voodoo followers. That is, rather than the impact of the rule per se, what we observe may be the effect of aversion towards change in the form of new fishing gear as well as new monotheistic religions. Another competing explanation may be that the *konou* is too costly for Voodoo followers to adopt. Yet this explanation is not supported by the data, as Voodoo fishermen in our sample are on average richer, and our estimates remain when controlling for asset ownership or education.

We have found evidence for a statistically significant impact of the modern rule on the use of the *konou*. However, quantitatively the impact is small. One reason for the observed compliance is that *konou* fishers have a short-term incentive to respect this rule. Collectively abstaining from the use of the *konou* for some weeks raises fishing yield, which is beneficial as four weeks of intensive fishing with the *konou* strongly decreases fishing yield. The reason why the quantitative effect remains small lies in the free rider problem. Little monitoring and

the absence of effective sanctions create strong incentives to free ride on the compliance of other *konou* fishers and so maximally reap the benefits from the increase in fishing yield.

It is not straightforward to interpret these results in terms of ecological effectiveness of the modern rule. Two weeks of closing may not be sufficient to allow the fishery stock to reproduce, but may merely result in larger quantities of fish and shrimp moving into the lakes, as many of the indigenous species are migratory species (see Gnohoussou, 2006 and Pliya, 1980). When these additional quantities are harvested in the open weeks before they can reproduce, they only cause local and short-term increases in the stock of fish. The modern rule could then prove ineffective to promote the regeneration of the fishery stocks and support the sustainability of the fishery resource. Future research should investigate the ecological impact of the existing rules as well as the possible impact of alternatives rules, such as spatially regulating the use of the *konou* in the form of protected areas.

