GAIA
Voice of the Voiceless

OCTOPUSES IN BELGIUM

A scientific recognition of their sentience, a major animal welfare issue.

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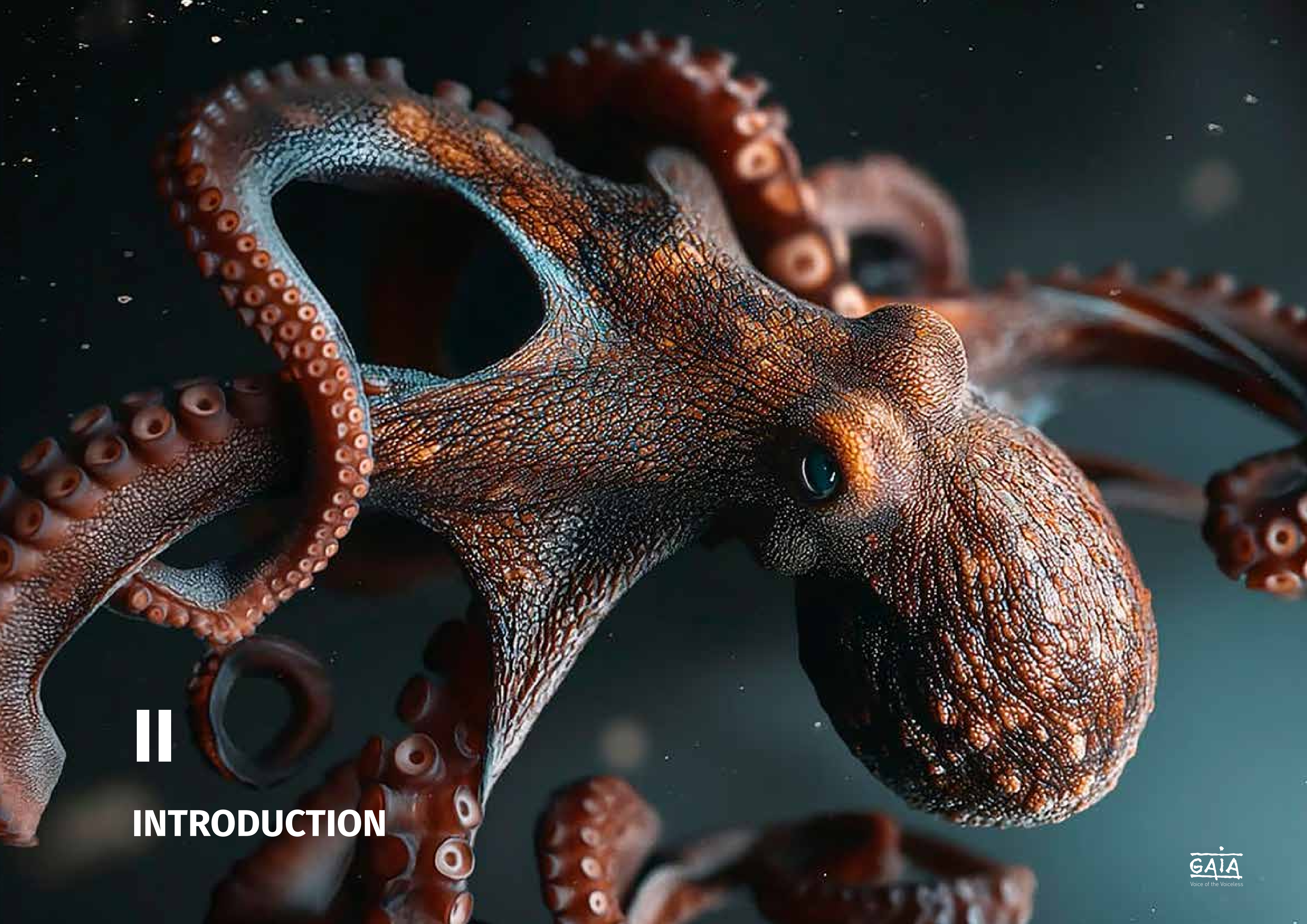
I. GLOSSARY

Sentience[1]	The quality of being able to experience feelings.
Nociceptive[2]	Reacting to something that may be harmful by sending pain signals to the brain.
Ectotherm[3]	Any so-called cold-blooded animal – that is, any animal whose regulation of body temperature depends on external sources, such as sunlight.
Swim bladder[4]	Buoyancy organ possessed by most bony fish.
Homochromy[5]	A form of camouflage or protective colouring in animals that makes an individual visually become part of the whole group or landscape.
Cephalopod[6]	Any of a class (Cephalopoda) of marine mollusks including the squids, cuttlefish, and octopuses that move by expelling water from a tubular syphon under the head and that have a group of muscular usually sucker-bearing arms around the front of the head, highly developed eyes, and usually a sac containing ink which is ejected for defence or concealment.
Food web[7]	A complex network of interconnecting and overlapping food chains showing feeding relationships within a community.
Osmoregulation[8]	In biology, maintenance by an organism of an internal balance between water and dissolved materials regardless of environmental conditions. In many marine organisms, osmosis (the passage of solvent through a semipermeable membrane) occurs without any need for regulatory mechanisms because the cells have the same osmotic pressure as the sea. Other organisms, however, must actively take on, conserve, or excrete water or salts in order to maintain their internal water-mineral content.

1 Cambridge Dictionary, « *sentience* ».
2 Cambridge Dictionary, « *nociceptive* ».
3 Britannica, « *ectotherm* ».
4 Britannica, « *swim bladder* ».
5 Collins Dictionary, « *homochromy* ».
6 Merriam-Webster Dictionary, « *cephalopod* ».
7 Britannica, « *food web* ».
8 Britannica, « *osmoregulation* ».



II

INTRODUCTION

II. INTRODUCTION

In recent years, octopuses have attracted increasing interest, largely due to the film *My Octopus Teacher*, which highlights these intelligent and sensitive creatures. Their ability to adapt to new situations, as well as their capacity to change colour according to their environment, are among their numerous abilities. The film compares their capacities to those of a domestic cat[9], with each having around 500 million nerve cells, a comparison that emphasises the sentience of octopuses. Additionally, their advanced vision, their three hearts, and their ability to change colours – not only to protect themselves from predators but also to hunt and communicate with other octopuses – further demonstrate their highly developed capacities. However, in contrast to domestic cats, octopuses do not receive the same level of recognition from the general public.

This report conclusively demonstrates that octopuses are sentient beings.[10] However, there are no policies or legal regulations in place to protect octopuses during capture or slaughter for human consumption. They often die naturally during capture (e.g., due to overcrowding or being crammed into nets) or suffocate once on board. The failure to apply more humane methods for the capture and slaughter of octopuses, leading to the suffocation of these sensitive and intelligent animals, utterly contradicts the scientific recognition of their sentience[11].

Octopuses, with their eight arms and their ability to eject ink, belong to the class of cephalopods, alongside squids and cuttlefish. The common octopus (*Octopus vulgaris*) is the most commercially fished octopus' species in Europe[12]. Belgian vessels capture approximately 224 000 octopuses per year, which are then sold in Belgian ports primarily for export. The majority of these catches are exported, notably to Spain and France, as octopus' consumption in Belgium is quite low. Moreover, due to global warming and the increase in sea temperature, as well as their ability to adapt to poor water quality, the number of cephalopods, including octopuses, is on the rise in the Belgian North Sea. In 2023, a group of cephalopod species, cuttlefish, were the most fished species group in Belgian waters.

Additionally, the commercial exploitation of *Octopus vulgaris* in aquaculture farms is beginning to develop, against scientific recommendations indicating these systems are not compatible with the requirements necessary for their well-being. This leads to various welfare issues for these sensitive beings, such as skin lesions or stress, which can ultimately result in self-mutilation and death.

9 Octopuses have about 500 million nerve cells, comparable to the number of nerve cells that domestic cats have.
10 Although this report refers to scientific research confirming the sentience of octopuses, GAIA objects to research techniques that negatively impact octopuses as test subjects. According to GAIA, animals should not have to suffer to achieve scientific findings.
11 Birch et al. (2021). Review of the Evidence of Sentience in Cephalopod Molluscs and Decapod Crustaceans. *The London School of Economics and Political Science.*
12 Pita et al. (2021). Fisheries for common octopus in Europe: socioeconomic importance and management. *Fisheries Research*, 235, 105820.

Although this report refers to scientific research confirming the sentience of octopuses, GAIA opposes research techniques that negatively impact octopuses as laboratory animals. According to GAIA, animals should not have to suffer to achieve scientific results.

The sentience of octopuses is now a scientific fact. It is long overdue for society to finally ensure their protection.

III

THE OCTOPUSES IN BELGIUM

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III. THE OCTOPUSES IN BELGIUM

1. Taxonomy

An introduction to 'cephalopods'. Cephalopods (within the class Cephalopoda) are a small but significant taxon of invertebrates (approximately 750 species)[13] within the phylum Mollusca, ranging in size from a few millimetres (dwarf cuttlefish) to over 14 metres (giant squid).[14]

Commercially, there are three important groups of cephalopods in Belgium: the cuttlefish *(Sepioidea)*, the squids *(Teuthoidea)*, and the octopuses *(Octopodiae)*.[15] These cephalopod species are representatives of the subclass Coleoidea of the class Cephalopoda.[16]

2. The Octopus

2.1. Characteristics, behaviour, and ecology

Introduction. Cephalopods are marine animals found in all the world's seas.

