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TRANSFORMATIVE INNOVATION POLICY CONSORTIUM

TRANSFORMATIVE INNOVATION LEARNING HISTORY

Opening spaces for sustainability transitions from public institutions: the case of the Mayan Octopus industry (Yucatan)

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1. Introduction

This study shows the emergence of new framings in public policies and actions in the socio-technical system of the Octopus fishery in the Yucatan peninsula. The socio-technical fishery system in the region is subject to growing socio-economic and environmental pressures that threaten both the sustainability of the fishery resource and development opportunities for local communities. The study focuses on the case of the Mayan octopus, one of the high value endemic species in the region that has often been a source of conflict between fishermen. Its sustainability is in high risks because it has been overexploited and faces other environmental threats. The study identifies a set of recent government interventions to support the sustainability of the fishery based on some Science, Technology and Innovation (STI) activities. These activities have opened participatory spaces for discussion, learning and reflection, to highlight the lack of sustainability of dominant practices in the socio-technical system of the Octopus fishery and propose some alternative changes. The findings of this case provide some transformative elements that might facilitate the transition to a new regime for the socio-technical fishery system. These elements address both the sustainability of the Octopus fishery and environmental protection of the aquatic life, as well as improvement in the economics and working conditions of the fishermen involved in the regional activity.

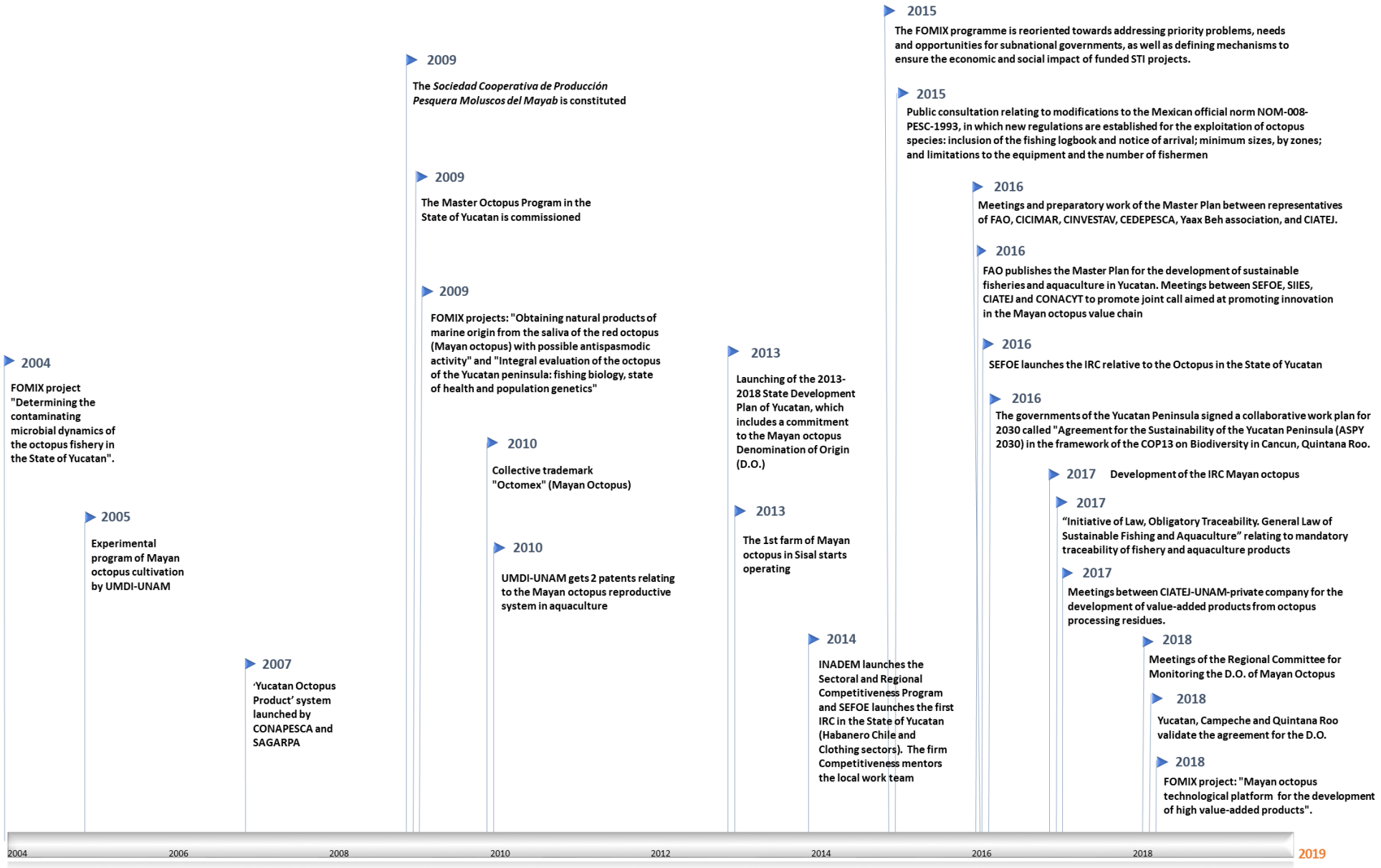
The case study was based on several documentary sources: 1) Analysis of documentary sources provided by the National Council for Science and Technology (CONACYT), the Development Agency of the State of Yucatan (ADY) and the Centre for Research and Assistance in Technology and Design of the State of Jalisco (CIATEJ). These sources include public plans and programmes, the Federal official bulletin, reports, meeting minutes and newspaper articles (mainly local ones); 2) A participative workshop on April 24, 2018 in Mérida (Yucatan), where approximately 25 representatives of the federal government, state government, R&D regional centres, companies and cooperatives. The aim of the workshop was: a) to present and discuss the conceptual framework of transformative innovation, which guided the research case; b) to reconstruct the history and the main elements of the case were reconstructed; and c) to discuss the transformative aspects of the case. A dozen of interviews (face-to-face and by phone) with other key actors were also carried out in the period comprised between March and September 2018. On April 25, 2018, the research team visited to the CIATEJ facilities in Mérida and a processing company in the fishing sector located in Progreso. On August 21, 2018, the research team visited the Multidisciplinary Teaching and Research Unit (UMDI) of the National Autonomous University of Mexico (UNAM) located in the Sisal Campus. Some of the case participants are cited in the contributions to the authorship of this document. The authors acknowledge all of them, as well as to the other interviewees and the participants of the workshop, for the time they have dedicated to this study.

2. Highlights of the Mayan Octopus case:

1. The case study identifies the proposal to move away from a fishing system operating on a massive scale to a ‘differentiated’ production system, which considers criteria such as product traceability and quality and safety procedures, as well as the promotion of healthy and differentiated eating habits. In this sense, the differentiated segments of the Octopus industry would constitute technology niches that could be the object of specific transformative innovation policies and programmes.

2. Although STI policies and actions for the Mayan octopus have mainly used the traditional approaches to R&D, regional systems, sectoral clusters, and entrepreneurship, they have also managed to open participatory spaces for discussion, reflection and learning. Actors have identified potential technology niches for transformative change and signalled the opportunity to move towards a new regime for the fishing industry.
3. In particular, the evolution of CONACYT's Mixed Fund programme (FOMIX) towards an approach guided by the needs of local users and State actors opened spaces for new initiatives with some transformative potential (see section 3 – Main government interventions on the Mayan Octopus fishery, Table A1 – Timeline and Box 1).
4. The Mayan Octopus case is the result of the participation and collaboration between different types of actors in the system, based on a kind of process of 'collective learning'. However, some of the actors (e.g. fishermen) seem to have remained more on the margins of this process.
5. The case participants perceive environmental sustainability as necessary for economic development and the urge to improve the living conditions of local communities.
6. Academies and R&D centres, including programmes involving university students, seem to have the capacity to train and mobilize civil society in local contexts where the latter is fragmented, marginalized or has limited space for action and decision-making.

3. Basic Timeline



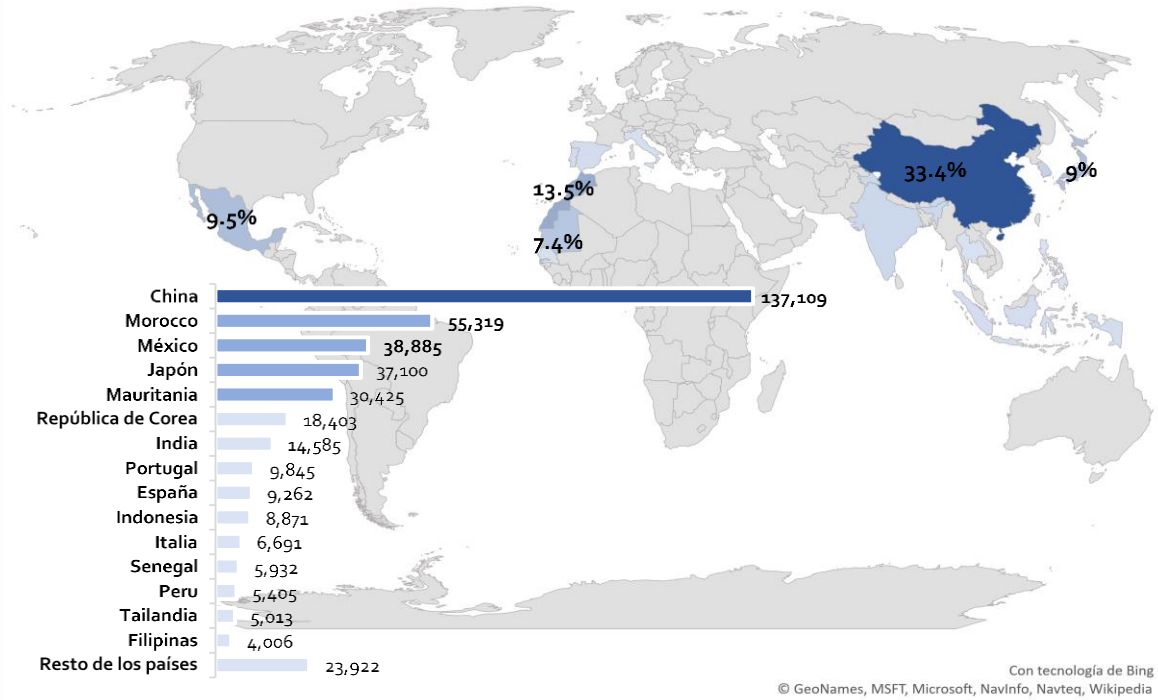
4. The socio-technical system of octopus fishing in the Yucatan peninsula

4.1. Description of the system

The socio-technical system of the Mayan Octopus can be conceptualised as part of the broader socio-technical system of production, distribution and consumption of the fishery resource, hereinafter referred to as the 'fishing socio-technical system'. Mexico is one of the world leaders in the production and export of fishery products (by volume and value added). During 2016 fishing and aquaculture in Mexico obtained a production of 1.73 million tons in live weight, with a value of 35,880.9 million pesos (MDP), of which octopus represented 2.2% with a value of $1,235.8 million pesos. For octopus fishing, Mexico ranks third as producer in the world and first in the continent (Figure 1). The figures relating to octopus fishing over the last decades have fluctuated greatly, although with an upward trend (FAO, 2016). This irregularity would derive mainly from natural phenomena such as the so-called "red tide" produced by specific algae, as well as by modifications in the demography of the species and the corresponding institutional reactions through reforms of the permitted fishing periods and minimum fishing sizes.

In the transition literature, a socio-technical system is composed of various elements and resources encompassed in the production of artefacts, and the distribution and use of technology. A socio-technical system refers to the linkages between different elements necessary to satisfy a social function (e.g., transportation, communication, or food). However, these systems function only because of the activities of humans, who belong to diverse social groups that share certain characteristics (norms, roles, responsibilities, perceptions…) (Geels, 2004).