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List of figures and tables

Figure 1: Map of the survey area

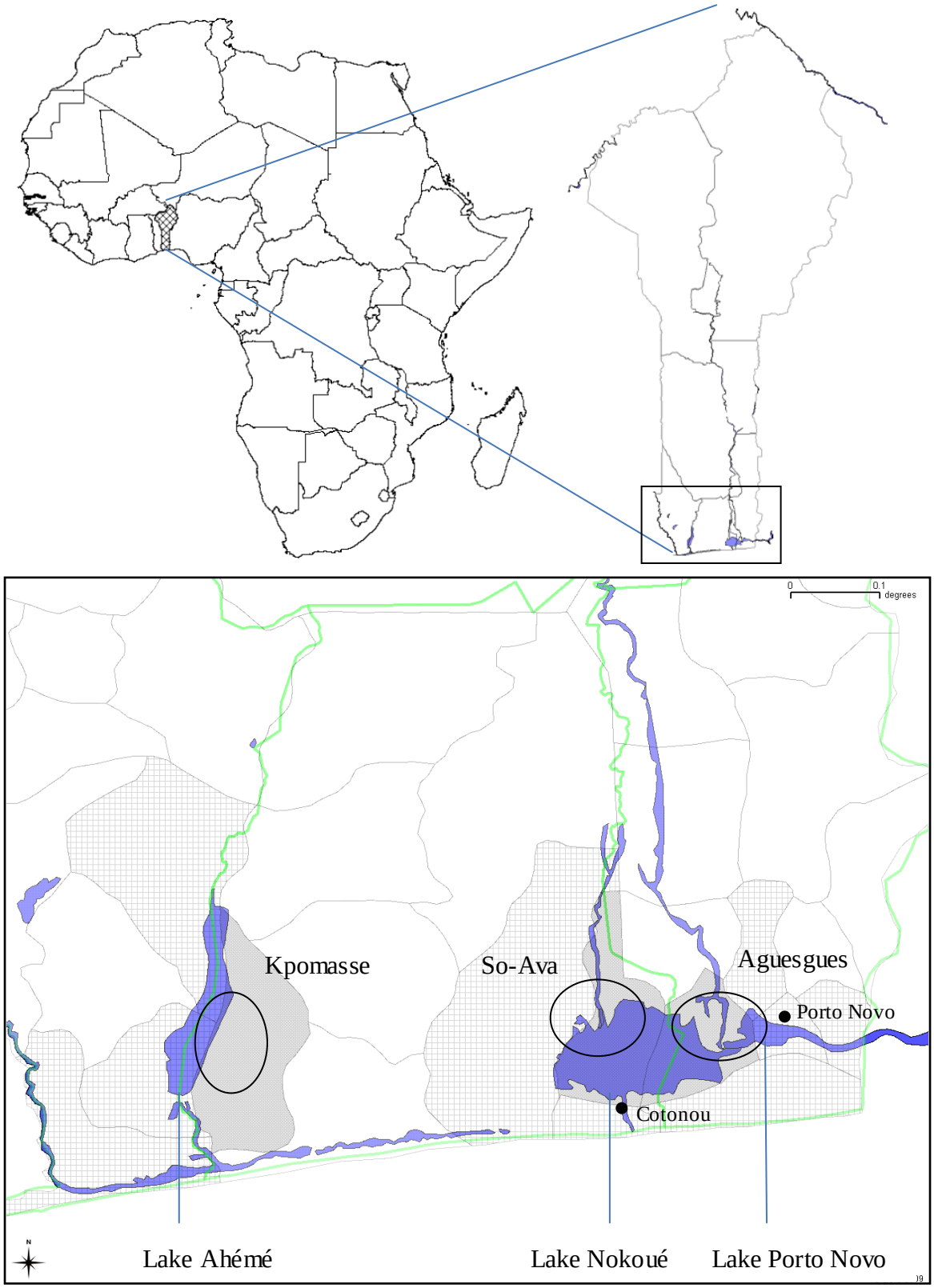
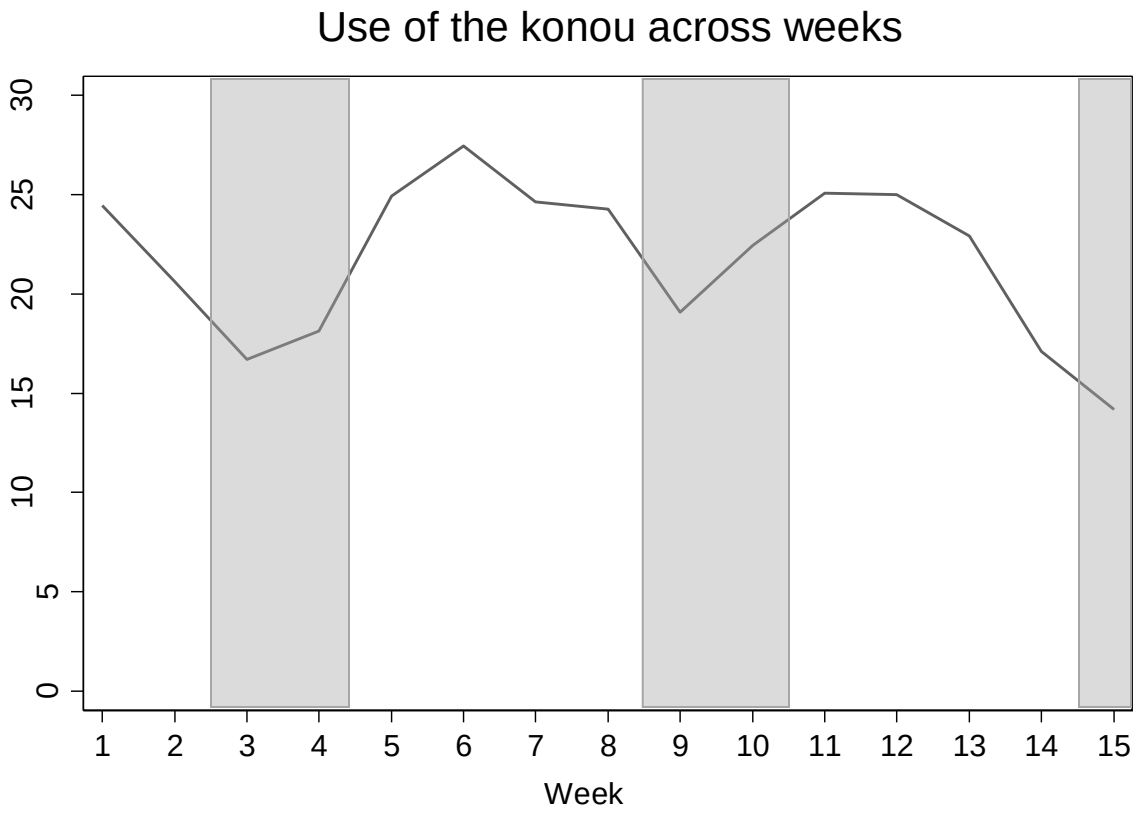
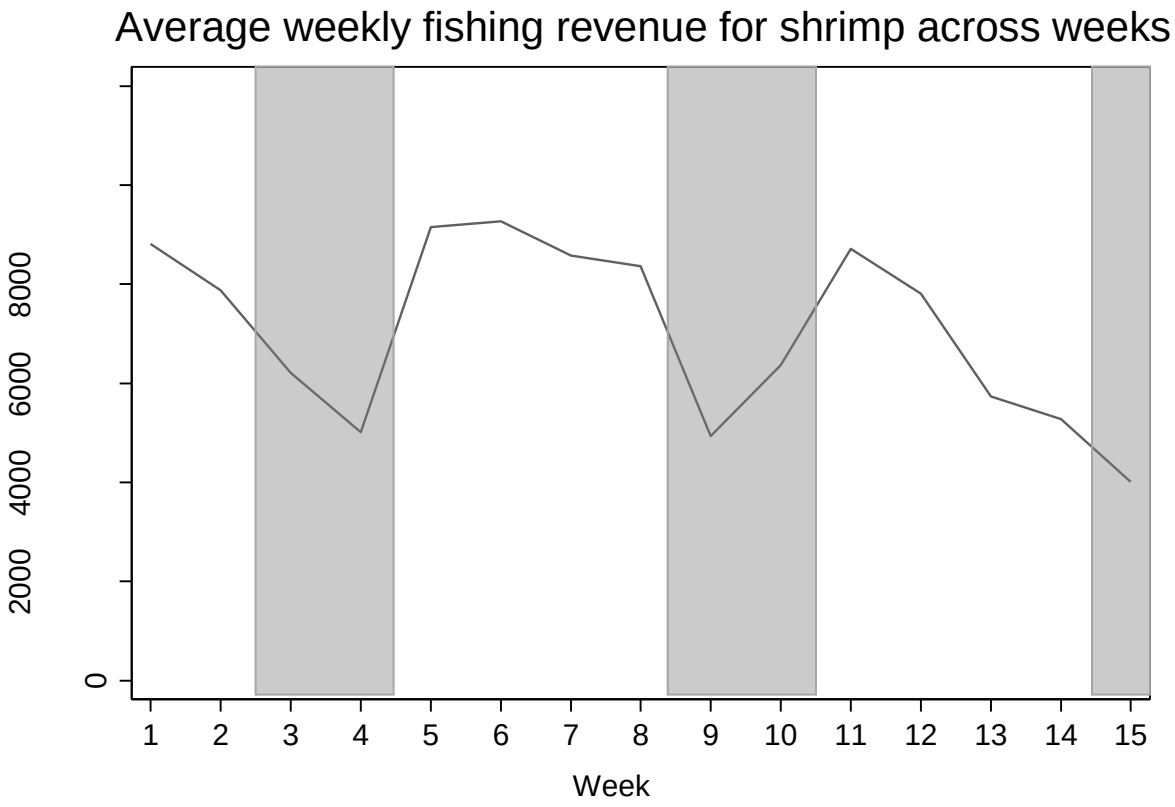