Characteristics and behaviour. Octopuses are identifiable by the distinctive crown of arms surrounding their mouth, equipping them with eight arms.[17] Octopuses have a completely soft body, except for the mouth, and can grow up to 40 cm in size, or even up to 140 cm including the arms. Each arm has more than 200 suction cups.[18] They possess complex vision, having more photoreceptors than vertebrates[19] and a hard, beak-like mouth for feeding.[20] Octopuses have three hearts: two branchial hearts, which push blood through the gill capillaries, and one systemic heart, into which the gills drain, supplying the rest of the body[21]. They often move by pumping water into their mantle and forcefully expelling it through a syphon, and they extract oxygen from water through their gills.[22] Additionally, they can also move by walking

13 H. Van de Vis, H.M. Bokma-Bakker en E. Schram, Risico-evaluatie dierenwelzijn in ketens van vissen, schaal- en schelpdieren; Deskstudie en expertopinie, 2019,Wageningen Livestock Research, Rapport 1167, 39.
14 G.M. Cooke et al., Care and enrichment for captive cephalopods in C. Carere and J. Mather (eds) *The welfare of invertebrate animals*, 180.
15 W. Vyncke, An overview of the methods for quality determination of squid (Cephalopods) Report of the National Center for Agricultural Research (Ghent) and the National Station for Sea Fisheries (Ostend) 2.
16 There are two groups of cephalopods (such as squid): the *Nautiloidea* (consisting of six species) and the *Coleoidea* (which include squids, cuttlefish, octopuses, and vampire squids); B. Hochner et al., 'The octopus: a model for a comparative analysis of the evolution of learning and memory mechanisms' (2005) 201 Biol. Bull. 308, 308–317.
17 Ibid. J. Birch.
18 G.J. Pierce et al., Cephalopod biology and fisheries in Europe, ICES Cooperative Research Report No. 303, 2010, 23.
19 Compassion in World Farming. (2021). *Octopus factory farming: A recipe for disaster.* Report.
20 Wikipedia, <https://en.wikipedia.org/wiki/Cephalopod>
21 Wells, M.J. (1980). Nervous control of the heartbeat in octopus. *J Exp Biol*, 85(1), pp. 111-128.
22 Wikipedia, <https://en.wikipedia.org/wiki/Cephalopod>

on the seabed using their arms[23]. These marine animals generally lead a solitary life, meeting only to reproduce.

Ecology. These cephalopods are carnivores, primarily feeding on fish, crabs, lobsters, and mollusks. [24] However, as they are mainly secondary consumers, they are also prey for certain fish and marine mammals. Therefore, they are an integral part of the proper balance of the marine food web.

Sensory perceptions. Although octopuses do not have ear-like organs, they are not deaf and may be able to detect low frequencies (<10 Hz). They detect water movements through a structure analogous to the lateral line in fish[25][26] and also have a structure for olfactory detection capabilities. They can pick up chemical signals (e.g., the secretion of 'juices' from predators or prey such as crustaceans)[27] and respond to them with behavioural changes.[28]

Life cycle. Male octopuses generally live longer than females[29]. Female octopuses lay eggs, and the life cycle of common octopuses (*Octopus vulgaris*) lasts approximately 12 to 14 months.[30] These cephalopods are semelparous species, meaning that females reproduce only once before dying. This phenomenon is explained by the fact that these animals invest a lot of energy in their growth and reproduction, which results in a relatively short lifespan. Indeed, no organism can simultaneously excel in growth, reproduction, and survival.[31]

Skills. Octopuses can change colour and alter their skin texture to mimic environmental patterns (e.g., rocks or the structure of coral) [32] , due to chromatophores, pigment cells present in their skin. They use this ability for communication[33], defence, and camouflage. When hunting, they paralyse their prey with venom and open the shells of mollusks and crustaceans with their beak-like mouth.[34] Given their soft and fragile bodies, most octopuses have developed various techniques to camouflage themselves or distract predators. Homochromy, this ability to change colour, is also used as a form of communication among octopuses, particularly in reproductive strategies. Solitary creatures like octopuses generally possess a greater number of chromatophores, allowing them to quickly adapt to their environment. This gives them an advantage both in hunting stealthily and evading predators[35].

23 Compassion in world farming (2021) *Octopus factory farming: A recipe for disaster.* Report.
24 Wikipedia, <https://en.wikipedia.org/wiki/Cephalopod>
25 The lateral line of fish is a sensory system that detects water movements, vibrations, and pressure changes. It helps fish navigate, hunt, and avoid becoming prey.
26 G.M. Cooke et al. (n 4) 181 and references therein.
27 Behavioural changes were observed when water from a tank containing predatory fish was added. Several squids produced ink after this addition. On the other hand, adding 'juices' from shellfish to the tanks led to an increased ventilation rate in octopuses, indicating that chemical signals may be used in hunting prey; Ibid. 181-182.
28 Ibid. 147-178.
29 Roura et al. (2024). Senescence in common octopus, *Octopus vulgaris* : Morphological, behavioural and functional observations. *Applied Animal Behaviour Science*, 275, 106294.
30 G.J. Pierce et al. (n 9) 23.
31 Roura et al. (2024). Senescence in common octopus, *Octopus vulgaris* : Morphological, behavioural and functional observations. *Applied Animal Behaviour Science*, 275, 106294.
32 G.J. Pierce et al. (n 9) 23.
33 Compassion in world farming (2021) *Octopus factory farming: A recipe for disaster.* Report.
34 Website 'Vist ik het Maar!' <https://vistikhetmaar.nl/onderwijs/lesmodules/weekdieren-2/>.
35 Carlier, P. et Renoue, M. (2007). *Variations colorées chez les céphalopodes selon l'environnement physique et social : un point de vue cognitif.* Colloque de l'Association pour la Recherche Cognitive - ARCo'07 : Cognition – Complexit´e – Collectif, pp. 189-202.

Intelligence and learning ability. Octopuses (*Octopus vulgaris*) are known for their sharp vision and high intelligence;[36] They have brains with a brain-to-body ratio comparable to that of mammals and birds.[37] They can learn[38] and adapt to new situations[39] and, for example, can learn to open a jar of food. It has also been shown that octopuses can have episodic memories (these are memories of specific events or experiences in life, including the time and place where they occurred), which enables 'mental time travel', i.e., the ability to mentally go back and relive these events.[40]

Catch. Octopuses are increasingly being caught in the North Sea[41] and are abundantly fished in the Mediterranean Sea as well as in the central-eastern part of the Atlantic Ocean, along the African coast.[42]

Octopuses can learn
and adapt to new situations.

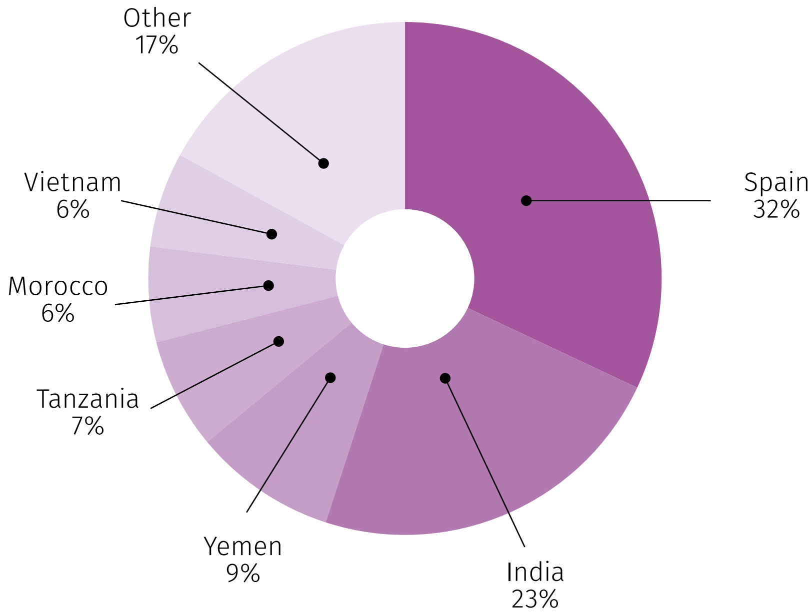
36 G.M. Cooke et al. (n 4) 183.
37 Ibid. 182.
38 Ibid.183.
39 R.C. Anderson en J.A. Mather, 'It's all in the cues: octopuses (*Enteroctopus dofleini)* learn to open jars' (2010) 59 Ferrantia 8-13; J.A. Mather, 'Cephalopod complex cognition' (2017) 16 Current Opinion in Behavioral Sciences 131-137 en J.A. Mather en R.C. Anderson, 'Exploration, play and habituation in octopuses (*Octopus* dofleini)' (1999) 113/3 Journal of Comparative Psychology 333-338.
40 G.M. Cooke et al. (n 4) 183.
41 Jarne Pollie, 'Meer inktvis gevangen voor Belgische kust: "Vooral om te exporteren naar zuiderse landen" (Vrt Nws, 15 september 2023) <www.vrt.be/vrtnws/nl/2023/09/15/meer-inktvissen-gevangen-voor-belgische-kust-vooral-om-te-expo/>.
42 Vis- en Zeevruchtengids (2018) 162.