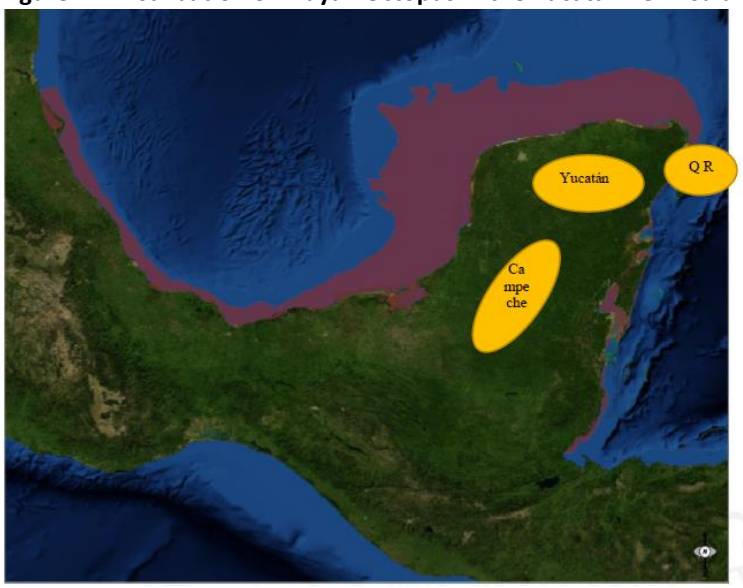
Figure 1 – Shares of octopus production by country (2016)



Source: elaboration by Ariana Couoh (CIATEJ) with data from Fisheries and Aquaculture Information and Statistics Branch, FAO

Octopus fishing is an essential resource and economic activity for the three States of the Yucatan peninsula: Campeche, Quintana Roo and Yucatan, the latter having the highest share of the national production. In this region, fishing is concentrated in five groups of species of high economic value: octopus, lobster, grouper, red snapper/*bargos* and sea cucumbers. There are two Octopus species in the peninsula: Mayan or "red" octopus (*Octopus maya*) and common or "*patón*" octopus (*Octopus vulgaris*). The Mayan octopus is the most important species for the fishery; it is endemic to the Yucatan peninsula and distributed from the waters adjacent to Isla del Carmen in Campeche to Isla Mujeres, Quintana Roo (Figure 2). Therefore, it is present along the entire coast of the State of Yucatan, almost the entire coast of the State of Campeche, and the northern coast of the State of Quintana Roo. The fishing, processing and distribution practices that will be discussed are similar between the two species. The main difference is that the fishing gear for the common octopus is by means of larger boats since it is found in deeper waters. The Mayan octopus, however, can be fished by means of larger or smaller boats, but in mostly coastal and shallower waters, given their very different biological characteristics of reproduction and growth. Besides, the international market requests more frequently the species of Mayan octopus in comparison with the common octopus because, given the fishing method, it is fresher (a larger boat can be at sea for at least a week).

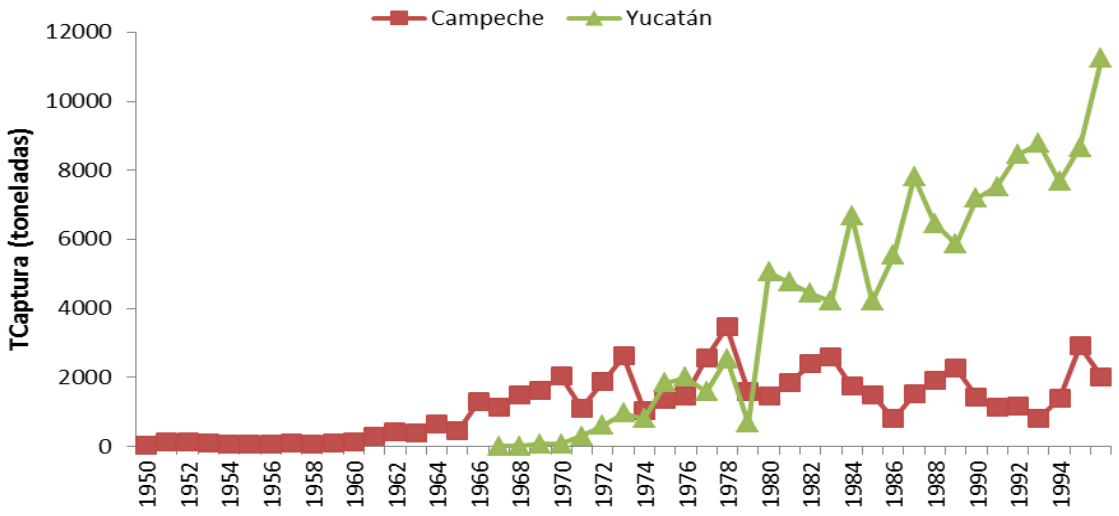
Figure 2 – Distribution of Mayan Octopus in the Yucatan Peninsula



Source: FAO-GeoNetwork

Massive commercial octopus fishing began in the State of Campeche, on the Yucatan Peninsula, in the late 1940s (Solís-Ramírez, 1975). Then, in 1970, there was a decrease in fishing in the State of Campeche and fishermen raided the waters of Celestún, within the State of Yucatán (Solís-Ramírez, 1967; 1975). Before the 1980s, the growth of octopus exploitation was quite moderate, but in 1982, the semi-industrial fleet of the State of Yucatan entered the octopus fishing industry and contributed substantially to an extension of capacity. Octopus production in Yucatan State has grown considerably since the mid-1980s, whereas this has not been the case for Campeche (Figure 3). The figures for the subsequent period followed a similar trend. Figure 4 shows the evolution of fishery production for the Yucatan State.

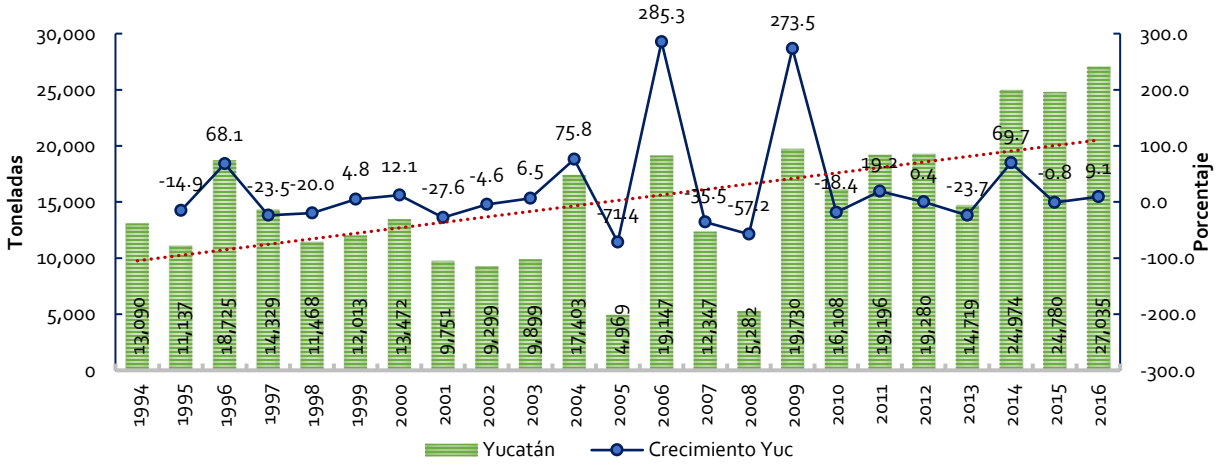
Figure 3 – Production of octopus in Campeche and Yucatán (1950-1996)[1]



Source: Fishing Sub-branch, SAGARPA, in Yucatán and Campeche (2018)

In 2016, the State of Yucatan contributed 27,034.5 tons of octopus capture to the national total (69.5%); together with the 9,459.7 tons (24.3%) of Campeche and the 199.2 (0.5%) of Quintana Roo, this is 94.4 % of the national production, for a total value of 1,149.3 million pesos (CONAPESCA, 2018). In the case of the Mayan octopus, the volume caught in Mexico in 2016 was 25,722 tons, representing 66.1% of the total species of octopus (FAO, 2016). In 2014 (last year for which these data are available), Yucatan caught much more Mayan octopus (15,224 t) than common octopus, while in Campeche and Quintana Roo much more common octopus than Mayan were caught: respectively, 8,356 t and 137 t of common octopus compared to 78 and 101 of Mayan octopus. This data points to the greater relevance of the Mayan octopus for the State of Yucatan (CONAPESCA, 2018).

Figure 4 – Evolution of Octopus production in Yucatan 1994-2016

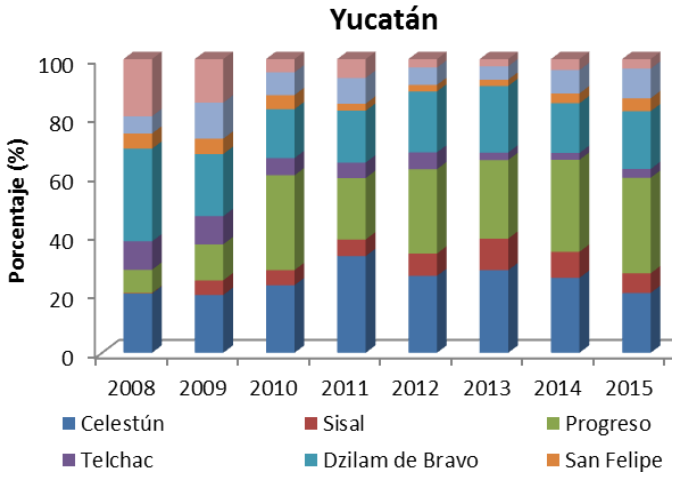


Source: elaboration by Ariana Couoh (CIATEJ) with data from CONAPESCA (2018)

[1] A similar historical series has not been found for Quintana Roo where, in any case, the volume of octopus capture has been significantly lower than that of Yucatan and Campeche over the last few years.

Within the State of Yucatan, there is also an unequal distribution of the importance of fishing (Figure 5). In 2008-2015, three of the eight main fishing localities stand out: Progreso, Celestún and Dzilam de Bravo, with a slight decrease in the percentage of fishing in Dzilam de Bravo and an increase in Celestún and, more significantly, in Progreso over the years. These three areas together contributed 70% of the total fishing volume obtained in the State of Yucatan, with an average fishing of 2640, 2450 and 1970 tons of octopus respectively (SAGARPA, 2018).

Figure 5 – Percentage of fishing of Mayan octopus taken in the different fishing zones of Yucatan (2008-2015)



Source: Fishing Sub-branch, SAGARPA

This system fulfils a key function for the territory and the community in Yucatan: providing an essential economic sustenance for the population through capturing and selling the fishing resource, e.g. the octopus. Fulfilling this function, it also maintains a link between the human population and the marine fauna, including knowledge related to the sea, navigation and fishing gears. This system is part of the lifestyle and the social and cultural identity of a considerable part of the coastal population of the Yucatan peninsula. [Researcher's Reflection]

Actors

In the socio-technical system of octopus fishing, different types of actors participate, positioned in different links of the value chain. In terms of fishing activities, there are two types of fishing fleets: the smaller fleet and the mid-water fleet, the former being the most numerous (Table 1). Fishers can also be divided into: a) free fishers who have a fishing permit and have their own vessel, b) fishers who are part of a cooperative, or c) fishers who work for a permit holder. The number of fishers and permits is very unevenly distributed among the three states on the Yucatan peninsula, with the State of Yucatan having the highest number (Table 1). However, there is no accurate information on how many fishermen are officially registered and how many are operating in the activity, either occasionally or full-time, permanent or pendular, according to the fishing seasons. An updated census of the population operating in the region is required, characterised by the type of activity they carry out (divers, engineers, fishermen, etc.). The fishermen can work on their own, in a cooperative, or on behalf of a permit holder. To these must be added the suppliers of boats and fishing equipment, who also play a relevant role.

Table 1 – Economic units Involved in production activities in the Yucatan Peninsula

	Mid-water fleet		Smaller fleet		Fishermen
	Permit holders	Boats	Permit holders	Boats	
Campeche	379	10	10	1,749	5,000
Quintana Roo	-	-	18	323	690
Yucatán	70	385	220	3,372	12,000

Source: National Fishing Chart (2017: pp. 83)

Moving forward in the value chain there are market intermediaries and the freezing, processing, transformation, logistics and transport companies. For example, in the State of Yucatan in 2016 there were 62 freezing and processing companies that employed 828 employees; 23 exporting companies, 19 of which had certificates to export to the EU and 18 of them to China; 25 supplier companies and 58 logistics and transport companies (SEFOE, 2017). Then, there are commercial intermediaries, customs agents and representatives of foreign importing companies, until reaching the final consumer through self-service stores, supermarkets, restaurants, hotels, small traders, etc. Since more than half of the volume of production is destined for the external market, the system extends beyond the borders of the State or the peninsula, encompassing actors that operate nationally and even internationally (in 2013, 56% of production went abroad; SEFOE 2017).[2] To all these should be added actors both from the institutional sphere (local and national government institutions, universities and other research centres) and others belonging to civil society (local media, environmental associations, fishing families, workers and entrepreneurs, etc.) involved in different ways in the activities of the system, both formal and informal. Finally, Octopus consumers (in Yucatan, Mexico and the rest of the world) are also part of the socio-technical system, although they are often located close to its borders.

