AQUATIC LIFE INSTITUTE

# What Lies Behind Mexico's Octopus Farm Research Facade?

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The small town of Sisal, Yucatan is the location of Mexico's first octopus farm, which has been touted extensively in national and international media outlets as a groundbreaking industry for the region and the country. In this document, Aquatic Life Institute will discuss potential threats to animal welfare, environmental degradation, biodiversity and public health that could occur as a result of octopus farming.

The Sisal unit of the Universidad Autonoma de Mexico (UNAM), the country's largest and most prestigious university, started the octopus farm project as a research center to study the physiology of the most common regional species: *Octopus Maya*. There has been an ongoing investigation related to *O. Maya* farming methods for over 15 years at this location.

UNAM's research center created an agreement with local families to establish Moluscos del Mayab, the commercial branch of the farm. Even though they are separate and independent, information, techniques and resources are constantly shared between both entities.

The farm is located in a federal concession of 6700 square meters, of which, 77% is destined for farm use, and 23% for conservation purposes; although it is not clear how that part of the land is used for conservation. The farm is located directly on the oceanfront.

## Background information

*Octopus Maya*

*O. Maya* dwells in the shallow waters of the Yucatan peninsula at depths between 2 and 25 meters. When the larvae emerge from the eggs they become benthic juveniles in just 7-10 days[1], making them an attractive species for intensive farming. Other species, such as *O. vulgaris,* go through a planktonic phase, where hatchlings are very vulnerable to external threats.

[1] "Chemical Tools of Octopus maya during Crab Predation Are Also ...." 19 Feb. 2016, https://journals.plos.org/plosone/article?id=10.1371/journal.pone.0148922.

*O. maya* is a semelparous species with only one reproductive egg-laying event in its lifetime[2]. On average, *O. Maya* females lay 1500-2000 eggs per laying event and their life expectancy has been estimated at 18 months.[3]

In 2020[4] 25,416 tons of octopus were caught in Mexico; 100% from wild capture fisheries with 92% caught in the states of Yucatan and Campeche. There was a reduction of 33% in the total catch compared to 2019. The continuous reduction of wild octopus populations has sparked an interest in pursuing intensive farming.

## Sisal octopus farm operations

The UNAM research facility obtains wild pregnant females from the surrounding ecosystem. They developed a patent for an egg incubator, which removes the need to keep the females with the eggs. Once they lay eggs, females are then discarded and commercialized. The eggs are artificially incubated for 50 days. This facility produces around 20,000 eggs per month.

The production cycle described by the researchers is as follows. After hatching, they are moved to pre-growth tanks. The Sisal unit has around 6-8 recirculating tanks for adults and 12-15 tanks for juveniles. The first pre-growth tank holds around 25 larvae per square meter. In total this tank fits approximately 707 larvae, and they grow from 0.1 grams to 2 grams in one month.

The second growth tank holds around 288 juveniles. They considerably reduce the density at this stage due to aggressive juvenile cannibalism. In the third month they are moved again, to a tank holding 469 individuals, and finally in the fourth month they have around 191 octopus per tank. The octopuses ultimately grow to 100-250 grams at a rate of about 6% per day.

After each cycle, an average of 388 octopuses are sent for slaughter and commercialization. **The farm has a 52% mortality rate, averaging around 5% per week, and around 30% is related to cannibalism.**

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[2] "Oviducal gland transcriptomics of Octopus maya through ... - NCBI." 30 Mar. 2022, https://www.ncbi.nlm.nih.gov/pmc/articles/PMC8976471/.
[3] "Population dynamics and stock assessment for Octopus maya ...." https://www.scielo.sa.cr/scielo.php?script=sci_arttext&pid=S0034-77442000000200005.
[4] "anuario estadístico de acuacultura y pesca 2020." https://nube.conapesca.gob.mx/sites/cona/dgppe/2020/ANUARIO_ESTADISTICO_DE_ACUACULTURA_Y_PESCA_2020.pdf.

The researchers have attempted to minimize cannibalism and aggression by reducing stocking density. They also claim to have reduced cannibalism by devising a special diet of freeze-dried crab paste (*Callinectes spp.*) meal, Humboldt Squid (*Dosidicus gigas)* meal and silages, all enriched with a mix of vitamins and minerals, and bound with gelatin[5]. Initially this diet was in paste form, but they have now created pellets that are more easily produced and handled. Researchers claim this diet reduces nutritional deficits that cause cannibalism in juveniles. However, the cost of this diet is very high therefore to reduce costs, they feed discarded fish scraps from local fishermen to the octopus.[6] The potential Octopus farm being planned by Nueva Pescanova in Spain has shown interest in this diet formula[7].

