Diagnosing Oceanic Commons: ICCAT and the Atlantic Bluefin Tuna

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Abstract:

The governance of oceanic fisheries is a growing concern in the twenty-first century as their contribution to global food security and livelihoods are threatened by declining stocks. Atlantic Bluefin Tuna (ABFT) is a prominent example of the complexities associated with managing oceanic resources with their extensive range, which includes much of the North-Atlantic and Mediterranean. This wide ranging distribution has led to limited attention from commons theorists that tend to focus on small-scale social ecological systems. In order to explore the fit between theories of the commons developed in small-scale systems, we applied the Social-Ecological Systems Meta-Analysis Database to systematically analyze ABFT governance over a 22 year period by the International Commission on the Conservation of Atlantic Tuna. The results, which focus on the effects of resource characteristics, broadly correspond to expectations from commons theory. Interestingly, however, the addition of resource storage in the form of ABFT ranches appears to be contributing to unsustainable harvests. This stands in contrast to previous findings in the commons literature that storage tends to enhance prospects for sustainable governance. As a result of this finding several alternative hypotheses are identified for future research to consider the conditions under which storage enhances prospects for sustainable governance. Secondary contributions of this study include demonstrating the potential value of linking case studies to a large-n database for the purpose of generating and testing hypotheses, and adding an alternative theoretical perspective with which to study and explore ABFT governance.

Keywords: fisheries; common-pool resource theory; resource storage, Atlantic Bluefin Tuna

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1. INTRODUCTION

The governance of oceanic fisheries have long been held as particularly challenging owing to the complexity of regulating the use of mobile, widely distributed stocks across international boundaries, including non-territorial waters (Berkes et al. 2006). Most attempts to shift from the traditional open-access regime to a regulated fishery rely upon traditional government command-and-control and scientific management techniques that devise harvesting rules in line with conventional notions of maximum sustainable yield. While this approach has often been criticized for failing to resolve fundamental issues related to overharvesting (Ostrom 1990; Dobson and Lynch 2003) and the regeneration of biological populations (Holling and Meffe 1996; Acheson and Wilson 1996), it remains unclear whether the participatory approaches that characterize the governance of common-pool resources (CPR) at local levels offers a viable alternative. CPR theory is best developed at the level of the individual where it can draw upon formal models of collective action and experimental methods to inform our understanding of the factors that influence choice (Ostrom et al. 1994). As the level of analysis moves up to focus on groups operating in complex social-ecological systems (SES's), CPR theory provides a set of principles that tend to be associated with long-enduring institutions and sustainable resource governance. However, these principles having been developed in the context of small-scale systems where a community of resource users has the opportunity to engage in face-to-face communication may not apply to large-scale governance arrangements such as oceanic fisheries. This study seeks to explore the extent to which theories developed in the study of small-scale systems apply to a widely distributed oceanic resource, Atlantic Bluefin Tuna (ABFT).

ABFT (*Thunnus thynnus)* is a large-bodied fish that inhabit much of the North Atlantic and Mediterranean. Since the late 1960s, it has been governed under the auspices of the International Commission on the Conservation of Atlantic Tuna (ICCAT). The creation of ICCAT was an attempt to foster joint decision-making activities among member states that would lead to coordinated/regulated fishing operations and sustainable resource use. However, ICCAT has in some respects been characterized as an institutional failure because of its inability to enforce catch limits and control extraction rates of its member states (Hurry et al. 2008, Korman 2011). While previous studies provide insights into the nature of the problems that ICCAT faces, none offer a diagnostic analysis of its governance performance that organizes inquiry in a systematic manner that is consistent with other analyses. This study is an attempt to address this shortcoming using a social-ecological systems (SES) framework (Ostrom 2007, 2009) approach that has been developed to capture, organize, arrange, and analyze a diverse set of social and ecological factors that are deemed relevant for a given CPR governance system. We applied an adapted version of the SES framework as described in Cox (this issue) to identify attributes of the system that may be contributing to observed governance outcomes. Whereas the other papers in this issue focus more intently on social and institutional characteristics of SESs, this paper emphasizes the relationship between resource characteristics and SES outcomes. As such it makes two main contributions to the literature. First it explores how existing theories (or hypotheses) about resource characteristics in small-scale settings scale up in larger systems. Secondly it adds to more general discussions about the effects of resource characteristics on sustainable governance of natural resources.

The unfortunate lack of attention to the effects of resource characteristics originally discussed in Agrawal (2001) continues to be an issue in the commons literature. In fact, ever since Schlager et al. (1994) published their well-received study on the effects of resource mobility and storage on self-organization, the only resource characteristic that has been discussed at length is the extent to which natural or artificial markings can be used to craft institutions (Poteete and Welch 2004; Acheson 1997). This paper responds

to this gap by considering how features of the resource system and resource units may be contributing to observed outcomes in the case of ABFT. The remainder of the paper is structured in the following way. Section two describes the methods employed in this study, while section three outlines important historical developments in the ABFT fishery and the ICCAT governance regime. Section four digs into the specifics of the ICCAT case across three snapshots to identify relationships between the state of variables and outcomes in light of CPR theory. Finally, a brief conclusion identifies several hypotheses developed in the analysis of this case and urges additional research on large scale CPRs.

2. METHODS

The ICCAT case, like the other cases presented in this special issue, relies upon methods developed as part of the Social-Ecological System Meta-Analysis Database (SESMAD) project and are described in greater detail by Cox (this issue). A mixture of peer-reviewed studies, publicly available data and the occasional piece of grey literature were used to inform this analysis. Approximately thirty studies were reviewed to code the case into the database. Following coding protocols described in the introductory article in this special issue (Cox 2013), we used the studies to (1) identify the important components (e.g. resources, governance systems) of the ICCAT SES; (2) identify the important interactions between these components; and (3) code each of these components and interactions into the appropriate tables in the database. This process was in turn validated with expert assistance.

