

Materializing the blue economy: tuna fisheries and the theory of access in the Western Indian Ocean

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Abstract

Many African countries are progressively embracing the blue economy. African islands of the western Indian Ocean, however, have been involved in it for more than twenty years through the exploitation of their 'blue gold': tuna. In this article, we use Ribot and Peluso's (2003) "theory of access" to map the different ways actors access tuna under diverse socio-economic contexts and how power relations are created through different mechanisms of access. We show that rights-based mechanisms such as fishing access agreements are highly questionable for their fairness and sustainability but bring benefits such as funding for fisheries-related infrastructures and projects. We also show that access to the resource is dependent on knowledge held by fishers, on technological advances as well as on diverse labor relations. These mechanisms significantly impact the quantity of fish that can be accessed by artisanal versus industrial market sectors, and generate narratives of unequal access to tuna. Furthermore, we take into consideration the materiality of tuna as a highly mobile resource in a space of fluid boundaries, to show how the fish can be an actant in shaping access but also how fishing practices can produce new materialities. Based on the above evidence, we propose an enhancement of the theory of access to consider the role of materiality of the resources and the sea. We conclude that to ensure that tuna fisheries continue to contribute to the blue economy of African islands, stakeholders need to balance between the diverse benefits produced by the fisheries and the uneven power relations that can arise, and to integrate the impact of a material sea and fish in this reflection.

Keywords: fishers, knowledge, materiality, power relations, spatiality of the sea, technology, Madagascar, Mauritius, Seychelles

Résumé

De nombreux pays africains adoptent progressivement le concept d'économie bleue. Les îles africaines de l'océan Indien occidental pourtant y contribuent depuis plus de vingt ans grâce à l'exploitation de leur «or bleu»: le thon. Dans cet article, nous utilisons la théorie de l'accès de Ribot et Peluso (2003) pour cartographier les différents mécanismes d'accès au thon dans des contextes socio-économiques différents et pour mettre en évidence les relations de pouvoir qui se créent à travers ces mécanismes. Nous montrons que les mécanismes fondés sur le droit, tels que les accords de pêche, sont hautement discutables pour leur équité et durabilité, mais sont aussi source de bénéfices divers dans des pays hôtes principalement par l'octroi de financement pour les infrastructures et projets liés à la pêche. Nous montrons également que l'accès à la ressource dépend des connaissances des pêcheurs, des progrès technologiques et de diverses relations de travail. Ces mécanismes ont un impact non-négligeable sur la quantité de poisson accessible par les secteurs artisanaux et industriels, et génèrent des discours sur l'inégalité d'accès au thon. Compte tenu de la spécificité du thon étant une ressource hautement mobile, nous utilisons le concept de matérialité pour montrer comment

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le poisson peut jouer un rôle dans la structuration de l'accès, mais aussi comment les pratiques de pêche peuvent produire de nouvelles matérialités. Sur la base des éléments ci-dessus, et afin de mieux comprendre l'importance de l'action des ressources en mouvement telles que le thon dans des espaces aux frontières fluides telles que la mer, nous proposons une amélioration de la théorie de l'accès consistant à donner plus d'importance au rôle de la matérialité des ressources et de la mer. Nous concluons que pour que la pêche thonière continue à contribuer à l'économie bleue des îles africaines, les parties prenantes doivent trouver un équilibre entre les divers avantages produits par cette pêcherie et les relations de pouvoir inégales, ainsi qu'intégrer l'impact de la matérialité des ressources dans cette réflexion.

Mots-clés : pêcheurs, savoir, matérialité, relations de pouvoir, spatialité de la mer, technologie, Madagascar, Ile Maurice, Seychelles

Resumen

Muchos países africanos han empezado de adoptar la "economía azul". Islas africanas del Océano Índico Occidental participan en ella desde hace más de veinte años gracias a la utilización de su oro azul: el atún. En este artículo, usamos la teoría del acceso de Ribot y Peluso (2003) para cartografiar las variadas maneras en aquellas el atún esta accedido al amparo de diferente contextos sociales y económicos, y para examinar como diferentes mecanismos de acceso generan variadas relaciones de poder. Demostramos que los mecanismos fundados sobre los derechos, como los acuerdos de acceso a la pesca, son cuestionables con respecto a su equidad y su sostenibilidad, aunque benefician a los países anfitriones gracias al financiamiento de infraestructuras y proyectos relacionados a la pesca. Demostramos también que el acceso al recurso depende del saber de los pescadores, del progreso tecnológico, y de variadas relaciones de trabajo. Esos mecanismos tienen un efecto mayor sobre la cantidad de pescado que los mercados artesanal versus industrial pueden acceder, y generan narraciones de acceso desigual al atún. Teniendo en cuenta la especificidad del atún, que es un recurso muy movable, usamos la materialidad para demostrar como el pescado puede ser un actant que influye en su acceso y también como prácticas de pesca pueden producir materialidades nuevas Basándonos en esas pruebas, y con el objetivo de entender mejor la importancia de las acciones de los recursos movibles como el atún en los espacios de fronteras fluidas como el mar, proponemos un aumento de la teoría del acceso, que tenga en cuenta la función de la materialidad del recurso y del mar. Concluimos que para asegurar que la industria pesquera del atún sigue contribuyendo a la economía azul de las islas africanas, sus protagonistas tienen que mantener el equilibrio entre los beneficios variados de las industrias pesqueras y las desiguales relaciones de poder que pueden aparecer, y que integrar la materialidad del mar y del pescado en su pensamiento.

Palabras Clave: pescadores, saber, materialidad, relaciones de poder, espacialidad del mar, tecnología, Madagascar, La isla Mauricio, Seychelles

1. Introduction

Tuna fisheries are one of the most valuable fisheries in the world (Campling 2012a; Pew 2016). In 2014, tuna's contribution to the global economy was estimated at more than US\$42 billion (Pew 2016). The Indian Ocean generates US\$2 billion from its tuna, of which up to 80% comes from the Western Indian Ocean (WIO) (Obura *et al.* 2017). Tuna fisheries are considered a key component for the emergent blue economy of Africa and especially the WIO region. They are providing important revenues, jobs, and food security for coastal communities. Industrial fisheries, focused largely on tuna and mainly undertaken by distant water fishing nations (DWFNs), are the third income provider in the WIO blue economy (after coastal and marine tourism and carbon sequestration). Small-scale fisheries provide livelihoods and food for coastal communities at an often underestimated value of US\$200 million (Obura *et al.* 2017). The management of fisheries depends on interactions between various stakeholders at different scales, from local fishing villages and ports, to national governments, to the regional Indian Ocean level and NGOs. Management is complicated by the fact that tuna is a multi-species resource that moves between territorial waters, exclusive economic zones and the high seas. This leads to intricate relations of access to the resources between actors but also between actors and the moving tuna.

This article presents an approach that allows us to show these different interactions in the fisheries in one frame. It does so by applying the 'theory of access' developed by Ribot and Peluso (2003) to the tuna question. By approaching the tuna fishery question through the angle of resource access, one is forced to consider multiple aspects, including the multiplicity of actors involved, their interactions over resource access, the array of benefit streams from the resource, and, crucially the role of the fish and their ecology in this access. The advantage of such an approach is that alternative entry points can be suggested when analyzing resource use and management. The goal of the article is twofold. **First**, we offer a better understanding of the diversity of ways in which tuna resources are accessed and the power negotiations that take place between actors in this process while having a common goal of better management of tuna and sustainability of the resources. **Second**, we propose to adapt and refine the theory of access, largely conceived with stationary terrestrial resources in mind, by taking into consideration the materiality of tuna and the spatiality of the ocean. By explicitly grafting materiality and spatiality to the theory of access, it can better analyze access to moving resources. As in the case of other moving resources, such as migratory wildlife, the specificities of the species, their ecological features, the socio-political and ecological environment in which they live, and the practices of exploitation and management create a dynamic, hybrid, spatialized materiality that influence the processes of access.