2.2 The Belgian Octopus Market

Belgian catch, export, and import. There are minimum weight requirements for trading octopuses. For European octopuses, this is 750 grams.[43] In 2023, Belgian vessels delivered approximately 224 000 octopuses, sold in Belgian ports. This amounts to about 168 tonnes of octopus, assuming an average weight of 750 grams per octopus. Additionally, approximately 10 270 octopuses were landed in foreign ports by Belgian vessels.[44]

In the same year, Belgium exported 148 000 live or fresh octopuses abroad, worth €1.2 million. These octopuses were mainly exported to Spain (77%) and France (19%). However, the export of frozen octopuses was seven times higher – approximately 1 039 000 octopuses worth €6.1 million.[45]

Export (%) of frozen octopuses by country from Belgium



In 2023, Belgium imported approximately 914 670 octopuses from abroad, worth € 4,7 million, mainly from the Netherlands (41,8%) and France (24,5%).

43 Regulation 850/98 of March 30 1998, on the conservation of fish stocks through technical measures for the protection of juvenile marine organisms, Annex XII, Minimum Sizes.
44 Statbel, statistics provided via email by Erik Vloeberghs and Catherine Van Rumst.
45 Ibid.

Consumption. The Household Budget Survey from Statbel, conducted every two years, provides insight into the average spending per person and per household on a wide range of products and services. Cephalopods, including octopuses, are grouped into three broader categories:

- "Other shellfish, crustaceans, and mollusks: lobster, langoustine, crab, oysters, scallops, escargots (fresh)"
- "Other shellfish, crustaceans, and mollusks, escargots… frozen" and
- "Other shellfish, crustaceans, and mollusks in cans: crab, lobster, langoustine, oysters, scallops, escargots in cans"

In 2022, the average spending of a Belgian household on these three groups (fresh, frozen, and canned) was 12 euros/year, all species included in these categories. This amounts to a total of € 61,3 million for all Belgian households combined.[46]

Photos of Octopus Catching and Culinary Preparation.

47

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46 It is important to note that these figures do not include expenditures in restaurants, snack bars, and company canteens – specific figures for these categories are not available. Email correspondence with Erik Vloeberghs from Statbel.
47 Vis- en Zeevruchtengids (2018) 163.
48 The photo can be found on this website: <https://alledieren.info/animales-acuaticos/pulpo/>.

IV

RECOGNITION OF SENTIENCE IN OCTOPUSES

IV. RECOGNITION OF SENTIENCE IN OCTOPUSES

The research in this chapter focused on the presence of sentience, the ability to have feelings, in octopuses.

1. The Relationship between sentience and nociception

Sentience[49] is distinct from nociception, which is the nervous system's ability to detect harmful stimuli.[50] Although these concepts are different, they are closely connected. For example, when people touch a hot stove and nociceptors are activated, it often results in feelings of pain. However, other responses, such as a reflexive withdrawal, can occur independently of this pain experience.[51]

Both vertebrates and invertebrates exhibit a self-protective reflex after being exposed to a harmful stimulus. This reflex, known as 'nociception' in the scientific world, serves as a signalling function and ensures that the animal can move away from the source of damage to prevent further tissue injury.[52] Detecting this harmful stimulus does not necessarily require sentience. It is possible for a harmful stimulus to be detected without any experience of feelings from the system that detects it.[53]

Pain in humans has both a sensory aspect, where an injury is perceived, and an affective aspect, which is unpleasant and negative.[54] The latter aspect is ethically concerning because pain that contributes to poor well-being is a legitimate ethical concern.[55]

49 J. Birch (n 7) 12.
50 De IASP (International Association for the Study of Pain) provides the following description of the concept of nociception on its website: 'Nociception is the neural process of encoding noxious stimuli. Consequences of encoding may be autonomic (e.g. elevated blood pressure) or behavioral (motor withdrawal reflex or more complex nocifensive behaviour. Pain sensation is not necessarily implied'.
51 J. Birch (n 7) 12.
52 R.W. Elwood, 'Assessing the Potential for Pain in Crustaceans and Other Invertebrates' in Claudio Carere and Jennifer Mather (eds) The Welfare of Invertebrate Animals, 2019, Springer, 147-148.
53 J. Birch (n 7) 12.
54 M. Auvray et al., 'The sensory-discrimantive and affective-motivational aspects of pain' (2010) 34 Neuroscience & Biobehavioral Reviews 214-223.
55 F.F. Caputi et al., 'Modulation of the negative affective dimension of pain: focus on selected neuropeptidergic system contributions' (2019) 20/16 International Journal of Molecular Sciences 4010.

2. Overview of sentience in octopuses

2.1. Current understanding

In line with developments in neuroscience and biology in the late 20th and early 21st centuries, the idea that sentience is unique to humans has become outdated. The scientific community now recognises that mammals, birds and other animals are sentient.[56,57]

The Cambridge Declaration on Consciousness from 2012[58] articulated the scientific consensus that humans are not the only sentient beings. The Declaration states that *"non-human animals, including all mammals and birds and many other creatures, including octopuses"*, have neurological substrates complex enough to support conscious experiences. Although this Declaration refers to consciousness rather than sentience, these two concepts are closely connected: in the most basic, elementary sense, feelings are 'conscious' experiences.[59]

2.2. Challenges in determining sentience in different animal species

There is substantial evidence of similarities in brain organisation, function, cognition, emotion, and behaviour among mammals, including humans. The neocortex, which is closely associated with subjective experiences in humans, is also present in other mammals. This suggests their sentience.[60] Birds have a structure, the dorsal pallium, similar to the neocortex of mammals, which supports the general consensus that birds are also sentient.[61]

However, determining sentience in fish and invertebrates, which are further removed from humans on the evolutionary tree, is more challenging. Their brains differ significantly from those of mammals. For example, fish lack a neocortex or a similar structure, while the brains of invertebrates, such as octopuses, show even more differences.[62] In a review article by Shigeno et al. (2018), the authors demonstrated that cephalopods have structures in their brains similar to the cerebral cortex, hippocampus, and amygdala in vertebrates.[63]

56 M. Boly et al., 'Consciousness in humans and non-human animals: recent advances and future directions' (2013) 4 Frontiers in Psychology, 625.
57 Proctor. (2012). Animal Sentience: Where are We and Where are We Heading? *Animals (Basel)*, 2(4), 628-639.
58 P. Low et al., Cambridge declaration on consciousness' (2012).
59 Ibid.
60 J. Birch (n 7) 15.
61 M. Boly et al., 'Consciousness in humans and non-human animals: recent advances and future directions' (2013) 4 Frontiers in Psychology, 625.
62 Invertebrates and humans are separated by more than 500 million years of evolution. Even the basic overarching structure of the vertebrate brain (which consists of a forebrain, midbrain, and hindbrain) is not present in invertebrates; Ibid. J. Birch, 15 and references therein.
63 S. Shigeno et al., 'Cephalopod brains: An overview of current knowledge to facilitate comparison with vertebrates' (2018) 9 Frontiers in Physiology 952.

Nevertheless, differences in brain organisation do not automatically lead to the conclusion that these animal species are not sentient.[64] Behavioural and cognitive indicators of sentience must be identified and integrated with the knowledge of the nervous system of the octopus to determine whether the species is sentient or not.

There is compelling evidence that octopuses have a centralised nervous system, which enables them to process information from various sensory sources, including pain signals.

2.3 Criteria for determining sentience in octopuses

Birch et al. (2021) have developed a framework to assess whether cephalopods, including octopuses, are sentient[65]. This framework is based on eight criteria. These criteria relate to the presence of nociceptors, the integration of information from various sensory sources in the brain, the connectivity between nociceptors and these integrating brain areas. Additionally, the framework considers the modulation of responses to harmful stimuli by chemicals, motivational trade-offs, flexible self-protective behaviour, associative learning, and the appreciation of a perceived analgesic or anaesthetic in case of injury.

Behavioural and cognitive criteria are particularly important for invertebrates, while neurobiological criteria are included for a balanced assessment. No single criterion is decisive for consciousness, but all criteria are relevant for determining sentience in cephalopods.[66]

64 J. Birch (n 7) 15.
65 Ibid. 17.
66 Ibid. 17

2.4. Evidence of sentience in octopuses: eight criteria[67]

2.4.1. Criterion 1: The animal possesses nociceptors that respond to harmful stimuli

There is compelling evidence that octopuses, particularly the species *Octopus vulgaris*,[68] possess such receptors.

A study by Hague et al. (2013)[69] demonstrated that amputated arms of freshly killed *Octopus vulgaris* quickly retracted reflexively in response to harmful stimuli (e.g., pinching with forceps) but not to harmless stimuli (e.g., gentle touch). This suggests that the arm is connected to central pathways in the nervous system.[70]

More recent studies have examined neural activity in cephalopods in response to tissue damage or harmful stimuli. These studies consistently showed that cephalopods possess afferent sensory neurons (nerve cells that transmit signals from the senses to the central nervous system, such as the brain). These neurons respond in various ways to harmful stimuli, with an increased response and sensitivity after exposure.[71]

There is molecular evidence, meaning information at the level of genes or proteins, for the presence of nociceptors, which detect painful stimuli, in the arms of the octopus. This was demonstrated in an extensive study of *Octopus vulgaris* by di Cristina (2017). In the study, various markers were discovered, specific molecules that serve as indicators for certain biological conditions. These markers are associated with pain perception, indicating the presence and activity of nociceptors in the tips of their arms.