Content analysis of the selected studies was used as the basis for entering data into the SESMAD database. This database contains approximately 200 variables based on CPR theory and the study of SESs (Ostrom 2007, 2009) which are stored in four main tables, in addition to several linking tables. The SES table contains general information about the SES, which is defined as a system containing at least one, but often more of: a resource, a governance system, and an actor group that affect a resource within the context of a governance system. A governance system (GS) is a set of institutional arrangements (rules, governance activities) that are used by one or more actor groups to govern interactions with a resource and each other. An actor group (A) is defined as any grouping of individuals, organizations, or nations that have developed a set of institutional arrangements in order to manage human interactions in a specific environmental system, or who alter resource characteristics through extraction or emission. A resource (R in figures) is a good, whether naturally occurring such as ABFT or anthropogenically created in the case of ozone-depleting substances that is directly or indirectly regulated for some purpose. Within the relational database, information on relationships between these components is stored in linking tables. In terms of CPR theory, many of the most important variables are contained within linking tables that link the governance system to the resource (GS-R) and then link this relationship to individual actors (GSR-A), allowing the coder to capture relationships between multiple resources, actors, and governance systems. The database also allows for linking tables between resources (GSR-R), but this table was omitted in this case. Figures 1 and 2 provide greater clarity regarding the underlying structure of the database.

3. TIMELINE OF THE INTERNATIONAL COMMISSION FOR THE CONSERVATION ATLANTIC TUNAS

ABFT fisheries have a long history dating back to the 7th century BC when they were harvested by Phoenicians and Romans in the Mediterranean (Fromentin and Powers 2005). This region

remained the primary fishing ground until the 19th century when new fisheries emerged throughout the Atlantic. While the historical Mediterranean fishery used mostly beach seines and traps, the Atlantic fisheries introduced a variety of fishing methods such as purse seines and long lines that gradually grew to dominate the fishery (Fromentin and Powers 2005). The comparative effectiveness of these fishing methods, as well as an overall increase in fishing effort after World War II led to general declines in ABFT catches and prompted the international community to develop a governance system that could regulate and coordinate resource use in the 1960's. A general outline of the contemporary history of the ABFT fishery can be found in Table 1.

Table 1: Major events characterising the governance of ABFT stocks given for the resource as a whole and for Western and Eastern stocks separately due to institutional and biological variations across these two stocks.

	Date	Event
All 1950-2007	1950's	Japanese fishing fleet starts to actively fish in the Atlantic (Korman 2011)
	1966	Creation of ICCAT
	1969	ICCAT entered into force
	1970's	Growth of Japanese sashimi market (Korman 2011)
	1971	ICCAT Secretariat permanently based in Madrid, Spain
	1974	Minimum size established for ABFT: 6.4 kg (~age 2)
	1981	Implementation of the two-stock regime: 45° W boundary line was used to separate East and West stock management areas.
	2003-2010	Quotas exceed scientific recommendations
	2010	Attempt to list ABFT under CITES
Western Bluefin Tuna	1970-1980	Development of the Japanese longline fishery in the Gulf of Mexico
	1981	Western ABFT fishery is closed with exception of scientific monitoring quota
	1982	Quota is raised despite lack of improved conditions
	1991	Attempt to have stock listed under CITES
Eastern Bluefin Tuna	Pre 1950	Small-scale fishing effort dominated by traps
	1940-1963	Large commercial catches in the North Sea
	1970-1980	Growth of purse seines, decline of traps
	1985-1995	Expansion and industrialization of fisheries in the Mediterranean
	1995-	Expansion of ABFT ranching in the Mediterranean

3.1. History and governance structure of ICCAT

ICCAT represents an ambitious attempt to govern ABFT, as well as other tuna-like species in a large-scale oceanic commons. Its origin, as mentioned previously, lies in the introduction of new fishing techniques that expanded the range of exploitation, prolonged the fishing season, and corresponded to declining ABFT catches (Hurry et al. 2008, Wagner 1996). The need to coordinate regulation in the Atlantic was formalized in 1966 when 17 national governments signed the international convention (ICCAT 2007). ICCAT officially came into effect in 1969 marking the start of a regime that would grow to regulate more than 30 species in the Atlantic Ocean (ICCAT 2007). Since ICCAT's inception, the number of contracting parties has steadily grown and now includes 48 contracting parties. Ratification of the convention requires that signatory parties share information, adopt regulations congruent with recommendations, and

enforce those regulations in their territorial waters and for ships flying their flag. There are benefits as well with ratification providing legal access to the lucrative BFT markets of other signatories, which may explain the addition of several countries in the developing world since the year 2000. However, the organizational structure and mandate of ICCAT have not been changed or modified since 1966.

The goal of ICCAT is to cooperatively maintain fish stocks "at levels which will permit the maximum sustainable catch for food and other purposes" (Preamble, ICCAT 2007). While ICCAT does not have regulatory or enforcing powers (Korman 2011), it is entrusted with collecting and compiling statistical data, generating scientific reports, proposing management recommendations based on its findings, and creating an arena for contracting parties to meet and discuss recommendations (ICCAT 2007). The commission meets annually at its headquarters in Madrid, Spain, to discuss statistical reports and recommend management measures (Wagner 1996). These recommendations are not binding for the contracting parties; instead, every party has a right to object to a proposed recommendation within a predefined time period (Article VIII, ICCAT 2007). In such case, if the number of parties who filed an objection is less than the majority, proposed recommendation will not apply to those parties. However, if the number of parties is more than the majority, the recommendation will be withdrawn in its entirety (Article VIII, ICCAT 2007). In practice this has led to a system of consensus decision-making.

The first enacted recommendation took effect in 1974 when an ABFT minimum size limit was established (Fromentin and Powers 2005). Since then many recommendations have been promulgated that limit total yearly catches, restrict fishing activities either spatially or temporally, and regulate the use of different fishing gear (Porch 2005, ICCAT 2010). One of the main management events occurred in 1981 when ICCAT elected to divide ABFT governance into Eastern and Western management units using an effectively arbitrary boundary of 45^{o} W longitude. The rationale for such a decision rested on the perceived absence of ABFT in the Central North Atlantic (Fromentin and Powers 2005). It is now apparent that this assumption was inaccurate and that both stocks frequently cross this boundary (Block et al. 2001; 2005); although the boundary remains in use to this day.

