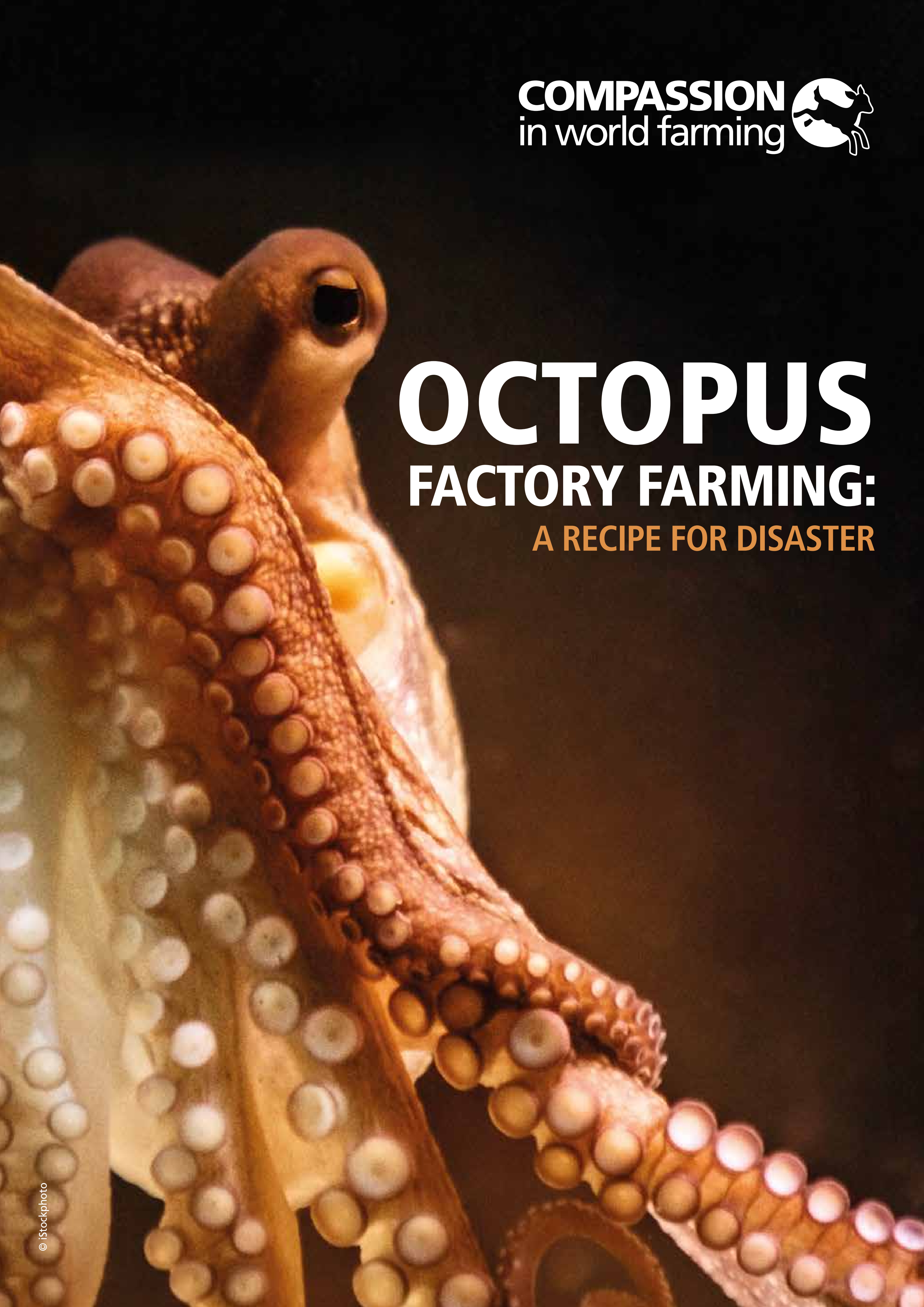
COMPASSION in world farming

OCTOPUS FACTORY FARMING:

A RECIPE FOR DISASTER



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A report by Dr Elena Lara, Research Manager - Fish at Compassion in World Farming International, October 2021.
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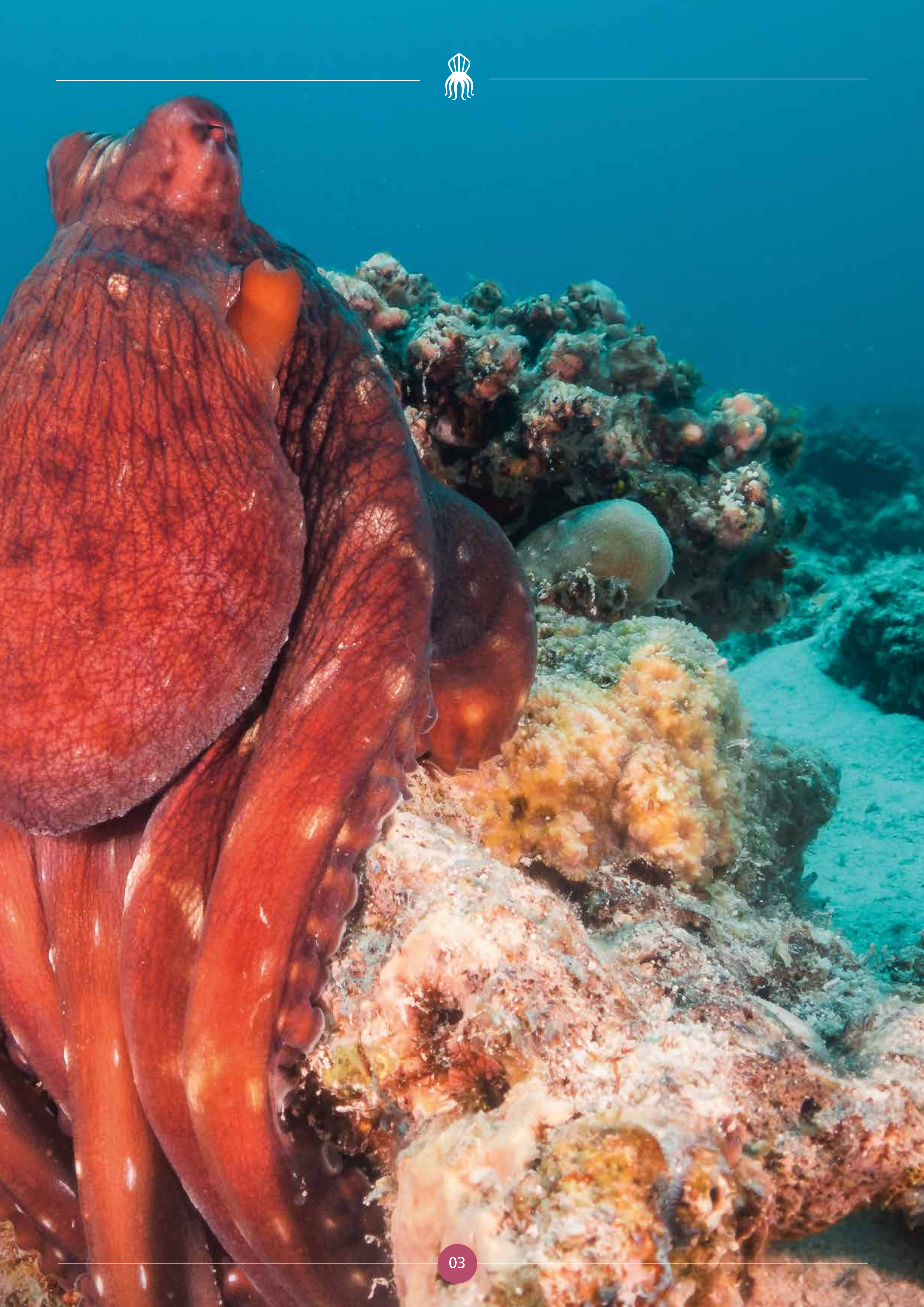
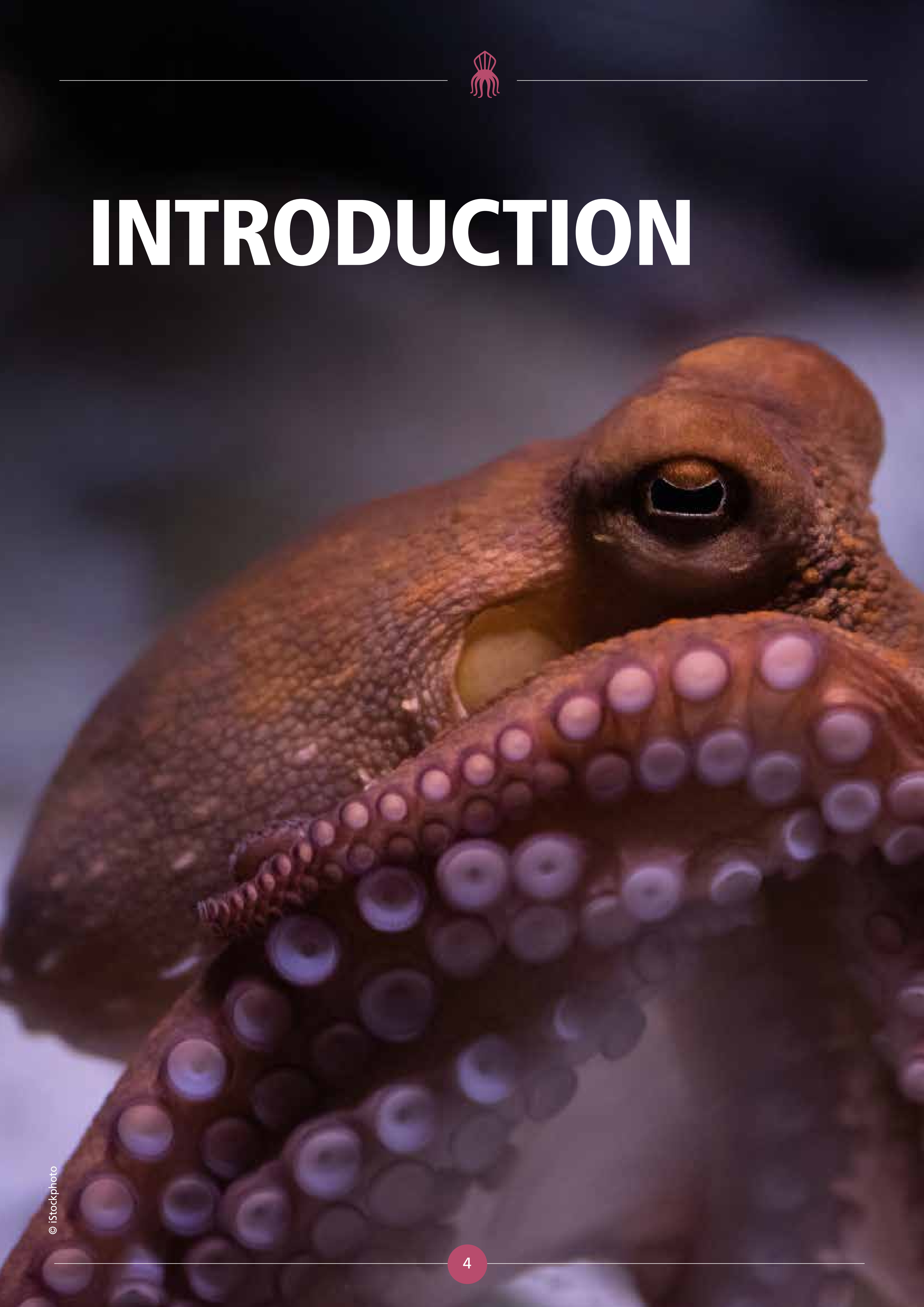