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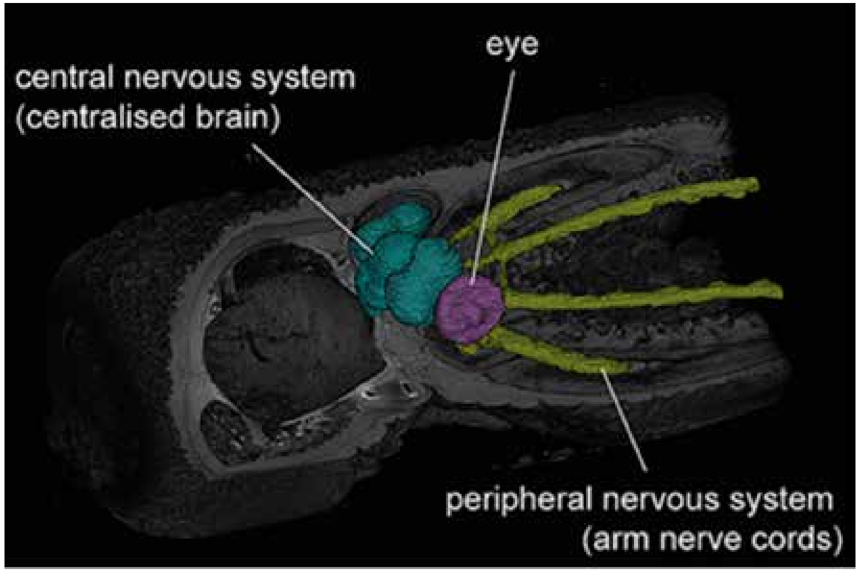
67 This section is based on the content of the report by J. Birch (n 7).
68 Ibid., 23.
69 T. Hague et al., ‘Preliminary in vitro functional evidence for reflex responses to noxious stimuli in the arms of Octopus vulgaris’, 447 Journal of Experimental Marine Biology and Ecology 100-105.
70 Severing the axial nerve cord in the arm resulted in no longer responding to harmful stimuli, indicating a connection to more central pathways. These findings build on earlier work by Rowell (1963), who found that severed arms retracted immediately and completely reflexively when exposed to harmful stimuli. This was in contrast to lighter responses such as skin flashes and sucker orientation to less intense stimuli. Altman (1971) also reported that amputated and denervated octopus arms retracted from food treated with quinine hydrochloride. An early study on neuronal activity in the arms of an octopus (*O. vulgaris*) identified some neurons that only responded to strong mechanical stimuli, such as hitting or pinching (Rowell, 1966), J. Birch (n 7) 24 and references therein.
71 Here is a brief summary of these studies, as presented in J. Birch (n 7) 24-25:
(1) Crooke et al. (2013) discovered pain-sensitive receptors in the fin of the squid (*Doryteuthis pealeii,* also known as *Loligo pealeii*) that only respond to harmful stimuli and become more sensitive due to these stimuli and injuries. The sensitivity was not limited to a specific area but was general.
(2) Howard et al. (2019) confirmed this in the bobtail squid (*Euprymna scolopes (order Sepiolida)* and noted increased sensitivity in the peripheral nerves after injury and a lasting increased excitability of the nerves in animals that had sustained an injury at a young age.
(3) Alupay et al. (2014) and Perez et al. (2017) found similar results in octopuses. They caused an injury to the arms and observed an immediate behavioural reaction and a lowered threshold for response to subsequent stimuli.
(4) Perez et al. (2017) discovered that octopuses have neurons that exhibit short-term sensitivity and spontaneous firing (a phenomenon where neurons automatically and without external stimulation emit electrical signals) after an injury in the mantle.
(5) Bazarini & Crook (2020) found increased firing rates in the pallial nerve after harmful stimuli in the Hawaiian bobtail squid.
(6) Crook (2021) conducted electrophysiological measurements of the nerve connections in the arms of the dwarf octopus of Boch and observed activity after administering a painful stimulus, which was suppressed by administering an anesthetic.

Nociceptors have also been found in various mollusks, such as snails, suggesting that they are likely present in cephalopods, including octopuses. These soft, flexible animals are at greater risk of injury, so nociception would provide a significant advantage. Additional indirect evidence from behavioural research, such as the observed avoidance of painful stimuli by octopuses, further supports the presence of nociceptors.

2.4.2. Criterion 2: The presence of integrated brain regions

There is compelling evidence that octopuses have a centralised nervous system, which enables them to process information from various sensory sources, including pain signals. Although their brain structure is not directly comparable to that of mammals, it exhibits a high degree of complexity and organisation.[72 73]

It is interesting to note that octopuses have a brain-to-body ratio that is higher than that of any invertebrate, and most fish and reptiles.[74] Specifically, the brain of an octopus consists of approximately 170 million nerve cells, of which 130 million are located in the optic lobes and 40 million in the central brain.



© Chung et al (2022)

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The vertical lobe, which is responsible for learning and memory, is often referred to as the 'highest' brain centre and receives a wide range of inputs from across the body, including the eyes, arms, mouth, and mantle.[75] A striking example is *Octopus vulgaris*, which is capable of combining information from its arms with visual information to guide its movements in a maze task.[76]

72 J. Birch (n 7) 25 and references therein.
73 Chung, W., Kurniawan, N.D. et Marshall, N.J. (2022). Comparative brain structure and visual processing in octopus from different habitats. *Current Biology*, 32, 97-110.
74 A. Packard, 'Cephalopod and fish: the limit of convergence' (1972) 47 Biological Reviews, 241-301.
75 J. Birch (n 7) 26 and references therein.
76 Ibid.

2.4.3. Criterion 3: Connections between nociceptors and integrative brain regions

There is indirect evidence that connections exist between nociceptors and integrative brain regions in octopuses. Despite the high connectivity between the peripheral nervous system[77]and the central brain, and between the different brain lobes, it has not been definitely proven that these pathways transmit nociceptive signals to integrative brain regions.

The evidence is assessed as follows:[78]

(1) Various studies indicate that the electrical activity in the nerve cords, which connect the peripheral nerves to the central brain, increases in response to harmful stimuli. This suggests that signals from nociceptors do reach the brain, but it is unclear whether they reach the vertical brain lobes. Although several connections between the peripheral nervous system and the vertical brain lobes have been documented, it has not been explicitly demonstrated that these are involved in the transmission of nociceptive information.

(2) Assumptions have been made about the possible transmission of nociceptive (pain) signals to the vertical lobe system, but these assumptions are primarily based on functional considerations, not structural ones. This means that the assumptions are based on how the system might work (functionally), rather than on the physical connections and organisation of the system (structurally). However, this has not yet been definitively proven.

(3) Although high connectivity between brain regions has been established, this is not direct evidence of nociceptive signal transmission.

(4) The nervous system of the octopus is complex. Many of the peripheral afferent nerves are not directly connected to the central nervous system, but to central ganglia (a type of mini-brain) in the arms.[79] These ganglia then send compiled information to the brain. It is unclear what might be lost in this 'compilation' and what information is actually transmitted.

(5) Behavioural observations suggest that information about harmful stimuli is processed in the central brain regions.

77 The peripheral nervous system is a part of the nervous system that is located outside the brain and spinal cord. It connects the brain and spinal cord to the rest of the body and allows the animal to respond to environmental stimuli.
78 The content of these studies is outlined in J. Birch (n 7) 27-28.
79 "Peripheral afferent nerves" in octopuses are nerves that send signals from various parts of the octopus' body to the ganglia in the arms. These signals can contain information about things the octopus feels, such as temperature, touch, or pain.

(6) Research has shown that both local and general anaesthetics can block afferent and efferent neural signals.[80] If a harmful stimulus (e.g., pinching an arm with forceps) is applied to an octopus after the administration of an anaesthetic, the transmission of painful or nociceptive signals is reduced or stopped.

(7) Previous assessments of the evidence for the connections between nociceptors and the vertical lobe conclude that it is 'uncertain' or 'likely but not proven' that connections exist between nociceptors and integrative brain regions in octopuses.

2.4.4. Criterion 4: Animal behaviour in response to a harmful stimulus is influenced by chemical compounds that modulate the nervous system

This can happen in two ways:

1. The animal possesses an endogenous neurotransmitter system that modulates responses to potential or actual harmful stimuli. This is consistent with the experience of pain, suffering, or harm.

2. Specific local anaesthetics, painkillers (such as opioids), anxiolytics, or antidepressants can alter an animal's responses to potential or actual harmful stimuli. This aligns with the hypothesis that these compounds reduce the experience of pain, suffering, or harm.