Figure 2: Use of the konou across open and closed weeks



Gray areas indicate weeks in which the lakes are closed

Figure 3: Average weekly fishing revenue for shrimp across open and closed weeks



Gray areas indicate weeks in which the lakes are closed

Figure 4: Average weekly fishing revenue for shrimp at Lake Ahémé: counterfactual

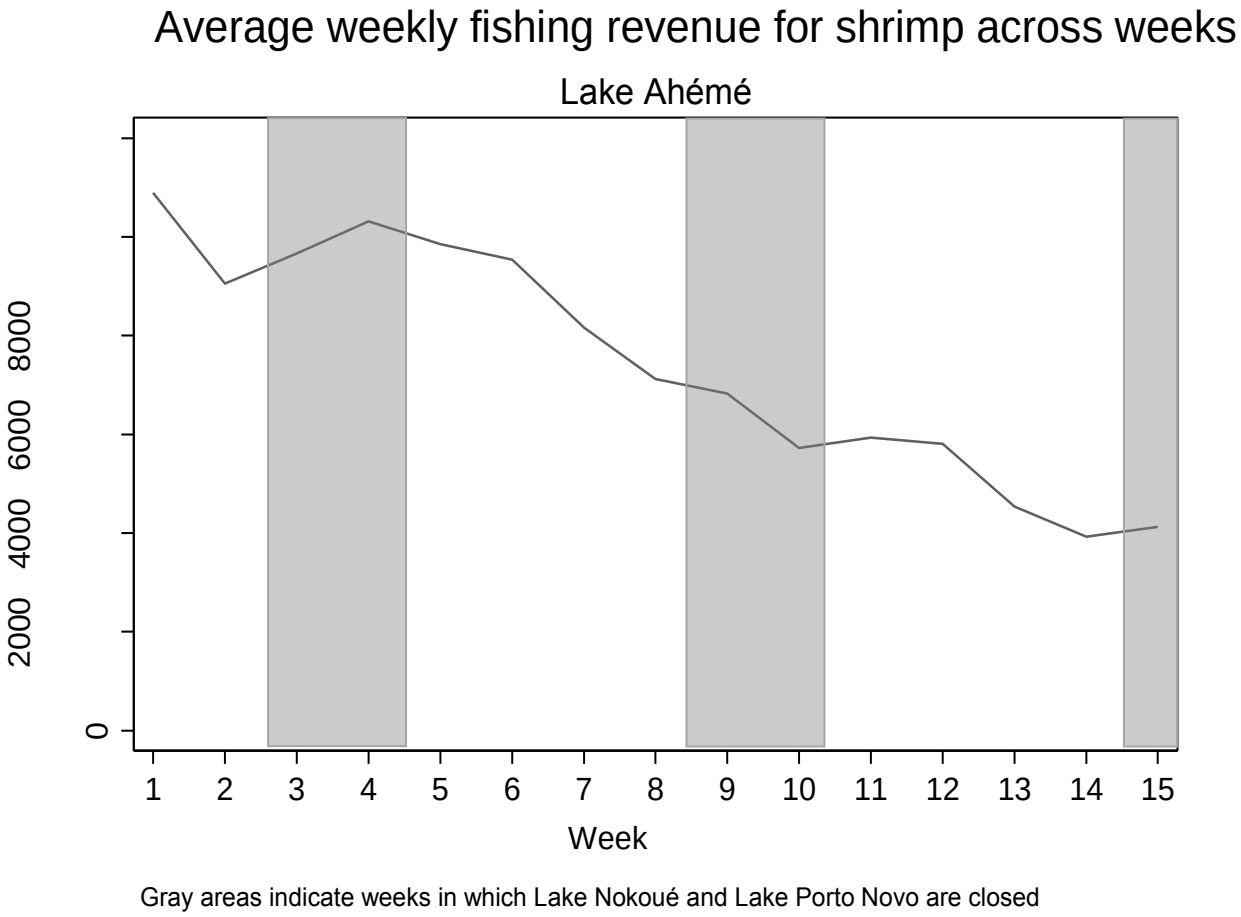


Table 1: Distribution of religious affiliation across the lakes: sample and fishery census

Panel A: Sample distribution of religious affiliation across lakes (% of individuals)

Religion	Lake Nokoué	Lake Porto Novo	Overall	N
Catholicism	21.8	45.8	34.7	123
Protestantism	9.1	25.3	17.8	63
Islam	1.8	13.7	8.2	29
Voodoo	30.3	2.1	15.2	54
Christianisme Céleste	26.7	4.7	14.9	53
None	6.1	0.0	2.8	10
Other	4.2	8.4	6.48	23
Total	100	100	100	355

Panel B: Fishery census distribution of religious affiliation across lakes (% of individuals)				
Religion	Lake Nokoué	Lake Porto Novo	Overall	N
Catholicism	25.05	33.00	27,0	4995
Protestantism	12.02	20.97	14,2	2628
Islam	3.19	9.72	4,8	885
Voodoo	21.65	5.81	17,8	3294
Christianisme Céleste	18.41	8.94	16,1	2981
Other Christianities	10.33	18.24	12,3	2268
None	9.34	3.31	7,9	1457
Total	100	100	100,0	18508