INTRODUCTION



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Interest in octopuses has skyrocketed in recent years: the Oscar-winning documentary, *My Octopus Teacher*, highlighted some of the incredible reasons these cephalopods have captivated us, including their intelligence, curiosity, and fascinating ability to change their appearance.

Unfortunately, octopuses have also captured the wrong kind of attention. Wild-caught octopuses have been consumed all over the world, especially in several Mediterranean countries in Europe, as well as in Asia and Mexico. Recently, there has been high demand for octopus in other markets, such as the United States and Japan. As a consequence, octopuses have been under increased pressure, leading to a decrease in wild populations. Growing market demand and rising prices have made food industries eager to farm octopuses in captivity.

The common octopus, *Octopus vulgaris*, is the main species of interest for farming in Europe, with researchers, primarily in Spain, exploring the development of open-ocean net cages and tanks on land. Outside Europe, there are also plans for octopus farming in the United States, Mexico, and Japan. Factory farming practices restrict animals' natural behaviours and lead to untold suffering, regardless of species. Octopuses' exceptional characteristics make them uniquely unsuitable for intensive farming, and this report sets out the main reasons why this should never be allowed to happen.

EXECUTIVE SUMMARY

8 REASONS TO STOP

1 Octopuses are solitary by nature

As naturally solitary animals, octopuses would not fare well in the crowded conditions and high stocking densities that are typical of factory farm systems. This can result in very poor welfare and creates the risk of aggression and territorialism that can lead to cannibalism.

2 They are highly inquisitive and intelligent

Octopuses are known for their extraordinary intelligence, and as a result of their natural inquisitiveness and tendency to explore, manipulate and control their environment, they would be easily susceptible to boredom in captivity. The mass production of octopuses is likely to have barren, controlled and sterile environments and, therefore, lack sensory inputs.

3 Their carnivorous diets would be unsustainable in a farming environment

We face a global crisis of overfishing. Fish farming is responsible for much of the industrial fishing of our endangered oceans. Approximately 20-25% of all wild-caught fish are used to make fishmeal and oil – feed for carnivorous farmed fish. As octopuses are carnivorous, industry and researchers are currently developing feeds for farmed octopuses based on the use of fishmeal and fish oil. This would place additional unsustainable pressure on wild fish populations – 90% of which are suitable for human consumption (and reduces the amount of food available for species that rely on small fish, like penguins). It also means that octopus farming would contribute to further food security issues in regions such as West Africa, Southeast Asia and South America where the main industrial fishmeal factories are located.

4 Little is known about their complex welfare needs and suffering in captivity

Octopus farming is an attempt to farm wild animals who have never been farmed before. It is therefore likely that their welfare needs will not be properly met in farms, and they will suffer as a result.

OCTOPUS FARMING

8 It is incompatible with the EU Strategic Aquaculture Guidelines (SAGs)

These guidelines encourage the reduction of aquaculture's reliance on fishmeal and fish oil produced from wild-caught fish and they stress the need for EU aquaculture to diversify, introducing species that do not need fishmeal or fish oil.

7 There is no current legislation to protect the welfare of farmed octopuses

Octopuses are totally unprotected from suffering and inhumane slaughter methods as there are currently no laws in place in the EU, the US, Mexico, or Japan, where octopus farming is being developed, to regulate their welfare and farming practices. It would be totally irresponsible for lawmakers to allow the continued development of plans to farm octopuses without proper legislation in place.

6 There is currently no scientifically validated method for the humane slaughter of octopuses

While slaughter methods are currently being studied, none has been scientifically approved as humane. Current literature on wild-caught octopus slaughter mentions a variety of methods, including clubbing their heads, slicing their brains, asphyxiation in a net, and chilling in ice. Humane alternatives to these methods – which would ensure that octopuses are rendered immediately unconscious before being killed – are yet to be developed.

5 They are fragile creatures that are easily injured

Octopuses do not have internal or external skeletons to protect them, and their skin is very fragile and easily damaged. In a farm environment, octopuses are likely to be injured, either through physical contact by a handler or aggressive interactions with other octopuses. Their fast jet-propelled locomotion means that if they are confined in small spaces, they can easily be injured by crashing into tank walls or cages. Therefore, there is a high risk of pain and suffering from injuries that are likely to occur.

CONCLUSION

In summary, these fascinating, intelligent, and sentient wild animals cannot be allowed to be exploited and suffer lives in factory farms that are simply not worth living. The serious environmental and animal welfare problems associated with octopus farming mean that it cannot be compatible with the EU's new Strategic Guidelines for the sustainable development of aquaculture.

Therefore, Compassion in World Farming is urging the aquaculture industry to stop the development of octopus farming altogether to prevent unnecessary suffering and environmental damage.

MEET THE OCTOPUS

Octopuses are remarkable marine cephalopod molluscs (in the same class as squid and cuttlefish), easily identified by their eight arms. They inhabit all marine habitats ranging from tropical reefs to polar latitudes, where they are ecologically important species, being both carnivorous predators and an important prey for fish and marine mammals (1). Their life-history is characterised by short life-spans with most species living one to two years (2-4). Octopuses grow fast and reach an average of 2-3 kg when they are adults. Another distinctive feature of these animals is that they have early maturity and little overlap of generation (5). They are also semelparous (6), which means that females die after reproduction.

> *“This is probably the closest we will come to meeting an intelligent alien.”*
>
> Peter Godfrey-Smith, Other Minds: The Octopus, the Sea, and the Deep Origins of Consciousness

> **DID YOU KNOW?**
>
> Octopuses can grow a new arm when one has been bitten off

THE OCTOPUS

Although there are some wholly pelagic species which spend their lives in the open sea, the majority of octopuses (more than 200 species) have a benthic or bottom-dwelling lifestyle, belonging to just one family, the Octopodidae (7). They are generally solitary animals, residing in dens in well-spaced areas, most likely influenced by a a feeding area versus rate of replenishment relationship (8). It is mainly these benthic octopuses who have been exploited in coastal areas around the world for more than 2,000 years, being caught with traps, hocks, spears, or pots (9).

DID YOU KNOW?

Octopuses have huge brains and 3 hearts!

Octopuses swim using jet propulsion or walk on the seabed using their arms (9–11). It is the suckers in their arms which have receptors that enable octopuses to touch and detect chemical stimuli (3). These receptors, called chemoreceptors, are tiny cells which can detect minor changes in their immediate environment (12). Octopuses have good eyesight (3,10) and their eyes have no blind spots. This means they can see everything that is going on in their environment and are more aware of predators and prey than some vertebrates. They also have many more photoreceptors than vertebrates, which means that their vision is much better than that of any human. Although they are colour-blind, being able to see only in greyscale, they are able to distinguish light's plane of polarisation (13).