While beyond the time period of this study, perceived declines culminated in a proposal to list ABFT under the Convention on International Trade of Endangered Species (CITES) in 2010 (Korman 2011). While the listing did not occur due to a heavy political pressure and lobbying by Japan, the latent threat of potential CITES listing prompted ICCAT to reduce quotas and propose new techniques that would strengthen its monitoring process (Korman 2011). However, overall ICCAT's efforts to achieve its management goal and maintain ABFT populations at levels that would allow maximum sustainable catch have not been achieved, and according to the recent official performance review of ICCAT, "there is little doubt that bluefin tuna in the ICCAT area is far from BMSY (maximum sustainable yield biomass) and there are indications that collapse could be a real possibility in the foreseeable future" (Hurry et al. 2008).

3.2. Western Bluefin Tuna Stock

The creation of the two stock regime in 1981 marked the regionalization of ABFT management with Western stock quotas being assigned primarily to the U.S., Canada, and Japan (Webster 2008). Western ABFT catches peaked in the early 1960s, mainly due to the increasing fishing

pressure by Japanese fishing boats, and after a few years of high catches the catch declined substantially, leveling off in the early 1980s (Figure 1). Recent spawning stock estimates suggest that Western ABFT is at approximately 35% of the 1970 reference level (ICCAT 2012).

Management decisions related to the Western stock suggest that ICCAT rarely adopts scientific recommendations when determining quota size (Webster 2008). Some suggest that political bargains and lobbying activities have leveraged scientific uncertainty to determine quotas and dominate ICCAT operations (Safina and Klinger 2008, Korman 2001). For example, the initial 1981 decision to cut the quota from 6,000 to 545 metric tons was quickly raised to 800 metric tons (Webster 2008). A year later, the quota was quadrupled with political arguments that the earlier estimates were overly pessimistic (Webster 2008). On the other hand, conservation organizations actively lobby ICCAT member states for more stringent regulations. In 1991, they successfully lobbied the U.S. government to propose a CITES listing for Western ABFT. Although the U.S. failed to follow through with the recommendation, ICCAT reacted by introducing a documentation program to track the origin of each captured fish and thus reduce illegally caught fish from reaching the market (Webster 2008).

3.3. Eastern Bluefin Tuna Stock

Eastern ABFT stocks as well as catches are considerably larger than their Western counterparts (Figures 2 and 3). Furthermore, unlike the Western stock, the Eastern stock is being exploited by at least 15 countries, out of which 8 are major quota holders that captured more than ninety percent of the total catch in 2011 (SCRS 2012). Recent assessments indicate that the Eastern spawning stock deteriorated markedly during the 1970-2007 period (Figure 2) although recently enacted conservation measures may have reversed this trend (SCRS 2012). Failure to prevent overexploitation and to stabilize the population has been attributed to illegal, unreported and unregulated (IUU) fishing that stems from the lack of an effective monitoring and enforcement system (Boustany 2011, Sumalia and Huang 2012).

The Eastern ABFT fishery has experienced increasing industrialization since the 1970's. The first change is characterized by increasing use of purse seines and decline of traps in the 70's and 80's; followed by a dramatic expansion in the use of tuna ranching technologies between 1995 and 2002 (Sumaila and Huang 2012). The two developments are related since purse seines catch live fish that can subsequently be transported to ranches where they are fattened and eventually harvested.

4. CODING AND ANALYZING ICCAT AS A LARGE-SCALE SES

4.1 Structure of the ICCAT Case

For the purposes of this study, the ICCAT case is defined by the relationships among the components of the database presented in Figure 1. The top-level actors in this system are ICCAT contracting parties, a group of nations that have signed and ratified an international convention to coordinate the science and management of tuna and tuna-like species in the Atlantic Ocean and Mediterranean (ICCAT 2007). The top-level governance system in this case is ICCAT, where all country-level information is aggregated, analyzed and used to develop annual quota recommendations which are assigned to member nations.

A total of 3 snapshots, or distinct time periods, were coded into the database to reflect important changes in state conditions. We distinguish, as is the convention in ABFT studies, between Eastern and Western stocks which differ with respect to breeding grounds, and the relative size of the stock. It is generally accepted that the Western and Eastern stocks mix on feeding grounds but do not interbreed (Carlsson et al. 2007; Block et al. 2005; Boustany et al. 2008). The Western case is coded as a single snapshot from 1985 to 2007, reflecting the absence of dramatic shifts in state or policy variables during this time interval. The Eastern case, which comprises stocks that breed in the Mediterranean, is coded over two separate time intervals, 1985-1995 and 2003-2007. The interval of eight years, reflects the increasing use of storage pens, or ABFT ranches which grew gradually in the Mid-90's but expanded ten-fold (by mass) between 1997 and 2003 (Sumaila and Huang 2012). The delineation of separate rules for Eastern and Western stocks creates two distinct second level-actors and governance systems. Eastern members are defined by the assignment of quota for Eastern stocks and implement the Eastern governance regime on the basis of ICCAT regulations. Western members are similarly defined by the assignment of a quota for Western stocks and implement the Western regime.