The article starts with a brief presentation of the 'theory of access' by Ribot and Peluso, and how we understand it. The relevance of integrating materiality into a theory of access for tuna fisheries is also presented. We then apply the theory to the case of tuna resources in the WIO region, analyzing rights-based mechanisms and three specific structural and relational mechanisms: knowledge, technology and the social relations of labor. To expand more on the role of materiality, we provide examples of how this influences the politics of access. The implications of the study are significant in the current context of the 'Blue Economy', which we understand as a frontier concept, gathering various stakeholders ranging from businesses promoting ocean-based private sector interventions, to small-scale actors claiming access rights and governments advocating for a sustainable blue growth (Childs and Hicks 2019; Hinder and Le Heron 2017; Silver *et al.* 2015). Examining access to tuna and the role of materiality allows us to highlight the biological and socio-economic processes at play between these blue economy actors and resources. The article also explores the role of a moving commodity in the ocean space, where sites of production involve both large and small-scale actors.

2. Study sites and methods

The western Indian Ocean region is typically considered to include the territorial waters and exclusive economic zones (EEZs) of 15 countries as well as a large area of open sea (Figure 1). Due to upwelling along coastal areas and energetic eddy processes, the WIO is an area of biological productivity, favorable for tuna species (Dagorn 1994). The region hosts eight main tuna species, of which four are considered key commercial species: skipjack tuna (*Katsuwonus pelamis*), yellowfin tuna (*Thunus albacares*), albacore (*Thunus alalunga*) and bigeye tuna (*Thunus obesus*). The other species are considered coastal tuna mainly caught by small-scale artisanal fishing (POSEIDON *et al.* 2014).

The different species occupy several ecological niches, as various species have preferences for different depths – from surface waters to 500m depth – and for coastal proximity versus open ocean. They also diverge in dietary specialties, though most do prey on other small fishes, crustaceans, cephalopods and mollusks (Collette *et al.* 2011; Froese *et al.* 2012). While coastal tuna (*kawakawa*, frigate, and longtail tuna) are more sedentary, the key commercial species are quite mobile, migrating around the region and beyond in search of food and suitable environments (Dagorn 1994; Gillett 2011; Nikolic *et al.* 2014).

Tuna fisheries can be classified into three types: industrial fisheries, small-scale fisheries and a so-called 'semi-industrial' longline fishery. While the industrial fishery is largely owned by third party countries, also known as 'distant water fishing nations' (DWFNs), the small scale and semi-industrial fishery originates in the WIO countries (Le Manach 2014; POSEIDON *et al.* 2014).

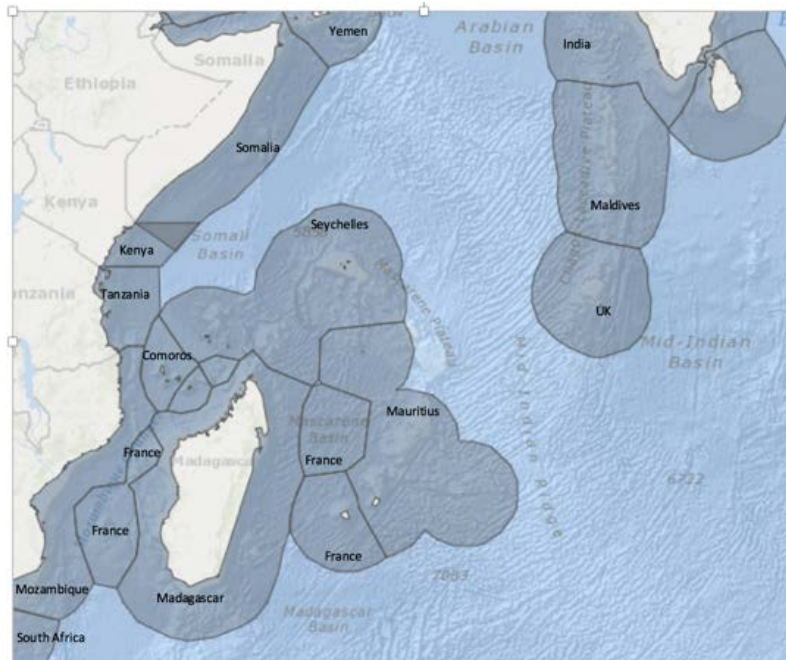


Figure 1: Map of the Exclusive Economic Zones (EEZs) of the countries of the WIO region. Source: Adapted by the authors from the "Sea Around Us" project <http://www.seaaroundus.org/data/#/eez>

The present study focuses on three countries, Madagascar, Mauritius and Seychelles. Despite being close to each other at the center of the WIO tuna fishery – each having active fishing ports and canneries – the three countries have very distinctive socio-economic and historical contexts and different levels of exploitation of tuna resources. In Madagascar, the contribution of tuna fisheries to the economy is considered less than 10% of the GDP (it is focused more on agricultural cash crops) despite a yearly 15,000 tons of production (Breuil and Grima 2014). The country has an under-developed national tuna fishery mostly composed of small-scale coastal fishing and a handful of semi-industrial boats. In Mauritius, the fishery's production of around 4,000 tons/year contributes to less than 2% of the GDP and constitutes around 20% of exports (COFREPECHE *et al.* 2016; GoMU 2017). The tuna fishery is more developed than in Madagascar with a better-equipped small-scale fishery and a larger national semi-industrial fleet. Mauritius also hosts the main transshipment port for longliners operating in regional waters. In Seychelles, tuna fisheries are at the center of the economy (Schutter and Hicks 2019). In 2011, tuna fisheries contributed to approximately 20% of the GDP as well as more than 90% of exports (Marsac *et al.* 2014). Seychelles has an important national semi-industrial tuna fleet and a small-scale fishery that also catches tuna, without targeting it. In 2015, the tuna catch in the Seychelles' EEZ was estimated at around 60,000 tons (SFA 2016). Seychelles plays a key role in the tuna fisheries of the WIO, having the most important port for the purse seine vessels to land and transship as well as being in the middle of tuna fishing grounds. The three countries all host industrial fishing by European and Asian fleets. In fact, the Spanish and French fleets have dominated the catch since their arrival in the WIO in the 1980s, when the WIO was the "last commodity frontier" for tuna (Campling 2012a). Socio-economically, Madagascar is much poorer than its two neighbors, with a Human Development Index ranking of 154 (out of 188 countries), while Seychelles and Mauritius are classified as countries with high human development, ranked respectively at 63 and 64 (UNDP 2016). While tuna fisheries have a more important place in Seychelles' economy compared to Mauritius, the latter's GDP is almost 10 times higher than its Seychellois neighbor, mainly through its developed tertiary sector (Sellström 2015; UNDP 2016).

The research draws on an empirical approach consisting of three main methods. First, the lead author gathered the perspectives of stakeholders regarding access to tuna through semi-structured interviews undertaken in 2017, with 86 fishers (61 small scale, 11 industrial and 14 semi-industrial), 40 government officials, 7 cannery staff members and 18 NGO representatives in Madagascar (interviews coded as MD), Mauritius (coded as MU) and Seychelles (coded as SE) as well as via Skype interviews (coded as SI). Second, we analyzed 20 fisheries reports from governmental archives regarding the means of access to the fishery, complemented by other reports such as annual reports submitted to the Indian Ocean Tuna Commission (IOTC) by countries, and reports produced by NGOs. Third, we observed fish landings at the main tuna ports of the three countries for both the small-scale, semi-industrial and industrial segments.