As they still rely on wild populations for replenishing their broodstock, they are researching a reproductive unit that could be self-sustainable.

We currently have no information related to the slaughter methods used at this farm. We would like to emphasize that there are no known humane methods for slaughtering octopus at present. Some of the historically used, inhumane methods include clubbing, slicing, asphyxiation, and chilling.

There is also a lack of clarity regarding the disposal of waste from the farm, but they use a salt water recirculating system for the tanks.

## Market

In Mexico, 1 kg of wild caught octopus is worth 51 pesos (Around $2.6 USD). The Mexican government established that *O. Maya* can only be captured in the wild once it is at least 110 centimeters long, and weighs at least 450 grams[8]. However, the octopus produced on this farm is harvested at just 250 grams. Therefore, despite claims by this farm, it does not reduce the pressure due to overfishing in the wild population of the species and does not support its conservation.

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[5] "Growth, survival and physiological condition of Octopus maya when ...." https://www.researchgate.net/publication/260947016_Growth_survival_and_physiological_condition_of_Octopus_maya_when_fed_a_successful_formulated_diet.
[6] "Growth, survival and physiological condition of Octopus maya when ...." https://www.researchgate.net/publication/260947016_Growth_survival_and_physiological_condition_of_Octopus_maya_when_fed_a_successful_formulated_diet.
[7] "Desechos de pescado alimentan a pulpos en granja en México, en ...." 18 Mar. 2022, https://www.infobae.com/america/agencias/2022/03/18/desechos-de-pescado-alimentan-a-pulpos-en-granja-en-mexico-en-medio-de-preocupacion-por-cautiverio/.
[8] "Definen peso y talla mínima para captura de Pulpo en el Golfo de ...." 8 Mar. 2019, https://www.gob.mx/inapesca/articulos/definen-peso-y-talla-minima-para-captura-de-pulpo-en-el-golfo-de-mexico-y-mar-caribe?idiom=es.

UNAM claims this reduces competition with local fishermen, as the product has a different target market. The farmed octopus is purchased mainly by local and regional high-end restaurants and hotel chains, where “baby octopus” is considered a delicacy. The farmed octopus is sold at 150 pesos per kg (Around $8 USD). Consequently this farm does not contribute to improving food security for the low-income coastal community of the area.

## Funding

The farm received a $50,000 USD grant from UNDP (United Nations Development program) through the SGP (Small grants program) of the GEF (Global environmental facility) from September 2019 to January 2021, which was extended due to the Covid-19 pandemic. The goal was to produce 10,000 octopus per year but the farm has not achieved this goal. The grant is part of the climate mitigation program and is described as a conservation effort for the biodiversity of the octopus[9].

UNAM also received funding from a campaign by the Yucatan Secretary of Fishing and Agriculture, the “campaña peso a peso”. It is unclear how much they received.

# Potential issues with the farm

Numerous animal protection and environmental organizations, scientists and policy makers are concerned over existing and potential cephalopod farms around the world. The potential risks and hazards surrounding cephalopod farms are related to animal welfare, biodiversity and biosecurity, environmental degradation, antibiotic resistance, public health, food security, and the livelihoods of coastal communities.

## Animal welfare concerns

In November 2021, the United Kingdom extended the scope of the Animal Welfare (Sentience) Bill to recognize octopus and cephalopod mollusks (squid, cuttlefish, etc.) as sentient beings (ones that can reason, learn, and experience sensations) following the findings of a government-commissioned independent

[9] "Engorda de Pulpo “Baby” en Cautiverio en Sisal - Project Detail." https://sgp.undp.org/spacial-itemid-projects-landing-page/spacial-itemid-project-search-results/spacial-itemid-project-detailpage.html?view=projectdetail&id=28459.

review by the London School of Economics and Political Science (LSE). The five-year project drew on more than 300 existing scientific studies to reach a sentient conclusion, and the authors recommended that the government expand its definition of animal welfare to include these animals. This report ultimately led to the inclusion of cephalopods in the Animal Sentience Act in the UK.

In the UNAM Sisal research center, ironically, they have also carried out studies that highlight octopus intelligence. A preprinted study shows that *O. maya* can differentiate between a new object and a known one, with high accuracy. To achieve object recognition, octopuses use both visual and tactile exploration for new objects, while familiar objects are only explored in a tactile way. This experiment shows that octopuses have outstanding memories[10].