Skin changing abilities

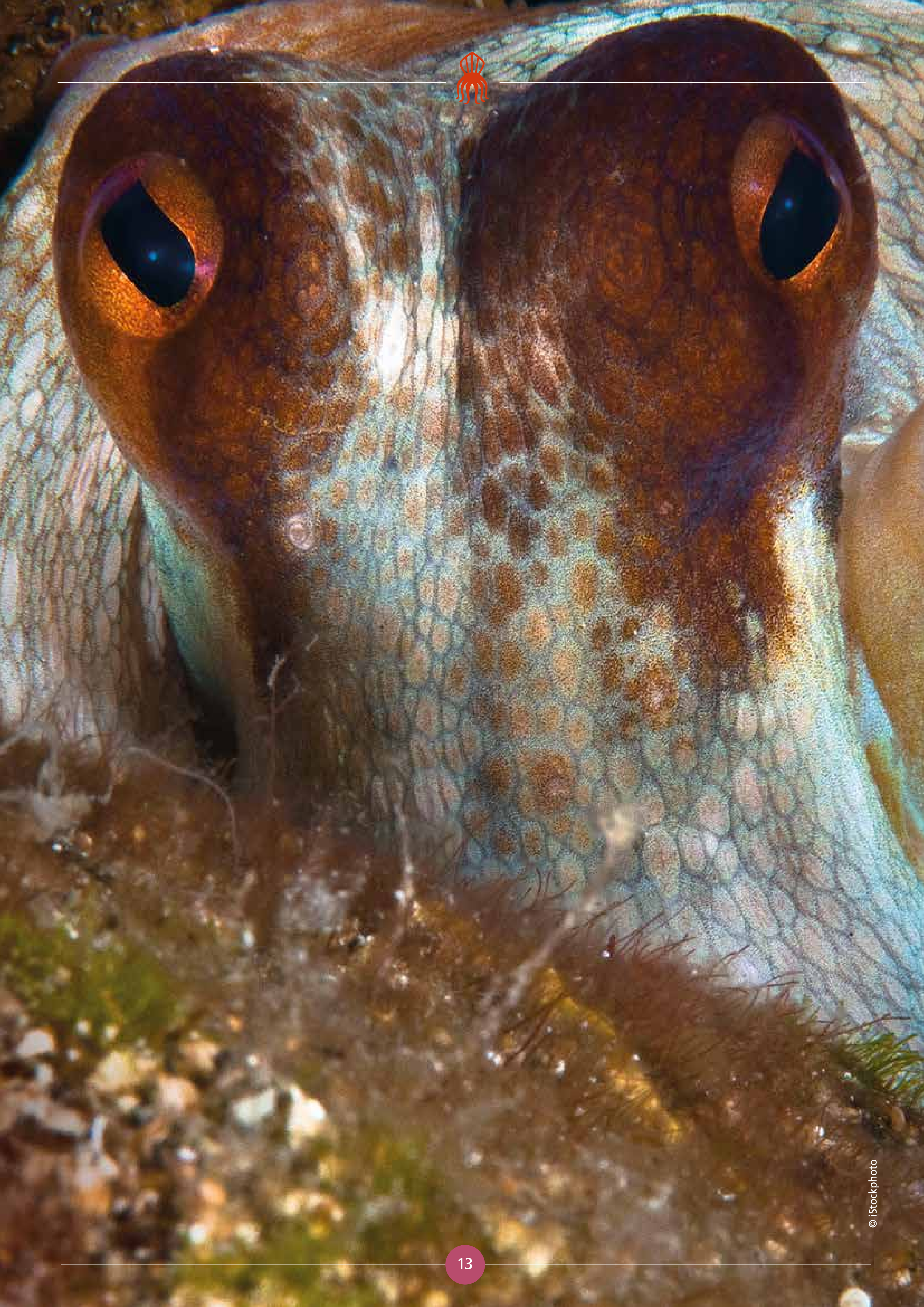
Octopuses have extraordinary features. They can grow a new arm when one has been lost (14,15) and they can change the shape and colour of their skin within a few seconds (16,17). Considering that octopuses are 'colour-blind', this is quite surprising, but these colour-changes are made possible by tiny organs in the skin called chromatophores (18). Octopuses have millions of chromatophores in their skin (16) which are directly controlled by the brain (10,12). They use these skin changing abilities to camouflage and hide from predators, as well as for conspicuous signalling (14,18). These abilities show how complex and unique these animals are.

But these are not the only distinctive characteristics of octopuses. They have copper-based blue blood (rather than iron-based red blood) (19). Their body has a closed circulatory system (20) and at the core of this system are three hearts (21). Octopuses possess a sophisticated nervous system (22), which consists of a central brain and the peripheral nervous system of the arms, with a brain to body size ratio greater than most fish and reptiles (23,24). There are 'only' 80 million neurons in the brain, whereas the arms contain about four times as many – 300 million neurons (25) – which can taste and touch independently, as well as control basic motions without input from the brain (26). Therefore, octopuses have a complex nervous system and are among the most intelligent and behaviourally diverse of all invertebrates.

SENTIENT, INTELLIGENT AND COMPLEX ANIMALS

A sentient being does not just detect, observe, or react to the things around them. They can also process information internally and feel something in response (27,28). Sentient beings also have some ability to evaluate the actions of others in relation to itself and third parties, to remember some of their own actions and their consequences, to assess risk, and to have some degree of awareness (28). There is scientific evidence of octopuses' substantial perceptual ability, pain and adrenal systems, emotional responses, long- and short-term memory, complex cognition, individual differences, deception, tool use, and social learning (8,9,31,32,10–14,22,29,30). This shows that they are complex sentient beings, with impressive cognitive abilities and the capacity to suffer.

> *"It's really an amazing experience to be down there and having this communication with an octopus and a diver, when you really begin to understand that this is a thinking, cogitating, curious animal... this is the kind of thing that really inspires me endlessly."*
>
> Roger Hanlon, The Amazing Brains and Morphing Skin of Cephalopods, TED Talk, 2019



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Several scientific articles have been published regarding the functioning of the octopus's nervous system and its capacity to feel pain. It has been shown that these animals have higher brain centres (part of the brain associated with cognitive processes). They also change their behaviour in response to painful stimuli, for example to avoid sea anemone stings. And they can learn to associate non-painful with painful events (22). Furthermore, Crook et al. (2021) (33) recently performed several experimental studies on octopuses using methods established to determine pain awareness in mammals. They demonstrated that octopuses avoided situations that had previously caused them pain, chose to spend time in places they received pain relief, and self-groomed the area of their body where they were injected with acetic acid, a behaviour which stopped after administration of local anaesthesia. Also, the authors showed that noxious sensory information (information about harmful experiences) is processed in the central brain. This clearly demonstrates that octopuses are able to feel pain, and therefore, their welfare should always be taken into account.

In fact, cephalopods were included in The Cambridge Declaration on Consciousness. The Declaration states that consciousness can be present in animals who have a different evolutionary pathway than humans, including the taxonomic category of cephalopod molluscs. It explicitly mentions octopuses claiming that they possess the neurological substrates that generate consciousness. The inclusion of this phylum recognised over fifty years of work of cephalopod behaviouralists (34). The Declaration is an official document with a scientific basis that should be taken into account to promote the protection of these animals.

Research has also demonstrated that cephalopods possess a suite of cognitive attributes that are comparable to those found in some vertebrates, including highly developed perception, learning, and memory abilities (34–36). These animals are also renowned for performing sophisticated feats of flexible behaviour, which have led to claims of complex cognition such as causal reasoning, future planning, and mental attribution (8).

Some examples of complex behaviour in octopuses:

Remarkable anti-predatory strategies reported among octopuses include defensive tool-use. Octopuses have been observed carrying coconut shells around as mobile dens, a behaviour that is thought to decrease the likelihood of predation as the coconut shells can be arranged into a protective shelter (35,37).

Octopuses can learn a spatial task in a single day and retain the information over seven days (38).

Social learning has been reported in the common octopus, *Octopus vulgaris*, whereby naïve octopuses were able to solve a colour discrimination task by first observing another octopus performing it (39).

Octopuses avoid visiting the foraging areas that they have depleted of resources (i.e., benthic prey such as bivalves – e.g., mussels and gastropods as sea snails) during previous visits (40,41). This suggests that octopuses update their memory to optimise their foraging behaviour.

The anti-predatory behaviours of cephalopods are perhaps the most iconic evidence of their behavioural flexibility. While many animals use camouflage to conceal themselves from predators, cephalopod camouflage is unique because they can change the pattern of their skin within milliseconds (42). The anti-predatory strategies exhibited by cephalopods involve learning and require decision-making guided by prior experiences.

Some species modify skin patterning, texture, and body posture to disguise themselves as moving algae or a rock (43,44). Specifically, there have been reports of octopuses disguising themselves as small sponges (45), flounder (43,46), lionfish, and banded sea snakes (46).

Octopuses also use their ability to change their appearance to communicate visually with other octopuses, facilitating rapid communication, production of deceptive signals, and flexible mating strategies.

In summary, the complex behaviour patterns of octopus species indeed suggest that they are highly intelligent animals (14,16,35,47).