3. Ribot and Peluso's 'theory of access'

The concept of access, as used here, is broader than often-used concepts of property or legal rights, and permits us to engage with not only regulatory instruments for tuna management, but also social, ecological, and economic contextual factors. By access, we then refer to the use and physical access to the resource as well as to the ability and means to gain benefits from that use. In their theorization of access, Ribot and Peluso (2003) focus on the ability of actors to benefit from resources through the social relationships between people and the webs of power that configure resource access. Their approach consists of distinguishing different types access mechanisms (rights-based and structural) and analyzing them in three steps (left side of Figure 2):

- (1) mapping of benefits from a resource,
- (2) identifying and situating the mechanisms used by actors to gain, control and maintain access to these benefits
- (3) analyzing the power relations involved in the process.

Ribot and Peluso notably distinguish between gaining, controlling and maintenance of access: gaining access is "the process to establish the access" (p.159); control is "the ability to mediate others' access and the power to direct other's actions" (p.158) and maintenance is "the use of resources and powers to keep access to the resources" (p.159). They identify various mechanisms through which access to resources is gained, controlled and maintained (Table 1).

We will focus on three of Ribot and Peluso's (2003) eight structural and relational mechanisms that influence how actors gain, control, and maintain access to tuna and create power webs where actors at different moments have power (or not) over the resources and the fishery. In the case of the tuna fishery, three mechanisms allow us to uncover particularly well the differentiated access to the resources by actors as they are present in the three segments of the fishery and engender very diverse interactions. These are knowledge, technology, and social relations. We focus particularly on knowledge and technology as they have a key influence on the benefits that could be derived from tuna in terms of catches. Those two mechanisms also have a strong role in the process of co-production of benefits and materiality through their impact on the biophysical aspects of the resources as well as on perceptions around tuna. They also have a direct link with capital, from which the availability of technology and investment in knowledge production around tuna derives. We have chosen the third mechanism, social relations, mainly to bring to the scene the people behind the fishery, whose stories of access to resources are often untold. Through social relations, especially around labor, we are able to explore perspectives on access and resources from the people that are close to those resources and involved at different stages of the commodity chain. It also allowed us to perceive other mechanisms such as social identity or authority. Other access mechanisms, like capital, market, labor and authority in tuna fisheries of the WIO region, have also been explored in other studies (see for example Campling 2012a, 2012b; Havice and Campling 2013, 2017; Lecomte *et al.* 2017; Wolff *et al.* 2013).

The approach outlined by Ribot and Peluso under their theory of access presents three advantages in understanding the dynamics of tuna fishing and management in the WIO. First, the mapping of benefits allows a clear identification of the actors involved. Tuna fisheries are ultimately not only of concern to fishers. They involve multiple actors at different geographical scales who access or control access to the resources and their direct or indirect benefits (Table 1). Second, the approach highlights how gaining, controlling, and maintaining access occurs not just by formal conventions (rights-based access), but many different types of structural and relational mechanisms at multiple scales. Third, through the analysis of power relations, it gives attention to political-economic circumstances that may affect access rights from one group or another.

4. Materiality and input to the theory of access

Now we turn to presenting the rationale for enhancing Ribot and Peluso's (2003) theory of access through materiality. Other scholars have attempted to enrich the theory with social concepts (Szaboova *et al.* 2019, for a recent example), or expand some components of the theory like power or authority (such as Sikor and Lund 2017). Our contribution lies in the integration of materiality. By materiality, we refer not just to the tangible biophysical and spatial characteristics of a resource, but also the ways in which those aspects are constructed through social processes (Bakker and Bridge 2006). This reflects a 'material turn' in political ecology (Bennett 2010; Walker 2005), which explores the active dynamics of non-humans and highlights the importance of biophysical ecology in socio-environmental research. As Robbins puts it, non-human actors "play an important political role in explanation" (Robbins 2003: 643). This leads to a kind of hybrid socio-natural materiality that has an impact on access to resources while it is also influenced by this same access. Ribot and Peluso's theory of access (2003) touches indirectly on materiality in mapping access or focusing on technology as a mechanism, but does not explicitly do so, perhaps because the dominant focus was on a shared understanding of land and forest resources. Other studies have emphasized the role of the biophysical characteristics of terrestrial resources in shaping access policies or influencing access negotiations along the commodity chain (Holland and Lansing 2016; Neimark 2010). A recent review of the theory of access has also suggested a better integration of materiality by either considering it as different to access mechanisms or that mechanisms take into account the agency of things (Myers and Hansen 2019).

For mobile resources, their biophysical characteristics and ecological dynamics, often shaped in part by human actions, influence the type of extraction used by commercial and subsistence actors (Sneddon 2007). They can either contribute to the accumulation of capital if extractors have the means to overcome the characteristics that can constitute an obstacle or also be used to claim ownership over a resource for those located nearest to resources (Kaup 2008; Mansfield 2003). Extraction of resources will then take place only where they are present and tangible. Their movement influences the location of their extraction. The case of marine resources, either migratory or fugitive (Giordano 2003), brings questions of biophysicality and spatiality to the fore. Bear (2012) for example discussed the influence of moving marine resources such as bottleneck dolphins in management decisions and how mobility intervenes as a strong force outside the control of human actants. Childs (2018) highlights the use of the fluidity and dynamic qualities of the seabed within deep-sea mining political technologies. Campling and Havice (2014) specifically discuss the role of tuna's characteristics and the spatiality of the sea in shaping the capitalist exploitation of tuna in the WIO.

Category	Role in access to resources	In the charcoal commodity chain (Ribot 1998)	In tuna fisheries
Rights-based mechanisms			
Law, conventions, permits, illegal means	Provide right-based access or illegal access to the resources	Permits, licenses and quotas to access the resources and market. Forest policies to manage the use of resources, threat of violence	The international Law of the sea, permits and licenses, fisheries' policy, piracy and illegal fishing
Structural and relational mechanism			
Technology	Equipment of all sorts that improves access or allows its control	Technical skills of woodcutters	Vessels' technology to locate and catch the fish
Capital	Finances that enable actors to gain and control access and benefits	Financial capital of wholesaler in accessing large quantities of charcoal leading to monopoly	Financial capital by fishing firms leading to more efficient vessels with more technology
Market	Access to markets influences who can benefit from the resources	Control of market access by merchants through licenses, permits and social ties with distributors, retailers and State agents	Tuna both goes to the international market, controlled by DWFNs through permits and rules of origin, and to local markets through fishers and intermediaries
Labor	Relations and opportunities that provide benefits to those in control and access to those without rights	Labor opportunity of woodcutters controlled by merchants	Labor opportunities to access the resources at fishing stage (controlled by industrial fishing companies and local boat owners) and at landing (controlled by handling and processing companies)
Knowledge	Provides access through belief systems and by shaping justifications of access	Technical knowledge of woodcutters, knowledge of price and demand by vendors to control distribution	Ecological knowledge about the fish by local fishers, through technology and research. Knowledge of subsidies through social ties with the State
Authority	Allows the control of access and influences who benefits	Power of local leaders to decide forest disposition	Governments' authority in deciding management measures
Social identity	Can provide access through local status or membership of a group	Ethnic identity to access labor opportunity	Coastal states nationals to access labor opportunities on foreign industrial vessels
Other social relations	Friendship, trust, reciprocity, patronage, dependence that can be used to control and maintain access to the resources, markets and labor opportunities	Social ties between wholesalers, vendors, the State and merchants to maintain access to the market and control access to distribution	Patronage and trust within small-scale fishing, patronage and dependence at the industrial fishing scale

Table 1: Categories of right based, structural and relational mechanisms to access resources, from Ribot and Peluso's framework (2003), illustrated for terrestrial resources (Ribot 1998) and tuna resources. (author's analysis)

Within a theory of access to tuna resources, we argue that materiality is present on three fronts (Figure 2). **First**, right based mechanisms of access play an important role in the spatialization of the sea, and in the same process aim to establish the right to access tuna resources within geographical boundaries. **Second**, biophysical attributes of tuna shape and influence structural access mechanisms such as knowledge and technology, which in turn have an impact of the quantity of tuna resources that can be accessed. **Third**, power relations that intervene between stakeholders can have an influence on the materiality of resources and frame various narratives of overfishing and equitability around the benefits obtained.