Strong evidence suggests that octopuses meet this criterion and therefore have an endogenous neurotransmitter system that responds to pain relief. This evidence includes the presence of opioids and similar compounds, as well as leucine-enkephalin and delta-opioid receptors in the peripheral nervous system of the octopus.[81]

Recent research also demonstrates the effectiveness of local anaesthetics, such as lidocaine and magnesium chloride, in suppressing activity in the peripheral nervous system (the part of the nervous system that lies outside the central nervous system) of the octopus. After anaesthesia, octopuses exhibit altered responses to harmful stimuli.[82]

Additionally, there is evidence that the endogenous modulator serotonin and estrogens play a role in the modulation of pain responses in octopuses. However, more research is needed to determine the effects of these and other compounds, such as cannabinoids or steroids.[83]

2.4.5. Criterion 5: Animals make trade-offs between risks and rewards, leading to flexible decision-making

Several studies show that injuries in octopuses can lead to long-term behavioural changes. This may indicate an awareness of injuries and related changes in priorities, or an increased sensitivity to threats as a direct result of injury.[84]

80 Afferent neural signals (also known as sensory or input signals) are signals that transmit information from various parts of the octopus' body to the brain. These can contain information about temperature, touch, or pain. Efferent neural signals (also known as motor or output signals) are signals that travel from the octopus' brain to different parts of the body, directing the octopus' responses and movements.
81 J. Birch (n 7) 28 and references therein.
82 Ibid. 30.
83 Ibid. 29.
84 Ibid. 30.

It is not clear whether octopuses meet this fifth criterion – the making of motivational trade-offs. There is some indirect evidence, but it is insufficient to draw definitive conclusions.[85]

For example, a study by Wilson et al. (2018) showed that cuttlefish stopped hunting when exposed to predator attacks. This behaviour suggests a trade-off between the value of food and the threat of the predator in these cuttlefish.[86] Given that cuttlefish, like octopuses, belong to the cephalopods, it is likely that this study on the behaviour patterns of cuttlefish is also relevant and applicable to octopuses.

There are also studies that show octopuses adjust their behaviour after an injury. For example, research by Ross (1971) found that octopuses avoid hermit crabs with stinging anemones.[87] Injured cephalopods exhibit altered defensive behaviour[88] and increase their defensive responses.[89] They also make different decisions regarding schooling.[90] Injury at a young age in the Hawaiian bobtail squid results in permanent behavioural changes.[91]

In all these situations, however, it is unclear whether the observed behavioural changes in octopuses result from a conscious trade-off or merely an increased sensitivity to threats.

Research on hermit crabs (*Pagurus bernhardus*) shows that these animals are capable of making trade-offs between different needs or requirements. After receiving an electric shock, the crabs were more willing to leave their shell if it was of lower quality, and they were slower to do so in the presence of a predator's scent. This behaviour suggests that, like crabs, octopuses might find a balance between responding to a harmful stimulus and avoiding predators or maintaining a good shell.[92]

This research indicates that some invertebrates, such as octopuses, are capable of complex behavioural trade-offs.

Injuries in octopuses can lead to long-term behavioural changes.

85 Ibid. 30.
86 Ibid. 30.
87 D.M. Ross, 'Protection of hermit crabs (*Dardanus spp.*) from octopus by commensal sea anemones (*Calliactis spp.*)' (1971) 230 Nature 401-402.
88 R.J. Crook et al., 'Nociceptive behavior and physiology of molluscs: animal welfare implications (2011) 52 ILAR Journal, 185-195.
89 R.J. Crook et al., 'Nociceptive sensitization reduces predation risk' (2014) 24 Current Biology 1121-1125.
90 M. Oshima et al., 'Peripheral injury alters schooling behavior in squid, *Doryteuthis pealeii* (2016) 128 Behavioral Processes, 89-95.
91 R.B. Howard et al., 'Early-life injury produces lifelong neural hyperexcitability, cognitive deficit and altered defensive behaviour in the squid *Euprymna scolopes*' (2019) Philosophical Transations of the Royal Society of London B; Biological Sciences, 374.
92 M. Appel en R.W. Elwood, 'Pain in hermit crabs' (2009) Animal Behaviour 77, 1243-1246.

2.4.6. Criterion 6: The animal exhibits flexible self-protective behaviour (e.g., wound care, guarding, grooming, rubbing) that indicates the location of an injury or harmful stimulus

Octopuses provide clear evidence of wound care and protection. They curl their arms around the injured area or try to remove a harmful stimulus.[93]

The research by Alupay et al. (2014) offers strong evidence that octopuses exhibit flexible self-protective behaviour when injured. Injured octopuses hold their injured arm with their beak, and after six hours, they focus on contracting the injured area and keeping the wound close to their body. Additionally, octopuses use their uninjured arms to guard their injury.

Similarly, a separate study on the horned octopus (*Eledone cirrhosa*), also reported protective reactions to injury.

In a study by Crook (2021), it was observed that octopuses injected with diluted acetic acid groomed the area with their beak, including brushing away some skin.

As mentioned in the previous section, there are several studies that have shown that octopuses withdraw from hermit crabs that carry stinging anemones on their shells, suggesting that this is a form of self-protection.

Octopuses provide clear evidence of wound care and protection.

A study by Crook et al. (2013) demonstrates that after an injury, nociceptive sensitisation in cephalopods is widespread and induces a general state of alertness in the squid. This finding is consistent with other studies that show even a minor injury in cephalopods increases the risk of predation.[94]

2.4.7. Criterion 7: Evidence of associative learning by the animal

This involves harmful stimuli being associated with neutral stimuli, or new methods being learned to avoid harmful stimuli.

It is essential to provide robust evidence that the animal is capable of making associations between harmful and neutral stimuli. This may include the animal learning to associate a specific location or an otherwise neutral odour with a harmful stimulus. It is also relevant if an animal can learn new behaviours – different from existing reflex reactions – to avoid a harmful stimulus.[95]

93 J. Birch (n 7) 33.
94 These studies are discussed in J. Birch (n 7) 33-35.
95 Ibid. 35.

It is important to distinguish associative learning from habituation, where an animal becomes less sensitive to a stimulus after repeated exposure, and from sensitisation, where an animal becomes more sensitive after repeated exposure. Although habituation and sensitisation are forms of learning, they are insufficient. They can be achieved without a brain and without any integrated, centralised processing of information.[96]

Overall, there is a clear scientific consensus among cephalopod researchers that octopuses are easily capable of associative learning.[97] Octopuses demonstrate a significant capacity for learning to associate reward or punishment with various visual and tactile stimuli in their environment.[98]

2.4.8. Criterion 8: The animal shows appreciation for the administration of analgesic or anaesthetic agents after injury

The animal may demonstrate this appreciation in one or more of the following ways:

(a) The animal learns to self-administer analgesics or anaesthetics when injured;

(b) The injured animal chooses a location where analgesics or anaesthetics are available; or

(c) The injured animal prioritises obtaining these agents over other needs (such as food).

Recent research, including a newly published study by Crook (2021), shows that octopuses meet criterion 8. When exposed to a harmful stimulus (acetic acid), octopuses learn to prefer a space where they have access to a local anaesthetic.[99]

The following is a comprehensive evaluation of the evidence supporting criterion 8:

- A recent study by Crook (2021) investigates criterion 8. Crook posed the question: "*Can an octopus (O. bocki) learn to avoid a previously preferred space after receiving a potentially painful injection of acetic acid in that space? Will the injured octopus learn to prefer a space where a local anaesthetic (lidocaine) is administered? Is this preference influenced by the injury, so that the preference for the room associated with lidocaine is not formed if the animal is not injected with acetic acid?*" Crook provided clear and statistically significant evidence showing that the answer to all the above questions is "*yes*". Crook used a conditioned place preference (CPP) paradigm, an established paradigm for demonstrating the emotional component of pain in mammals. The study results showed that the octopuses avoided their originally preferred space and chose the space where they experienced pain relief. In contrast, the control octopuses did not show a change in room preference after injection with a saline injection, and the injection of lidocaine also did not induce a change in room preference.