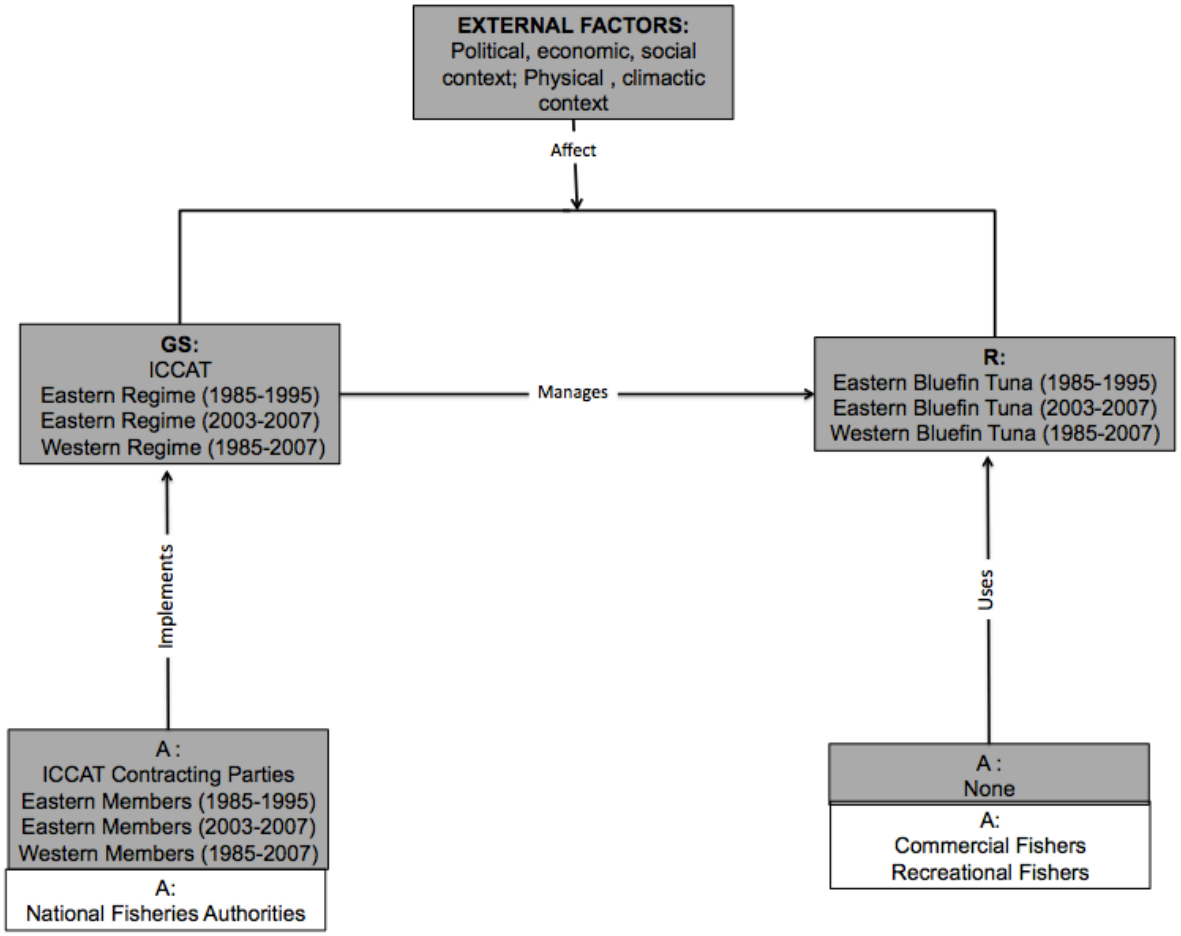

Figure 1: Schematic representation of the ICCAT case. Components in shaded boxes were coded in the SES-MAD database, while those in white boxes were not coded.

4.2 Social-ecological outcomes

The governance effects of ICCAT on ABFT stocks and flows are told in a context of considerable uncertainty. Nonetheless, estimated catches (1950-2007) and stocks (1970-2007) are presented for each stock in figures 2 and 3, respectively. Table 2 summarizes this information to report the relative magnitude of stocks and catches in relation to historical peaks, the trend during the snapshot interval and a qualitative assessment of institutional performance based on these figures. Overall, in two of the three snapshots ICCAT appears to have maintained stable stocks, with a sharp rise in catches in the latter half of the first Eastern ABFT snapshot. However in relation to historical peaks, the estimated size of both stocks in 2007 is well below their respective historical peaks. The Western stock fluctuated around twenty percent of its peak between 1985 and 2007; while catches were mostly stable around 10% of their peak. The catches are less concerning than it initially appears, given that peak catches in the 1960's were almost certainly unsustainable (Fromentin and Powers 2005; Webster 2008). As a whole we can suggest that ICCAT in combination with the surrounding social-ecological conditions has managed to maintain stable stocks and flows, albeit around what appears to be a sub-optimal basin of attraction.

ICCAT governance of the Eastern stock is described in two separate snapshots as per the structure of the case described in section 4. Between 1985 and 1995, the Eastern stock was stable around 70% of its peak, while catches increased dramatically from less than 50%, to more than 90% of the maximum catch. While the stability of stocks coupled with an increase in catches could be described as a successful case of environmental governance, it appears likely that this increase may have contributed to the eventual decline in stocks that occurred in the second snapshot. In this last snapshot Eastern stocks fell to about 55% of their peak, while catches increased slightly from about 61% to 68% of the peak catch, although poor reporting makes it difficult to estimate the true total catch during this time period.

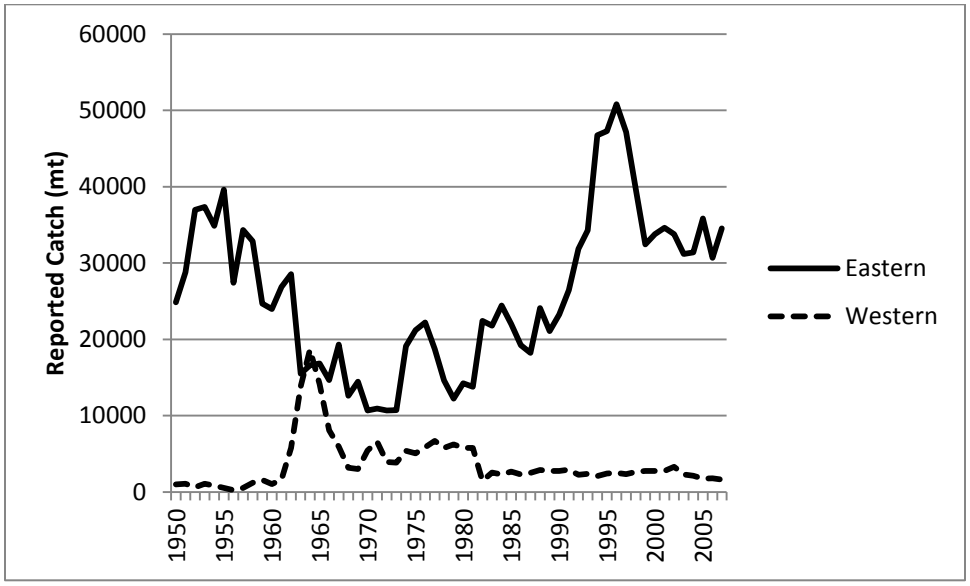

Figure 2: Annual catches for Eastern and Western stocks from1950 to 2007 (Source: ICCAT 2010)