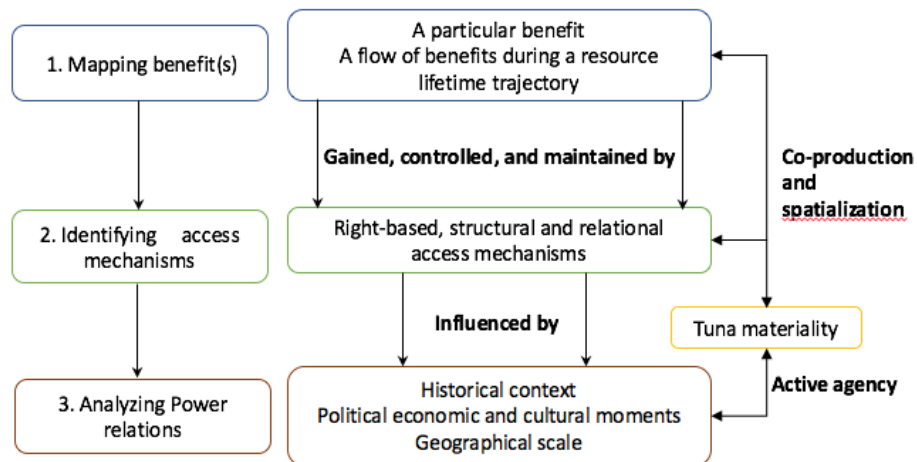


Figure 2: A summary of Ribot and Peluso's mapping of access, enhanced by materiality (2003).
Source: authors.

5. Applying the classic theory of access to tuna resources of the WIO

We will now illustrate how the theory of access elicits the complexity of tuna fisheries in the WIO. We will first present three rights-based access mechanisms, providing the legal framework of access. Following this, we present three structural mechanisms that are relevant for access to tuna resources. We address refinements for the theory to take account of mobile resources and materiality in a later section.

International rights to the resources: The Law of the Sea and fishing access agreements

Tuna resources are formally under the control of coastal states when the fish are in the countries' territorial waters or exclusive economic zone (EEZ). These sovereign access rights to marine resources were codified by the United Nations Convention on the Law of the Sea (UNCLOS) in 1982. Outside these zones, in the high seas, no state can claim sovereignty over tuna, which are considered a property of humankind (Figure 3).

In the WIO, countries' EEZs are contiguous in the Mozambique Channel and between the island states of Madagascar, Seychelles, Mauritius and insular territories of France. High seas envelope the WIO to the north, east, and south (Figure 1). This makes the tuna fishery subject to different levels of regulation and control, starting from national property rules (in territorial water), national controls within countries' EEZs, to no control rules in the high seas. The appropriation of tuna resources and the rent they generate under those different rules are highly influenced by the socio-historical context as well as the role of the state in maximizing or mitigating this appropriation (Campling and Havice 2014).

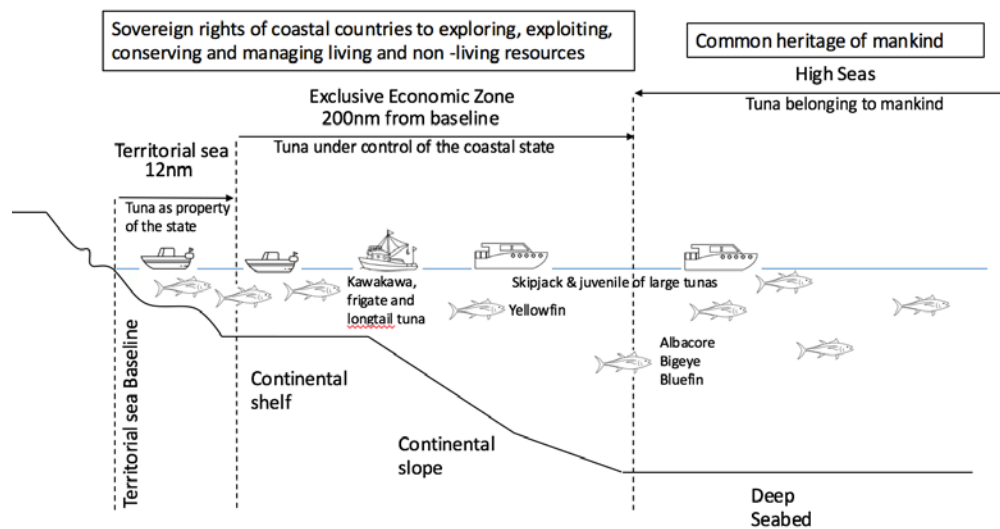


Figure 3: Spatialization of the ocean by the Law of the Sea and rights over tuna in their different location/depths. Source: the authors, adapted from FAO 2000.

Article 62 of the Law of the Sea, stipulates that countries with a limited capacity to harvest their resources shall provide access to the 'surplus' resources to other States (UNCLOS 1982). This provision creates a second type of right-based access mechanism: bilateral fishing access agreements between host countries and distant water fleet nations. In the WIO, the countries involved are mainly Spain, France, Japan, South Korea and Taiwan. The first two typically negotiate fishing access agreements under the flag of the European Union and its program for Sustainable Fisheries Partnership Agreements (SFPAs). Fishing access agreements have been criticized for their lack of sustainability, equity and transparency (Gagern and van den Bergh 2013; Le Manach *et al.* 2013a, 2013b). They also create challenging geo-political negotiations for coastal states, struggles regarding the setting of the appropriate rent, and force states to find a balance between global production demands, national pressure for revenue as well as equity (Barclay and Cartwright 2007; Campling and Havice 2014). This type of access to tuna is therefore linked to highly (geo)political and economic interests, and to unequal negotiations with wealthy countries also highly involved in development aid to the host countries (Barclay and Cartwright 2007; Gegout 2016; Schurman 1998).

National licencing system: control of access within the EEZ

Other access mechanisms operate at the national level, mainly through various licenses and permits. In the three countries studied, access to resources by national operators depends on the types of activities undertaken and whether they are for the local market or for export. It can range from the issuance of fisher's cards to industrial agreements or export permits (Table 2) (GoMA 2015; GoMU 2007; GoS 2014).

These diverse regulatory and administrative frameworks are, however, not as straightforward as they appear. In addition to challenges of enforcement and monitoring (MD72, government official), there can be conflicts over the fair distribution of licenses, notably between local artisanal fishers and foreign vessels operating under access agreements. In the three countries studied, the activities of foreign boats can be perceived by local fishers as illegal fishing when they are fishing close to the coastline. Fishers made statements such as "there is illegal fishing. We do not know who they are but they come too close to the coast to be legal boats" (MD 06) or "there are big boats that do illegal fishing in our waters, they come close to the coasts at night" (MU 11). This perception of illegal fishing by artisanal fishers exacerbates the issue of fairness of fishing access agreements raised above as it is not seen by some fishing communities as legitimate

access to resources. This is especially tangible in countries like Mauritius and Seychelles where knowledge about the existence of access agreements is more widespread. Local fishers interviewed in those countries often mention that the state gives too many licenses to big industrial vessels (MU 8, 11, 35, 24; SE 9, 24, 26, 61). Fierce comments such as "we have to reduce the number of tuna purse seiners in our waters as they take all the resources" (SE 9) were commonly heard amongst the semi-industrial fishers in Seychelles.² These conflicting perceptions of legality of access fuel the opposition against industrial fishing, especially purse seiners, in the WIO and make benefits brought by that segment of the fishery less appreciable especially in the opinion of local and semi-industrial fishers.