Systems of relationships

Today, the octopus capture in the Yucatan peninsula takes place from August 1st to December 15th of each year, according to the Law NOM-009-SAG/PESC-2015. Octopus fishing is carried out exclusively during the day, using the "*gareteo*" method, originally developed in the State of Campeche. This method consists of leaving the boat adrift, dragging monofilament lines or ropes where the bait (consisting mainly of crab – Callinectes spp. – and spider crab – Libiniadubia) is held (Arreguín-Sánchez et al, 1987, Solís-Ramírez 1962, 1967, 1991, 1994, Solís-Ramírez et al., 1997). This fishing method particularly protects females that have spawned, because they are less likely to feed. Thus, the fishing method used in the Yucatan Peninsula (if it respects official regulations) is considered a relatively sustainable method, because it allows the capture of more males than females, in addition to protecting the females that are taking care of the laying.

The next stage refers to the activity of landing and unloading the captured product, this is where the classification of the product is made depending on its characteristics. In general, in this stage the main activities are carried out in order to obtain the traceability of the product along the chain. A large percentage of free fishermen, cooperatives and permit holders who market their products do not have the infrastructure for freezing and preserving the product, which allows them to expect better prices for its sale. The only process that the latter carry out is freezing for delivery to the next link.

[2] A mention apart should be made about the '*pacotilleros*', small intermediaries who usually buy marine products directly from boats in small quantities, offering a small surcharge compared to the value paid by large wholesalers or even by fishing cooperatives. Its market is mainly regional and national (Pedroza, 2013).

Subsequently, the collection centres and/or industrial companies receive the raw material gutted for the most part, only a few ones buy the octopus with viscera. From this, the transformation process related to the product is carried out. The cooperatives are responsible for marketing the product mainly to the freezers and large wholesalers located mostly in Progreso and Merida (State of Yucatan). However, they are also used to sell the product in retail and medium wholesale to small intermediaries. Once the product is reported to the buyer, who will industrialise it, the latter proceeds to classify it by size, in order to carry out a more specific product quality control. The octopus usually arrives gutted and fishermen are asked to bring it in plastic bags and between ice sheets. This helps maintain the freshness of the product. However, this step is optional and will depend on the requirements of the customer to whom the product is addressed. In this way, each piece is separated and individually bagged for subsequent freezing. Once it arrives at the plant, the octopus is classified according to its weight. It is then placed in iced water and processed directly.

> "Fishermen are the most affected, as the final sale value is not reflected in the price paid to them. There is a 'beach price', which is set day-by-day according to demand and supply, and it is the same price that runs along all the beaches, but this price is usually very low and is independent of the price of the processed product. If the processing companies sell the most expensive octopus, this value is not reflected in what is paid to the fishermen". [Member of a cooperative]

The companies dedicated to transformation are usually family MSMEs. The main process they use is that of freezing the product and selling it directly, which is the most basic process. Some other companies also carry out processes to cook, beat, intubate or eviscerate the octopus. In this way, the main presentation that the companies have been implementing is the raw frozen product. Other presentations are whole-cooked, intubated octopus, "beaten in flower", presentations in individual packaging or by boxes. The domestic market requires a more elaborate presentation (cooked), while, in exports, buyers only require the octopus gutted in bulk, since they are responsible for adding value to the product. Japan receives the octopus from Mexico, processes it and sends the transformed product to the United States. Something similar happens with Spain. The process is usually carried out by commercializing companies or retailers of fish products. Some freezing plants, especially those located in the area of Progreso, Yucalpetén and Mérida, have specialised workforce in filleting and boning, although very few companies add value to the product, because the automation of processes does not add value. However, during the last three years and as a result of the demands of international clients, the certification process for freezing plants has been increasing, as well as for larger and smaller boats in good on-board handling practices that guarantee product traceability. For example, the European Union requires that products comply with a Certificate of Conformity of Good Health Practices.

Logistics plays a decisive role in guaranteeing the efficiency of the value chain. The main technology used refers to freezing systems, and the relationship between their efficiency ($ / time / kilo) and the quality and price of the product. International buyers usually arrive in Yucatan in July with the aim of negotiating with producers and closing purchase deals. It is a comfortable situation for industrial entrepreneurs, because there is a constant demand from Europe and Asia in recent years. This is a standard channel where there are hardly any alternatives: the customer pays and sends the containers; the exporter packs the product; the trading company (if it is not the same company) transports the containers to the point of shipment. The containers then pass through customs, stevedoring and shipping. Most of the production goes to the international market, where producers can get a higher

price. The main destinations are usually Europe (Italy, Spain), Asia (South Korea, Japan) and the United States of America (USA). In particular, the USA and Japan tend to purchase mainly unprocessed octopus. The demand for octopus is growing and changing to new consumption trends, which increasingly value the endemic characteristics of the resource, sustainability and traceability. Due to fixed international customers, mainly from European and Asian countries, there is a constant demand.

> "Normally the product that stays in the national market is the one that does not fulfill the requirements for its sale in the international market. It is a product of lower quality." [Executive a processing company]

4.2. The role of public policy in the system

This session briefly traces the evolution of public policies around the fishing industry over the last few decades and discusses the role they have played for the socio-technical system of fishing.[3] The commercial exploitation of octopus in the Yucatan peninsula began in the 40s and 50s. However, only at the end of the 60s the first formal policies for its promotion were undertaken, such as the creation of the shelter port of Yucalpetén (1968) or the first establishment of an annual closed season for octopus (from November 16 to July 31) to protect juveniles and females during the incubation of eggs.[4] Another early milestone was the foundation of the first Regional Fisheries Research Centre (CRIP) in Yucalpetén (1978) by INAPESCA, with the objective of – among others – favouring an entrepreneurial vision oriented to the export of fish products.

> The relationship between sub functions and resources on one hand, and social groups on the other hand, is inherently dynamic. The configuration of social groups is the outcome of historical differentiation processes. Over time, social groups have specialised and differentiated, leading to more fine-grain social networks (Geels, 2004: 901).

In 1986, Mexico became an effective member of the General Agreement on Tariffs and Trade (GATT), allowing it to enjoy all the tariff concessions negotiated by the other members since the entry into force of the General Agreement in 1948. Along these lines, at the beginning of the 1990s, direct actions were developed to favour the export of fishery products in the Yucatan peninsula. In the first place, the National Program for the Development of Fishing and its Resources (1990-1994) was drafted, which marked as a line of action the promotion and consolidation of collaboration and exchange links between Mexico and the (then) member countries of the European Economic Community (EEC). Along these lines, the NOM 008-CFSP-1993 standard came into force to order the exploitation of octopus species (Octopus Maya and Octopus vulgaris) in the waters under federal jurisdiction of the Gulf of Mexico and the Caribbean Sea, as well as towards the certification granted by COFEPRIS to fishing plants to allow exports (1994). On the other hand, in 1993, Mexico had joined the Asia-Pacific Economic Cooperation Forum (APEC), an event that accelerated the opening of the Asian market to Mexican fisheries exports. Then, in 1994, Mexico was accepted as a member of the Organization for Economic Cooperation and Development (OECD) and the North American Free Trade Agreement (NAFTA) entered into force. The

[3] Box A1 (Annex) shows a list of the main institutions, while Box A2 (Annex) lists the main rules and norms governing fishing activity.

[4] Subsequently (1984), the closure period was shortened in 1984 to December 16, but a minimum fishing size of 110 mm was established (Solís-Ramírez et al., 1997).

important result of these actions was the beginning of export operations of fishery products from Yucatan to the markets of Asia (from the port of Veracruz) and Europe (from the port of Progreso), respectively in 1994 and 1995.

Along with the beginnings of export operations, the result of these reforms and political actions was that the National Fisheries and Aquaculture Program 1995-2000 recognised “favourable export expectations mainly due to the Free Trade Agreement with the United States and Canada, and the increase in imports from the European Union, as well as some Asian countries”. In fact, bilateral trade agreements were already in place in 1995. Furthermore, in 1997 a group of EU experts visited Mexico to evaluate the health surveillance system, concluding that the regulatory systems were equivalent to those of the EU and recognizing the Ministry of Health as a competent authority (Commission Decision 98/695/EC, 24 November 1998). In the same year, Mexico became the first Latin American country to sign an Economic Partnership, Political Coordination and Cooperation Agreement with the EEC, which entered into force in 2000; in October of that same year, as part of the same global agreement, the Free Trade Agreement (FTA) for goods between Mexico and the European Union entered into force, followed in 2001 by another FTA on services. This boosted the development process of the fishing industry in the State of Yucatan, mainly led by octopus exports.

At the end of the 20th century, the opening to international markets and the regulatory changes that preceded and accompanied it, marked a new phase in the development of public policies related to the fishing and Octopus sector in the Yucatan peninsula. In 2001, in order to ensure the sustainability of the fishery resource, a fishing quota for the Mayan Octopus was allocated according to an abundance assessment that allows 50% of the population to escape for breeding purposes to ensure recruitment for the following season. This norm also allowed to maintain a spawning population’s fraction size proportional to the population size at the beginning of the fishing season (this assessment is based on an annual estimate of biomass, which has since varied between 10,200 and 13,000 tons). This regulatory change was followed, in 2002, by a series of more active public policies (‘Alliances for the countryside’ program) oriented, among others, to the fishing sector, thanks to the initiative of SAGARPA and CONAPESCA. Likewise, in a period of export expansion characterised by the elimination of 88% tariffs on Mexican fishery products by the EU (2004), in 2005 the Technological Institutes of Yucatan were unified in a single subsystem: the Industrial Institutes; the Sea (‘*Del Mar*’) Institutes (mainly oriented towards the formation of human capital); and the Agricultural Institutes.

Regulations and standards, which are part of the socio-technical regime, are one of the ways in which technological trajectories are stabilized (Geels y Schot, 2007).

In 2007, the Ecological Management Program for the Coastal Territory of the State of Yucatan was launched, being aligned with Pillar II of the 2007-2012 State Development Plan: "Regional Development for Balanced Growth". Along the same lines, in 2009, indicators began to be used to evaluate regulatory measures in the octopus and grouper fishery. Other regulatory measures taken in this period are consequences of an EU reform in 2011 that establishes the implementing rules for Council Regulation (EC) No 1224/2009 establishing a Community control system to ensure compliance with the rules of the common fisheries policy. As a result, Yucatan companies require a Legal Fishing certificate as a requirement to export octopus to the EU. Besides, in view of the growing pressures regarding the environmental sustainability of fishing activities, in 2012 a technical assessment is set for the establishment of fishing quotas for Mayan Octopus. Subsequently, in 2015, the Octopus closure times

are again set by means of Official Decree NOM-008-SAG/PESC-2015, which modifies the previous Mexican official norm NOM-008-PESC-1993. SAGARPA, through CONAPESCA, initiated the public consultation of the project of modification of the Mexican official norm NOM-008-PESC-1993, in which new regulations are established for the exploitation of octopus species in national waters of the Gulf of Mexico and the Mexican Caribbean.[5] The modifications referred to the following aspects:

1. Inclusion of fishing logbooks and arrival notice for fishermen;
2. Minimum fished sizes, by area;
3. Limitations on equipment and number of fishermen.

On the other hand, the actions related to the promotion of product competitiveness are becoming more and more relevant, progressively shifting the focus from fishing or commercialization activities to those of transformation, or competitiveness at the system level. For example, in 2009 the Master Octopus Programme was published in the state of Yucatan, which establishes the strategies and projects required for the development, growth and strengthening of the productive chain. This programme was financed by the Productive Linkage Program 2008 in charge of SAGARPA-CONAPESCA. Another example is the registration in the Mexican Institute for Industrial Property (IMPI) of the collective commercial mark "Octomex" (n. 1168830) by the Yucatan Octopus Product System Committee. The objective of Octomex was positioning the Mayan Octopus product in the international market, mainly in countries of the European Union, such as Spain, Italy and Germany, and in the Asian market (e.g. Japan).[6]

These initiatives from the Committee were followed in February 2014 by the publication in the Official Journal of the Mexican Federation (DOF) of the Fishing Management Plan for the Mayan Octopus of the Gulf of Mexico and the Caribbean. This was followed, during the same year, by the reissue by the State government of the Ecological Management Program for the Coastal Territory of the State of Yucatan, in order to update its provisions with contents that ensure sustainable development in the short, medium and long term. Within this, the programme of Good Management Practices on Board in the octopus fishing in Yucatan begins.[7] Likewise, there is a rapprochement of companies transforming octopus-product to the Secretary of Economic Development (SEFOE) of the state government and CIATEJ to think about how to develop the sector, balancing the necessary aspects of competitiveness and marketing, on the one hand, with those of environmental sustainability on the other. One of the possibilities discussed was participation in the CONACYT's call from the 2015 Program for Stimulating Innovation (PEI).