Table 2: Use of the konou in open and closed weeks

Week	Freq.	N	% N
All	1029	4683	22.0
Open	747	3161	23.6
Closed	282	1522	18.5

Table 3: Sample characteristics of fishermen and weekly fishing activities

Variable	Mean	St. Dev.	Max	N
Age	42.09	14.41	90	361
Literacy (% of fishermen)	14.41			354
Total value of assets	29,537	41,862	427,000	389
Yearly household income	1,362,278	1,155,375	7,850,000	392
Yearly household income from fishery sector	1,246,755	1,079,191	7,850,000	392
Number of fishing days	3.96	2.3	7	4,681
Number of persons fishing	2.12	1.8	23	3,677
Total value of fishing gear used	122,897	251,652	3,090,000	4,682

Notes: Assets consist of the number of motorbikes, bicycles, radios and mobile phones owned by the household. Earnings are expressed in FCFA. One euro is approximately equal to 666.66 FCFA.

Table 4

OLS estimation results: Use of the konou across weeks
Dependent variable: Use of the konou

Variables	(1)	(2)	(3)	(4)	(5)	(6)	(7)
Voodoo	-0.078***	-0.078***	-0.067***	-0.076***	-0.076***	-0.075***	-0.094***
	(0.017)	(0.017)	(0.018)	(0.018)	(0.018)	(0.018)	(0.024)
Closed	-0.055***	-0.056***	-0.060***	-0.058***	-0.223***	-0.224***	-0.236***
	(0.014)	(0.014)	(0.014)	(0.015)	(0.088)	(0.088)	(0.082)
Time		-0.001	-0.000	0.000	0.000	0.000	0.001
		(0.002)	(0.002)	(0.002)	(0.002)	(0.002)	(0.002)
Log(Age)			-0.242***	-0.232***	-0.231***	-0.224***	-0.126***
			(0.021)	(0.023)	(0.023)	(0.023)	(0.022)
Literacy				-0.097***	-0.124***	-0.121***	-0.076***
				(0.022)	(0.028)	(0.028)	(0.027)
Literacy*Closed					0.089*	0.089*	0.096**
					(0.046)	(0.046)	(0.043)
Log(Assets)						0.006***	0.006***
						(0.002)	(0.002)
Arrondissement	No	No	No	No	No	No	Yes
Constant	0.263***	0.269***	1.180***	1.327***	1.377***	1.296***	0.849***
	(0.009)	(0.016)	(0.082)	(0.092)	(0.096)	(0.100)	(0.101)
Observations	3,947	3,947	3,664	3,432	3,432	3,432	3,432
R-squared	0.008	0.008	0.044	0.050	0.051	0.055	0.162

Notes: Coefficients are reported with robust standard errors in parentheses. ***, ** and * denote significance at the 1, 5 and 10 % levels respectively. The acadja is excluded from the regression sample. Arrondissement fixed effects are included in column (6).

Table 5

Fixed effects estimation results: Fishing revenue across weeks					
Dependent variable: Logarithm of fishing revenue for shrimp					
Variables	(1)	(2)	(3)	(4)	(5)
Closed first week	-0.977***	-1.038***	-0.729***	-0.724***	-0.698***
	(0.168)	(0.166)	(0.140)	(0.181)	(0.175)
Closed second week	-0.556***	-0.605***	-0.381***	-0.364**	-0.351**

	(0.133)	(0.133)	(0.116)	(0.150)	(0.146)
Time trend		-0.129***	-0.144***	-0.214***	-0.239***
		(0.028)	(0.024)	(0.032)	(0.032)
Log(Fishing days)			2.737***	2.226***	2.230***
			(0.153)	(0.464)	(0.464)
Log(Persons fishing)				0.535	0.209
				(0.524)	(0.527)
Log(Value fishing gear)					0.364***
					(0.060)
Constant	3.829***	4.895***	1.263***	2.200**	-1.051
	(0.049)	(0.223)	(0.280)	(1.004)	(1.141)
Observations	4,031	4,031	4,029	3,028	3,028
R-squared	0.013	0.031	0.222	0.065	0.092
Number of individuals	391	391	391	374	374

Notes: Coefficients are reported with individually clustered standard errors in parentheses. ***, ** and * denote significance at the 1, 5 and 10 % levels respectively. The acadja is excluded from the regression sample.