	Madagascar	Mauritius	Seychelles
Artisanal/subsistence	Fisher's card		Fisher's card Boat license
Local semi-industrial	Fishing access agreement Boat license		Fishing permit Boat license
Selling to local markets	Selling permit for fishers Collection and selling permit for intermediaries		
Exporting	Export permit (issued to fishers or processing companies)		

Table 2: Different types of permits to access the fishery and sell the catch.

Conservation measures regulating access to fishing grounds

Other forms of regulations beyond licensing also shape access to marine resources. These can include no-take zones from marine protected areas, fisheries closures, prohibition of some types of gear or local conventions between community members (Bennett and Dearden 2014; Kincaid *et al.* 2014; Walker and Robinson 2009). We do not elaborate on these here; however, we will briefly mention how tuna fits within these forms of regulation.

In the three countries studied, tuna is not subject to any closure periods, the reasons being that most tuna are caught further from the coast and their movement combined with seasonality make it difficult to establish a closure. Tuna species travel in schools that may be a mix of different species and include both juvenile and catchable fish. Setting up closures would require a precise knowledge of the movement patterns and species constitution of the various schools of tuna present in the WIO. Enforcement would require substantial investment in control and surveillance for coastal states. More sedentary tuna (such as *bonitos*) are present close to the coast and could be present in marine protected areas, hence access is limited. In Madagascar and Mauritius, fishers did not mention marine protected areas as a major obstacle to their fishing because their fishing grounds were not close to MPAs (MD 51, MU 18, local fishers). In the Seychelles, however, news about an upcoming large new MPA raised concerns amongst fishers as a threat to access to tuna grounds (SE 29, 47, 48, local fishers) while the government positions itself as a lead player in the blue economy through this initiative (Schutter and Hicks 2019). Madagascar has developed many local conventions in managing its marine resources. However, while it has restrictions on species such as octopus, crabs and sea cucumbers, these restrictions do not address big pelagic species like tuna (MD 80, 81, government official and NGO representative). In the broader Indian Ocean region, however, yellowfin tuna species are considered overfished and currently under a rebuilding plan (IOTC 2015). The latter involves the reduction of catch by different fishing methods, from 5% to 15% from fleets' 2014 or 2015 catch levels (IOTC 2016).

² Similar comments were made by SE 24, 26 and 61.

Looking at rights-based mechanisms of access to tuna resources highlights the multi-layered facets of managing an international and mobile resource. In the current context of the blue economy where marine assets such as seabed resources or oil and gases are seen as holding important potential, African countries need to be aware of the legal framework and rights associated with such resources, especially in regards to access by foreign countries and entities. We will now show that tuna fisheries are shaped by more than the legal frameworks under which they are regulated.

Knowledge as key to locate the tuna and access the fishery

Ribot and Peluso (2003) see 'knowledge' as a category of access mechanism. This mechanism includes not only the direct influence of knowledge (e.g. fishing expertise) on who can benefit from resources, but also the role of control over information and knowledge in shaping access. The knowledge held by fishers has been recognized as contributing to a better management of fisheries through their contribution to local rules and institutions and by providing key information regarding the socio-ecological state of marine resources and ecosystems (Robinson *et al.* 2014; St Martin 2007). This knowledge plays an important role in how fishers perceive resources and the benefits provided, as well how they prioritize one type of management or another (Daw 2008; Hicks and Cinner 2014). For the case of tuna, two types of knowledge are key. First, there is the knowledge about the tuna itself. This includes knowledge about where which species of tuna is found at what period of the year. Second is the knowledge about the means to access the fishery. This includes knowledge about the licensing system or about accessing subsidies for equipment, fuel or upgrading of boats. This knowledge is generated differently by participants in the artisanal and industrial fisheries and is key in determining the amount of tuna that can be fished.

For artisanal and semi-industrial fishers, knowledge about tuna is gained through long individual experience, often over a period of five to twenty years as well as from information transferred among generations regarding the seasons, the warmth of water preferred by tuna, the area and distance where the tuna can be found. Amongst the 75 small-scale and semi-industrial fishers interviewed, 53 were able to provide knowledge about the location of the fish, seasonality or specific features and catchability of tuna in the EEZs.

Knowledge is not limited to so-called 'locals.' In the Seychelles, the semi-industrial fishing fleet is crewed mainly by Sri Lankans. Here, knowledge regarding tuna fishing is mainly produced by the Sri Lankan crew. Some boat owners (often former artisanal Seychellois fishers) consider the Sri Lankans as better seafarers for tuna and talk of their Sri Lankan crew members as having a more advanced knowledge on where and how to fish tuna compared to the Seychellois (SE 21, 42, 45, 61). They make statements such as "they look at the moon and know where the fish is going" (SE 42) or "they – the Sri Lankans – have fished tuna for many years in their country, their fishing technique is better, the catch is better with them fishing" (SE 45).

The transmission of knowledge is not just through experience and between individuals, but also through, for instance, fisher associations. These fora allow fishers to share their knowledge on fishing techniques and state of the resources or obtain knowledge on the latest developments in the fishery, like new legislation, licensing processes or potential subsidies (Belahy 2017, MU 24, SE 29, SE 47, local fishers).

In the industrial sector, knowledge about tuna's location and their biological characteristics is produced through numerous channels. There is first the experience of fishers. In the WIO region for example some Spanish captains of European purse seiners have been fishing in the region between five to ten years (MD 44, 45), accumulating knowledge about the migration pattern of tuna in the region. For foreign fleets operating in the region, technology also plays a key role in the production of knowledge regarding tuna. Vessels are equipped with various radars and screens that indicate where the fish are located from buoys and fish aggregating devices that have been placed during previous fishing trips. European fleets in the WIO also have access to their home countries' research institutes that are dedicated to producing knowledge regarding tuna based on catch data, observers on board and specific research activities on tuna behaviors. These research institutes – specifically the French *Institut de recherche pour le développement* (IRD) and the Spanish *Instituto Español de Oceanografía* (IEO) – both have offices focused on tuna fisheries in the Seychelles. The

knowledge produced is then shared with fleets and managers of the fisheries, via the ship-owner associations or the country representatives negotiating at the regional management meetings of the Indian Ocean Tuna Commission (IOTC).

This availability of knowledge to the foreign fleet raises the issue of equity with the artisanal fishery and national fleets. Fishing associations of artisanal fishers claim that industrial boats know exactly where the fish are and their quantity before they even leave the port. Members of a fishing association vigorously argued that "there is a substantive problem regarding access to the tuna as the purse seiners, before leaving the port, already appropriate the fish" (SE 29) or that "research on tuna is mostly funded by the industry, means that are not available to local fishers" (SE 47). This situation is perceived as an unbalanced access to knowledge that leads to unequal access to tuna resources.

Looking at knowledge using the framework of Ribot and Peluso allowed us to map the different actors that produce the knowledge needed to access tuna and its fishing. We also highlight the importance of control over knowledge not only in accessing more resources but also in shaping more general knowledge about the state of resources and in generating narratives of unequal access to them, often carried by the artisanal fishery. This control over knowledge will be an important issue for other activities of the blue economy in Africa, where local knowledge on the use of marine resources is only starting to be recognized and where there is currently limited production of knowledge regarding other marine assets.