GLOBAL DEMAND FOR

CEPHALOPODS

Cephalopods (octopus, squid, cuttlefish, and nautilus) are eaten on a large scale in Asia, the Gulf of Mexico region, and in Mediterranean countries – especially Spain, Portugal, Italy, and Greece (6,10) (Figure 1). In the United States, the apparent consumption of octopuses has increased four-fold in the last four decades (Figure 1). Cephalopods' use in fisheries has been increasing since the latter half of the twentieth century (48). This is, at least partially, related to global changes in the marine environment (48). The decreasing abundance of fish stocks caused by industrial commercial fisheries, combined with cephalopods being sufficiently available, led to an increased interest in cephalopods by fisheries (1,49). The registered cephalopod landings indeed show a rapid increase in captures since the latter half of the 1980s (Figure 2). The landings peaked in 2014 with a yearly catch of almost five million tonnes – more than eight times the catch of 1950 (Figure 2).

> *“One consequence of understanding the octopus mind should be a refusal to subject octopuses to mass production.”*
>
> Jennifer Jacquet, Becca Franks and Peter Godfrey-Smith;
> The octopus mind and the argument against farming it, 2019.


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DID YOU KNOW?

Octopuses have copper-based BLUE blood

Octopus landings show an increase since 1950 (Figure 3). In 2015, global octopus landings reached 400,000 tonnes for the first time (Figure 3). This is over ten-fold of the catch in 1950 (Figure 3). Asia and the Mediterranean are the main areas that catch octopus and, in the last seven decades, Asia has accounted for more than half of the registered octopus landings (Figure 3). The main countries involved in octopus fisheries are China, Morocco, Mauritania, Japan and the EU, all 5 regions accounting for 76% of world catches of this species (50). It must be emphasised that the actual number of landings is likely to be much higher, since captures are often under-reported, especially in artisanal and nearshore fisheries (10,17).

In Europe, octopuses are targeted mainly around the Mediterranean region, where the three largest octopus fishing countries are Spain, Portugal and Italy (Figure 4). Spain has seen a vast increase in landings since the 1960s, which has resulted in octopus wild populations now being in an overfished state and on average have been decreasing since the 1990s (Figure 4). Given that the demand and consumption of octopus remains the same (48), Spain has become the main importer of octopus in Europe which accounts for 91% of the national supply. The main countries of origin are Morocco and Mauritania followed by Mexico, Senegal and Indonesia (48). This situation has also led to a significant increase in octopus prices which is due to the combination of reduced supplies and increasing demand in some countries, especially the US and Japan, but also in Spain[1].

Therefore, the growing gourmet markets and the inflation of octopus prices has meant that the rearing of octopuses for human consumption has been considered a profitable candidate for industrial culture (17). Research was initiated in northern Mediterranean countries. In the 1990s, this led to many trial cultures with *Octopus vulgaris* (51). Some research groups around the world are now looking at the aquaculture potential of other octopus species, for example *Octopus maya* and *O. bimaculoides* in Mexico (52,53), *O. ocellatus* and *O. vulgaris* in Japan (54,55), and *O. mimus* in Peru (56).

The perceived characteristics leading the EU industry to favour *Octopus vulgaris* in the first place were: high growth rate, acceptance of low-value natural foods, high reproductive rate and high market price (57). However, significant problems in farming this species have been reported, such as cannibalism, confinement, dependence upon live food and a single reproductive episode during their lifetime (6,8,17).

Despite these serious issues, some governments, universities, and private companies have invested major resources in developing octopus farming systems.

[1]See: http://www.fao.org/in-action/globefish/market-reports/cephalopods/en/

APPARENT CONSUMPTION OF OCTOPUSES BY CONTINENTS AND COUNTRIES (1990-2018)

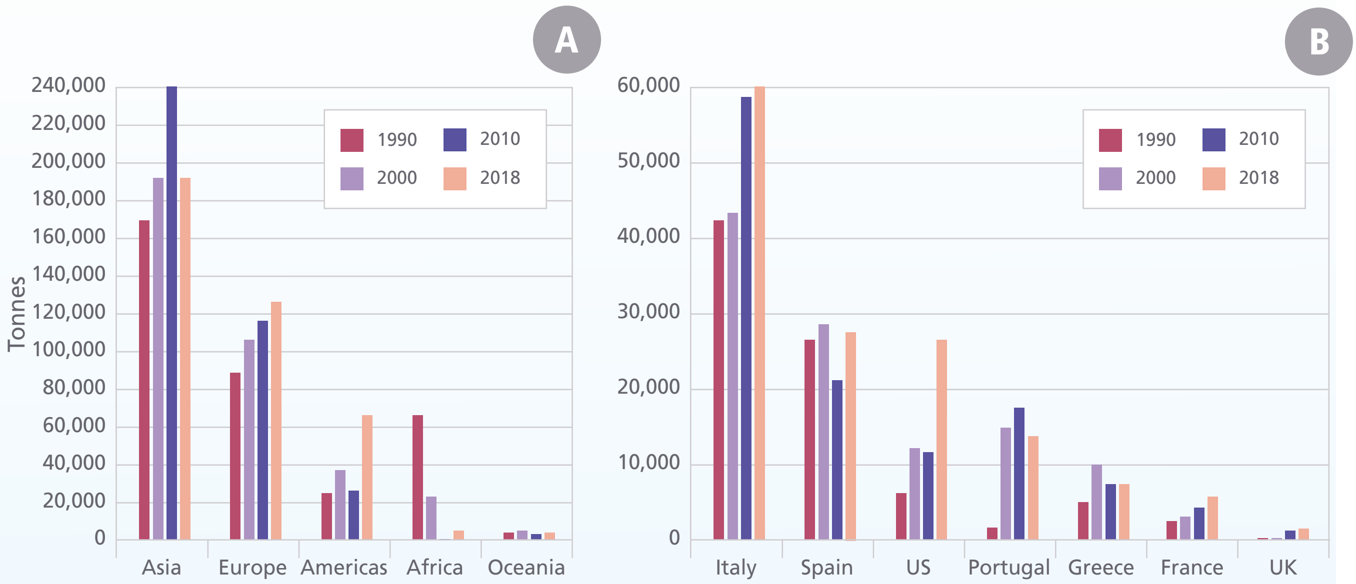


FIGURE 1. Apparent consumption of octopuses by continents (A) and by countries (B). The main European octopus consuming countries have been included as well as the United States. Apparent consumption was estimated as catches plus imports minus exports. Data obtained from FAO database.

GLOBAL CEPHALOPODS LANDINGS (1950-2018)

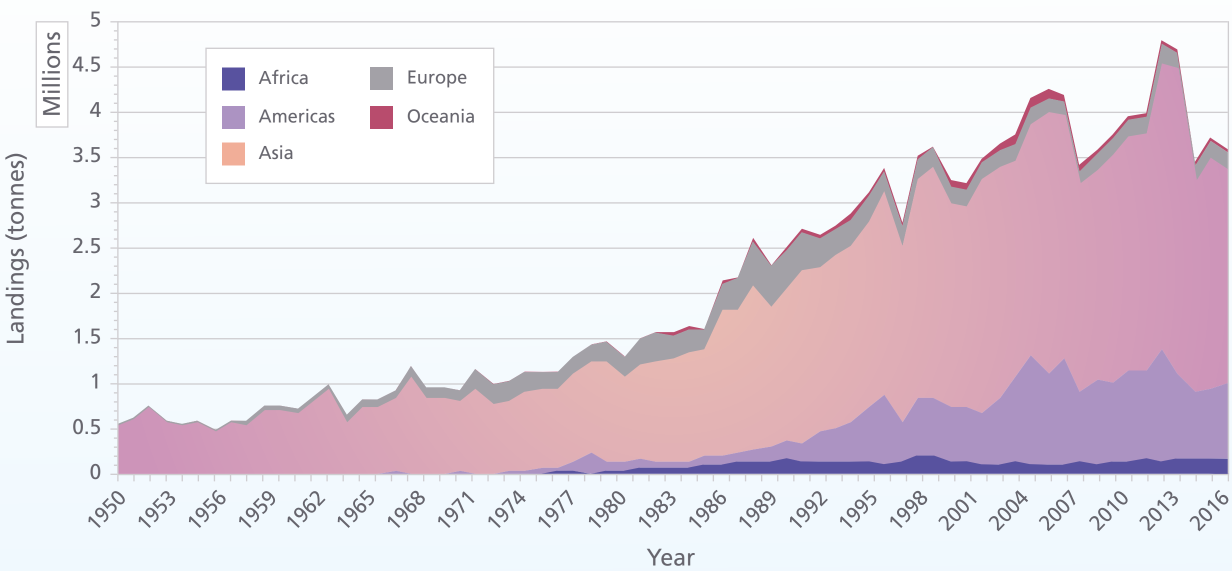


FIGURE 2. Global cephalopod (squids, cuttlefishes & octopuses) landings from 1950 to 2018. Data obtained from FAO database.