Scientists have highlighted the many issues of octopus farming, all of which are related to the fact that these animals, like many others, are not suited in any way, shape, or form for large-scale farming. Aquatic Life Institute (ALI) turns to 5 pillars of welfare in our engagements with key decision-makers, in addition to other welfare concerns mentioned below:

1. Environmental Enrichment:
   They are intelligent and inquisitive. They would require a high level of enrichment which would not be possible in a farm scenario, resulting in extreme boredom, and chronic mental/physical stress. The Sisal farm claims to be experimenting with different types of enrichment, however, replicating the true diversity of their natural ecosystem is not feasible.
2. Feed Composition:
   Recent studies have demonstrated that octopuses are voracious and active carnivores; they have a complex feeding behavior which starts from the detection until the consumption of prey, which cannot be replicated in a farm setting[11]. Their nutritional requirements put further pressure on existing wild populations commonly used for fish meal/fish oil for the aquaculture industry, including many species which also could be used instead for human consumption. An octopus farm adds the pressure for new potential species added to feed, such as crab and squid as used by the Sisal farm. These species are also for human consumption, which generates direct competition with the food security of the population of the coastal region.
3. Stocking Density & Space Requirements:

[10] "Novel Object Recognition in Octopus maya. - Research Square." 11 Mar. 2022, https://www.researchsquare.com/article/rs-1439375/v1.pdf.
[11] "Octopus insularis (Octopodidae), evidences of a specialized ...." 8 Aug. 2009, https://link.springer.com/article/10.1007/s00227-009-1264-4.

These animals are solitary by nature. High stocking densities, which is a standard industry practice to amplify production in farms, results in high levels of aggression, cannibalism and social stress. The Sisal farm has a 52% mortality rate, of which 30% is directly related to cannibalism.

4. Water Quality:
   They are very fragile due to the lack of internal or external skeletons, and could be highly susceptible to any sudden changes in their environment and human manipulation.
5. Stunning & Slaughter:
   Presently, no humane method of slaughter exists. Slaughter methods have been studied, however, none have been scientifically approved as humane.
6. Transportation and Handling:
   a. The transport of any live octopus could pose a significant threat to welfare and survival due to demanding environmental requirements. High mortality rates and transportation costs could be expected.
   b. Injuries may be inflicted by captive conditions, handling, and transport. For example, O. vulgaris may fight if transported together and eventually bite or cannibalize one another[12].
7. Health and Medical Treatment:
   a. The major threats to health/disease in octopus are water quality issues, physical injury, and infection (due to parasites or other pathogens), all of which may be interrelated. Disease risk is exacerbated by crowded conditions.
   b. The immune system of octopus is poorly known to date. The lack of genomic information makes it difficult to understand vital processes like immune defense mechanisms and their interaction with pathogens at a molecular level. No farm-level treatment plans, prevention strategies, and risk assessments have been developed at this time.
   c. In terms of reproduction, broodstock welfare considerations are nonexistent.
   d. Large-scale aquatic farms are a breeding ground for pathogenic bacteria, and therefore contribute to the overuse of antibiotics and the dangerous creation of multidrug-resistant bacteria.
   e. Pathogens associated with skin lesions (*Photobacterium swingsii, Lactococcus garvieae* and betanodavirus) have been found in deceased octopuses in previous studies[13].

[12]Borrelli, L, Gherardi, F, Fiorito, G. A Catalogue of Body Patterning in Cephalopoda, Napoli, Italy: Stazione Zoologica A. Dohrn; Firenze University Press, 2006, pp. 626–626.

[13]Fichi, G, et al. “Skin Lesion-Associated Pathogens from Octopus Vulgaris: First Detection of Photobacterium Swingsii, Lactococcus Garvieae and Betanodavirus.” Diseases of Aquatic Organisms, vol. 115, no. 2, 23 July 2015, pp. 147–156, 10.3354/dao02877.

## Environmental concerns

1. Octopus farming raises significant environmental concerns due to new effluents being produced and subsequently discharged into surrounding ecosystems.
2. Ample evidence gathered around the world[14], has shown that intensive farming of other carnivorous species, such as Salmon, have caused the progressive and grave decimation of related wild species due to the pathogens, competition, genetic abnormalities, and many other factors. There is profound concern that this farm would cause similar impacts on the already vulnerable and declining wild *O. maya* population in the Yucatan peninsula.
3. Octopus farm escapes could also threaten local habitats and animal populations with a high potential of transferring any on-farm diseases, antibiotics, etc. Octopus are notorious for escaping their enclosures.