Technology as a determinant of tuna catch levels

Technology, in Ribot and Peluso's (2003) framework, is a mechanism that can be used to improve access or restrict others' access. In terms of tuna fishing, we have seen above that technology plays an important role in the production of knowledge that in turn facilitates access. But technology also plays a direct role in getting to fishing grounds, catching fish, storing fish, and transporting them in larger quantities. The evolution of technology after World War II has been well documented as the main factor of a drastic increase in catch and an improvement of efficiency in fishing techniques (Pauly and Le Manach 2012; Sumaila *et al.* 2016). Technology has brought more powerful vessels, a diversification of fishing strategies and especially highly efficient fish detection devices (Torres-Irineo *et al.* 2014). Technology as a mechanism of access to the resource is therefore a central component for tuna fisheries in the WIO. Availability of technology is mainly driven by operators' capacity to access capital but also the socio-economic contexts within which they operate. Similar to the availability of knowledge, technology available in the two segments of the fishery varies considerably and impacts the quantity of fish that can be caught.

The role of technology in shaping access is important because extraction rates depend on the technology that is used. Table 3 summarizes the types of technology utilized by fishers in each of the segment of the fishery. The disparities between the three sectors are immense and the catch of the industrial sector much higher than the two other sectors.

In tuna fisheries, in addition to operators' ability to invest in technologies, the state also plays an important role in bringing capital in to provide technologies in the two segments of the fishery. In Madagascar, the small-scale fishers often have very limited technology available and can catch a limited amount of tuna. In Mauritius and Seychelles, provided their more favorable socio-economic contexts, artisanal fishers, in addition to their own capital and investments, receive assistance in the form of loans to buy boats and improve their fishing gears, or they have fish aggregating devices installed by the fisheries departments to increase their productivity (see section 6). Here being registered as a fisher through licenses is the key condition to access financial support such as free interest loans to buy gear and boats.

Segment and Technique	Boats	Equipment	Estimated catch in the WIO and source	
Artisanal handline and trolling	2m to 12m boats (wooden or fiber glass)	<ul style="list-style-type: none"> • GPS devices • 2 to 5 lines with hooks • Fish Aggregating Devices (in Mauritius) 	50mt/year (Seychelles)	SFA 2016
Semi-industrial Longline	12m to 34m boats	<ul style="list-style-type: none"> • GPS devices • Lines (of 20 to 100km) and hooks • Long view binoculars 	Up to 500mt/year (Madagascar) Up to 200mt/year (Mauritius) Up to 970mt/year (Seychelles)	Razafimandimby and Joachim 2016; Mootoosamy <i>et al.</i> 2017; Assan <i>et al.</i> 2017
Industrial Longline and purse seine	<ul style="list-style-type: none"> • 40m to 60m longliners • 80m to 110m purse seiners 	<ul style="list-style-type: none"> • Lines (of 20 to 100km) and hooks • Nets (1500m to 2000m) • Fish Aggregating Devices (FADs) • Sonars • Support vessels³ 	<ul style="list-style-type: none"> • 14,000mt for longliners • 300,000mt for purse seiner (for 2015) 	SFA 2016

Table 3: Types of technologies used in the three segments of the fishery and their recorded catches.

In the semi-industrial sector, access to improved technology has been a key policy. In Mauritius, a campaign in 2017 was launched by the Fisheries Department to help fishers buy semi-industrial boats in the form of loan by the Mauritian Bank and a grant by the State of up to US\$100,000 (4 million Rp), with the condition that fishers be part of an officially registered fishing cooperative. Five cooperatives out of eleven received this financial support in 2017 (GoMU 2017). In Seychelles, loans to purchase semi-industrial boats have been encouraged over the past 5 years. The number of semi-industrial boats have increased from 4 in 2006 to 29 in 2016 (Assan *et al.* 2017; SFA 2010). Financial solvency of the investors was the main criteria of accessing those loans (SE 60).

In the industrial fishery and especially for foreign fleets, investment in technology is high and state subsidies are available to ship owners. A global study of subsidies estimates that around US\$20 billion have been invested in 2009 by developed country governments in capacity-enhancing subsidies with around US\$5 billion for the EU and US\$3.5 billion for Japan (Sumaila *et al.* 2016a). Those include subsidies for boat construction, renewal and modernization programs or tax exemption through fuel subsidies.

The divide between the different segments of the fishery created by technology is clear. The domination of the industrial sector in the fishery is apparent. This is perceived by host countries and their local fishers as one of the main contributors to the overfishing of tuna resources in the region. Phrases like "there are too many boats and FADs in the sea" (MU 33, SE 19) were commonly heard from both fishers and processing companies.

Exploring the role of technology through the framework of Ribot and Peluso shows that technology is the mechanism of access that allows the industrial segment to benefit the most from the fishery. Technology

³ Vessels that help to locate the tuna and supply fuel to the tuna vessel.

in tuna fisheries enhances access to resources in terms of their physical distance, but also in the tangible quantity of resources gained. We also showed that the state, which can contribute to providing access to these technologies, plays an important role in providing capital to facilitate this access to the different segments of the fishery, and also in assisting the industrial sector in maintaining the same type of sophisticated access through provision of subsidies. In the context of a sustainable Blue Economy, the involvement of the state in providing capital and access to technology requires holistic thinking, especially on the level of investments made and the actual ecological impacts of such investment on ocean resources. As tuna fisheries show, investment in technology has been substantial without enough consideration of either ecological sustainability nor equity between local and industrial sectors.

Relations that provide access for hidden actors

The two previous sub-sections showed that accessing tuna requires different types of knowledge but also technologies. Here we will show that gaining, controlling, and maintaining access to particular parts of the tuna commodity chain is also very much about who you know, and how you interact with the actors in the tuna fishing arena. This is the central element of Ribot and Peluso's (2003) 'social relations' mechanism of access. Fishing in general and tuna fishing in particular is a social activity, in the sense that it involves diverse social relations of production, can encompass the creation of social networks, often requires effective communication between fishers, and can create connections or social conflicts between the different segment of a fishery (Barclay 2010; Barnes *et al.* 2016; Voyer *et al.* 2017). As presented in Ribot and Peluso's theory of access (2003), social relations can include complex relations of friendship, trust, patronage, reciprocity and dependence. In the WIO tuna fisheries, in each segment of the fishery and up and down the value chain, these relations determine who controls labor opportunities and improve or limit actors' access to tuna markets. We give two examples of relations that allow locals of host countries to access tuna fished by the EU-run industrial sector. Those relations take place at two stages of the commodity chain, at production when fish are caught, and at processing, when they are landed for canneries. We found that at those two stages, some local actors play a non-negligible part in resource access, without much recognition in other studies of tuna fisheries.

First, patronage relationships exist between locals of the WIO and EU fishing firms. In the industrial fishery run by EU companies, Fishing Access Agreements establish labor opportunities for nationals of host countries. The crews of industrial boats are comprised of a majority of Europeans as well as nationals from developing countries. A typical purse seiner fishing in the WIO region would include Spanish or French together with Senegalese, Ghanaian, Ivorian, Seychellois or Malagasy crew members. This diversity of the crew is legislated by the Fishing Access Agreements within which a percentage of the crew must come from African, Caribbean and Pacific (ACP) countries including the host countries where the fishing takes place (Goulding 2016; Macfadyen 2015). In the Indian Ocean, an average of 700 ACP nationals are annually employed by the EU tuna fleet (Macfadyen 2015, annexes), of which around 200 are operating in the WIO (POSEIDON *et al.* 2014).