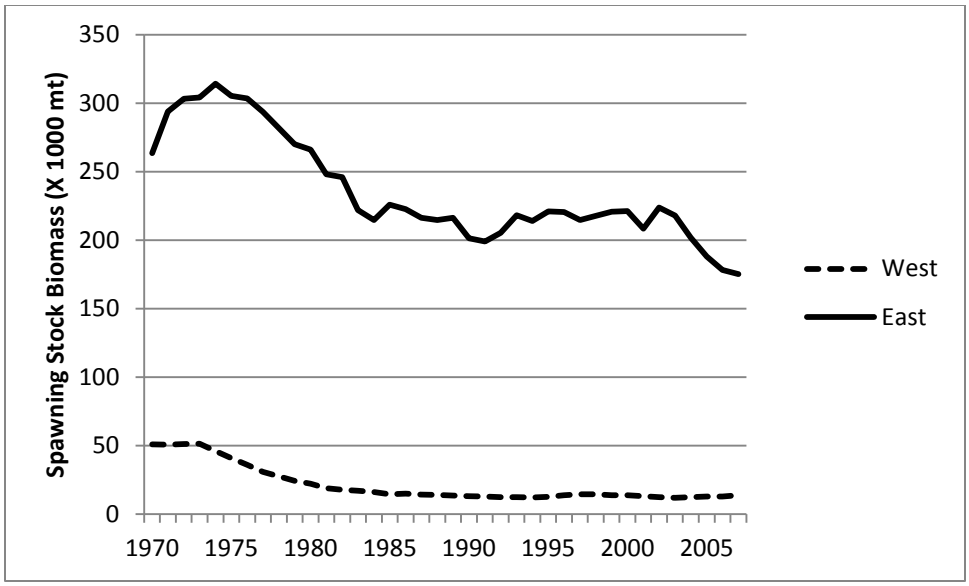

Figure 3: Annual estimates of spawning stock biomass for Eastern and Western stocks from 1970 to 2007 (Source: ICCAT 2010)

Table 2. Social and ecological outcomes of ICCAT governance as coded in the large-scale common pool resource database.

Governance Outcomes	Western ABFT (1985-2007)	Eastern ABFT (1985-1995)	Eastern ABFT (2003-2007)
Size of stocks	Small	Moderate-Large	Moderate
Stock trend	Stable	Stable	Decreasing
Size of catches	Small	Large	Moderate
Catch trend	Stable	Increasing	Increasing
Governance effect	Remained the same	Remained the same	Worsened

4.3. ICCAT case alignment with CPR theory

This section focuses on identifying the attributes of the ICCAT SES that affect its performance. Its approach broadly reflects previous work on CPRs (Ostrom 1990; Cox et al 2010) and SESs (Ostrom 2009) which presumes that outcomes are a function of the configuration of multiple social, ecological and political aspects of a system. Figure 4 below outlines the attributes of the system as they appear in the SESMAD database (Cox this issue) that are commonly associated with studies of small-scale commons. Variables in bold, such as actor size and physical boundaries were seen to be particularly influential in the ICCAT case. Table 3, while similar to figure 4 identifies the absolute and relative values of the influential variables to identify factors that may be contributing to the outcomes outlined in the previous section, and are further elaborated in the following text.

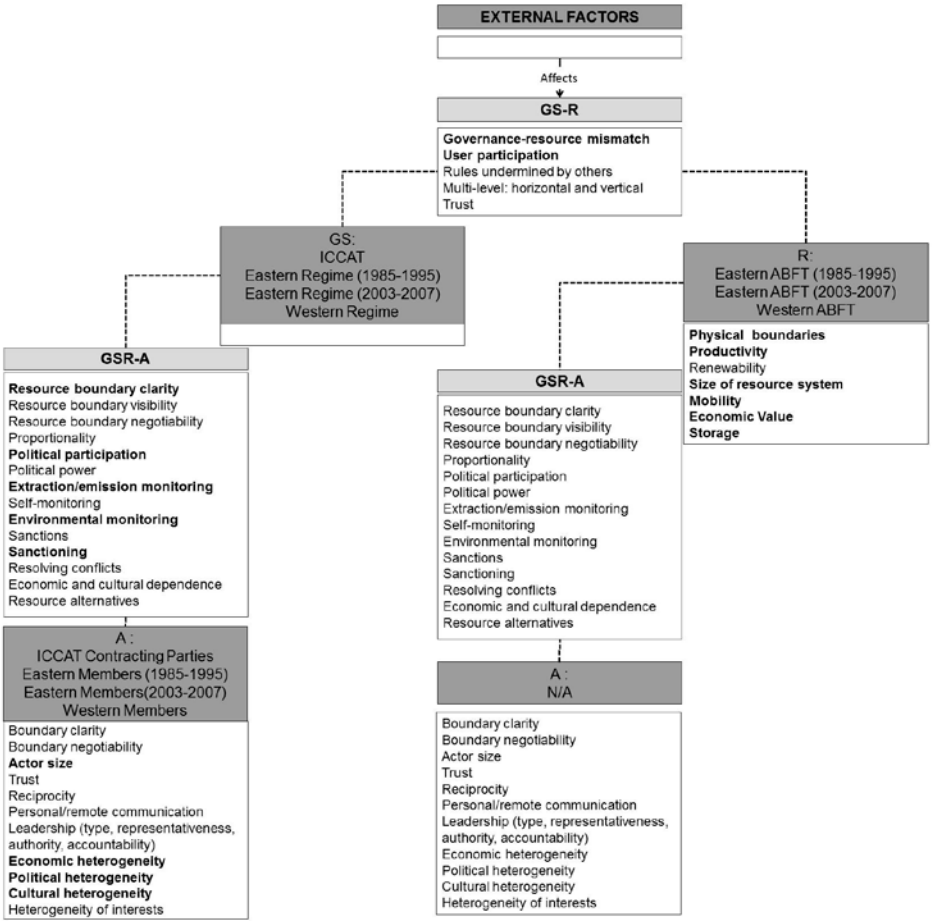

Figure 4: SES variables based on the CPR design principles that contribute to ecological and social governance outcomes in the ICCAT case. Light grey tables represent the links between the coded components of the SES. **Bold** indicates variables that are particularly relevant to this case.