GLOBAL OCTOPUS LANDINGS (1950-2018)

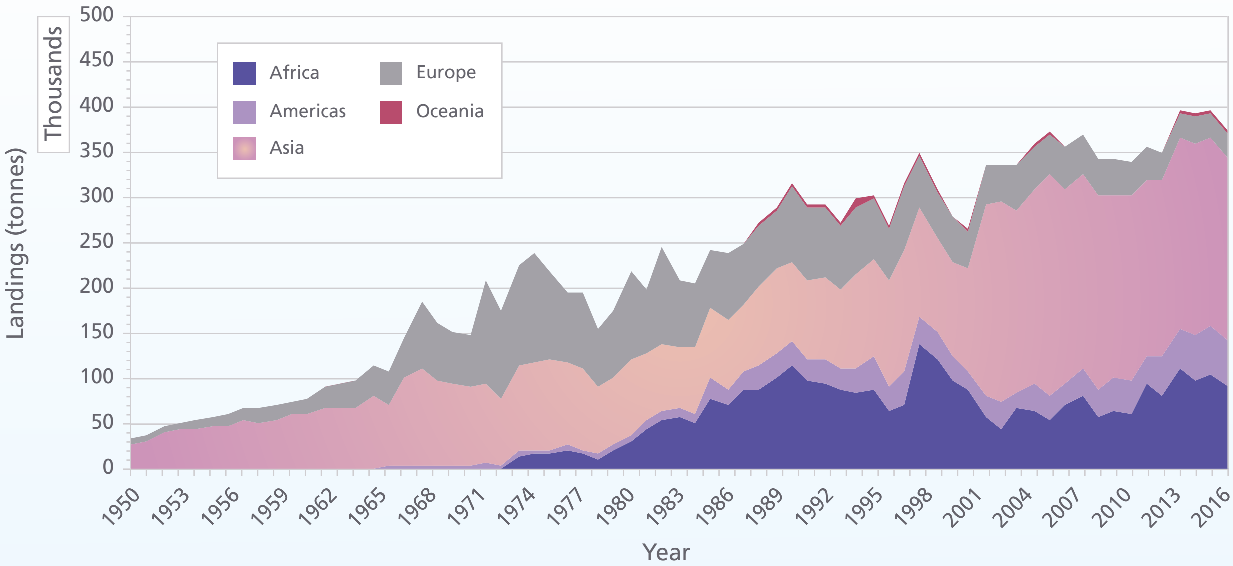


FIGURE 3. Global octopus landings from 1950 to 2018. Data obtained from FAO database.

EU MAIN OCTOPUS LANDINGS COUNTRIES (1950-2018)

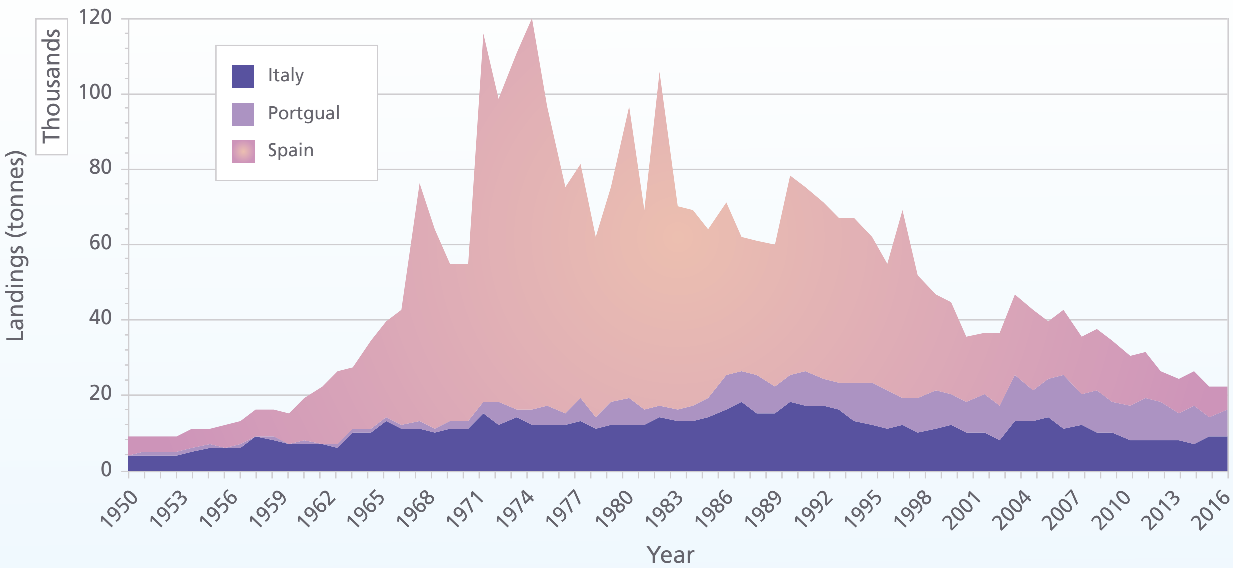


FIGURE 4. Europe's top three countries of octopus landings from 1950 to 2018. Data obtained from FAO database.

THE DEVELOPMENT OF
OCTOPUS FARMING

Commercial octopus farming is a relatively recent development (57). The first attempts to farm octopuses, as well as other species of cephalopods, took place during the 1960s (58). But it was during the 1980s, when large-scale octopus culture experiments were performed, where information was gathered on rearing methodologies, details on seawater systems were tested and several types of diets were assessed (58). Researchers also started to investigate octopus pathologies and healing methods. As octopuses started to be considered as species with farming potential (59), during the next few decades, more attention was given to developing the technology needed for the commercial expansion of octopus farming (58).

> *"Decoupling the ethical and environmental consequences of food production from this system is a daunting challenge, and it should lead us to ask whether we want to repeat mistakes already made with terrestrial animals with aquatic animals, especially octopus."*

Jennifer Jacquet, Becca Franks, Peter Godfrey-Smith and Walter Sánchez-Suárez.
The case against octopus farming, 2019

Traps used by fisheries to catch wild octopuses

As far as we know, there are currently two practices:

- **The fattening of octopuses in sea cages** (also referred to as ranching or ongrowing). In Spanish farms, juveniles of around 750g are commonly caught from the wild and fattened for 3-4 months in sea cages (60). The sea cages contain tubes for shelter and are aimed to be located in calmer areas of the sea since strong waves and constant movement cause high stress to the octopuses and lead to high mortalities (61). The increase in water temperature in summer and the decreased salinity in winter is also associated with high mortality rates (61), but water temperature is the greatest factor determining octopus growth. Trials in tanks and cages in the Mediterranean have shown that mortality notably increased at temperatures above 22°C (62,63). The survival for a production process has been reported to range between just 50% (64,65) and 80% (60). Given that environmental parameters are not subject to control and octopus living natural conditions are difficult to achieve in sea cages, leading to high mortality rates, this method has not been successful on a large scale and has led to the development of octopus farming in tanks on land.

- **The farming of octopuses in tanks on land.** The whole lifecycle is controlled on farm; octopuses are bred and fattened in tanks. This method is not currently commercially available, but the industry is working to farm octopuses on a mass scale. In Europe, the development for this method is mainly taking place in Spain with the species *Octopus vulgaris*. The development of large-scale octopus farming has been constrained by high mortality rates (66,67) mainly due to difficulties controlling the animals' reproduction and developing a sustainable diet (6).

Octopuses in tanks (left) and sea cages (right).

The control of the reproductive cycle is challenging since octopuses are semelparous; this means that they have a single reproductive episode during their lifetime, then they die (6). Therefore, broodstock must be renewed every culture cycle. Octopus eggs are obtained either by spontaneous spawning of broodstock taken from the wild or are collected directly from the wild and are fertilized *in vitro* (6), which has harmful effects on the natural population. Another significant problem has been feeding octopuses during the paralarval phase of development. Historically, ensuring survival of octopuses at this stage has been the major bottleneck to developing octopus farming and the major factor behind high rates of mortality (6).

During the paralarval phase, octopuses experience significant structural changes mainly due to the growth of the arms. Therefore, they need feed of high nutritional value, specifically with high levels of fatty acids and phospholipids (69). Despite past experimentation efforts, the mortalities of paralarvae are still high, especially during the first two months of the paralarval rearing period, and juvenile settlement is very difficult to achieve. The most successful trial used live prey (Artemia and spider crab, a crustacean (66)) and in the Spanish patent it is reported that the best paralarvae diet is based on small crustaceans called *Phtisica marina*, *Caprella equilibra* and *Jassa* sp. This methodology would mean that a large amount of live prey would need to be used in order to culture octopus for commercial purposes, which is difficult to obtain. In fact, suitable feed for the entire life cycle of octopus remains one of the biggest bottlenecks for commercial-scale production.

In addition to the reproduction and the dietary challenges, Villanueva *et al*. (2014) (6) highlighted other issues. For example, zootechnical parameters (tank type, light type and intensity) need further improvement as well as preventing cannibalism and avoiding animal escapes (8).

Paralarval phase of octopuses: an octopus of the first post-hatching growth stage that swims in the water column near-surface waters and that has a distinctly different mode-of-life from that of juveniles and adults which live on the seabed (68).

CANNIBALISM

Cannibalism is a major issue for industries keeping octopuses in captivity. In the wild, octopuses are perhaps the most solitary of cephalopods (8) and in the laboratory it has been observed that they maintain dominance hierarchies based on size (70). By definition, rearing animals on a commercial level means keeping them at high densities, which is stressful for them (71) and creates a potential situation for the animals to kill and eat each other. Cannibalism is a response to a high stocking density, limited food supply, size difference between individuals as well as the general lack of sociality in octopuses, combined with short lifespan, semelparous reproduction, and high metabolic rate (8). In the wild, it may contribute to population limitation, although for culture in the laboratory it is a major problem. To some extent, cannibalism could be avoided by keeping animals of the same size together and, since cannibalism is also partly dependent on food supply, it is useful to have a good supply of preferred food, which may be difficult to procure (8). Also, giving octopuses a complex environment in captivity may maximize their ability to escape from conspecifics who would consume them, as well as increasing their growth and learning capacity (72). Yet, these may only be weak and partial solutions. It is clear that farming octopuses on a commercial scale is unethical given their solitary natural behaviour and the detrimental consequences that rearing them in group may have.