Table 6

Fixed effects estimation results: Fishing revenue across weeks

Dependent variable: Logarithm of fishing revenue for shrimp					
Variables	(1)	(2)	(3)	(4)	(5)
Open first week	1.402***	1.483***	1.189***	1.267***	1.176***
	(0.187)	(0.185)	(0.156)	(0.198)	(0.191)
Open second week	1.093***	1.308***	1.011***	1.067***	0.964***
	(0.211)	(0.207)	(0.179)	(0.231)	(0.225)
Open third week	0.761***	0.910***	0.479***	0.423*	0.444**
	(0.198)	(0.194)	(0.170)	(0.217)	(0.213)
Open fourth week	0.587***	0.670***	0.345**	0.325*	0.393**
	(0.158)	(0.157)	(0.135)	(0.174)	(0.171)
Time trend		-0.138***	-0.150***	-0.218***	-0.242***
		(0.028)	(0.024)	(0.032)	(0.032)
Log(Fishing days)			2.735***	2.140***	2.154***
			(0.152)	(0.467)	(0.467)
Log(Persons fishing)				0.560	0.249
				(0.519)	(0.523)
Log(Value fishing gear)					0.348***
					(0.060)
Constant	2.935***	3.966***	0.642**	1.683*	-1.433
	(0.106)	(0.254)	(0.297)	(1.013)	(1.158)
Observations	4,031	4,031	4,029	3,028	3,028
R-squared	0.018	0.039	0.230	0.075	0.099
Number of individuals	391	391	391	374	374

Notes: Coefficients are reported with individually clustered standard errors in parentheses. ***, ** and * denote significance at the 1, 5 and 10 % levels respectively. The acadja is excluded from the regression sample.

Table 7

OLS estimation results: Use of the konou in the 2006 fishery census

Dependent variable: Use of the konou					
Variables	(1)	(2)	(3)	(4)	(5)
Voodoo	-0.054***	-0.055***	-0.055***		-0.054***
	(0.009)	(0.010)	(0.010)		(0.010)
Share of Voodoo in village				-0.071**	-0.017
				(0.036)	(0.038)
Log(Age)	-0.105***	-0.082***	-0.095***	-0.105***	-0.095***
	(0.011)	(0.011)	(0.011)	(0.011)	(0.011)
Education	0.024***	0.035***	0.028***	0.029***	0.028***
	(0.006)	(0.006)	(0.006)	(0.006)	(0.006)
Village	No	Yes	No	No	No
Arrondissement	No	No	Yes	Yes	Yes
Constant	0.484***	0.277***	0.325***	0.362***	0.327***
	(0.038)	(0.041)	(0.041)	(0.041)	(0.042)
Observations	8,744	8,744	8,744	8,744	8,744
R-squared	0.017	0.187	0.083	0.081	0.083

Notes: Coefficients are reported with robust standard errors in parentheses. ***, ** and * denote significance at the 1, 5 and 10 % levels respectively. The acadja is excluded from the regression sample. Village fixed effects are included in column (2). Arrondissement fixed effects are included in columns (3), (4) and (5).

Table 8

Probit estimation results: Use of the konou across weeks

Dependent variable: Use of the konou							
Variables	(1)	(2)	(3)	(4)	(5)	(6)	(7)
Voodoo	-0.277***	-0.277***	-0.235***	-0.264***	-0.264***	-0.262***	-0.330***
	(0.066)	(0.066)	(0.068)	(0.068)	(0.068)	(0.068)	(0.087)
Closed	-0.186***	-0.189***	-0.202***	-0.191***	-0.604**	-0.609**	-0.742***
	(0.048)	(0.048)	(0.050)	(0.051)	(0.263)	(0.263)	(0.269)
Time		-0.002	-0.000	0.002	0.002	0.002	0.003