Table 3: Comparing the governance of Atlantic Bluefin Tuna

Component	**Theoretical Variable**	**1st snapshot Western ABFT (1985-2007)**	**2nd snapshot Eastern ABFT (1985-1995)**	**3rd snapshot Eastern ABFT (2003-2007)**
Actors	Group Size	Smaller (3)	Larger (~30)	Larger (~30)
	Heterogeneity	Less	More	More
Resource	Size of resource system	Large	Large	Large
	Boundaries	Unclear	Unclear	Unclear
	Productivity	Lower	Higher	Higher
	Mobility	High	High	High
	Economic Value	High	High	High
	Storage	Absent	Absent	Present
Governance	Clarity of social boundaries	Clear	Clear	Clear
	Fuzziness of social boundaries	Rigid	Rigid	Rigid
	Participation of affected parties	Limited	Limited	Limited
	Fit to local conditions	No	No	No
	Nested Enterprise	Yes	Yes	Yes
	System-wide monitoring	Limited	Limited	Limited
	National-level monitoring	Less variable	More variable	More variable
	Monitoring by Fishers	No	No	No

4.3.1 Boundaries

Boundaries are important attributes of an SES as they help to internalize the benefits and costs of governance within a set of appropriators (Cox et al. 2010), while also allowing for the coordination of harvesting rules throughout the range of a resource. Boundaries are thus often distinguished between those that mark membership in a group (social boundaries) and those that mark the distribution of a resource (resource boundaries).

Resource boundaries, particularly those that define the Eastern and Western stocks have been an important issue for ICCAT governance of ABFT since the stocks were first separated for management purposes in 1981. The choice to delineate separate stocks was based on mounting evidence that ABFT consisted of two non-interbreeding stocks that required distinct regulations to achieve the stated goal of maximum sustainable yield. The 45th meridian, however, was chosen as a matter of convenience that corresponds well to their respective spawning grounds but not the annual distribution of these highly mobile fish (Block et al. 2005; Fromentin and Powers 2005; Hurry et al. 2008). The potential effects of incorrect assignment are asymmetric in nature given the order of magnitude difference in population size between the Eastern and Western stocks (Boustany 2011). For instance, incorrect assignment of one metric ton of western stocks would represent approximately ten percent of the total stock, while this same figure would constitute less than one percent of the eastern stock. At present, there remains considerable uncertainty regarding the level of mixing amongst stocks (Hurry et al. 2008; Boustany 2011; Fromentin and Powers 2005), and whether the simple, but arbitrary boundary rule should be retained, abandoned or modified.

Membership in ICCAT, as an international body organized under the auspices of the UN FAO is technically open to (i) any government that is a member of the UN, (ii) a specialized agency of the UN, or (iii) organizations such as the EU to which States have transferred competence over issues pertaining to ICCAT (ICCAT 2007). ICCAT has also introduced a lower level membership category, denoted as a cooperating non-contracting party that provides much of the same benefits and obligations in an attempt to enhance implementation of conservation measures throughout the convention area (ICCAT 2003). Nevertheless, boundaries as to who is, and who is not a member is quite clear and rigidly defined by a countries contracting or cooperating status. Members of the Eastern and Western group are equally clear and defined by the assignment of quota for a given stock in a given year. It must be noted that membership in ICCAT does not, in and of itself, define rights to harvest ABFT in the design principle sense (Cox et al. 2010; Ostrom 1990); but it does define the ability to trade captured fish with contracting parties, most notably Japan.

4.3.2 Congruence between rules and local conditions and contributions

Congruence between rules and the social-ecological context of a resource, and the users of that resource has often been identified as an important factor in the success or failure of environmental governance (Ostrom 1990; Folke et al. 2007; Acheson et al. 1998). As a whole ICCAT could be said to sacrifice alignment with local conditions in favour of symmetric implementation (i.e. quotas) of ICCAT conservation measures (ICCAT 2003). While there is considerable formal flexibility for ICCAT members, the emphasis on consensus decision-making means that once recommendations are adopted, members are constrained within the terms of their quota assignment, size restrictions and restricted areas leaving little room for meaningful

adaptation. The use of quotas in fisheries as a modern scientific management tool has also been criticized by some scholars that argue that the regeneration of many marine resources are chaotic in nature and better suited to alternative regulatory instruments (Acheson and Wilson 1996).

4.3.3 Participation of affected parties

The design principles, a core part of CPR theory first developed in Ostrom (1990) and supported in a more recent meta-analysis (Cox et al. 2010) are quite clear that user participation, if not direct provision of rules and monitoring by resource users are often important for successful environmental governance. The ICCAT case violates this principle by situating rulemaking at the international level, and monitoring at the national level for each of the contracting parties with little direct input from resource users. While there is evidence that some users have been able to organize and lobby governmental participants, and more recently conservation and technical organizations have participated in ICCAT processes; their influence appears to be limited.

4.3.4 Monitoring and Sanctioning

Continual monitoring and sanctioning have been found to be one of the key aspects of successful resource management in both marine and terrestrial systems at the local level (Basurto 2005, Gibson et al 2005). In the case of ICCAT, both monitoring and sanctioning capabilities are greatly restricted. While ICCAT conducts limited fishing fleet as well as resource capture and distribution monitoring through fish observers and catch reporting mechanisms, ICCAT does not have any enforcing or sanctioning powers with the exception of trade restrictions that have never been applied (Hurry et al. 2008, Korman 2011). Instead, ICCAT relies directly on member states to enforce the agreed-upon rules and to perform most monitoring activities. In a sense this type of self-monitoring resembles the classic allegory of the fox guarding the henhouse, at least with respect to countries that by virtue of choice or constraints are unable or unwilling to devote sufficient resources to monitoring.