The US, Mexico, Japan, and Spain are the main countries working to develop octopus farming on land in tanks. Currently, there is only one active octopus farm – the "Kanaloa Octopus Farm" based in Hawaii[2] – which works as both a cephalopod aquaculture research facility and a tourist attraction. Here, the fattening of octopuses is already in place; they collect Hawaiian juvenile octopuses from the ocean to fatten them in tanks. Also, research on the environment and feeding requirements of the larval phase is being studied to develop octopus farming at commercial level. The National Autonomous University of Mexico (UNAM) has reported that they have successfully farmed *Octopus maya* and attempts to farm octopus are under way in other parts of Latin America, including Chile[3]. In Japan, the seafood company Nissui reported hatching octopus eggs in captivity in 2017 and predicted a fully farmed market-ready octopus by 2020[4], however this has not yet been achieved. In Europe, Spain is the main country currently developing octopus farming.

Development of octopus farming in Spain

Spain, supported in part by the European Union, has led the research into *O. vulgaris* farming, first in open-ocean net cages and more recently in tanks on land. The Spanish Institute of Oceanography (IEO) in Vigo has carried out the majority of published research on octopus farming. The research institute has made an exclusive agreement about the patented production method with the company Nueva Pescanova, which has progressed the research at their facilities. The company announced in a press release: "We will continue to research how to continue improving the well-being of octopuses, studying and replicating their natural habitat, with the expectation of being able to sell aquaculture octopus starting in the year 2023[5]". In September 2021, the company announced that it plans to open an octopus farm in a harbour in Las Palmas, Canary Islands, costing 65 million euros. The island's authorities have declared this "the largest private investment in history in that area[6]". Interest in octopus aquaculture is now growing among other companies in Spain. For example, the Aquaculture Technological Centre (CTAQUA) is now considering the farming of octopuses[7].

In order to conduct research for octopus farming in tanks, wild octopuses of around 700-800g are caught from the Northeast Atlantic coasts (Spanish, Portuguese and Moroccan waters)

[2] https://www.kanaloaoctopus.com/
[3] https://blogs.scientificamerican.com/octopus-chronicles/how-to-grow-a-patagonian-red-octopus/
[4] https://asia.nikkei.com/Business/Fully-farmed-octopus-on-its-way-to-your-dinner-table

and transported to tanks on land. The typical catching systems use traps and the animals designated for ongrowing are individually placed in a mesh bag, which can cause injuries, or they are put in separate containers to avoid attacks between individuals, which is stressful for the animals and can lead to mortalities (73).

Once in the rearing facilities, octopuses are kept alone in tanks to avoid aggression or cannibalism (74). After this period of habituation, they are moved to group housing areas. At the beginning of the ongrowing cycle, octopuses are put in tanks of about 1m × 1m x 1m with 120 PVC tubes provided as dens to avoid competition for shelter. The initial stocking density in tanks and cages is of great importance since the growth rate is so high that the initial biomass can triplicate in a few weeks. The scientific literature reports that the initial density is 10kg/m^3, when the animals are approximately 0.75-1kg each (10 octopuses per m^3), and during the fattening process the culture density increases to roughly 40kg/m^3 when the weight of the animals reaches around 2.5-3.5kg each (60). This high stocking density could generate problems related to oxygen consumption and waste production and even the creation of hierarchies as a result of size variations, which may lead to stress and cases of cannibalism and autophagy, when the animal eats (parts of) its own arms.

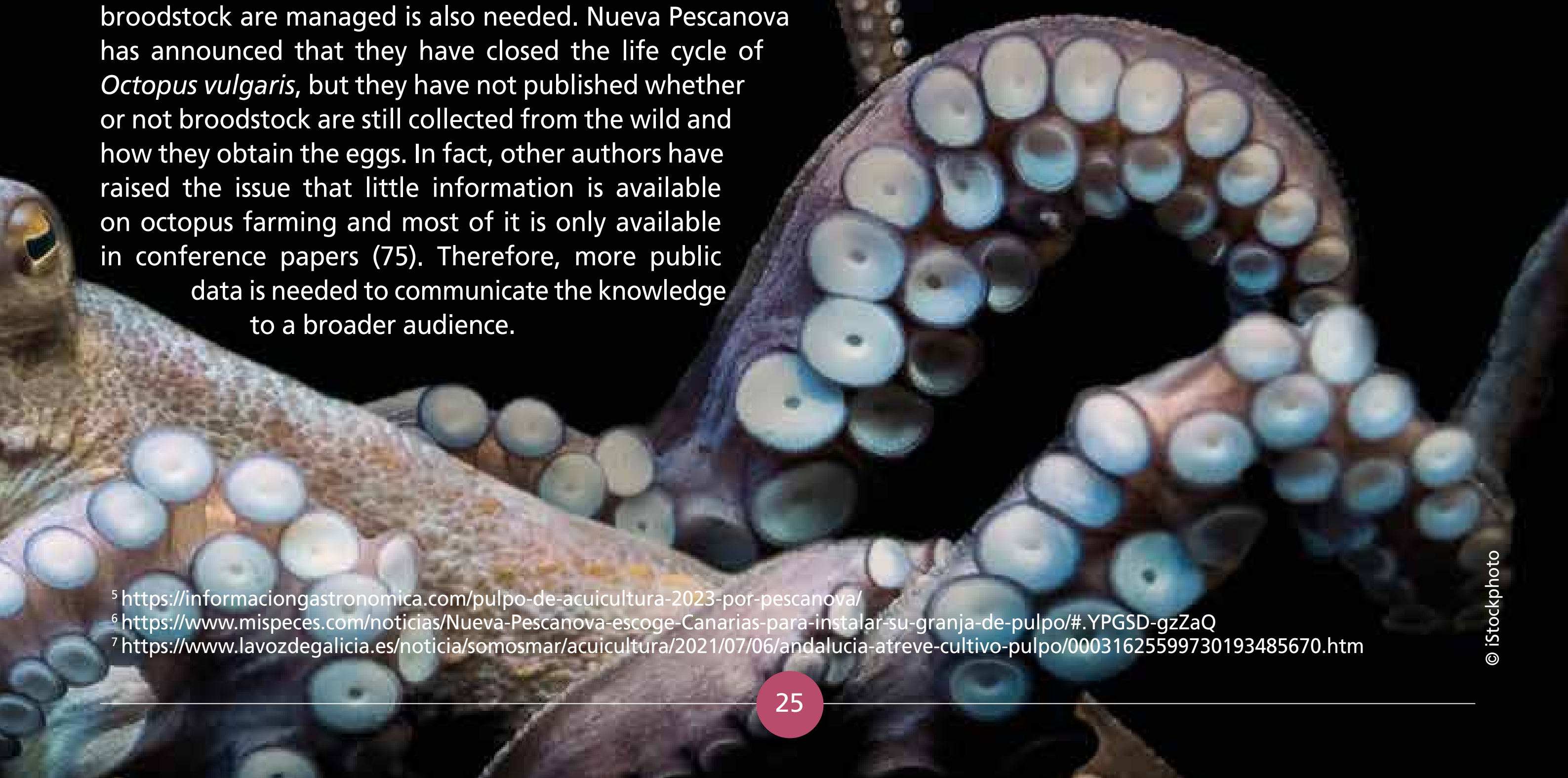
DID YOU KNOW?

An octopus's nervous system runs through its arms, so each individual arm can taste and feel, as if it has a mind of its own

1 in 5 would not survive

Another important issue is that experimental trials to farm octopuses suggest that the mortality in these systems would be around 20%, meaning that 1 in 5 individuals would not survive the entire production cycle (75). Despite all the challenges it faces, commercial farming continues to develop.

Further information does not appear to be available about the practices that have been established by Nueva Pescanova in their trials to farm octopuses. We do not know which are the main welfare issues they are facing, such as specific data on mortality rates at each stage, frequency of cannibalism or autophagy episodes as well as injuries, how animals are handled in the facilities and which slaughter methods are used. Information on how broodstock are managed is also needed. Nueva Pescanova has announced that they have closed the life cycle of *Octopus vulgaris*, but they have not published whether or not broodstock are still collected from the wild and how they obtain the eggs. In fact, other authors have raised the issue that little information is available on octopus farming and most of it is only available in conference papers (75). Therefore, more public data is needed to communicate the knowledge to a broader audience.



[5] https://informaciongastronomica.com/pulpo-de-acuicultura-2023-por-pescanova/
[6] https://www.mispeces.com/noticias/Nueva-Pescanova-escoge-Canarias-para-instalar-su-granja-de-pulpo/#.YPGSD-gzZaQ
[7] https://www.lavozdegalicia.es/noticia/somosmar/acuicultura/2021/07/06/andalucia-atreve-cultivo-pulpo/0003162559973019348567O.htm

WELFARE AND ENVIRONMENTAL ISSUES

Significant attempts to farm octopus are underway. However octopus farming has the same damaging environmental consequences as other types of carnivorous aquaculture. And, like other carnivorous aquaculture systems that depend on wild-caught fish to feed the animals, octopus farming would increase, not alleviate, pressure on wild aquatic animals. Even if aquaculture researchers could develop a sustainable diet for octopus, and were also able to reduce other ecological impacts, farming octopus would still be fraught with welfare problems. Here, we describe the main environmental and welfare issues related to octopus farming.