In 2013, the 2013-2018 State Development Plan was published. At the federal level, in 2014 the INADEM launched the programme to Promote Sectoral Competitiveness. In 2015, FAO begun its work to draw up the Master Plan for the Development of Sustainable Fishing and Aquaculture in the State of Yucatan, financed by the State of Yucatan and based on the work that CINVESTAV was carrying out on scientific aspects related to territorial and coastal planning. The project, which was submitted to the Secretary of Tourism, planned the strengthening of quality, safety, and traceability structures for the supply of innovative regional food for tourist areas.

[5] However, someone commented that as of 2016 the protection of the females of the species is not carried out yet (Anonymous notes, TIPC Workshop, 2018).

[6] The collective mark may be used by 14 members of the Yucatan Octopus Product System Committee.

[7] However, some stakeholders have commented that there has been no follow-up to the Fishery Management Plan and the proposed research programs have not been carried out.

At the end of 2015, representatives of the Secretariat of Research, Innovation and Higher Education of the Yucatan State (SIIES) approached CIATEJ to talk about the needs of the Octopus sector. In February 2016, during a visit of FAO representatives to the CIATEJ facilities, the idea of a value-added plan and a pilot plant for the Octopus sector was discussed for the first time, because CIATEJ has an experimental plant for food processing and a laboratory to determine traceability and safety. On March 29, 2016, FAO delivered the document of Diagnosis and Master Plan of the Fishing Sector of Yucatan at the Extraordinary Session of the Council for Sustainable Fisheries and Aquaculture of the State of Yucatan (CPASEY). On that occasion, CIATEJ presented a proposal for a 'Value Added Plan' for the Mayan octopus. As shown below, these reforms and early actions were key inputs to the actions described in the following section. However, another spill-over of these interactions is the idea of applying for a Denomination of Origin (D.O.) for the Mayan Octopus.

"When you asked whether the Master Plan << worked or not>> I would further specify [...] It's very complex, you can't say clearly if it worked or not, this has nothing to do with the document." [SIIES Executive]

The idea of applying for a D.O. for the Mayan octopus product arises in parallel with the Competitiveness Reinforcement Initiative (CRI) activities and meetings described in the next section. This is not a completely new idea - it is an initiative that was previously undertaken in the case of the habanero chili but was not very successful due to a complex situation in which many factors were involved. By early 2017, many of the actors involved in the CRI activities knew the idea, also supported by several previous diagnostic studies. Due to the technical complexity of the matter and the need for dialogue and negotiation between representatives of different institutions and different territories, the D.O. was eventually developed as a separate line of work. The main objective established was to ensure the sustainability of the resource and generate new opportunities for economic development, adding value (economic, social and environmental) to the product. Then, it was not so much a question of commercially 'shielding' the product, but of seeking its regional differentiation, fostering collaborative participation for its transformation. It was a strategy consistent with the idea of competing in a differentiated consumption segment, combining the quality of the product with its social and environmental sustainability.

The work began at the beginning of 2017, dialogue sessions were carried out with the other States (Campeche and Quintana Roo), as well as with some representatives of other sectors at the national level (e.g. university). The main milestone in this line of work was the constitution of a Regional Committee for following up the Mayan octopus D.O. activities. Four follow-up meetings were held between May and December 2017. The main result of this work was the drafting of a technical document, eventually approved in March 2018 and recognized by the IMPI. It is worth noting that, although the work has been carried out in collaboration by the three States, Yucatan led the process, although this does not initially imply any advantage for the product and companies from Yucatan.

"The negotiations for the D.O. have not been particularly conflictive, rather the contrary, although there is fear that the conflict may arise after the approval of the D.O. For example, coordination problems related to the location of the future Regulating Council of the D.O. in a specific State. These potential problems are taken into account and legal and organizational tools are being considered to combat them." [ADY Employee]

In short, it can be stated that the fishing socio-technical system in the Yucatan peninsula has (had) abundant and specific regulations. However, it is not clear whether the frequent non-compliance with formal rules in the system, especially about fishing, has to do with the quantity or quality of the rules, or whether it has to do with structural aspects of the system that cannot be solved by regulation. On the other hand, the reforms and agreements stipulated throughout the 1990s have fostered exports and the international competitiveness of the fishing industry. In this sense, policies have favoured economic development, but it is not clear whether such development is sustainable in both socio-economic and environmental terms.

4.3. Internal and external pressures over the system

The fishing socio-technical system in the Yucatan peninsula is facing serious structural factors that threaten its sustainability in both socioeconomic and environmental terms. Some of these factors have been putting pressure on the system for decades, while new ones have emerged in recent times, aggravating pre-existing pressure factors in some cases. It is worth distinguishing between internal and external pressures on the system.

Internal factors

The main pressure emerging from within the system is about fishing activities problems. The first factor is the uncontrolled increase in the number of concessions and licenses, especially considering the current limitations on capture (rules, overexploitation, etc.). In particular, the number of small boats has increased uncontrollably due to low maintenance costs and lack of compliance with regulations and standards. As a result, there is no accurate information on how many fishermen are officially registered and how many are operating, either occasionally or full-time. Therefore, there are also no fully reliable figures available on fishing activities, jeopardizing measures to ensure sustainability. In addition, this generates a great deal of discontent for those who comply with proper permits. Often, novel illegal fishermen often do not comply with good practices on board, or hygiene rules, putting at risk the quality of the product.

> "It is common for children to capture the octopus illegally and then sell it to cooperatives. However, in this way the tracking of the time and process of capture is lost." [Cooperative Member]

This problem is related to the persistent and more general problem of illegal fishing, caused by the high numbers of illegal fishing, both by fishermen without a license, and by regular fishermen operating during the closure period.[8] The consequences of illegal fishing are quite serious. Firstly, they contribute to further exacerbating the growing competition between fishermen, and create problems of trust, social cohesion and legitimacy around the legal and institutional framework. Secondly, it seriously affects the sustainability of the marine resource, which is threatened by increasingly massive and invasive fishing. Finally, it affects the traceability and innocuousness of the value chain, since it is not possible to identify the origin of the product. On the one hand, fishermen often complain that the current closure times (e.g. in the case of octopus) no longer correspond to the reproduction cycle (e.g.

[8] In addition, many fishermen have a permit (plaque) for one specific place and fish in another place, causing monitoring and control problems.

during the first fishing month, the octopus is still very small, and production is very low). However, on the other hand, it is very common to hear or register cases of bad practices in terms of fishing techniques and gears, such as the following:

- Crochet fishing in caves where females spawn (during the first month of capture)
- Add chlorine to make the octopus come out faster
- Using explosive to blow up coral

> "Here people fish during the closure period, they fish the octopus all year round." [Cooperative Member]

In addition, there are other more eminently social or economic problems. A first problem relates to the cost and availability of fisheries inputs, which often come from outside the state borders. For example, a critical factor is the use of crab from other states (e.g. Campeche or Tabasco) or spider crabs as bait, which involve high costs. In fact, some voices from the Secretary of State for the Environment stated that, under current conditions, it is difficult for fishing in the State of Yucatan to become an engine of development. This is because the inputs come from outside and there are high costs related to the fishing activity, which implies that fishermen borrow and/or get into debt, sometimes with the ship-owners themselves. This feeds back into the relationship of dependency that many fishermen already have with ship-owners or large concessionaires. Sometimes it has been denounced that the relationship between fishermen and large companies in the region is not employment but overexploitation. On the other hand, the SEFOE has pointed out that the cooperative model "is very exhausted, it ends up resembling business practices where there is a 'cooperative regime' who acts as a capitalist" (that is, who has lances, loaders, etc.), rather than as a cooperative with a social purpose. Finally, because of the growing demand for octopus in recent years, caused mainly by international demand (e.g. the United States), prices have become volatile. Consequently, transformers see no need to increase their value added. However, the current value is not equally distributed across the different links in the system. Fishermen are the ones most affected by the so-called 'beach prices', set by some representatives of processing companies or heads of small businesses.

External factors

The external factors of pressure on the system come from other socio-technical systems in the region, or even from socioeconomic and environmental dynamics that transcend the borders of Yucatan and acquire a global dimension. The first factor is the increasing global competition: more and more countries are competing for the international markets for the Yucatan octopus and, especially, the Mayan octopus. Although Mexico has been increasing considerably its production in recent years[9] (, the current processing of octopus in Mexico is compromised, the local fishing industry does not have state-of-the-art freezing technology, resulting in low product quality and requires improvements in sanitary control of fishing (FAO, 2016).

Secondly, among the economic factors, we must point out the peculiar demographic situation of the Yucatan coast. Several decades ago the henequen business ended in the interior of the peninsula and there was a massive migration (supported by some governments) of former henequen workers towards

[9] In the period 2006-2016, production increased a 9.6%, while in the period 2011-2016, it increased a 11.8%. Specifically, there has been a 43.4% increasing from 2013 to 2014 capturing an additional 10,789 tons.

the coast attracted by the possibility of working in the fishing sector. Then, during time, the resident population in the coastal strip has been increasing in an almost uncontrolled way and this has clear impacts on the demography of the population dedicated to fishing, and it is related to the problem of the increase in the number of licenses and fishing permits seen previously. Another problem is the 'bubble' generated around the sea cucumber fishery a few years ago. Being a high value-added resource, it was a further factor of attraction to fishing by people engaged in another trade. This dynamic has gone hand in hand with the disorderly growth of coastal communities together with the lack of territorial planning, which has led to problems of solid waste management, deforestation, and eutrophication of fishing resources and their habitat.

Third, there are pressures related to the ecological and biological dimension. Yucatan is in an area of high vulnerability to extreme hydro-meteorological events. In recent decades, hurricanes such as "Gilberto" and "Isidoro" had catastrophic consequences that have negatively affected regional economic activities. In the case of fisheries, hurricanes degrade the areas of reproduction and breeding. Other similar natural phenomena are the red tide, or the arrival of invasive species such as lionfish. To these, we must add other factors such as the absence of programs to collect dangerous substances in the State's ports of refuge, the ignorance of the impact that would be having potentially harmful practices for the Octopus environment such as recreational fishing, or the exploration activities of PEMEX in the Yucatan platform, which pose a risk of water pollution.[10]

> "The issue of incentives for fishermen is a sensitive one, and it would be worth breaking it down. The State has mainly invested in the capitalization of the conflict (through infrastructure, insurance, etc.). Overall, this means benefits for the big ship-owners." [State Secretary for Rural Development]

These pressures are exacerbated by the current regime's lack of capacity to respond to them. Fishing infrastructure and facilities are often deficient for processing, including those necessary to add value to the product. The installed processing (freezing) capacity is underutilized most of the year due to the decrease in fishing. There is not a State fisheries agency, fishermen and processors have no one to whom to address their demands, as all existing dependencies in the state argue that it is not within their mandate to pay attention to such demands. Cooperatives and transformers feel abandoned by the government. Consequently, when they have an unheard demand, their only strategy is striking.

4.4. Diagnostics of the system

The socio-technical system of fishing in the Yucatan has undergone some changes since the emergence of the fishing industry in the late 40s. The main transformations that have occurred since then is the opening up of the system to the external environment starting from the mid-90s through trade agreements and the adaptation of regulations and standards of quality and health to the demands of target markets. This implied the emergence of the currently dominant regime in the system. This regime is characterized by a mode of production based on massive and largely uncontrolled capture of

[10] Likewise, PEMEX's activities in the Gulf of Mexico may have (had) other destabilizing effects on the fishing socio-technical system, for example, its impact on the national and local economy through increased foreign direct investment, dependence on an individual source of natural resources and consequent over-specialization to the detriment of other sectors.