## Public health concerns

1. *Todarodes pacificus* (Japanese flying squid) have been reported to be positive for Betanodavirus,[15] which is an agent of a serious viral disease known as VER (viral encephalopathy and retinopathy) that has been detected in a wide range of vertebrate and invertebrate hosts worldwide, and caused severe mass mortalities in both farmed and wild marine organisms[16]. Betanodavirus was also identified in skin lesions, in the eye, and in the branchial heart of O. vulgaris.[17,18]
2. A wide variety of pathogens have been isolated from infection sites of octopuses and squids in a laboratory[19]: *Acinetobacter lwoffi, A. hydrophila,*

[14] "A Global Assessment of Salmon Aquaculture Impacts on Wild ...." 12 Feb. 2008, https://journals.plos.org/plosbiology/article?id=10.1371/journal.pbio.0060033.
[15]Gomez, DK, Mori, K, Okinaka, Y, Nakai, T, Park, SC. Trash fish can be a source of betanodavirus for cultured marine fish. Aquaculture 2010; 302: 158–163.
[16]Vendramin N, Patarnello P, Toffan A, Panzarin V, Cappellozza E, Tedesco P, Terlizzi A, Terregino C and Cattoli G. Viral encephalopathy and retinopathy in groupers (Epinephelusspp.) in southern Italy: a threat for wild endangered species? BMC Vet Res 2013; 9: doi:10.1186/1746-6148-9-20.
[17]Vanni A, Fichi G, Cardeti G, Cersini A, Perrucci S, Lenzi F, DeWolf T, Fronte B, Ricci E, Campeis F and Susini F. Potenziali patogeni in popolazione naturale e in soggetti stabulati di Octopus vulgaris. Atti Società Italiana di Patologia Ittica, XIX Convegno Nazionale 2013; 80.
[18]Fiorito, Graziano, et al. "Guidelines for the Care and Welfare of Cephalopods in Research –a Consensus Based on an Initiative by CephRes, FELASA and the Boyd Group." Laboratory Animals, vol. 49, no. 2_suppl, 9 Sept. 2015, pp. 1–90, 10.1177/0023677215580006.
[19] "A Synopsis of Cephalopod Pathology in Captivity - IAAAM1987 - VIN." https://www.vin.com/apputil/content/defaultadv1.aspx?pId=11104&id=3981710&print=1. Accessed 10 Mar. 2023.

*Cytaphaga sp, P. putrifaciens, P. stutzeri, Vibrio alginolyticus, V. carchariae, V. costicola, V. cholerae, V. damsela, V. fluvialis, V. natriegenes, V. parahaemolyticus, V. pelagius (biovar 2)*.

- Vibrio spp. is considered as a significant problem to the development of the aquaculture sector with severe economic losses worldwide.
- Vibrios are gram-negative, ubiquitous in marine, estuarine ecosystems as well as aquaculture farms and one of the major microbiota of these ecosystems. Many vibrios are serious pathogens for animals reared in aquaculture.
- Cholera is a potentially zoonotic epidemic and life-threatening secretory diarrhea characterized by numerous, voluminous watery stools, often accompanied by vomiting, and resulting in hypovolemic shock and acidosis. It is caused by certain members of the species Vibrio cholerae.
- Cholera is endemic or epidemic in areas with poor sanitation; it occurs sporadically or as limited outbreaks in developed countries. In coastal regions it may persist in plankton.[20]
- Octopus farming could become a serious public health risk, as captive cephalopods could be vectors of multiple unknown pathogens and zoonotic diseases such as cholera.

3. These treatments (antibiotics and protozoacides) used against disease were applied to octopuses in various dosages, durations and frequencies: Acetic acid, antimony, acriflavine, amikacin sulfate, atabrine, calcium hypochlorite, cefotaxime, chloramphenicol, formalin, furazolidone, gentamicin sulfate, kanamycin, malachite Green, metronidazole, minocycline hydrochloride, neomycin sulfate, neosporin, nifurpirinol, nitrofurazone, oxytetracycline hydrochloride, panos and piperacillin.