Overall, this governance structure has been recognized to greatly impede the proper functioning of ICCAT (Hurry et al. 2008, Sumaila and Huang 2012). In the independent review of the Commission, Hurry et al (2008) point out that ICCAT's failure to achieve its management objective partially results from a lack of political support of member states to fully implement and enforce agreed upon rules. This situation, according to some of the more recent analyses, has led to a proliferation of illegal fishing activities, especially in the Mediterranean (WWF 2006, PEW 2011). PEW has estimated that the quantity of ABFT international trade in 2010 was approximately 140% higher than ICCAT's adjusted quota for the same year. Misreporting of catches and a lack of government oversight and control has been reported for several Mediterranean countries (ICIJ 2011).

While the apparent inadequacy of the current monitoring and enforcement system is evident, there has been no visible reaction within ICCAT to deal with this problem, in spite of numerous recommendations by academic and non-governmental institutions. Furthermore, it seems that effective monitoring and sanctioning mechanisms are equally relevant in local and international contexts. However, the second-order dilemmas might be more challenging to overcome at the international level given the sovereign character of each member state. It has also been

suggested that ICCAT could benefit greatly by devising monitoring protocols that actively encourage fishers to monitor the behavior of their peers (Korman 2011)

4.3.5 Nested governance

Nested governance is commonly found to be an important factor in the successful governance of natural resources where physical boundaries or some other characteristic of the good requires that management activities are coordinated across scales (Ostrom 1990; Hanna et al 1995; Cox et al 2010). Nested governance serves a variety of roles in a polycentric system (Ostrom et al. 1961; Ostrom 2010), but in general allows a governance system to better match rules or levels of public good provision to local conditions while ensuring that the actions of multiple groups align in such a way as to promote the sustainable exploitation of a stock.

The presence of nested governance in the ICCAT case was virtually guaranteed by the international nature of the ICCAT governance regime which views coordination as one of its primary aims (ICCAT 2003) and where the rights of States supersede the rights of an international body. In general, the ICCAT regime adopts a nested approach on the basis of governance functions. Scientific analysis of stocks and catches, as well as the determination and assignment of quotas and system-wide rules are conducted at the international level and coordinated by the ICCAT secretariat (Korman 2011). Member states are responsible for the implementation of regulations, monitoring, sanctioning and collection of data for harvesting that occurs within their national waters, and for ships flying their flag in international waters. In theory regulations can and do vary across States; but the fact that these regulations must fit within the context of their assigned quotas (and other rules) severely constrains the ability of States to design rules that fit their particular conditions and capacities. For example traditional fishery regimes often employ closed seasons, assigned fishing grounds, release certain individuals and apply bans on harvesting in certain areas to conserve their resource (Johannes 1978; Schlager 1994); all of which are difficult to align within the confines of a quota system. Furthermore variability across States in terms of the availability of resources to effectively and efficiently perform the required tasks means that levels of monitoring, and data collection vary; and even developed countries lack the ability to fully monitor fishing in their territorial waters (Korman 2011). Notably absent from the system of nested governance are the fishers themselves who could make major inroads into the monitoring problems given appropriate incentives (Korman 2011).

4.4 The Peculiar Effects of Storage: Tuna Ranching

The most interesting finding from the ICCAT case is the co-occurrence of declines in Eastern tuna stocks alongside a significant growth in the availability and use of live storage technologies. While the limited frame of the study does not allow us to conclude that storage is directly responsible for the decline of Eastern stocks, it certainly shows that storage has done little to resolve the underlying appropriation problem. This finding stands in direct contradiction to a longstanding and generally supported hypothesis in commons theory that storage helps groups to resolve problems associated with natural variations in the availability of resource stocks (Schlager et al. 1994; Agrawal 2003).

The first possible explanation for the observed effects of storage in this case is to reject the hypothesis that storage enhances prospects for sustainable governance in favor of the alternative hypothesis of no, or perhaps even a deleterious effect. The problem with this assertion is not in its reflection of the one-way relationships present in this case, but rather in its failure to consider the possibility that the effects of storage on sustainability are mediated by other aspects of the SES. In other words, certain aspects of the ABFT fishery may differ from the characteristics of the canal irrigation systems discussed in Schlager et al. (1994) such that storage produces divergent outcomes across the cases. Table 4 below outlines some of these differences in an attempt to identify possible explanations.

Table 4: Potential mediators affecting the influence of storage on resource sustainability.

Variables	Case	
	Canal Irrigation (Schlager 1994)	Eastern ABFT
Size of resource system	Small	Large
Sector	Irrigation	Fishery
Economic Value	Indirect	Direct
System characteristics	Open	Open
Property rights of stored resources	Mostly Common	Private

First of all, given the emphasis placed on large scale systems in this project we would be remiss if we failed to consider the possibility that differences are a function of the relative size of resource systems. The largest irrigation case for which data were available had a total command area of 300 hectares (Schlager et al. 1994); as compared to over 10 billion hectares for the Atlantic Ocean. Even accepting that ABFT are not present throughout this range, and that storage is confined to coastal areas; size would tend to increase the costs associated with monitoring (Agrawal and Goyal 2001) and allow for opportunistic individuals and groups to situate storage in favorable settings where enforcement is absent or weak.

An alternative hypothesis is that storage is an effective solution in the irrigation sector, but that something about the characteristics of a fishery erodes the sustainability-enhancing effects seen in the irrigation cases. While there is no evidence available to reject such a hypothesis, there is also no clear, or rather several possible theoretical mechanisms that could underlie this finding. For example, expensive maintenance in the form of fish feed (Volpe 2005), potential for mortality within the storage facility (De Stefano and Van Der Heijden 2007), and the high economic value of stored fish could indicate an economic optimization problem that favors shorter-term storage. This argument presumes a measure of risk aversion in which individuals choose to harvest moderately fattened fish, rather than assume the costs of additional feed, risk of mortality, and loss of potential income at high market prices. However, this ignores other equally plausible factors with independent or interactive effects. Nonetheless given the global proliferation of aquaculture, it seems a worthwhile avenue for future research to ask whether it meaningfully reduces pressure on wild stocks.