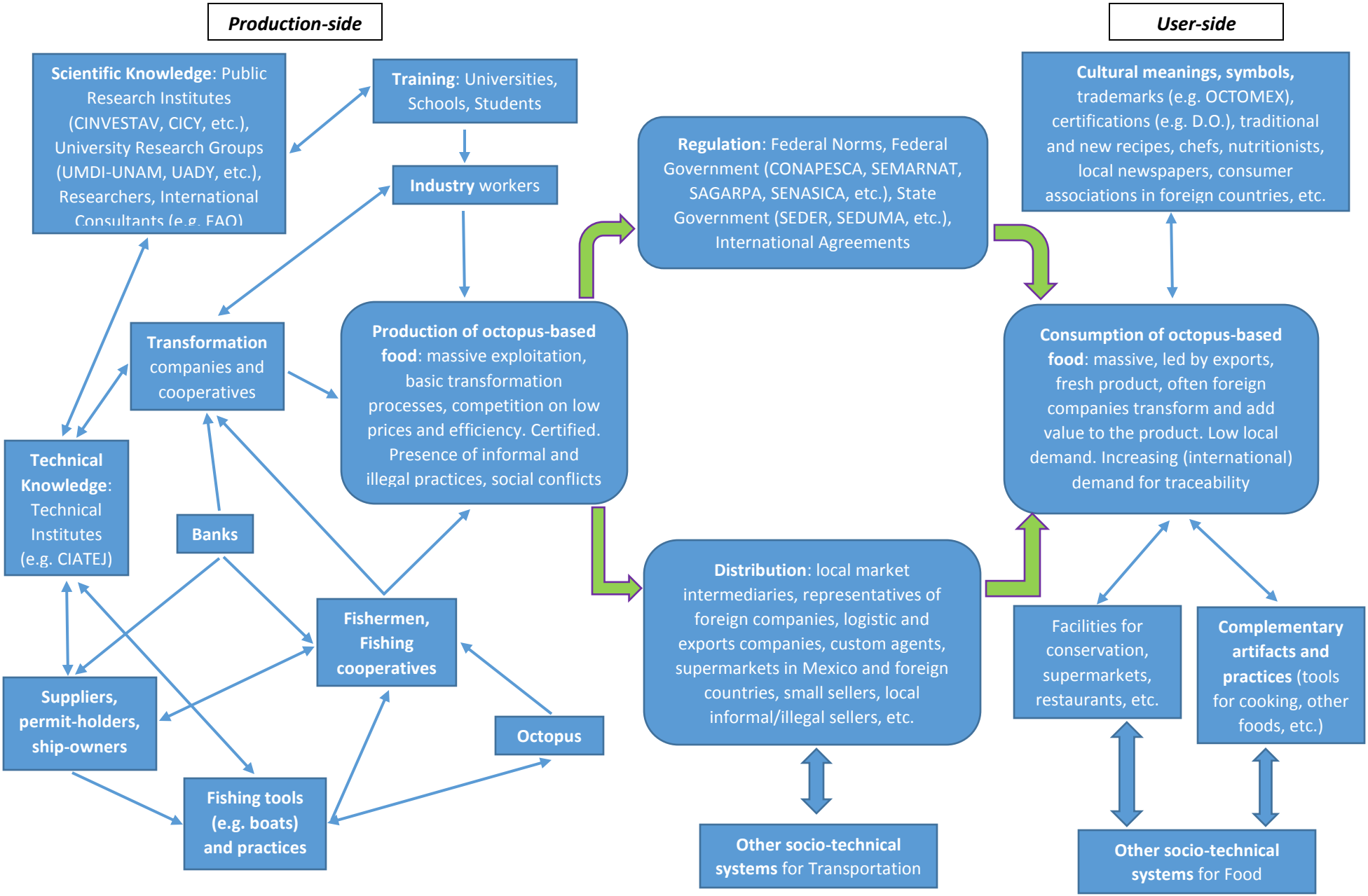
resources, despite the amount and level of detail of the existing regulation. Fishing plays an important role in the economy of the community; the fishing gears used remain traditional and the – initially – ensure the conservation of the species. However, the introduction of new technologies does not seem to have had a significant impact on fishing methods, while the increase in illegal or invasive practices threatens this situation and generates problems of trust and compliance among fishermen. Besides, fishermen seem to be the weakest ring in the value chain and their grouping in cooperatives has not been a solution to guarantee better working conditions, nor have social protests. On the other hand, processing companies enjoy a situation of relative comfort, guaranteed by growing demand and the intrinsic quality of the product. However, this situation could change radically in recent times due to increasing international competition, changes in consumer demands and tastes, and the reduction of marine fauna due to climatic factors and overexploitation. Intermediaries and commercial companies do not seem to play a determining role in the system and seem to enjoy a comfortable situation, albeit with little room for improvement. In this sense, they seem to be subject to the same risks that processing companies are. Finally, regulations in the system are quite extensive and detailed, and there are numerous public institutions ensuring compliance with the regulations, as well as their updating and revision. Fishermen and companies can find subjects of support at both the Federal and State level between the different dependencies and entities that deal with fishery regulations, the promotion of research and training in fisheries and marine sciences, or compliance with health standards and quality required both in the internal and external market.

In short, this production mode has prevailed in the production and commercialisation of perishable foods, where transformation and commercialisation companies opt for the international market because it offers greater profits to them. At the same time, this regime leaves the fishing community and local markets in a marginal position, surviving in conditions of increasing competition, social conflict and diffusion of illegal or harmful practices. From an environmental point of view, the most striking element of the present situation is that, according to the growing internal pressures in the system, there are no contingency plans for the vulnerability of fishing to factors such as climate change or habitat degradation (although it is recognised that there is a lack of research in these areas). In this sense, the document "Analysis of the Octopus sector" drafted in 2016 by the SEFOE recognizes that:

"[...] Historical trends could modify the structure of participation of coastal fishing in the future. The reduction in octopus fishing could be interpreted as the risk of depletion of the species, so it is necessary to conduct research on the maximum exploitation capacity, as is done for the biomass of some species in the National Fisheries Institute and implement monitoring mechanisms to ensure the permanence of resources. If trends reflect the behaviour of species in their exploitation process, by 2020 the octopus could reduce its fishing to 500 [tons]. A reduction of these magnitudes would leave the population that depends on this activity in greater conditions of poverty."

This would have very serious implications for the local communities and the entire fishing industry that receives from the capture of octopus a crucial input for its existence. Figure 6 resumes the main elements, actors and processes of the socio-technical system for octopus fishing in the Yucatan Peninsula.

Figure 6 – The socio-technical system for octopus fishing



Source: own elaboration

5. Policies and actions with transformative potential in the field of Mayan octopus

As we have seen, over the last few decades public policies in the fisheries system in the Yucatan peninsula have privileged regulation and trade agreements with other countries as strategies to promote the socioeconomic development and sustainability of the system. It is possible that these actions achieved some positive effects and even opened some paths for development. However, there are several structural pressures on the system, both internal and external, that have grown over time and show the limitations of the policy approaches that have been undertaken. On the other hand, policies have progressively shifted from standards, input-based approaches, R&D projects, stand-alone schemes, etc., to programs that are more comprehensive and initiatives that seek to transform the whole system. Specifically, over the last few years, some institutions of the Yucatan or Federal Government have become aware of the need for other types of actions, based on continuous exercises of research, discussion, reflection and inclusion of actors that have normally been little included in decision-making processes, such as researchers, processing companies, cooperatives, sector representatives and fishermen. Three of these initiatives, all focused on the Mayan Octopus species, are described below. These are the Competitiveness Reinforcement Initiative (CRI) launched by the Secretary of Economic Development of the State of Yucatan (SEFOE), the project presented by CIATEJ to the Mixed Funds (FOMIX) program, and the octopus farm located in Sisal.

5.1. Competitiveness Reinforcement Initiative (CRI)

In 2012, the Government of the State of Yucatan hired the consulting firm Competitiveness to train and advise the local work team of the SEFOE for working seven months in two initiatives to reinforce regional competitiveness, jointly funded by the State Government (20%) and the INADEM (80%). The State selected strategic sectors in order to promote their development as competitive clusters. After the successful experience in the area of clothing and the other related to habanero chili, in January 2017 a third CRI was launched in the Mayan Octopus sector, with the participation of representatives of producers, processing companies, universities, R&D centres and government entities at both federal and state levels. From its inception, the Mayan octopus CRI focused on defining demand-driven support policies to create profitable and sustainable business models. The main action strategy was defined a priori: to study the best strategic and economic development options for the sector, by gathering first-hand information from the main actors in the value chain, in order to understand needs, strengths and opportunities; and then to create a work plan based on the conclusions of the study.

The CRI articulated in three phases: 1) identification of the challenges; 2) definition of the strategy and 3) launch. During Phase 1 (December 2016-January 2017), the state of the Octopus ecosystem was researched and described through a series of 30-40 interviews. This phase served to obtain the necessary information, as well as to generate trust and commitment among the actors that make up the sector and each link in the value chain (producers, processing companies, R&D centres, foundations, business chambers, public agencies, etc.). From its outset, the work was oriented towards a specific direction: increasing the competitiveness of the sector in a critical link in the value chain, i.e. the transformation of the product.

"The consumer buys a set of values that are produced along the entire value chain. You have to bear in mind that octopus, like habanero chili, is a very 'political' product, because it has to do with the way of life of many people, and has opportunities for 'community challenge'. However, it also presents some competitive opportunities. They began then with the freezing companies because the economic opportunity was there." [Consultant of *Competitiveness*]

Based on the information obtained through the interviews, the work team performed a strategic market analysis, as well as a cabinet analysis involving both the work team and representatives from various sectors, institutions and links in the value chain. The work team submitted these results for discussion with the representatives of all the interested parties, identifying the following challenges for the development of the cluster:

- Lack of regulation or enforcement in the face of the increasing number of small fishing boats due to low costs
- Implementation of good safety practices in boats and collection centres
- Monitoring and follow-up of the regulations about the sustainability of the product
- Incorporation of the 'cold chain' to ensure quality and longer shelf life
- Linking successfully to very demanding markets about the high quality of seafood products
- Relative comfort of the sector, need to compete for value and not price
- Conservation of the species

Two documents resumed these challenges: "Analysis of the Octopus sector" (December 2016) and "Description of the Octopus sector, Yucatan" (January 2017).

"In the meetings there is no difference of personalities, the space is flat, that is, without hierarchies, all are part of the problem and all are part of the solution, all go to the same objective. Nor is it a dialogue table. They involve issues of innovation, currently it has been identified that in the case of octopus are not going in the best way." [ADY Employee]

During Phase 2 of CRI (January-March 2017), a more detailed strategic analysis was carried out, which ended with a diagnostic study containing the future strategy. Representatives of the fishing sector performed a reference trip to Galicia (Spain), a region that has very similar conditions to Yucatan, with the aim of learning from the success and failures of the Galician experience and contrasting the hypotheses formulated in the previous phase regarding the challenges of the cluster. Important conclusions were drawn from the trip, about issues such as the following:

- Product demand (relevance of the context, gastronomic culture and new consumption trends);
- Sustainability (promotion of safety and traceability through both R&D and traditional fishing gear);
- Policy (relevance of regulatory levels);
- Marketing (relevance of brands and marketing);
- Logistics (to ensure speed and quality);
- Transformation processes (importance of diversifying the product);
- Integration of the value chain, generating and strengthening relationships between the various parts of the system.

"The trip was a neuralgic point in the development of the strategy since it was observed which of these practices are useful, although it was not easy to access and gather the information. Then, we made an analysis of the best practices about which ones would work; what they did, what they are doing and what can be improved; even from the mistakes, one can learn. Important lessons were learned, such as the importance of logistics, the experience of the Galician fish markets, or the relevance of the integration of the value chain." [ADY Employee]

These results resulted in the "Strategy Document" (March 2017), which contained the results of the diagnosis. The most important result was the differentiation between the 'massive' and 'differentiated' strategic market segments, detailing their opportunities, weaknesses and differences, around four major food consumption trends (Box A3, Annex):

- Food experience (gastronomic culture)
- Convenience (adaptation to prices, time and space)
- Health care (lifestyle, balance)
- Responsible consumption (consciousness and environmental care)

A differentiated business starts by identifying and knowing the consumer. The underlying idea is that the consumer increasingly demands environmentally and socially responsible management of the supply chain. Closeness to the consumer is key to reacting quickly and with complex differentiations that respond to more than one trend. The Strategy Document defends that the differentiated strategic segment is more attractive for the State of Yucatan, because the raw material (the Mayan octopus) is differentiated by origin, i.e. it is valued and catalogued as differentiated by the global market in terms of origin, flavour and texture. Therefore, companies could develop in a differentiated or 'gourmet' segment, taking advantage of the gastronomic culture of Mexico and especially Yucatan as a key factor in attracting customers. In order to move from a massive business to compete in a differentiated one, the actors of the Yucatan cluster (companies and institutions) should generate significant changes, especially in the integration of the value chain, ensuring good practices on board, sustainability and protection of the species, marketing strategies and respond to global consumption trends. The strategy to achieve this objective identified in the document is to compete in niche markets differentiated by current food trends with market intelligence that can transmit information along the value chain.

"For the time being, the impression is that there is the (apparent) paradox that producers, fishermen and cooperatives welcomed the initiative more enthusiastically than processing companies. The explanation is that the latter are in a more comfortable situation, because the business continues to be profitable and it is not easy for them to perceive the need for a transformation in the medium and long term while the short-term benefits still relatively stable. In other words, they have more to lose, but also more to gain. On the other hand, the institutional, economic and environmental pressure is more on top of the producers, who have to deal with regulation and the challenges generated by the overexploitation of marine fauna and others." [ADY Employee]

In order to achieve this transition in the system, they identified a series of limitations and objectives. Among the limitations, the Strategy Document highlights aspects such as the following:

- Bad practices in fishing gear in terms of safety, traceability and freezing;
- Lack of control over the number of boats, fishing volume and landing points;
- Lack of transformation processes that add value to the product;

- Lack of connection in general between the links that make up the value chain.