Those non-EU crew members have resource access through their jobs, depending on fishing companies for contracts and gaining a financial benefit through wages rather than fish. When those working on EU vessels for more than five years were asked about their compensation, many of them responded that they were satisfied by the wages and work conditions they had, against what they can make in their home countries but not compared with the profits of the fishing companies (MD 42, 46, 87 – Malagasy, Senegalese and Ghanaian crew members on Spanish vessels). Sentences like "I make a good living compared to what I can earn at home" were common amongst the non-EU crew along with "In the end it's the big bosses sitting in Madrid that make the money, we are only fishers, we do not gain much." They were often performing non-specialized roles on tuna vessels. Therefore, despite the labor opportunity they get, their wages are much lower than EU nationals on board, estimated at around 7 times less (Campling 2012b). Similarly, while wages are usually considered a substantial operational cost for EU vessels (amounting around 30%), the EU fleet in the Indian Ocean, including in the WIO has been evaluated as highly profitable, generating more than US\$100 million in gross profit for 2016 (Carvalho *et al.* 2018). Non-EU crew members play an important role

and help to generate these profits, gaining more revenue than other home-based fishers and yet less than EU crew members.

Secondly, another labor opportunity that foreign fleets provide is stevedoring at the port. In Madagascar, landing boats employ local stevedores to unload the fish to the canneries. In this process, non-tuna species, and damaged or undersized tuna are given or sold to them at US\$0.1/kg, on top of their wage (USTA 2017). With an average landing of 480t/year, these fishes are then sold at the port by stevedores every evening of landings at US\$1 to US\$1.5/kg (USTA 2017). The socio-economic context in Madagascar means wages for these positions are not very high (less than \$US2/hour according to MD 04, government official), so the 'real wage' includes the sale of fish they are offered. The importance of these local market events has made access to these jobs a very competitive business, requiring stevedores to build personal and economic ties with those holding authority at the handling companies, including through financial gifts (MD 04, 36, government officials). This supply of fish is seen by some as unwanted competition to local tuna fishers (SI 01, NGO representative), and by others as a welcome source of cheap fish in a city with a high cost of living (MD 05, 39, local residents of Antsiranana). One resident emphasized that "the coming of tuna from the big boats periodically regulates the price of all goods in Antsiranana. Without this tuna, everything remains at high price the whole year" (MD 05). Local fishers, asked about this competition, acknowledged a decrease in price of locally caught tuna when the industrial ones are landed. However, they considered this was manageable as they could still sell their fish, and the competition was only a couple of months a year (MD 24, 26, local tuna fishers). The stevedores are, in the North of Madagascar, an important but easily neglected part of the tuna fishery scene, supplying the local market. They also change the perception on the industrial 'unwanted' tuna to an economically local 'needed' fish. Labor, and reciprocity through diverse social relations, are a key mechanism for different actors to gain access to the tuna value chain at sea or at port.

We have highlighted the diverse and often unseen actors in the fishery, and the social and labor relations that allow them to access and obtain benefits. As provision of jobs constitutes one of the pillars of building Africa's blue economy, less visible opportunities need to be accounted for appropriately. As seen in tuna and fisheries in general, the indirect value of fisheries is still vastly underestimated, at least in the WIO (Obura *et al.* 2017). This is important for new ocean related projects that aim to improve labor opportunities for African populations.

6. A materiality-infused theory of access

We will now illustrate the role of materiality in access to tuna resources. We will do so with two examples. One highlights the influence of the geographical configuration of the sea and the migration of tuna for resource access. The second will show how technology and practices produce a new materiality of tuna. We will end the section by presenting the mapping of access to tuna resources in the WIO under our materiality-infused theory of access.

Spatiality and movement

Tuna fishing takes place in waters that are ecologically distinct (from near coastal reefs to deep water), carved into particular geo-political and economic territories, through which the different species move and circulate. Tuna move within high seas, with an open access regime, and also within the legally defined space of EEZs between countries of the WIO region. Tuna become the property of different nations when they pass into their EEZs, and in effect become fugitive resources as soon as they move and are caught in another EEZ (Giordano 2003). This pushes host countries to profit from them before they move on. One government official commented "the resources move beyond our waters, if they are not fished in our waters, they will be fished elsewhere, it will be a loss for us" (MD 02). This situation is different when fish reach the high seas. As there are no access rules or property regime applicable here, fishing vessels are free to catch tuna without any specific regulation. However, they are constrained, when full, by their need to land and transship at the closest ports, which in the WIO are in Victoria, Antsiranana, Port Louis and Mombasa, far from the high seas (MU 30, government official; MD 42 and SE 66, industrial fishers). Catching fish in the high seas still requires going back to ports in order to respond to canneries' demands. Industrial fishers interviewed that were landing

in Madagascar for example made statements such as "if we fish in the Mozambique channel, we land in Madagascar because it is closer and we can go back fast at sea, it gives us more time to fish" (MD 42) or "we fish in the EEZs and in the high seas, we land and transship where it is the closest for us, it could be in Madagascar, Seychelles or Mauritius" (MD 45).

The imagined political boundaries of the sea are, however, not respected by mobile tuna. Skipjack for example are found in the waters of Madagascar and Seychelles between March and June, gather in the waters of Seychelles between June and October then travel to the waters of Madagascar between November and February. Other species can be found all year long in different countries' waters or undertake circular migration. Yellowfin and bigeye tuna for example are found in the coastal waters of Madagascar, Mauritius and Seychelles between April and December and further offshore between November and March. Coastal tuna are also present all year in the coastal waters (Davies *et al.* 2014; Fonteneau 2014; analysis of authors).

Tuna has a hybrid spatiality, in which fish migration traverses geopolitical boundaries. This makes access mechanisms highly diverse in terms of the actors and content. Here, tuna is an agent that deterritorializes established legal access boundaries. It forces foreign fishing vessels to negotiate access with different host countries of the WIO to catch the same school of tuna. It also gives power over controls on access to the coastal states in the EEZs, but only until fish move to the high seas.

Co-produced tuna spatiality

Tuna are undisciplined and mobile, and can be a productive resource one year and not in another. Their materiality is produced by fishing practices. That can be illustrated by two cases in the WIO region: the use of Fish Aggregating Devices (FADs) and piracy.

In the Indian Ocean, 30 to 50% of purse seine catches are made using FADs (Dagorn *et al.* 2013; Kaplan *et al.* 2014). FADs are manufactured floating objects that attract fish. They can be anchored (consisting of a float, mooring line, anchor and some type of underwater structure/attractant) or drifting (made of a floating structure such as a bamboo raft or using naturally occurring floating objects such as logs). They are accompanied by locating buoys and sometimes an echo sounder that can predict biomass (Dagorn 2012; Pew 2011). The use of FADs has been adopted as a fishing practice from an understanding that fish are naturally attracted by floating objects for protection against predation, for food, association or protection of eggs and larvae (Castro 2002; Dagorn 2012). FADs are used in the industrial and in the artisanal sectors. In tuna fisheries they are mainly used by the purse seine industry. It is estimated that around 7,000 units were deployed by purse seiners in the Indian Ocean in 2010, rising to 14,000 in 2013 (Pew 2015).

While they increase productivity and facilitate the localization of the fish, their impact on the ecological behavior of the fish is debated. There may be higher risks of overfishing for some species such as skipjack, because of the aggregation of juveniles under FADs or the disruption of the fishes' natural search for food, hence altering migration patterns (Davies *et al.* 2014; Pew 2015). Tuna could be attracted to FADs in areas of otherwise poor conditions, changing their natural movements as well as impacting their growth (Dagorn 2012; Davies *et al.* 2014). The use of FADs has therefore produced another type of tuna materiality, changing migratory behavior and even biophysical traits. Interactions between fishers and tuna through FADs co-produce materiality that increase the catch, reduce the extent of tuna agency, and modify fish traits.