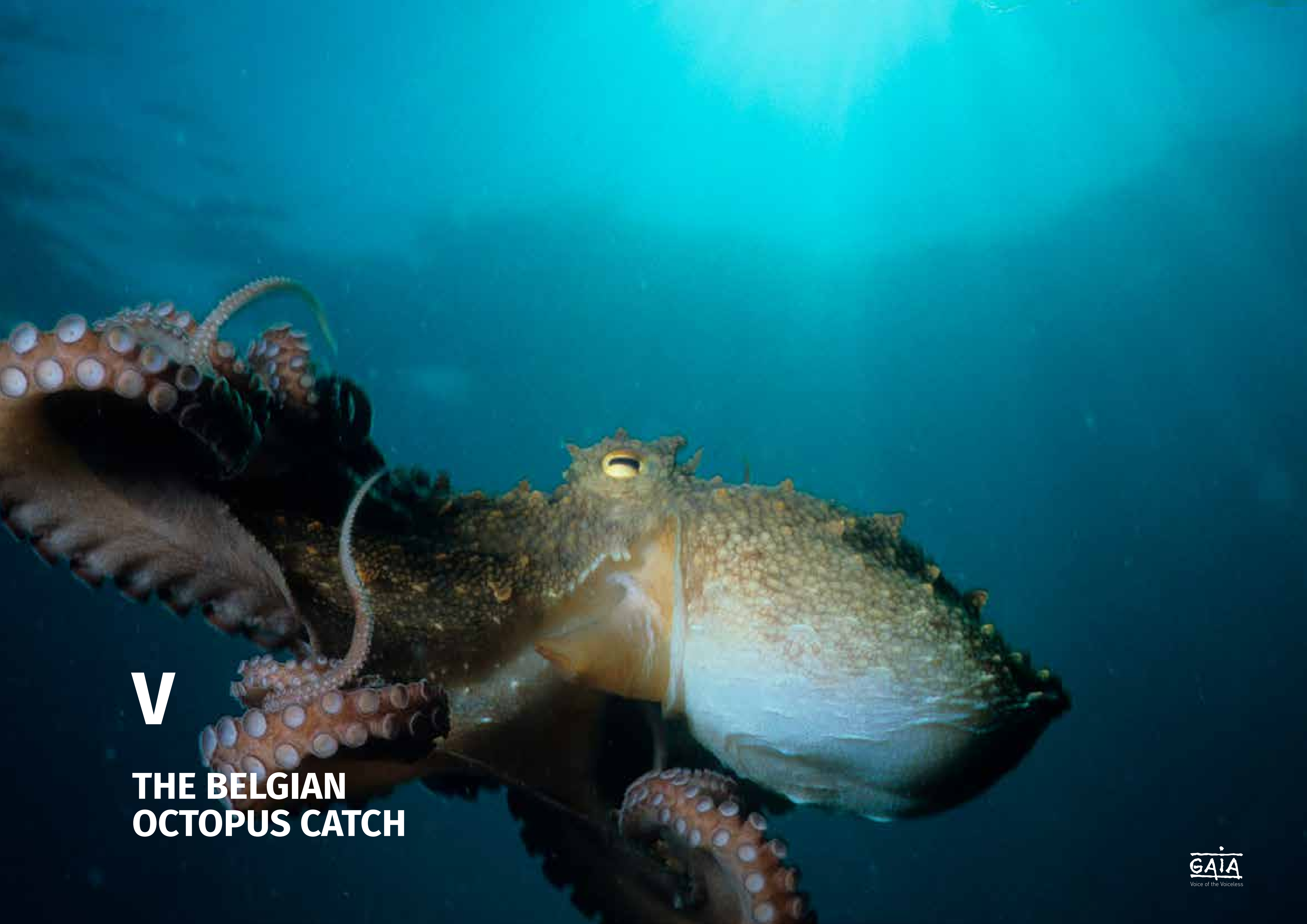
96 Ibid. 35.
97 Ibid., 36 and references therein.
98 Ibid. 36.
99 Ibid., 39 and references therein.

- Additionally, Crook made electrophysiological recordings of activity in the brachial connectives, which are the nerve cords connecting the octopus' arms to the brain. The recordings showed a prolonged period of activity (following the administration of the painful injection) that subsequently decreased after the injection of lidocaine.

2.5. Conclusion

There is strong evidence that octopuses are sentient, meaning they are capable of conscious perceptions and experiencing subjective sensations. This evidence includes the presence of neural pathways for pain perception, complex and organised brain structures capable of information processing, and evidence of octopuses' ability to make decisions based on motivations. However, some points still require further research before definitive conclusions can be drawn. This includes the precise nature of the connections between nociceptors and integrative brain regions, as well as the full extent of octopuses' ability to make motivated decisions.

There is strong evidence that octopuses are sentient, meaning they are capable of conscious perceptions and experiencing subjective sensations.



V

THE BELGIAN OCTOPUS CATCH

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V. THE BELGIAN OCTOPUS CATCH

1. Increasing catch

In Belgium, three main taxa of cephalopods are commercially exploited: cuttlefish *(Sepioidea)*, squids *(Teuthoidea)*, and octopuses *(Octopodiae)*.[100] Despite the focus on flatfish in Belgian fisheries, recent data shows a significant increase in squid catches. In 2022, there was an almost doubling (+98%) in squid landings compared to 2021.[101]

In 2023, cuttlefish became the most caught and sold group of species by Belgian vessels in the ports of Ostend, Nieuwpoort, and Zeebrugge, with a total catch of 2,487 tons. [102] Additionally, in 2023, cephalopods ranked second in terms of market value, with an increase of 8% to €10.6 million.[103] That year, Belgian vessels delivered approximately 224 000 octopuses to Belgian ports, which equates to about 168 tons of octopus, assuming an average weight of 750 grams per octopus. Octopus's consumption in Belgium is quite low, therefore they are mostly exported to Spain, Italy, and other southern countries.[104]

2. The Belgian Fishing Fleet

The Belgian fishing fleet consists of 64 vessels,[105] of which 2 vessels are used for passive fishing.[106] This latter technique involves placing fishing gear in the water or on the seabed so that octopuses can swim toward the gear (e.g., fixed gillnets, pots, or traps). The remaining 62 vessels are used for active fishing, namely beam trawling, otter trawling, and fly-shooting. There is also one vessel that uses the technique of dredging.

100 W. Vyncke, An overview of the methods for quality determination of squid (Cephalopods) Report of the National Center for Agricultural Research (Ghent) and the National Station for Sea Fisheries (Ostend) 2.
101 Ibid. 39.
102 Statbel, Statistics of sea fisheries, figures 2023.
103 Agentschap Landbouw en Visserij, 'Aanvoerwaarde van Vis', <https://landbouwcijfers.vlaanderen.be/visserij/totale-visserij/aanvoerwaarde-van-vis>.
104 Jarne Pollie, 'Meer inktvis gevangen voor Belgische kust: "Vooral om te exporteren naar zuiderse landen" (Vrt Nws, 15 september 2023) <www.vrt.be/vrtnws/nl/2023/09/15/meer-inktvissen-gevangen-voor-belgische-kust-vooral-om-te-expo/>.
105 Visserijrapport 2024, 8.
106 <www.lekkervanbijons.be/vis/welke-vistechnieken-in-de-belgische-visserij>.

3. Fishing Methods

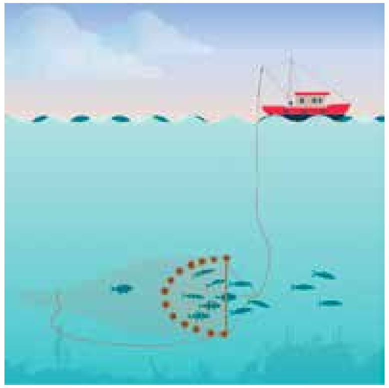
Octopuses are caught using trawl and seine nets, fixed gillnets, pots, and traps. Dredging – a method where a heavy net is dragged across the seabed – is also used as a catching method.[107]

These fishing methods generate bycatch[108], meaning the capture of non-targeted and sometimes vulnerable species, such as seabirds, marine mammals, and others. These non-targeted catches are considered discards, as they result in unnecessary mortality and represent wasted fishing effort, with no economic benefits.

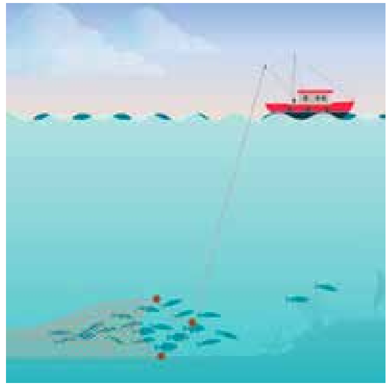
3.1. Catching octopuses with trawl and seine nets[109]

3.1.1. The beam trawl

The beam trawl is the primary fishing method of the Belgian fleet, responsible for approximately 78% of the catch in 2022 (about 50 of the 64 Belgian vessels use this technique).[110] This method uses a metal tube, the 'beam', which holds two nets on either side of the vessel. The metal shoes or skids at the ends of the beam slide over the seabed. The trawl nets, also known as 'kor', are lowered to the bottom and dragged behind the vessel.[111]



The beam trawl[111]



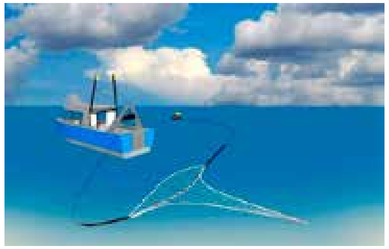
Bottom Trawl[113]

3.1.2. Bottom Trawl

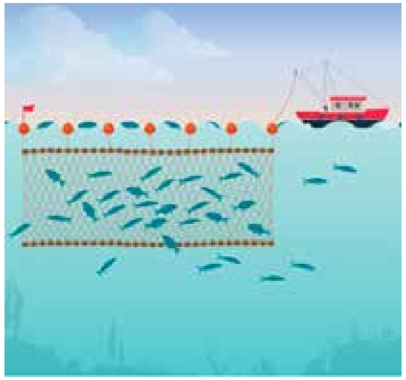
Bottom trawling is similar to the beam trawl method, where a trawl net is attached to the vessel using a fishing line. Unlike the beam trawl, the net is kept open by two boards on the sides of the net opening. These boards drag along the seabed and form an angle that keeps the net open in a horizontal position. These boards also ensure frontal contact with the seabed and create turbulence that drives the fish toward the nets.[113]

107 G.J. Pierc (n 9) 49, 51, 54, 55, 60.
108 Lively, J.A. & McKenzie, J. (2023). Chapter One – Discards and bycatch: A review of wasted fishing. *Advances in Marine Biology*, 95, pp. 1-26.
109 This section is based on the Report from Wageningen University, H. Van de Vis (n 3) 52 and following.
110 Fisheries Report 2024, 9.
111 https://www.lekkervanbijons.be/vis/welke-vistechnieken-in-de-belgische-visserij>.
112 Eurogroup for Animals, 'Handle with care – Lessen the suffering of the fish in EU wild capture fisheries' (Policy Briefing and Recommendations 2020) 11, 2.2.
113 Ibid.
114 Ibid. 2.3.