On the other hand, in order to move towards a differentiated segment of octopus production and consumption for companies and institutions, actors should inter-connect, integrate into the system and be aware of the role they play to favour synergies between companies and institutions. The transition (they say) also requires greater precision in the extraction phases, more advanced technologies and a strengthened brand. To achieve these objectives, the Strategy Document sets out the following final objectives and requirements for transforming the value chain:

1. Companies' investments in controlling the product chain and distribution
2. Highly qualified workforce to perform good practices on board and to use elevated processing equipment
3. Easy access to funding
4. Product differentiation and market niche diversification
5. Extraction methods that ensure product sustainability
6. Target supermarkets or other specialized channels revitalizing the consumption of differentiated products at the regional level and contributing to consumer education
7. Advanced logistics infrastructure with cold chain
8. Presence of fisheries certifying bodies
9. Integration between each member of the value chain
10. Promote strategic actions and programs in conjunction with members of the business sector to position the brand and product of the region, through activities such as marketing strategies, or comply with the required capture records
11. Public and public-private programs that contribute to the education of local consumers on ethical, healthy and innovative food issues
12. Existence of landing control points that provide information in real time

"The basic idea is as follows: the fishing technology currently used in the Yucatan is not invasive and relatively sustainable from an environmental point of view. It would suffice to keep the fishing volume more or less constant and to comply with the regulations in force regarding the closure period, minimum size of the fish, etc. What needs to change are the steps involved in transforming the product into higher quality, so that the same volume of product has more added value and – at the same time – fishing environmental criteria like safety, traceability, and safety are promoted. The idea is to destine the product mainly to exports, because these can generate more added value, but it is also considered to address specific niches in the local market (e.g. tourist complexes of the Riviera Maya), following the example of a Galician company specialized in supplying chefs, with high economic returns. [...] What is innovative about the initiative is the network, that is, the bringing together of different actors and institutions, around a common initiative in a collaborative way and in the general interest." [ADY Employee]

Finally, in Phase 3 of CRI (March-June 2017), the working groups (made up of 30-40 people, representatives of the sector and other interested parties) generated through consensus possible solutions as areas for improvement (e.g. safety, traceability, safety, etc.) and defined future actions. The main outcome of this phase of reflection and intense dialogue was the drafting of the "Action Lines Document" (May 2017). Short-term actions aimed to reinforce the strategic articulation and activities of the value chain, aligning them with the relevant funds (National Entrepreneur Fund, private funds, etc.). The demand presented to FOMIX, which is presented below, is part of these reinforcement actions.

Another of these actions is the Octopus Product Innovation Program, which would involve SEFOE and CIATEJ through INADEM funding, aiming at a small group of interested companies, including training, prototyping and dissemination within nine months. The document also defined a series of specific objectives in different timeframes, related to the promotion of coordination, economic investment and research in the sector (medium term), as well as the creation and strengthening of adequate human resources, collaboration networks and scaling up of activities at sectoral and regional levels, in order to maintain and increase regional and sectoral competitiveness. In short, these objectives and actions respond to what the working groups identified as improvement options for the octopus sector/cluster in the State of Yucatan: to guarantee high-quality supply, adding value to the product, and identify specialised market niches.

"Public research centers consider the diversity of directions that technology can take. However, they try to implement the one that best meets the demand to be met and, in the case of the Mayan octopus, this technology will be subject to the value-added products identified by the market study." [Researcher]

5.2. The Mixed Fund (FOMIX) Program

The Mixed Fund (FOMIX) is a program of CONACYT that, through its regional directorates, operates in close collaboration with State-level and local actors to fund, advise and evaluate research projects, training and scientific-technical intervention, although its characteristics and functions have changed over time (Box 1). Following the classification scheme and terminology proposed by Schot and Steinmueller (2018), FOMIX moved from a "Framing 1" approach (R&D, regulation, market failure) to incorporating elements of "Framing 2" innovation policies (system failure, networks, learning, entrepreneurship, etc.) during the last decade. Currently, FOMIX supports State-level and municipal scientific and technological development, through a Trust constituted with contributions from the State or Municipal Government, and the Federal Government, through CONACYT.

Box 1 – The FOMIX and regional STI policies in Mexico

CONACYT's regional offices began to operate in the 1970s, dealing with scholarships, basic research, etc. They were initially called 'delegations' and then became 'regional divisions'. At first, CONACYT's regional policies were more interested in technology development and knowledge transfer. At the end of the 1990s, an attempt was made to establish a regional STI system in each state. Then, in 2002, the Law of Science and Technology was radically reformed. The National Conference on Science and Technology was introduced for coordination between CONACYT and the States. The State Science and Technology Councils were also created and, finally, the Mixed Fund (FOMIX) instituted.

In its first phase (2002-2012), the FOMIX was aimed at promoting research in the States, following a science-driven approach. Scientists were proposing the projects to be funded. However, resources used to disperse among various research groups carrying out small-scale projects. Each State agreed with the local scientific community on general topics, but specific topics were chosen – in practice – by the researchers. The reason is that regional or local researchers found difficult to compete in national call against the big universities and research centers located in the Capital City. Thus, the idea that FOMIX served to 'please' the local scientific community of each State, funding basic research and, sometimes, applied research, infrastructure or equipment, was spread. In this phase, it is worth mentioning that Yucatan was a pioneer in supporting and launching projects of higher impact, some of them aimed at companies (e.g. the construction of the science and technology park), especially considering that until 2009 there was not yet the Program for Stimulating Innovation (PEI) among companies, currently funded by CONACYT.

From 2012, in coincidence with the broader political change, FOMIX was diverted from basic research or towards companies. The new administration stated that FOMIX must serve to define and solve specific problems of each State through STI. However, there were two problems: a normative one, because each State had its own manual and its own rules of procedure; and that of reorienting FOMIX towards projects of greater impact for the States. Then, CONACYT decided to strengthen the figure of the 'user', that is, the State Unit in charge of each problem considered. From then on, the Units are in charge of defining the problem and raising the need, for example, with the scientific community. So, the calls address more specific problems.

In 2013, under the impulse of CONACYT, the Science and Technology Law was reformed, and so the FOMIX normative base and the specific FOMIX Trust Contract. A modifying agreement was also signed, from which the new 'operating rules' emerged, and the procedures manual was rewritten. This reform process had many administrative passages internal to CONACYT, but also required – many times – consultations with State-level actors. Until then, States had some control over some FOMIX rules and processes, such as evaluation. In addition, States had some inertia of their own. Then, it was a process of long and dense negotiations. As a result, the rules were homogenized and FOMIX became a more agile tool with greater impact. The new procedure for each State is as follows: definition of the FOMIX Action Plan, from which deriving strategic demands and – from these – developing specific demands. CONACYT's concern was that the demands must be aligned with FOMIX's general priorities at the Federal level (i.e., identifying and solving the specific problems of each State). From this new approach, CONACYT tried to approach other Dependencies in each State, i.e., those that were not traditionally directly involved with FOMIX. Finally, an important aspect of the FOMIX reform is that it is not taken for granted that the actors or resources involved in the solution are limited to the State in which it is implemented, whereas previously the focus was on the use and development of local capacities. The new FOMIX requires a diagnosis and an executive plan of the project, both consulted with all relevant regional actors.

Own elaboration from information provided by CONACYT (2018)

So far, the FOMIX funded at least four projects – of different sizes – in the field of octopus in the Yucatan peninsula, with special attention to the case of the Mayan octopus. In this regard, there was not much background, apart from the evaluation of the Octopus population in the Yucatan peninsula carried out by CRIP and CONAPESCA in 2004. The FOMIX policy changes mentioned in Table 1 have resulted in a greater degree of applicability of the funded projects, for example, in octopus-related research in the Yucatan peninsula (Table 3). This also allowed FOMIX to fund projects or areas of intervention that CONACYT calls aimed at financing R&D, such as the Basic Science Fund, cannot address.

Table 3. 2004-2018: research projects on Mayan octopus funded by FOMIX

Code	Title	Institution	Person Responsible	Budget	Starting year	Closing year
YUC-2004-C03-009	Determining the contaminating microbial dynamics of the octopus fishery in the State of Yucatan	Instituto Tecnológico de Mérida	Elsy Noemi Tamayo Canul	$220,292.00	2004	2010
YUC-2008-C06-107350	Obtaining natural products of marine origin from the saliva of the red octopus (*Octopus maya*) with possible antispasmodic activity	Universidad Nacional Autónoma de México - Facultad de Química	Sergio Rodríguez Morales	$ 300,000.00	2009	2013
YUC-2008-C06-108675	Integral evaluation of the octopus of the Yucatan peninsula: fishing biology, health status and population genetics	Universidad Autónoma de Yucatán	Sergio Guillén Hernández	$5,045,120.00	2009	2013
YUC-2017-01-01-6559	Mayan octopus technological platform for the development of high value-added products	Centro de Investigación y Asistencia en Tecnología y Diseño del Estado de Jalisco. A.C.	Patricia Ocampo Thomason	$ 13,968,896.00	2018	(on-going)

Source: CONACYT, Southeast Regional Direction

It is worth mentioning that some of the members of the processes related to the Mayan octopus D.O. and CRI managed, winning a FOMIX call, to obtain funding for the development of a technology platform for the development of high value-added products related to the Mayan Octopus. The project presented was – in some sense – an evolution of the findings and the advances obtained thanks to the CRI. Then, there is a continuity and alignment in the objectives and networks that have managed to consolidate around the Mayan Octopus from approx. 2015. Indeed, the objective of the application was to provide funding for the third line of action presented in the "Action Lines Document" (SEFOE, 2017): the construction and development of a Platform for Technological Transformation and Innovation to Strengthen and Enhance the Competitiveness of the Mayan Octopus Value Chain (Mayan Octopus Platform). The objective contained in the Specific Demand states as follows:

"[...] contribute to the increase in competitiveness and innovation of the value chain of the Mayan octopus of Yucatan, as well as diversify and add value to the products derived from this resource and increase their safety and traceability so that they can access the regional markets of Cancun and the Riviera Maya."

"The project should be governed by a Committee of Sectoral Experts which, apart from CIATEJ, SIIES, ADY and CONACYT, includes representatives of the demand, including the Government through CONAPESCA, INAPESCA, etc., knowledge agents, civil society (e.g. the Octopus System Committee), cooperatives, enterprises, fishermen, etc. Many of these representatives are also part of the D.O. initiative. The operation of the plant will base on the indications of the Committee. The plant intends to generate at least eight product prototypes (according to demand) that will be accessible to all. It also undertakes to provide training (e.g. on safety issues) and to promote regulatory changes (e.g. related to the closure period for fishing)." [R&D Center Director]

5.3. The octopus farm in Sisal

Independently of the policies mentioned in the previous sections, for almost fifteen years there has been an initiative around the Mayan octopus in the coastal town of Sisal, in the State of Yucatan, around a series of R&D and experimentation projects carried out by the Multidisciplinary Teaching and Research Unit (UMDI) of the UNAM located in the Sisal Campus. This Unit moved to the State of Yucatan around the year 2000 from the State of Campeche, coinciding with a period of decline in fishing production. At that time, it specialized in the study of white shrimp in the Gulf of Mexico as an alternative to the introduction of endemic species. The Governor of the State asked them to address the Octopus issue, because, at that time, it was a conflictive object in the relations between Yucatan and Campeche and entailed some social violence. The State Government recognised the need to deepen knowledge of the ecology and biology of octopus in order to regulate and administer the fishing sector. The first investigations of the UMDI in the sector focused on psychological and anthropological aspects, trying to understand the reasons and the way of life of the Octopus fishermen, in the first place. They concluded that fishing is an activity associated almost exclusively with males and a betting mentality, from which they deduced that in order to generate a transformative change in the dominant practices they need to challenge this perspective. Therefore, they began to work with the fishermen's wives (2004). Most of them used to complement their household tasks and support to husband activities with small activities of cultivation in orchards and selling vegetables at the retail level. The UMDI proposed the cultivation of octopus: fattening the animal in three tanks of six meters in diameter, containing between 80 and 100 octopus, to have at home, feeding them with fish waste (mainly crabs).