Another practice that had an impact on the materiality of tuna in the WIO is Somalian piracy. Between 2005 and 2009, piracy was rife in the Indian Ocean, preventing many industrial vessels from fishing safely (Chassot *et al.* 2010). IOTC Reports note that the tuna catch shrunk in the region during the piracy period and that Somalian piracy could have been one of the causes of this decrease in catch and reduction of active vessels (e.g. IOTC 2012: 38; IOTC 2014: 38).

Since 2011, however, the production of tuna has steadily increased in the region (IOTC 2016a). Between 2010 and 2016, the number of purse seiners operating in the WIO increased by 53%. In addition, the number of supply vessels that help locate the tuna increased from 7 in 2010 to 26 in 2016 (MU 33, processing company representative). Interviewees confirmed this anecdotally, for instance: "there is a lot of fish in the canal this year, because of the pirates, the resources could rest and rebound" (MD 42, industrial fisher) or "the piracy had a major impact in reducing the numbers of boat coming in the WIO region" (SE 31, government

official) and "the piracy events between 2008 and 2012 almost closed the fishing which relieved the pressure on the resources" (SI 02, government official). The health of the tuna stock can then be influenced by socio-political practices such as piracy taking place far from the national waters. The frantic race to fish since controls on piracy were implemented since 2009 could be one reason why the yellowfin tuna stock collapsed in 2015 (SI 02).

Those two examples illustrate how intrinsic and co-produced materiality can shape the benefits from the fishery, notably the quantity of tuna resources. In any Blue Economy initiative, the role of non-humans will be a key aspect, be it the seabed, the characteristics of oil and gas, or the movement of species between territorial boundaries. As we have demonstrated here for tuna fisheries, involvement with the ocean and its resources without much attention to its materiality can result in unexpected (and more likely, negative) impacts on resources and the marine ecosystem.

Looking back at the theory of access and the importance of material conditions, we argue that materiality requires more attention, particularly for mobile resources, migratory species, and the marine space. We suggest enhancing Ribot and Peluso's theory (2003) by making the role of materiality and its hybrid origins more obvious when mapping access. This could be done at all three stages: linking materiality to benefits received, considering the role of access mechanisms in producing materiality (through co-production), and examining how biophysical and socially constructed materiality shape power relations (Figure 4).

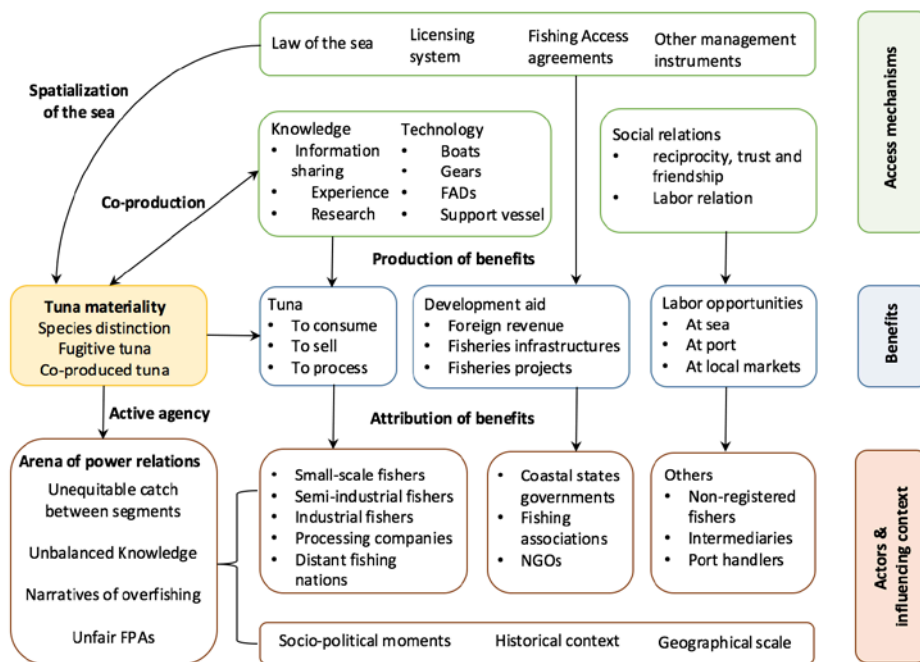


Figure 4: A mapping of access to tuna fisheries in the WIO, integrating materiality.

7. Discussion and conclusion

Using Ribot and Peluso's theory of access (2003) to explore tuna fisheries in the WIO gave us a deeper understanding of the array of actors behind the fishery, their interactions, and the different power relations that form through the different mechanisms of access to tuna. Exposing right-based access mechanisms showed that beyond direct revenues from the fishery, a range of indirect actors from intermediaries to port workers and coastal community members also benefit. Rights-based mechanisms are also a source of geo-political interactions between countries that can influence aid and development trajectories. Analysis of structural and relational mechanisms showed that access to the benefits of tuna fishing is shaped by composite

knowledge, advanced technology and a multiplicity of social relations, generating power relations that are not fixed or permanent. Actors, through various mechanisms, depending on the socio-political contexts and the interactions, have power over the resources at specific temporal and spatial scales. Countries and their fishers benefit from labor opportunities and development aid that the fisheries bring, as well as their contribution to food security. However, in the broader picture, the distant fishing nations and especially their powerful fishing firms are the ones who accumulate the majority of the benefits by harvesting large amounts of tuna. Our study is a 'reality check' on how ocean-related activities create situated winners and losers from the current way of extracting marine resources. Other Blue Economy activities will face even greater challenges if African countries rely on the same model of resources use, mainly dependent on foreign actors for exploitation and with limited knowledge production.

Looking back at Ribot and Peluso's theory of access, we can also say that for mobile resources and especially tuna, materiality plays a substantial role in the co-production of benefits and mechanisms of access. It infuses the different steps of the mapping of access and gives tuna an active role in determining how the fishery takes place across the various spatial boundaries of the Western Indian Ocean (Figure 4). Ignoring the biophysical specificities of tuna contributes to contestations between fishing actors who may not always be talking about the same species. The movement of fish across various jurisdictions requires actors to negotiate and control access to them, but that control is lost in the high seas. It has also prompted access by more powerful actors through advanced technology. In the current Blue Economy framework, measures addressing sustainability of tuna as a resource must control access in the EEZs but also in the high seas that are currently in an open-access regime. Materiality can constitute and mediate power relations, making different actors – small scale/industrial fishers or host countries/distant fishing nations, at different spatial scales – competitors, negotiators or protestors over resource access.

It is also evident from this case that using the theory of access can be difficult in a multi-scaled study. One of the challenges is in introducing the role of geopolitics in shaping access and influencing mechanisms of access. To use the theory requires a careful attention to the question of scale. However, it offers several clarifications to often-overlooked aspects of tuna fisheries and could be helpful in making discussions of access to similar types of resources more mindful of the entanglement between human and non-human actors, and the heterogeneity of means of access involved.

Despite the potential that other Blue Economy activities present in and around Africa, tuna remains essential to the economies of the island nations of the WIO, especially in vulnerable countries like Madagascar where there are few alternative revenue sources. Questions of access to tuna are important in building the blue economy of those countries. If the goal is to attain economic development and sustainability, the interests of all parties should be taken into consideration, including those of the tuna species in the WIO region. Management of tuna needs to be a co-production by humans and non-humans that considers the spatial implications of their mobility, and the situated relations of power that take place at different geographical scales.

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