3.1.3. Fly-shooting

115 

The fly-shooting method uses seines, which are rectangular nets with long lines at the ends. The net is secured at the starting point with an anchor. The ship then sails in a half-circle while deploying the net. Afterward, the ship returns to the starting point, marked by a buoy, and the net is hauled in. [116]



Fixed gillnets[116]

3.2. Catching octopuses with fixed gillnets, pots, and traps

3.2.1. Fixed gillnets

Fixed gillnet fishing refers to all fishing methods where the net remains stationary in the water. These nets are set up in the water using floats and a weighted line at the bottom. They are deployed around a wreck or in open sea, and after a certain period, the catch is retrieved. Small fish can swim through the nets, while fish of the targeted species and size become entangled in the net.

3.2.2. Pots and traps

Traps The purpose of this fishing method is to lure octopuses with fresh or salted fish as bait. Most traps are placed on the seabed. Once lured into the trap, they cannot escape due to a funnel-like net structure. A retrieval line is used to check the traps and add new bait. [118]

This technique is also used in Belgium for catching octopuses.[119]

115 This method only works well in daylight and when the water is clear, as the bottom fish need to be able to see the seine ropes approaching. Therefore, flyshooters fish only during the day. Website Visbureau Nederland, <https://visbureau.nl/viskids/trawlers-kotters-visserijtechnieken>.
116 Ibid.
117 Eurogroup for Animals Rapport (n 95) 13, 2.6.
118 CareFish/catch Consortium, Carefish report, Welfare assessment in pots and traps fisheries (2023) 2.
119 <https://vistikhetmaar.nl/onderwijs/lesmodules/passieve-visserijmethode>.

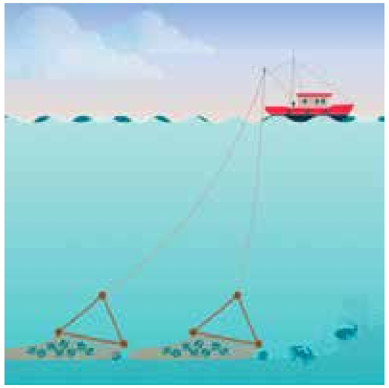
A stack of traps on the quay.[120]

Pots Fishermen place pots on the seafloor to serve as shelters for octopuses, which can enter and leave them voluntarily[121]. These pots are connected to a buoy by a rope weighted with an anchor. Typically, the pots are hauled up after about a week.

This technique is mainly used along the Mediterranean coast.

3.2.2. Dredging

Dredging involves the use of steel frames with a net. The front of the frame is often equipped with steel teeth that function like a rake to plough the seabed.[122]



Dredging[121]

120 A stack of traps on the quay. Website 'Vist ik het Maar' <https://vistikhetmaar.nl/onderwijs/lesmodules/passieve-visserijmethode>.
121 Midi Libre, « Quatre techniques de pêche expliquées en illustration », 2021.
122 Website 'Goodfish' <https://www.goodfish.nl/woord/drijfnetten>.
123 Eurogroup for Animals rapport (n 95).

4. Welfare of octopuses during capture

4.1. Introduction

The capture of octopuses poses serious risks to their welfare. These animals can be brought on board a ship alive, but as soon as they are exposed to air, they begin to suffocate. By the time they arrive at the port, they are usually already dead, as they can survive only 20 to 30 minutes outside of water. Despite these known risks, there are only a limited number of scientific studies that examine the impact of commercial fishing practices on the welfare of octopuses. Therefore, the following discussion of welfare risks is primarily based on studies in which octopuses are captured for scientific purposes.[124]

Octopuses brought on board a ship alive begin to suffocate when they are exposed to air, surviving only 20 to 30 minutes outside of water.

124 J. Birch (n 7) 60.

4.2. Assessment framework for the welfare of octopuses during capture

During the capture process of octopuses, twelve welfare issues can arise:

1. **Oxygen deprivation**: Octopuses can survive 20 to 30 minutes without water, depending on factors such as temperature and activity level.[125] However, those attempting to escape from the net are more vulnerable to oxygen deprivation, which can eventually lead to organ failure.[126]

2. **Fatigue and exhaustion**: Fatigue and exhaustion in octopuses can occur during the capture process. In particular, octopuses attempting to escape from the net may experience physiological disturbances caused by a buildup of lactate and other metabolites in their blood, which can lead to their death. Additionally, physical exhaustion can increase the impact of other stress factors they experience during capture.[127]

3. **Temperature shock**: Octopuses are ectothermic/poikilothermic, meaning their body temperature varies with the ambient temperature. During capture, especially when being removed from water and exposed to air, rapid temperature changes can occur. These rapid changes can affect the octopus's metabolism and sometimes lead to death.[128]

4. **Osmoregulatory stress**: This stress occurs in octopuses when they must regulate their water and salt balance.[129] This is an ongoing process that becomes particularly important when the octopus is removed from its natural water environment.

5. **Overcrowding**: Overcrowding occurs when too many octopuses are confined in a small space, such as in nets or containers on board the fishing vessel. This can lead to stress, injuries, and even death among the octopuses.[130]

6. **Injuries**: There is a significant risk of injuries during the capture, handling, and potential release of the caught octopus.[131]

7. **Exposure to light**: When they are brought to the surface, octopuses are exposed to a much higher light intensity than in their natural habitat, which can cause visual damage due to the levels of light and UV rays, which they are not adapted to.[132]

125 Marine biologist Ken Halanych, <www.vanityfair.com/hollywood/2016/06/finding-dory-octopus-fact-check>.
126 H. Van de Vis (n 3) 55 and references therein.
127 Ibid.
128 Ibid. 56.
129 Under stress, blood circulation to the gills increases, which enhances oxygen uptake from the water. This leads to increased water-ion exchange due to the increased permeability of the gills, which can result in dehydration in saltwater species (due to an increase in salt concentration) and dilution of blood in freshwater species (due to a decrease in salt concentration). Ibid. 56.
130 Ibid. 56.
131 Ibid. 56.
132 Exposure to light can cause disorientation and eye problems in squid. Additionally, UV radiation can lead to burns on uncovered parts. This can occur when the squid is stored in a holding tank on the vessel. Ibid. 56.

8. **Pressure trauma**: During capture, octopuses can experience pressure trauma. This is a welfare issue due to the rapid pressure change when the octopus is brought from great depths to the surface. Pressure trauma can result in visible external injuries, such as bulging eyes and a bloated body, as well as internal injuries due to rapid decompression. It is important to note that, unlike some marine animals, octopuses do not have a swim bladder that could burst.

9. **Exposure to air**: During this process, octopuses experience their own weight in air for the first time, to which most species are not adapted.[133]

10. **Displacement**: The location where octopuses are released may differ from the location where they were captured, potentially providing a less suitable habitat. This can further reduce the survival chances of the already stressed animal.[134]

11. **Predation**: Seabirds, among others, are significant predators of octopuses thrown overboard that weigh less than 750 grams (the minimum catch weight). Returned animals are weakened, making them vulnerable to predators.[135]

12. **Weather conditions**: Extreme weather conditions during capture, boarding, and storage can add an additional stress factor.[136]

4.3. Evaluation of welfare issues by capture phase

4.3.1. Welfare issues during the capture of octopuses

A. Fishing methods: trawl and seine nets

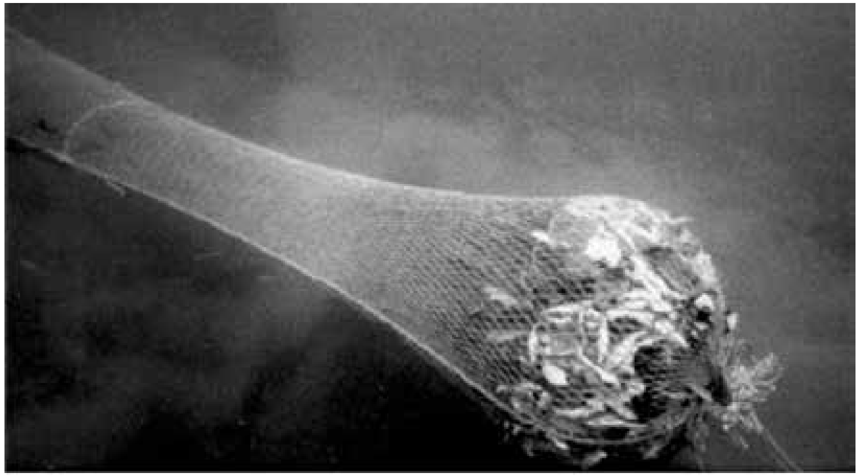
The process of catching with a net can take some time. The aquatic animals, including octopuses, initially swim along in the net at the speed of the fishing vessel.[137] Over time, some animals can no longer keep up with this speed, become exhausted, and end up in the rear part of the net, the cod end, where they can suffocate or be crushed under the weight of other animals.

The most critical situation concerns the aquatic animals that end up in the cod end first. Often, they are pressed against the net by the current, exposing them to water pressure as well as debris and sediment carried along. [138] Additionally, collisions with other caught animals or the side of the net can cause skin damage.