In 2005, the UMDI launched its first Mayan Octopus cultivation program and a cooperative including six fishermen families, the "Mayab Seafood Cooperative". However, the participants soon saw that there were some problems related to the cannibalism of the mothers with their eggs. In 2006, the researchers began to study the subject of reproduction and saw that it was a problem of stress due to captivity. The solution found was the design of an incubator for Mayan octopus, an innovative project for which they applied for an international patent in 2008. The next problem they had related to feeding, in order to obtain a balanced and accessible solution to feed the offspring. They studied several solutions, using also the knowledge related to the project titled 'Determining the contaminating microbial dynamics of the Octopus fishery in the State of Yucatan' funded by FOMIX and mentioned above. In 2009 – 2010, they solved the problem by identifying the most appropriate type of crab for feeding. They then went on to build tank-pilots to make experimental demonstration modules. SAGARPA funded the project under the idea that it had to be scaled up, in collaboration with the Mayab Cooperative. The Metropolitan Technological University (UTEM) also collaborated to improve the training of the women who were part of the cooperative. The course ended with an experimental sale of products made by the women themselves and by specialized chefs, including visits, exhibitions and tastings, until 2012. However, one of the difficulties they experienced was the relative upturn in fishing, which led to a decline in interest in alternative solutions to massive octopus fishing, a difficulty that has persisted until the present day.

The cooperative and the experimentation around the Mayan octopus are still going on, but they are in a difficult situation mainly due to two factors: one internal and one external. The internal factor refers to the technical difficulties and bottlenecks related to aquaculture and, especially, to Octopus cultivation. The costs are very high, especially about feeding the octopus, because they depend on the crab

obtained by local fishermen who set the price with a wide margin of discretion. Moreover, from an energy point of view, it is not an optimal solution because they use animal and protein resources to generate others of the same type. Currently, they are experimenting with waste from the fishing industry to provide an economic and ecological solution at the same time. Other technical problems relate to scaling up the project to industrial production, avoiding intermediaries, selling directly to consumers and ensuring product traceability. The latter is a problem that is limited both by the availability of accessible and cheap technology, and by the need to modify the routines and socio-technical practices of fishermen.

> "Derived from the research and work done by the CRI management team, it was identified that the law says that fishermen must keep a logbook when they are fishing; but when you speak with them, they argue that they cannot do so because of they are too busy at fishing." [ADY Employee]

However, there are also external problems relating to the relationship of this new type of industry with the local community. The relatively successful experience of farming techniques, the growing attention it has received in the media (e.g. concerning the issue of the patented incubator) and the satisfaction of the cooperative members caused some criticism and (apparently) some envy in the fishing community, especially on the part of those who have felt excluded by experimentation. There have been, for example, problems with the local administration regarding the expansion of the octopus farm, around an issue of allocation of land for building. This reflects the problem of fitting this scientific-social experimentation with the local fishing community and representative associations. Likewise, the intervention and experimentation projects carried out by the UMDI around the theme of fishing encounter difficulties to get funding, due to its very applied and social nature which does not fit in very well with the requirements of traditional calls for R&D or innovation.

What is the vision or the narrative of this experience? The participants maintain that the current fishing regime in Sisal and Yucatan is not sustainable. In this sense, quality aquaculture is a complementary activity:

- on the one hand it would guarantee the sustainability of the resource, maintaining or reducing the volume of fishing, while increasing population control due to the need to ensure traceability;
- on the other hand, it also favour a more 'democratic' distribution of the benefits of fishing, involving families that are currently excluded or disadvantaged by the fishing activity, while promoting the competitiveness of the sector by offering a higher quality product.

This higher quality does not only refer to innocuousness and traceability (like in the CRI case or the FOMIX project seen above), but also to a specific competitive advantage offered by the aquaculture of Mayan octopus. This is the possibility of raising "gourmet octopus", slightly smaller than the size allowed by the existing Federal norms and corresponding to the preferred size of chefs or specialized consumer segments dedicated to high quality catering (approx. 250-300 grams). In addition, being younger, it has better gastronomic properties.

A last aspect to emphasize refers to the possibility of extending the consumption of octopus in the region itself, which is currently very low. There is the possibility of recovering and recombining traditional recipes that are part of local culture and knowledge with the innovation of modern chefs and the knowledge provided by scientific studies of the UMDI. As has also been seen in the case of the CRI

and the FOMIX project, there are market niches in the region or in nearby states, especially those related to international tourism, which can constitute interesting laboratories for experimenting with new products, new recipes, and new practices in the transformation and commercialization of the product. In this sense, the participants also defend that it is necessary to avoid that cultivation substitutes fishing, because this could lead the State government to give aid to the fishermen to fish less or even for not fishing, and this would be a very harmful practice for the economy and the local communities. What is called for, rather, is to diversify and make the fishing industry more flexible, in order to favour the conjunction of profitability and sustainability.

> "We have learned a lot, for example, from the students, we didn't know many things about the octopus [...]The octopus we grow has the same taste as what comes out of the sea, because we feed it with crab. However, the other fishermen and their women think that the taste is different, although they probably only envy us [...] I cooked octopus in their ink, octopus in pickled sauce... We went to test at a school in Mérida. [...] Impacts? From everything, we have learned a lot and from everything. As a cooperative, we don't have a salary, but I really like coming here, I'm looking forward to working in the cooperative, and I'm learning a lot." [Cooperative Member]

In short, the idea behind this initiative is that the cultivation of octopus is a profitable alternative to fishing and community-based, but also complementary, aimed at ensuring the sustainability of the fishery resource. This would go hand in hand with constituting natural reserves in the sea to carry out population studies and contribute to guaranteeing the traceability and innocuousness of the octopus. The idea is to enter and compete in a differentiated market, complementary but alternative to the massive segment that currently makes up the dominant regime, like in the case of the CRI and the FOMIX projects. The Principal Investigator who has led these initiatives during the last fifteen years believes that the initiative has generated some interesting impacts. In the first place, it would have generated training in the members of the cooperative and learning in terms of technical scientific knowledge regarding the ecology and biology of the Mayan Octopus, especially thanks to the involvement of high school and university students (up to postgraduate level) in many of the activities of the UMDI, the farm and the cooperative. Another impact would be the change generated in the expectations of the members of the cooperative, who would have realized that fish and the fishing industry have many more relationships than those they knew and that go beyond the experience of local marketers, but also encompass marine population ecologies, environmental problems, global markets, etc. In the final analysis, the main objective is to change the current relationship between the Mayan octopus (and the fishing resource in general) and the local community, changing fishing, marketing and consumption patterns. This would have important implications for the education, identity and social cohesion of the community.

> "The important thing is not to generate academic results, but different visions and new connections, through experimentation, to break with the traditional paradigms of fishing production in the community." [Octopus Farm Director]

6. Some transformative elements of the Mayan Octopus case

The case study shows that, in recent years, the approaches to the fishing socio-technical system in the Yucatan peninsula have begun to change, opening the way for the idea of an integral transformation of

the system, e.g. moving from a massive system of production and consumption based on quantitative criteria, to another one, differentiated and based on qualitative aspects. In this sense, some STI policies and actions moved in this direction, with the aim of generating an impact on the system that will improve the living conditions of local communities. Although these actions are based on characteristic STI policy elements of Framing1 (social extension of science and research) or Framing 2 (networks, collaboration, learning, clusters, technological platforms), they also have incipient elements of Framing 3, such as social and environmental objectives, systemic impact, reflectivity, inclusion and experimentation. For example, the case of the octopus farm seeks to combine 'expert' knowledge with traditional knowledge in a multi-disciplinary and reflexive fashion. All these initiatives opened spaces for discussion about new socio-technical pathways with some transformative potential for the fishing socio-technical system in the Yucatan peninsula. It is also necessary to differentiate between the CRI approach, where the State Government 'top-down' creates a space for research, discussion and deliberation, albeit participatory and inclusive, and the octopus farm approach, arising 'bottom-up' by the collaboration between the UMDI and some fishermen's wives.

"The success of these actions is based on the participation and collaboration of various Federal and State government agencies, as well as associations of businessmen, fishermen, entrepreneurs, etc. It could be said that they are based on a collective learning process." [CONACYT Executive]

The actions undertaken in recent years have not only aimed at optimising the socio-technical system of octopus fishing but have also 'seen' and proposed its radical transformation, for example, by a market strategy based on differentiation. The actions described in section 5, despite their differences, seem to coincide in one crucial aspect: they served to generate discussion and alternative narratives about the fishing socio-technical system in the Yucatan peninsula, opening spaces for reflection and training, and generating internal pressure within the system for an endogenous change of regime. However, the case shows the difficulty of opening-up or creating discussion spaces for transitions in local communities where questioning the dominant socio-technical regime can be a source of social conflicts (e.g. octopus farming in Sisal). It also shows the obstacles generated by the inertia of dominant practices, especially by those incumbents with a greater risk of losing in the short term (e.g. processing companies). Other problems have to do with the long periods needed to generate integral transformations of the system, or the conflicts generated by the displacement of actors and modes of production and consumption that are part of the current regime.

The main transformative innovation element I see in the case of the Mayan octopus refers to the process of discussion of the dominant regime in the system by national, regional and local actors. This process allowed the identification of 'ideal' socio-technical niches and regime alternatives, through processes of research, study, training and discussion that have had a participatory, inclusive and sometimes experimental character. [RESEARCHER'S REFLECTION]

In conclusion, the case showed that policies and actions with transformative potential around the case of the Mayan octopus:

- Act in the socio-technical system of the fishing industry;

- Are oriented towards responsible production and consumption patterns, which are also capable of generating economic growth, decent working conditions and more equal relations between the genders;[11]
- Operate through new networks and alliances between change-oriented sectors.

Observing the transformative potential of the Mayan Octopus case in the light of the framework of the Sustainable Development Goals (SDGs) that have been proposed by the United Nations, as well as its subsequent inclusion in the model of transformative innovation policies by Schot et al. (2018), at least six SDGs stand out. Regarding the SDGs that refer to areas of application for policies (socio-technical systems), there are at least two: 'Life below water' (SDG 14) and 'Industry, innovation and infrastructure' (SDG 9). Regarding the SDGs indicating transversal directions for socio-technical change, there is a pattern in correspondence with 'Responsible consumption and production' (SDG 12), 'Decent work and economic growth' (SDG 8) and 'Gender equality' (SDG 5). The latter refers to the transformation of socioeconomic relations in fishing communities through the inclusion of women, as suggested by the case of the octopus farm. Finally, new networks and organisational arrangements provide contextual conditions such as 'Partnerships for the goals' (SDG 17). This classification makes possible to see with more clarity the possibility of combining socio-environmental sustainability and economic competitiveness/profitability of the fishing resource observed in the case study.

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[11] For example, experimentation in octopus farming showed the possibility of a redefinition of gender roles in the system. This is a relevant issue for an activity that is strongly masculinized (fishermen's wives usually play a secondary role in the activity) and in a State characterized by a structural inequality in gender relations, as evidenced by the wage gap or the land inheritance system.

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8. Annex

Table A1 – Timeline (complete)

Date	Event
1972	INAPESCA establishes the first annual closure season for octopus (16/12-31/07)
1978	INAPESCA founds the Regional Fisheries Research Centre (CRIP) in Yucalpetén
1982	Establishment of a first semi-industrial fleet in Yucatan
1984	Extension of fishing closure times (starting 16/11) and establishment of a minimum size of 110mm
1986	Mexico becomes an effective member of the General Agreement on Tariffs and Trade (GATT)
1990	First National Programme for the Development of Fisheries and their Resources (1990-1994), which promoted collaboration and exchange between Mexico and the member countries of the EEC.
1993	Mexico joins the Asia-Pacific Economic Cooperation Forum (APEC) as a member
1993	INAPESCA publishes the standard NOM-009-PESC-1993 regarding the closed seasons for octopus fishing.
1993	The National Consultative Committee for Fishing Standardization is constituted.
1994	Mexico joins the OECD and the North American Free Trade Agreement (NAFTA) enters into force.
1994	Export of octopus from the port of Veracruz to Asia begins
1995	The export of octopus begins from the port of Progreso (1995) to Europe.
2000	Mexico is the first country in Latin America where a free trade agreement for goods and services with the EEC enters into force.
2001	Fishing quota is allocated according to an annual assessment of the availability of the resource
2002	The public policy instrument "Alliance for the Countryside" is created.
2004	CRIP and CONAPESCA carry out an evaluation of the Octopus population in the Yucatan peninsula, after the damage caused by Hurricane Isidoro.
2004	The FOMIX program funds the project "Determine the contaminating microbial dynamics of the octopus fishery in the State of Yucatan".
2005	Launching of the experimental program of Mayan Octopus cultivation by UMDI-UNAM. The 1st farm of Mayan octopus in Sisal starts operating.
2005	Unification of the Technological Institutes: Industrial; Marine (formation of human capital); and Agricultural; in a single subsystem.
2007	Decreeing the Ecological Management Program of the Coastal Territory of the State of Yucatan
2007	Launching of the 'Yucatan Octopus Product' system by CONAPESCA and SAGARPA
2008	CINVESTAV publishes the Management Plan and Operation of the Fishery Management Committee for Scale and Octopus, sponsored by CONAPESCA-SAGARPA.
2009	The *Sociedad Cooperativa de Producción Pesquera Moluscos del Mayab* (Mayab Cooperative Society of Molluscs Fishing Production) is constituted
2009	The Octopus Product System Committee commissions the "Master Octopus Program in the State of Yucatan"
2009	The FOMIX program funds the following projects: "Obtaining natural products of marine origin from the saliva of the red octopus (Mayan octopus) with possible antispasmodic activity" and "Integral evaluation of the octopus of the Yucatan peninsula: fishing biology, state of health and population genetics".
2010	The Yucatan Octopus Product system Committee obtains the collective trademark "Octomex" (Mayan Octopus)
2010	UMDI-UNAM gets 2 patents on Mayan Octopus reproductive system in fish farming
2011	The EU establishes the rule of having a Legal Fishing Certificate as a requirement to export octopus to the EU.
2012	Publication of a technical opinion for the establishment of fishing quotas for Mayan octopus.