Some of these compounds, e.g. malachite green, have been banned in various EU member states. Denmark banned the compound in the 1990s. Many of these antibiotics are used to treat diseases in humans, so using them in octopuses significantly increases the risk of generating antibiotic resistance, which is a serious threat to the public health of humans, animals and the environment, as established in the report of the United Nations Environment Program, UNEP, in 2021.[21]

[20]Finkelstein, Richard A. “Cholera, Vibrio Cholerae O1 and O139, and Other Pathogenic Vibrios.” Nih.gov, University of Texas Medical Branch at Galveston, 2015, www.ncbi.nlm.nih.gov/books/NBK8407/.
[21]Environmental Dimensions of Antimicrobial Resistance Summary for Policymakers. https://wedocs.unep.org/bitstream/handle/20.500.11822/38373/antimicrobial_R.pdf

## Additional concerns

1. Adequate Employee Training:
   a. There are no octopus-specific training programs for farm employees.
   b. Octopus are fragile and would require high levels of care when any type of handling occurs. Care would be compromised during production due to stocking densities, lack of knowledge, and "fast" procedures.
   C. There are no protocols of employee safety in the farm as can be evidenced in the pictures in this article published by UNAM. Octopuses can pose severe health risks to humans when handled incorrectly. Evidence shows that all species of octopus are venomous[22] and can cause potential adverse health conditions in humans.[23]
2. Data-Driven Approach, Record Keeping, and Reporting:
   Adequate, regular, and detailed monitoring procedures or emergency preparedness plans related to imminent environmental damages or threats do not exist as an industry standard at this point in time.
3. Legislative Considerations:
   There is currently no legislation protecting the welfare of farmed cephalopods in Mexico, and the species is not currently included in the Mexican national Aquaculture letter[24].
4. Livelihoods
   Even though this farm consistently claims they are trying to improve the lives of the local population, these projects could have detrimental effects on the livelihoods of the surrounding communities . The United Nations General Assembly declared 2022 the International Year of Artisanal Fisheries and Aquaculture (IYAFA 2022). This vision statement seeks to develop "A world in which small-scale artisanal fishers, fish farmers and fish workers are fully recognized and empowered to continue their contributions to human well-being, healthy food systems and poverty eradication through the responsible and sustainable use of fisheries and aquaculture resources." In Chile and Argentina for example, large scale salmon aquaculture has caused severe impacts on the local communities, and only produced profits for large salmon companies. The effects were so detrimental that salmon farms were banned in Tierra del Fuego, Argentina through pressure from local communities, in an effort to recover the ecosystem.

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[22] "Tentacles of venom: toxic protein convergence in the Kingdom ...." https://pubmed.ncbi.nlm.nih.gov/19294452/.
[23] "Infiltrated plaques resulting from an injury caused by the common ...." https://www.researchgate.net/publication/268447002_Infiltrated_plaques_resulting_from_an_injury_caused_by_the_common_octopus_Octopus_vulgaris_A_case_report..
[24] "Acuerdo mediante el cual se aprueba la actualización de la Carta ...." 15 Apr. 2021, https://www.dof.gob.mx/nota_detalle.php?codigo=5615929&fecha=15/04/2021.

Industrial cephalopod farming operations could negatively affect traditional-scale artisanal fisheries in Yucatan, as well as the communities that rely on these activities to sustain their livelihoods. If diseases spreads from the farm it could considerably reduce the local population of *O. maya* on which the local farmers rely for sustenance. In terms of food safety, this product is not meant to provide nutritious and affordable food for local communities, but it is a premium product meant for tourists and higher income populations.

## Conclusions

Aquatic Life Institute strongly opposes the operation of this farm and research center. Given all the concerning potential long term risks of this project, we urge UNAM university to end the program, and instead invest in supporting the local community with more sustainable endeavors, that will also support the food security for the 2000 inhabitants of the Sisal town. UNAM university is committed to sustainability and it is a proud supporter of changing systems to improve environmental conservation. As such, a project of this nature is contrary to the university's values.

We will also advocate directly with UNDP to stop financing cephalopod farms around the world and focus on more sustainable food system alternatives to current overfishing and overexploitation practices such as shifting from carnivorous farmed species to herbivorous or omnivorous species, extractive species, and systems where animals and their feed are co-produced and are fed a more herbivorous diet. We advocate shifting toward plant-based alternatives (both for feed and for human consumption), especially in the global north where there is wide availability of substitutes. Additionally, they should support recovery programs for dwindling wild cephalopod species by supporting temporary or complete fishing bans and marine protected areas. The UN high seas treaty was approved recently on March 6th, which aims to protect 30% of the world's oceans by 2030, and UNAM should look to support alignment to these global objectives for conservation.

## Final note

The information provided in this document is a summary of anecdotal reports from the farm, research papers issued by the UNAM research center in Sisal, and multiple interviews available in the media. As a result, the information can be contradictory,

inconsistent or incomplete. However, it allows us to have a broad overview of what is happening on the farm, and the overall challenges that this industry is currently facing regarding its sustainability. It also shows that there is a lack of farmed octopus welfare knowledge, and what the long-term impacts might entail.