> *"Even the best-intentioned octopus farming would not satisfy the necessary conditions to make an octopus' life meaningful."*
>
> Jennifer Jacquet in"Inside the Race to Build the World's First Commercial Octopus Farm" Time, 2019

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Large amount of fish are used to produce fishmeal and fish oil

ENVIRONMENTAL IMPACT

As aquaculture of carnivorous species grows, there is increased demand for fishmeal and oil, and additional pressure is placed on wild fish populations.

Octopuses naturally feed on crabs, clams, small fishes, etc. in the wild. In order to feed them in farms, a large amount of live or frozen natural food such as crustaceans and fish are needed, which is an unsustainable practice. Industry and researchers are also developing artificial feeds for farmed octopuses which will be based on the use of fishmeal and fish oil (6). Huge numbers of wild fish will be caught and reduced into fishmeal and fish oil, key ingredients of feed for carnivorous species such as octopus. The species caught by "reduction" fisheries are forage fish such as anchovy, sardines, herring and mackerel (76). Forage fish play a key role in the marine environment because they feed near the base of the food chain on plankton and are preyed on by larger predators (76). Therefore, they are crucial in transferring energy from primary producers to higher trophic-level species including large fish, marine mammals and seabirds (77).

It is estimated that 0.5–1.0 trillion fish caught each year are used for reduction to fishmeal and fish oil (78), estimated to represent nearly 20% of wild-caught fish landings (77). Approximately 90% of these wild-caught fish are suitable for human consumption (77) and therefore this also represents a waste of resources, as calories are lost in the conversion of one fish species to another. The use of wild-caught fish in aquaculture is not only an unsustainable practice, but also creates food security issues in regions such as West Africa, Southeast Asia and South America where the main industrial reduction fisheries are located.

Industrial fishmeal producers are equipped with better fishing technologies and enter into competition with local fisherman, thus affecting local communities since they rely on small pelagic fish for their livelihoods. Furthermore, many forage fish populations are subject to overfishing and are declining (79). Therefore, aquaculture based on the farming of carnivorous species increases the pressure on wild-fish stocks and hunger in the Global South. Aquaculture should move away from carnivorous species and promote farming systems that are environmental and animal welfare friendly, as well as improving food security rather than aggravating the situation for more vulnerable communities.

On top of this, octopuses' food-conversion ratio intensifies the threat to wild stocks. Jacquet et al. (2019) (17) stated that octopuses have a food conversion ratio of 3:1, indicating that an octopus eats three times its own weight in food. For these reasons, carnivorous aquaculture is not just a senseless solution for protecting wild marine animals; it actually puts additional pressure on these stocks and thus is a part of the problem. The researchers from Nueva Pescanova claimed that the octopus food conversion rate is 2:1 in correspondence with National Geographic[8]. Nevertheless, this still would be unsustainable. Sánchez et al. (2014) (75) mentioned octopus diets with food conversion rates close to one may be achieved if formulated diets are developed, however the alternative of using more sustainable (vegetarian) feed may also provide its own challenges. For example, it is a potential use of resources that could be eaten directly by humans and there is evidence of vegetable meal producing the worst amino acid balance for *Octopus vulgaris* (6). Therefore, plans to develop the intensive production of farmed octopuses are being developed even though a sustainable artificial feed for cephalopods is yet to be obtained.

DID YOU KNOW?

Octopuses can learn a spatial task in a single day and retain the information over seven days.

[8] https://www.nationalgeographic.com/animals/article/octopus-aquaculture-debate


Kay Burn Lim www.instagram.com/kayburn

WELFARE CONCERNS

Major health and welfare risks are created when animals are kept in conditions that do not meet their natural needs and do not fit with their wild environment. Moves to farm octopuses are an attempt to farm wild animals that have not been domesticated. Octopuses are also intelligent and complex animals with large cognitive capacities that need a complex and varied ocean environment, not empty and barren tanks or pens. Some of the major welfare risks for these animals in commercial facilities are summarized below.

- **Animal health**: Intensively farming any species is associated with a risk of health problems, particularly those due to infectious diseases which are a problem when huge numbers of animals are kept in close confinement and experience stressful conditions (8,15). Several diseases have already been detected in small-scale captive conditions (15). However, the available knowledge on infections and general pathologies is still very scarce and needs further research. These animals will be subjected to different conditions at industrial scale, where diseases will predictably be more common (15). The main disease-causing agents already detected are related to microorganisms (viral and bacterial infections), parasites, chemicals, and mechanical agents such as injuries produced during handling in the laboratory, lesions provoked by interactions under crowded conditions, and abrasions (15).

- **Stocking densities**: Octopuses are mostly solitary-living animals (3,8,17,80) but industrial farming practices mean that these animals will be kept in groups at high densities to make production profitable. Housing species who are solitary by nature in high densities can result in poor welfare (80) and creates the risk of aggression and territorialism leading to cannibalism (8,17).

- **Injuries**: The skin of an octopus is very fragile and can be easily damaged (2) because it lack an internal or external skeleton to protect itself. Also, as octopuses have fast jet-propelled locomotion, they could crash with the walls of the tanks and be injured. Therefore, wounds can easily occur. Other potential problems that may cause injuries to octopuses are physical contact by a handler (2) or aggressive interactions (8). Octopuses captured from the wild to be used in the experimental studies have injuries caused by fishermen, nets or traps during the capturing process. This can happen, for example, when an octopus is trying to escape, or when a fisherman removes an octopus very quickly from the net/trap (81). Furthermore, injuries can occur during the transport period (2). Fiorito et al. (2015) propose guidelines for the care and welfare of cephalopods in research settings. One of these guidelines is to handle cephalopods as little as possible, just as their removal from the water should be kept to minimum.

- **Enrichment**: Octopuses are sentient animals, so when considering their welfare it is important to take into account their need to express natural behaviours and their psychological well-being (2). Farming systems should not only minimise suffering and negative experiences but should also provide animals with positive experiences and the opportunity to have a life worth living. Environmental enrichment refers to stimuli added to enhance the level of physical and social stimulation provided by the captive environment (82). Enrichment should improve an animal's ability to express its normal behaviours and is integral to providing it with the conditions to promote good welfare (80). Effective enrichment should be based on the needs of the species in its natural wild environment (83). Octopuses like to explore, manipulate, and control their environment (84). Thus, they are susceptible to boredom in captivity (17,85) and need sufficient cognitive stimulation. They also need structures for shelter in order to hide and feel safe (8). Therefore, their cognitive, sensory, and motor abilities must all be challenged. It is important to note that environmental enrichment is only a partial solution to having octopuses exhibit natural behaviour in an unnatural setting (8). The mass production of octopuses is likely to have barren, controlled and sterile environments and therefore, lacking sensory inputs (86). Enrichment techniques may be difficult to implement in aquaculture or lead to negative effects. For instance, sand in the tank may compromise water quality and cleanliness (5).

DID YOU KNOW?

Their camouflage is unique because they can change the pattern of their skin within milliseconds and some can even change texture.

- **Mortality**: The mortality rate in octopus farming experiments is high (5,15,17). For example, around 20% of octopuses in Spanish aquaculture are reported to die (75). The main factors affecting the survival rate are water temperature, culture density, size dispersion and the type of feed supplied (75).

- **Humane slaughter**: For a killing method to be humane, it must either stun, rendering the animal instantly unconscious (i.e., in less than one second) with no recovery of consciousness before death, or if unconsciousness is gradual, the method must not cause pain, discomfort or be unpleasant (87). CephRes (Association for Cephalopod Research) was awarded with funding from the Humane Slaughter Association in 2020 to research and develop humane methods to slaughter cephalopods. However, the current situation is that the industry is planning large-scale production of octopuses, possibly within the next two years, despite the lack of scientifically validated methods to humanely slaughter them. Octopuses have a complex and largely un-centralised nervous system, which makes it very difficult to kill them in accordance with requirements for humane slaughter (22).

More detail on the three potential methods that are being studied are given below based on the latest scientific publications:

- **Chemical methods**: An overdose of an anaesthetic agent is administered to the octopuses. Magnesium chloride, ethanol and clove oil are the most frequently used agents. These methods have the potential to cause adverse effects prior to unconsciousness, such as skin or eye irritation, or asphyxia (22). Therefore, animals should be exposed gradually to the anaesthetic from low concentrations to higher and not use directly the full concentration needed to cause death (22). If anaesthesia is only used as stunning method and not as the killing method, it is important to effectively assess the depth of anaesthesia, to establish that the animal is actually in a state of general anaesthesia and is not just appearing to be anaesthetised (i.e., unresponsive but conscious) (22). Further research needs to be done to identify efficient analgesic agents in octopuses as well as appropriate dosing to avoid any potential suffering.