2012	EU visit to observe octopus fishing in Yucatan.
2012	Exponentially increasing sea cucumber exports, which creates a disruption in the Octopus system.
2013	Launching of the 2013-2018 State Development Plan of Yucatan, which includes a commitment to the Mayan octopus Denomination of Origin (D.O.)
2014	INADEM launches the Sectoral and Regional Competitiveness Program and SEFOE launches the first CRI in the State of Yucatan (Habanero Chile and Clothing sectors). The firm Competitiveness mentors the local work team.
2014	Publication in the Federal Bulletin of the Fisheries Management Plan for the Mayan Octopus of the Gulf of Mexico and the Caribbean.
2014	The Government of Yucatan reissued the Ecological Management Program of the Coastal Territory of the State of Yucatan, in order to update its provisions with contents that ensure sustainable development in the short, medium and long term. It also starts the program on Good Management Practices on Board in the octopus fishing in Yucatan.
2015	The re-engineering of CONACYT's Mixed Fund (FOMIX) ends, reorienting the program towards addressing priority problems, needs and opportunities for the States, as well as defining mechanisms to ensure the economic and social impact of funded STI projects.
2015	SAGARPA, through CONAPESCA, initiates the public consultation of the project of modification of the Mexican official norm NOM-008-PESC-1993, in which new regulations are established for the exploitation of octopus species: inclusion of the fishing logbook and notice of arrival; minimum sizes, by zones; and limitations to the equipment and the number of fishermen.
2015	INAPESCA publishes the standard NOM-008-SAG/PESC-2015 which updates the closure times for octopus fishing.
2015	FAO begins work to develop the Master Plan for the Development of Sustainable Fisheries and Aquaculture in Yucatan, funded by the State Government.
2016	Visit of FAO and SIIES representatives to CIATEJ; discussion on the problems of the Octopus sector, related to overexploitation and sustainability.
2016	Amendment to the Standard for the Protection of Female Octopus (NOM-008-PESC-1993).
2016	Meetings and preparatory work of the Master Plan between representatives of FAO, CICIMAR, CINVESTAV, CEDEPESCA, Yaax Beh association and CIATEJ.
2016	FAO publishes the Master Plan for the development of sustainable fisheries and aquaculture in Yucatan. Meetings between SEFOE, SIIES, CIATEJ and CONACYT to promote joint call aimed at promoting innovation in the Mayan octopus value chain.
2016	SEFOE launches the CRI relative to the Octopus in the State of Yucatan, with the support of INADEM, SEDER, CONACYT and IMPI, which includes the participation of companies, associations, foundations and R&D centres with interests in the sector.
2016	CONAPESCA and Government of Yucatan sign an agreement for the modernization of fishing fleet, for $50 million pesos (Derived from the Master Plan; 2015).
2016	The governments of the Yucatan Peninsula signed a collaborative work plan for 2030 called "Agreement for the Sustainability of the Yucatan Peninsula (ASPY 2030) in the framework of the COP13 on Biodiversity in Cancun, Quintana Roo.
2017	Developing of the Mayan octopus CRI
2017	Senators working on “Initiative of Law, Obligatory Traceability. General Law of Sustainable Fishing and Aquaculture” so that the traceability of fishery and aquaculture products is to be complied with in a mandatory manner.
2017	Meetings between CIATEJ-UNAM-private company for the development of value-added products from octopus processing residues.
2017	Meetings of the Regional Committee for Monitoring the D.O. of Mayan Octopus
2018	CIATEJ publishes a study on the transformation of the Mayan Octopus sector
2018	The Yucatan, Campeche and Quintana Roo law secretaries validate the agreement for the D.O.
2018	The FOMIX program funds the project: "Mayan Octopus technological platform for the development of high value-added products".
2018	Amendments to the Industrial Property Law for "Geographical Indications".

Box A1 – List of the main institutions involved in the system

At the Federal level:

- The National Fishing Commission (CONAPESCA), a Federal entity that oversees fishing regulations and establishes the corresponding regulations. Among its tasks is to promote mechanisms for participation, exchange and dialogue among the different actors of the system, conceiving a horizon where fishing constitutes a sustainable factor of social and cultural development. It also researches, trains, informs and encourages the search for alternatives that contribute to the achievement of sustainable fisheries in Latin America and the Caribbean.
- The Secretariat of Environment and Natural Resources (SEMARNAT), which, through the PROFEPA, carries out fisheries inspection and surveillance actions within federal protected natural areas and is responsible for the Management Plans of these natural areas.
- The Secretariat of Agriculture, Livestock, Rural Development, Fisheries and Food (SAGARPA), responsible for administering federal resources for rural development and promote research for rural purposes and regulate activities related to fishing.
- The National Service for Agrofood Health, Safety and Quality (SENASICA), which is responsible for ensuring the health, safety and quality of food (among others) from aquaculture or fishing. It also applies, inspects and monitors existing health regulations and stable certificates, and food quality standards.
- The State Aquaculture Health Committee of Yucatan (CESAY), a civil association created in 2006 to support SENASICA by aquaculture producers in collaboration with CINVESTAV to address the dangers of diseases in aquatic animals and ensure health status in Yucatan. Since then, it has been engaged in epidemiological surveillance and health status of aquaculture crops and fishery products, through the implementation of biosecurity measures, constant training and good practices to ensure the safety of the products.
- The Federal Commission for Protection against Sanitary Risks (COFEPRIS): certifies larger boats and processing plants.
- The Secretary of the Navy (SEMAR), the Port Captaincy, the Secretary of Finance and Public Credit and the Secretary of Health.
- CONACYT, as an entity that promotes training and scientific and technical research through the financing of scholarships and R&D and innovation projects, which also include disciplines and areas related to fishing, marine ecology and biology, the Agrofood industry, the application of ICTs to navigation, etc.

At the State level, there are several public entities directly involved in the fishing sector:

- The Secretariat of Rural Development (SEDER) which, through the Commission for Sustainable Fisheries and Aquaculture of the State of Yucatan, carries out normative actions and adherence to federal instances, in order to monitor and coordinate the proper development of fishing and aquaculture activities.
- The Secretariat of Environment and Urban Development (SEDUMA), which promotes and oversees the proper implementation of environmental policy and urban development in the state of Yucatan, including the management of protected natural areas.
- The Secretariat of Public Security and the Attorney General's Office, who monitor and maintain social security and ensure compliance with federal and state regulations.

Beyond governmental entities, it is worth mentioning academies, universities, R&D centers and higher education institutes carrying out training and research programs related to the fishing sector:

- the local headquarters of the National Autonomous University of Mexico (UNAM)
- the Advanced Study and Research Center (CINVESTAV)
- the Center for Research and Design and Technology Assistance of the State of Jalisco (CIATEJ)
- the Autonomous University of Yucatan (UADY)
- the Yucatan Center for Scientific Research (CICY)
- the State network of Technology Institutes (unified in the same entity since 2005)
- some of the higher and high school institutes of the region
- regional delegations of the Food and Agriculture Organization of the United Nations (FAO).

Box A2 – List of the main norms involved in the system

In the last 30 years, several regulatory and public policy instruments have been established for the Octopus exploitation:

- The NOM-128-SSA1-1994 of Goods and Services, establishes as a requirement the application of a system of hazard analysis and critical control points (HACCP) in the industrial processing plant of fishery products.
- The NOM-008-PESC-1993, establishes the minimum size of 110 mm in length of the mantle for the capture of all species of octopus, in the waters of federal jurisdiction of the Gulf of Mexico and Caribbean Sea. It also establishes that the capture of octopus must be carried out using equipment and methods authorized by SAGARPA, except the use of hooks and harpoons.
- The NOM-009-PESC-1993 establishes a period of protection of the octopus during the season of reproduction and care of offspring, establishing a period of prohibition for the fishing in the waters of federal jurisdiction of the coasts of the states of Campeche, Yucatan and Quintana Roo, in the period between December 16 and July 31 of each year.
- The National Fisheries Charter (CNP, 2012) states that SAGARPA, through the National Fisheries Institute, will establish fishing quotas by species for each fishing season, as well as permissible fishing effort limits, based on available scientific evidence.
- The 2014 Gulf of Mexico and Caribbean Sea Octopus Fisheries Management Plan, which concentrates knowledge of biological, fisheries, environmental, economic, cultural and social aspects.
- The Program of Ecological Ordinance of the Coastal Territory of the State of Yucatan. Its object is to regulate or to induce the use of the soil and the productive activities, with the purpose of achieving the protection of the environment and the preservation and the sustainable use of the natural resources, from the analysis of the tendencies of deterioration and the potentialities of use of the same ones. It is considered the most appropriate environmental policy instrument to harmonize human activities and the environment in such a way as to ensure sustainability conditions in the short, medium and long term.
- The Octopus Master Program in the State of Yucatan.
- The Master Plan for the Development of Sustainable Fishing and Aquaculture in the State of Yucatan.

Box A3 – Massive vs Differentiated Strategic Segment in the Octopus Sector

Massive Segment: high rivalry between the actors along the vertical axis because of few entry barriers, but there are many substitute products (e.g. other mollusks). In terms of horizontal relationships, the supplier has low power; it requires just a basic Octopus fishery, while the customer has very high price-sensitive power. Consumption depends on the volume/price ratio, so it is necessary for this segment to make a larger volume of fishing or reduce production costs to keep prices lower in the face of competition (threat to marine resources).

Differentiated Segment: low local rivalry, as there are several different barriers to entry in terms of time, technology and integration among participants (although there is a relatively high global rivalry between a few global competitors). There are not many substitute products, and success depends on the ability of the value chain to adapt to specific market demands. Profits are shared equitably among actors with a similar level of power: suppliers have high bargaining power vis-à-vis buyers, if they provide acceptable quality and value chain management conditions. However, the customer has an intermediate power, being willing to pay more for a differentiated product. In terms of market and consumption, this segment participates strongly in global trends in food demand and incorporates them into its value proposition.

Evolution in time (real and predicted). The global market is progressively evolving towards criteria that increasingly favor the differentiated segment: the volume/price ratio is less important, whereas the differentiation between products has increased enormously, as has the openness of information (e.g. nutritional value, food education), beginning to diversify until the presentation of the product to meet the different demands of the market. In addition, regulation is becoming stricter, while trade openness increased. The constant increase in demand generates the overexploitation of natural resources putting at risk the presence of species, and the ability to guarantee a standard price and volume. Companies must adapt to new regulations and standards to control fishing and counteract the negative effects of overexploitation. Instead, the Differentiated segment is expected to grow over time. However, the requirements to enter or remain in the market could increase and diversify, making the sector more competitive:

- Consumers will look for healthier choices that go hand in hand with their diets trying to change their lifestyle and therefore their diets.
- Governments will need to legislate and create policies that encourage companies to be responsible and transparent with the formulation of their products.
- Food manufacturers will have to accept the challenge of implementing strategies that meet these needs: smaller sizes, new formulas, diversity of supply, giving a new approach to their products.

According to the diagnostic study, the most innovative options to meet advanced purchasing criteria within the Differentiated strategic segment will reward those companies that:

- Have products with differentiation value (format, level of convenience, commercial brand, certifications and activities, etc.) capable of competing on an international scale ("Highly differentiated product").
- Offer a differentiated product plus a service (e.g. delivering ready-to-eat dishes, or a fresh product for certain restaurants, etc.), on a regional scale ("Differentiated Product + Service").

Key success factors for the most innovative options require:

- Ability to invest in equipment (vacuum packer, baking ovens, and slicing machines, among others) that helps to obtain innovation and diversification in the products offered.
- Strengthening of logistic networks for the improvement of distribution channels and supply chain.
- Experience in the selection of products with the quality and traceability standards required by the client.
- Ability to develop and position brands.
- Commercial synergies; multi-local and multinational to access other markets.
- Identification of marketing channels according to the profile and purchase criteria of the demand.

Source: Strategy Document of the Octopus Cluster (SEFOE, 2017)