		(0.005)	(0.006)	(0.006)	(0.006)	(0.006)	(0.006)
Log(Age)			-0.767***	-0.721***	-0.720***	-0.708***	-0.445***
			(0.068)	(0.071)	(0.071)	(0.071)	(0.074)
Literacy				-0.283***	-0.348***	-0.338***	-0.235***
				(0.063)	(0.075)	(0.076)	(0.081)
Literacy*Closed					0.224	0.227	0.282**
					(0.140)	(0.140)	(0.144)
Log(Assets)						0.023***	0.024***
						(0.006)	(0.006)
Arrondissement	No	No	No	No	No	No	Yes
Constant	-0.631***	-0.612***	2.244***	2.618***	2.733***	2.483***	1.350***
	(0.028)	(0.051)	(0.256)	(0.282)	(0.291)	(0.302)	(0.330)
Observations	3,947	3,947	3,664	3,432	3,432	3,432	3,432

Notes: Coefficients are reported with robust standard errors in parentheses. ***, ** and * denote significance at the 1, 5 and 10 % levels respectively. The acadja is excluded from the regression sample. Arrondissement fixed effects are included in column (7).

Table 9

Fixed effects estimation results: Fishing revenue across weeks at Lake Ahémé					
Dependent variable: Logarithm of fishing revenue for shrimp					
Variables	(1)	(2)	(3)	(4)	(5)
Closed first week	-0.236	-0.417**	-0.245*	-0.314**	-0.337**
	(0.179)	(0.177)	(0.131)	(0.146)	(0.144)
Closed second week	0.362***	0.302**	0.180*	0.158	0.138
	(0.125)	(0.124)	(0.094)	(0.098)	(0.095)
Time trend		-0.187***	-0.171***	-0.183***	-0.198***
		(0.035)	(0.027)	(0.031)	(0.030)
Log(Fishing days)			4.059***	3.219***	3.103***
			(0.126)	(0.708)	(0.673)
Log(Persons fishing)				2.300***	2.242***
				(0.524)	(0.502)
Log(Value fishing gear)					0.165***
					(0.062)
Constant	6.565***	8.143***	1.144***	0.968	-0.245
	(0.049)	(0.292)	(0.337)	(1.380)	(1.490)
Observations	2,080	2,080	2,072	1,836	1,836
R-squared	0.004	0.059	0.412	0.141	0.152
Number of individuals	174	174	171	166	166

Notes: Coefficients are reported with individually clustered standard errors in parentheses. ***, ** and * denote significance at the 1, 5 and 10 % levels respectively. Lake Nokoué

and Lake Porto Novo are excluded from the regression sample.

Table 10

Fixed effects estimation results: Fishing revenue across weeks at Lake Ahémé

Dependent variable: Logarithm of fishing revenue for shrimp					
Variables	(1)	(2)	(3)	(4)	(5)
Open first week	0.270	0.445**	0.228	0.276	0.237
	(0.180)	(0.178)	(0.152)	(0.172)	(0.173)
Open second week	0.215	0.548***	0.311**	0.412**	0.388**
	(0.197)	(0.192)	(0.156)	(0.170)	(0.170)
Open third week	-0.217	0.085	0.041	0.126	0.196
	(0.233)	(0.236)	(0.173)	(0.191)	(0.182)
Open fourth week	-0.581***	-0.424**	-0.211	-0.197	-0.124
	(0.171)	(0.167)	(0.129)	(0.140)	(0.131)
Time trend		-0.190***	-0.173***	-0.186***	-0.200***
		(0.035)	(0.028)	(0.031)	(0.031)
Log(Fishing days)			4.045***	3.179***	3.086***
			(0.127)	(0.705)	(0.674)
Log(Persons fishing)				2.329***	2.277***
				(0.515)	(0.496)
Log(Value fishing gear)					0.154**
					(0.062)
Constant	6.677***	8.076***	1.128***	0.929	-0.265
	(0.099)	(0.293)	(0.329)	(1.343)	(1.466)
Observations	2,080	2,080	2,072	1,836	1,836
R-squared	0.009	0.064	0.413	0.143	0.153
Number of individuals	174	174	171	166	166

Notes: Coefficients are reported with individually clustered standard errors in parentheses. ***, ** and * denote significance at the 1, 5 and 10 % levels respectively. Lake Nokoué and Lake Porto Novo are excluded from the regression sample.