- **Mechanical methods**: Octopuses are killed by mechanical destruction of the brain, such as cutting between the eyes (midline incision) or decapitation (by severing the head from the mantle collar) but the nature and degree of suffering is not known since these animals have a decentralised nervous system. Also, these methods are difficult to apply and require highly skilled operators due to difficulty in restraining the animals. For both reasons, mechanical methods are not recommended according to the scientific literature (2,88) if anaesthesia is not previously provided to the animal (2).

- **Electrical methods**: The application of electrical current to octopuses may be a potential humane method of killing them. Electrical stunning is already applied on other aquatic animals such as fish and crustaceans. The method consists in applying electrical current to the animals, which causes an immediate interruption in the nervous system function and prevents the animals from receiving stimuli and thus from feeling pain or suffering distress. A separate kill method is often required after electrical stunning. This method might be considered but it needs to be specifically developed for octopuses and it needs also to be scientifically evaluated to prove its suitability to be a humane method (2,22).

Given that electrical methods are still not scientifically validated, and the use of mechanical methods involves many welfare risks, the use of chemical methods followed by brain destruction is the method recommended by several scientists. According to Andrews (2013) (22) it is the most humane method currently available. However, the efficiency and potential aversion effects need further research according to the different species and taking parameters such as body weight, sex and water temperature into account (22). Moreover, chemical methods cannot be used in commercial octopus farming since this practice would contaminate the final product. Therefore, humane slaughter is not currently possible to apply in octopus farms.

Octopuses also suffer inhumane capture and killing in wild fisheries

Octopuses are caught by wild fisheries via bottom trawling or using fishing lines, traps or pots between 20 and 200 metre depth, but they are also caught as bycatch (9). These methods cause significant suffering to octopuses. During bottom trawling, they are chased and can be compressed for around 30 minutes, which causes a lot of stress to these delicate animals (81). In trapping, they also suffer from stress when the traps are moved from the bottom to the surface, which can take around 15 minutes (81). Once on board the vessel, many octopuses may be kept in nets. Some of them try to escape back to the water, which shows that the situation is very stressful for them, and they can suffer injuries from the nets and the handling. There is a general lack of information about the killing methods used but some literature mentions procedures such as clubbing the head, slicing the brain, reversing the mantle (muscular sac behind the head that contains all the organs), asphyxiation en masse in a net, and chilling in ice (81). In some countries, such as South Korea, octopuses are even eaten alive. Humane alternatives to these methods, ensuring that octopuses are rendered immediately unconscious before killing, are urgently needed to avoid the severe pain and suffering currently experienced by these animals. Procedures to minimise handling and reduce stress should also be of high priority.

DID YOU KNOW?

Octopuses are able to feel pain and feel relief with painkillers

LEGISLATION

Since octopus farming is a new practice that is mainly developing in Europe, an important question needs to be considered: what European legislation exists to protect octopuses if they are farmed commercially? The answer: none.

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"How we treat those who are at our mercy, is the truest reflection of who we are as individuals, communities and nations."

Philip Lymbery in "Justice For Animals – Not Just Kindness"

Octopuses used in research are covered by the European Directive 2010/63/EU on the protection of animals used for scientific purposes. This applies to experiments where methods are tested to develop commercial octopus production, but not the farms themselves. Cephalopods are the sole invertebrates who are included in this legislative act (89). The Directive considers cephalopods as animals who are capable of experiencing pain, suffering, distress and lasting harm. This Directive also covers animal supply, housing, handling, analgesia, and euthanasia. It states that cephalopods must be kept in conditions that meet their welfare needs, all procedures must be done in a way that minimises pain and suffering, and if killing is necessary, they must be killed humanely. However, this Directive has no specific guidelines for humane slaughter and does not apply to octopuses raised for human consumption.

Lack of legislation for farmed octopuses

The EU holds various legislative acts that protect farm animals. Council Directive 98/58/EC, Council Regulation (EC) No 1099/2009 and Council Regulation (EC) No 1/2005 protect farm animals at the time of farming, transport and killing, respectively. However, they exclude invertebrates from their scope. Therefore, there is currently no European legislation that would protect octopuses if they were produced commercially for human consumption.

The World Organisation for Animal Health (OIE)[9] has considered the welfare of farmed aquatic animals and has developed welfare guidelines for farmed fish but not for cephalopods, and therefore, octopus welfare.

In other parts of the world where octopus farming is being developed, such as the US, Mexico, and Japan, octopuses are not protected by law either.
In the US, the two main pieces of federal legislation, the Animal Welfare Act and Humane Methods of Slaughter Act, do not apply to cephalopods. Cephalopods are currently not even considered "animals" by the US federal government when it comes to their treatment in research. With no legal requirements for ethical considerations when conducting experiments, there is a risk they may be exposed to extremely painful or stressful procedures.

In Mexico, several provisions concerning the welfare of animals used in farming appear in Articles 19 to 23 of the Federal Animal Health Act (2007). This Act applies to all animals except aquatic animals (Article 4). In Japan, the animal welfare legislation is the Act on Welfare and Management of Animals, but it does not specifically address the welfare needs of animals used in farming. It exists only a guidance produced under the Act that includes the Standards relating to the Care and Keeping of Industrial Animals.

In Europe, there is some national legislation where cephalopods have been included.

i) United Kingdom: The Animals (Scientific Procedures) Act 1986 currently applies to living cephalopods. Similarly to the aforementioned European Directive, this act protects animals during scientific research (The National Archives, 2018). Initially, the act included only one species, *Octopus vulgaris*, within its scope through an amendment in 1993 (The National Archives, 1993) but a later amendment in 2012 extended the protection to all cephalopods.

ii) Norway: The Animal Welfare Act 2010 is a Norwegian legislative act that includes octopuses within its scope. This legislative act aims to promote good animal welfare and respect for animals and, therefore, sets out various general requirements such as keeping the animals in appropriate conditions and ensuring their health. This Act also requires that animals must be stunned before being killed and the stunning method shall ensure loss of consciousness. Moreover, it is stated that animals are kept in an environment which is consistent with good welfare and which meets the animals' needs giving them the opportunity to carry out stimulating activities, movement, rest and other natural behaviour.

iii) Switzerland: The Animal Protection Ordinance (AniPO) of 2008 regulates the captive holding of cephalopods. It regulates their use, handling, housing, and any interventions. Cephalopods are included in the animal experimental chapter, but no specific indications are given for them in terms of housing, handling or killing. However, the Act gives specific rules of stunning methods for livestock animals including fish and decapods.

[9] https://www.oie.int/en/what-we-do/animal-health-and-welfare/aquatic-animals/

SHOULD OCTOPUS FARMING BE ALLOWED?

The aquaculture industry farms a diverse range of species, many more than the number of species reared in the agricultural sector (90). The vast majority of these species are either wild or only recently domesticated and therefore they are not biologically adapted to life in captivity (91). This which poses serious knowledge gaps regarding the welfare requirements of many (if not most) farmed aquatic species (91). The farming of octopuses will be yet another example of species being produced on a large scale without accounting or providing for their welfare needs (91).

From an animal welfare perspective, these animals are fundamentally unsuited to farming and there are serious animal welfare problems associated. As they are sentient and highly intelligent, they will suffer greatly in intensive farming systems, which involves rearing them at high density in barren tanks. These environments are unlike their natural environment, i.e., they lack any enrichment or complexity. It is particularly worrying that there is no validated humane slaughter method. Moreover, farmed octopuses would not be protected by European Union, American, Mexican or Japanese legislation.

From an environmental perspective, it is important that new farming systems do not pollute, do not damage wild populations in any way and ideally, they should provide ecosystem services (i.e., have a positive effect on the environment in some way). Furthermore, they should be truly sustainable and resource efficient – turning resources humans cannot eat into resources we can. Fed aquaculture goes against this concept, when the feed contains human-edible ingredients such as soyabean or fish (90% of the wild fish caught to produce fishmeal and oil is human edible). Octopuses are carnivores and need a high-quality diet that includes live prey and high number of fish. Farmed octopus therefore cannot be part of a sustainable food system.

In addition, development of this intensive farming practice is not in line with the new "Strategic Guidelines for the sustainable development of aquaculture" adopted by the EU Commission in May 2021. These guidelines set out standard priorities and targets to ensure the sector is run and developed sustainably. Here, the Commission encourages producers to limit the use of fishmeal and oil and to reduce aquaculture's reliance on these ingredients produced from wild-caught fish: *"The EU aquaculture sector needs to ensure sustainable feed systems. This means using feed ingredients that are sourced in the way that is most respectful of ecosystems and biodiversity and which, at the same time, are appropriate for ensuring the health and welfare of the animals. It also means limiting feed producers' reliance on fish meal and fish oil taken from wild stocks*[10]". Linked to this point, the Commission proposes that EU aquaculture diversifies, introducing low-trophic species that do not need feed and with a lower environmental footprint such as algae, shellfish, and extensively reared herbivorous fish. As we have explained in previous sections of this report, octopus farming will highly depend on fishmeal and fish oil since they are carnivorous, high-trophic animals. The development of octopus farming appears to be at odds with the new European strategy for the future of aquaculture. Therefore, Compassion in World Farming is urging the aquaculture industry to stop octopus farming altogether to prevent unncessary suffering and environmental damage.

[10] https://eur-lex.europa.eu/legal-content/EN/TXT/HTML/?uri=CELEX:52021DC0236&rid=2

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