One similarity between the two cases that merits some additional discussion is that both storage systems are open in nature meaning that stored units are drawn from the external environment, and do not regenerate within a storage facility (or network thereof). In the case of canal

irrigation attempts to “close the loop” are logically impossible; but many captive fisheries systems close the loop via captive reproduction (Zohar 1989; Brummett 1995; Sumaila and Huang 2012). While recent developments have demonstrated that captive reproduction of ABFT is possible (Mylonas et al. 2007); prospects for a commercially viable closed-loop system remain somewhat unlikely in the near to medium term (Locke 2008). Thus an alternative hypothesis to the simple difference across fisheries and irrigation systems is that positive effects of live storage in fisheries depend upon the development of a closed-loop system that meaningfully reduces capture of wild stocks.

Finally there is one additional difference that may be of particular interest to CPR scholars which is the variation in terms of property rights that are assigned to stored units. Whereas Schlager et al. (1994) describe storage facilities where stored units are owned collectively by a group of potential appropriators, the ABFT stored in ranches for fattening are held privately. Discussions about the effects of property rights on sustainability have broadly settled on the conclusion that government command-and-control, and common property systems are equally prone to succeed or fail, although typically for different reasons. Common property failure is often linked to characteristics of communities in which groups are unable to devise and implement rules due to the absence of clear boundaries, social capital and presence of cultural differences (Acheson 2006). Private property failures on the other hand are linked to profit maximization, rational discounting of future returns, uncertainty and the economic situation of owners (Acheson 2006); the first three of which are almost certainly present in the case of ICCAT storage facilities.

4.5. Challenges

The complexity implied by a SES approach for the study of environmental governance is a common problem for scholars seeking to define causes of outcomes amongst a large range of independent variables whose effects may vary according to the presence, absence, or magnitude of other independent variables (Agrawal 2003; Poteete et al. 2010). Whereas these problems are a feature of both small and large scale SESs, secondary analysis and coding of large scale systems introduce additional problems of method that were evident in the analysis of this case. The source of most of these problems rests in some combination of (a) the availability of data, (b) assigning values to variables in the context of heterogeneity, and (c) the loss of heterogeneity important to the case in favour of relative homogeneity across multiple cases.

The omission of resource users as a component of the ICCAT SES was the most significant issue to arise in the coding of this case, and was driven by the scarcity of information about the groups and individuals that harvest ABFT in the Atlantic Ocean and Mediterranean Sea. Aside from discussions of compliance problems (Hurry et al. 2008; ATRT 2005; PEW 2011), few details emerge about the characteristics of users or their interactions and role in National-level management regimes. The absence of users was not taken lightly given their prominence in the commons literature (Ostrom 1990; 2009), and the fact that environmental outcomes inevitably flow through the choices made by this important group. In fact an attempt was made to code the attributes of resource users which resulted in a table composed almost entirely of missing data, ultimately leading to the decision to omit them entirely. In retrospect it seems almost inevitable that the emphasis on large-scale systems would at times lead to the omission of user groups, but it remains unclear what effect this omission portends for the analysis of large-scale SESs.

The choice to adopt a relational database approach for this project was explicitly situated in a desire to capture important heterogeneities across actors, resources and governance systems (Cox this issue) that may have differential effects on important outcomes of interest for a case or set of cases. Inevitably, however, data constraints when combined with trade-offs between depth and breadth, as well as between validity and reliability led to the aggregation of actors into groups based on some underlying shared characteristic. In this case aggregation was facilitated by important differences across stocks (Fromentin and Powers 2005), the stock-based governance system, and the assignment of quota for those stocks to member countries. This grouping, while theoretically appropriate, required that coding take into account heterogeneities within these groups. Thus Western nations actor which effectively consist of Canada, the USA and Japan was fairly easily coded as having a fairly high economic status and low economic heterogeneity; while Eastern nations actor consisting of Western and Eastern European nations as well as North Africa were coded as having a moderate economic status with high levels of economic heterogeneity. An alternative grouping, based on geography for instance would have produced different measurements pointing to potential problems of method driven by the specification of the components of a case.

Finally, some important attributes of the ICCAT case are lost when data is taken from the literature and entered into the SES-MAD database. For instance, individuals from the Eastern stock reach sexual maturity at earlier stages and in aggregate are more productive than the Western stock (Fromentin and Powers 2005); but the difference is not captured in the database due to the presence of coding thresholds designed to capture heterogeneity across multiple types of SESs. This problem is not a feature of this study where table 3 reports relative values of influential variables. Furthermore, this compromise between specificity and generalizability reveals the potential value of the project as a whole that adopts a case-based analytic approach for the analysis of snapshots and specific insights, in addition to the accumulation of cases from which more generalizable results could eventually emerge.

5. CONCLUSION

The future of Eastern and Western ABFT stock remains unclear. Are they in a state of dangerous decline (Safina and Klinger 2008; Collette et al. 2011; Juan-Jordá et al. 2011; MacKenzie et al. 2009; Hurry et al. 2008); or are they on a pathway to eventual recovery (SCRS 2012). These contrasting positions are not uncommon, but their joint prevalence is nonetheless surprising in that they are derived more or less from the same set of publicly available data. This analysis does not bring us any closer to the fundamental question of sustainable resource use which seems to have eluded ICCAT and scholars as well that have dedicated their careers to better understand this fish species, the people that use it, and how to effectively govern its use. In fact the single most interesting contribution of this study is external to this case and consists of a set of testable hypotheses for commons scholars surrounding the effects of storage in natural resource settings. Why does the addition of storage appear to be exacerbating, rather than ameliorating the exploitation of ABFT despite longstanding predictions to the contrary (Schlager et al 1994)? Is it simply that storage has a different effect in large systems or in fisheries? Perhaps the effects of storage in fisheries depend upon the development of a closed-loop system, or perhaps the perceived effect of storage in this case is simply standing in for one or more other factors that have been omitted in this study? In any case, the answer to these questions cannot be found in

the ICCAT case, but rather in the accumulation of evidence from multiple cases and multiple methods of inquiry (Poteete et al 2010) which undoubtedly includes a large-n database on similar large-scale commons.

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