133 Ibid. 56.
134 Ibid. 57.
135 Ibid. 57.
136 Ibid. 57.
137 H. Van de Vis (n 3) 52.
138 Ibid. 53.

Octopuses, which have soft skin, are particularly vulnerable to skin ulcers and injuries to their arms.[139]

Photo: accumulation in the cod end.[140]



Skin and arm injuries become a major welfare issue when octopuses are left in nets for hours or days before being brought ashore, and when small, live octopuses with injuries are released back into the water. The skin plays a crucial role in the survival of octopuses, as they use body patterns for both camouflage and communication.[141] Additionally, research indicates that small injuries in cephalopods increase the risk of predation[142] and that cephalopods with skin and arm injuries respond poorly to changes in temperature and salinity compared to unharmed cephalopods.[143]

The following welfare issues occur when catching octopuses in nets:

1. **Lack of oxygen**: Octopuses can become exhausted and struggle to escape from the net, causing them to experience oxygen deprivation.

2. **Fatigue and exhaustion:** Octopuses that cannot keep up with the speed of the fishing vessel during the catch become exhausted and can die due to the accumulation of lactate and other metabolites in their blood.

3. **Injuries**: The risk of injuries during net capture is significant.

4. **Overcrowding:** The compression and high densities of aquatic animals in the bag of the net can cause stress, injuries, and mortality.

In total, 4 out of 12 welfare issues are specific to catching octopus with nets. However, there are also other welfare issues, such as temperature shock, osmoregulatory stress, exposure to light and air, displacement, predation, and weather conditions. While these can also occur when using nets, they are not specific to this fishing method.

139 A. Crump et al., 'Invertebrate sentience and sustainable seafood' (2022) 3 Nature Food 884-886.
140 Marine Laboratory Aberdeen; H. Van de Vis (n 3) 53.
141 R.T. Hanlon en J.B. Messenger, Cephalopod behaviour, 2018, University of Cambridge.
142 R.J. Crook et al., 'Nociceptive sensitization reduces predation risk' (2014) 24 Current Biology 1121-1125.
143 R.T.Hanlon, R.F. Hixon en W.H. Hulet, 'Survival, growth, and behavior of the loliginid squids *Loligo plei, Loligo pealei,* and *Lolliguncula brevis* (Mollusca: Cephalopoda) in closed water systems' (1983) 165 Biol. Bull. 637-685.

These welfare issues are well-established and evident in the fact that most octopuses die during the capture process and thus are no longer alive when arriving on board.

B. Fishing methods: fixed gillnets, pots, and traps

Octopuses that become entangled in a net or caught in a trap experience negative welfare effects while still underwater.[144]

If octopuses remain trapped in these devices for an extended period, they can become exhausted from attempts to escape. They can also fall victim to predators if they are unable to escape.[145]

Since octopuses are solitary animals, confining them in a small space with other species, such as in a trap, can cause stress and lead to conflicts between individuals. In wild-caught octopuses, limb amputation is often observed, which may be the result of self-mutilation or fighting.[146] Additionally, octopuses can exhibit cannibalistic behaviour, especially when food is scarce.[147]

When catching octopuses in fixed gillnets and traps, the following specific welfare issues occur: oxygen deprivation, fatigue and exhaustion, crowding, and injuries.

It is important to emphasise that there is currently no regulation requiring regular checks of the capture devices. This can lead to situations where octopuses are left in traps for days, with all the associated negative welfare effects. Leaving devices unattended for multiple days causes discomfort and stress and may lead to death, as the limited space can prompt the captured animals to become aggressive or eat each other.

4.3.2. Welfare issues during the boarding of octopuses

A. Boarding of octopuses caught with trawl and seine nets

During the hauling of the nets, octopuses are compressed, which can lead to abrasions, skin injuries, and increased stress. The use of pumps – a commonly used method to remove octopuses from the nets – can cause bruising, injuries, and even death in octopuses.[148] Rough handling can even cause the mantle of the octopus to detach from the head.[149]

144 Ibid. 57.
145 H. Van de Vis (n 3) 57.
146 M. Florini et al., '"Monco": a natural model for studying arm usage and regeneration in *Octopus vulgaris*' (2011) 30 J Shellfish Res 1002.
147 G.J. Pierce (n 9) 68 en 102.
148 H. Van de Vis (n 3) 55.
149 A.K. Schnell, personal observation; J. Birch (n 7) 61.

When boarding octopuses caught with trawl and seine nets, various welfare issues can occur:

1. **Oxygen deprivation**: Suffocation can occur if octopuses become stressed and try to escape.
2. **Fatigue and exhaustion**: Energy depletion can result from the physical effort during the capture process.
3. **Injuries**: Injuries can occur from friction against the nets and the pressure from the pumps.
4. **Exposure to air and light**: Harm from unnatural exposure occurs when the octopuses are brought above water.
5. **Predation:** Increased risk of predation occurs due to releases at an unfamiliar location.
6. **Extreme weather conditions**: Weather disturbances can cause additional stress during capture and boarding.

In total, 6 out of the 12 identified welfare issues are observed during the boarding of octopuses caught with nets.

> "Spraying bleach on the octopuses, to expedite their release from the traps, causes severe burns to their bodies, especially their eyes."

B. Boarding of octopuses caught with fixed gillnets, pots, and traps

Quickly hauling and emptying fixed gillnets, pots, and traps can cause injuries to octopuses due to friction and pressure trauma. Two factors contribute to the impact on their welfare during the removal of octopuses from the trap. First, the fact that the octopus is brought above water and exposed to air for an extended period. Exposure to air leads to the collapse of the gill membranes and suffocation. The octopus experiences oxygen deprivation, which is worsened if the animal tries to escape. Direct contact with people and materials on board can cause pain. Overcrowding in the containers can lead to injury and pain from contact with other other aquatic animals, as well as crushing, decompression, and exhaustion.[150]

150 CareFish/catch Consortium, Carefish report, Welfare assessment in pots and traps fisheries (2023) 6.

In octopus fishing, animals are often handled with excessive force, which can lead to severe external injuries, including mutilation, when emptying the traps. The octopus invariably suffers injuries if it is forcibly pulled out of the trap or pot.[151] Spraying bleach on the octopuses, to expedite their release from the traps, causes severe burns to their bodies, especially their eyes. If the octopuses are thrown back overboard, they are more vulnerable to predation and death.[152]

They show signs of awareness of their situation, crawling around on board and trying to return to the water.

4.3.3. Welfare issues during the onboard storage of octopuses

During the boarding and processing of octopuses, various welfare issues arise.

Some octopuses arrive on board already dead,[153] caused by welfare problems during the capture process, such as oxygen deprivation, exhaustion, and physical injuries. The dead octopuses are sorted and placed in coolers for storage.[154] Larger vessels sometimes have facilities to freeze the catch, while smaller vessels usually use refrigerated baths and coolers with slurry ice.[155]

Live octopuses also come aboard the boat.[156] They are exposed to the air and usually die from suffocation before being frozen.[157] This causes extremely high stress levels in the animals. They show signs of awareness of their situation, crawling around on board and trying to return to the water.[158] Some of these octopuses are still alive when they are placed on the conveyor belt for sorting, cleaning, and freezing. This happens because octopuses can survive for 20 to 30 minutes after being exposed to air.[159] It is possible that octopuses are brought alive to the hold, where they are cooled or frozen, and then die from a combination of suffocation and freezing.

151 CareFish/catch Consortium, Carefish report, Welfare assessment in pots and traps fisheries (2023) 5.
152 CareFish/catch Consortium, Carefish report, Welfare assessment in pots and traps fisheries (2023) 2 and 4. A study on catching octopuses in traps and pots in Portugal indicates that bleach is used on 40% of the octopuses.
153 Octopuses caught with nets are usually dead upon arrival on board.
154 Website 'Vist ik het maar' <https://vistikhetmaar.nl/onderwijs/lesmodules/passieve-visserijmethode>.
155 Ibid.
156 Octopuses caught with gillnets, pots, or traps are often still alive upon arrival on board.
157 Ibid.
158 Pereira, J., en Lourenço, S. 'What we do to kill an octopus (*Octopus vulgaris)* – Anecdotal information on octopus suffering in fisheries and what can be done about understanding the processes and minimizing consequences' (2014) Barcelona: Cost Action FA 1301, CephsinAction, 9.
159 Industriebronnen.

Another significant welfare issue is the storage of too many live animals in cramped compartments, resulting in a slow and painful death. This suffering is further exacerbated by the common practice of using freshwater in containers to artificially increase the weight of the catch, which causes additional and intense osmotic stress. This additional suffering can be prevented by applying a slaughter method before storage.[160] To reduce suffering, octopuses should be stunned and slaughtered as soon as they are brought on board. Percussive stunning can be performed by inserting a sharp, pointed object such as a knife or awl into the brain), which destroys the central nervous system and causes the octopus to lose consciousness and die immediately in an irreversible manner. This slaughter method must be carried out with precision by a trained crew member. Improper piercing of the brain does not disrupt the central nervous system but only severs the connection between the brain and limbs, leaving the octopus "*octaplegic*"[161] but still conscious and alert.[162]

4.3.4. Welfare issues related to the release and escape of octopuses

The risk of predation and reduced survival chances for octopuses that are released back into the sea after being caught arises because the capture process weakens the octopuses. Additionally, they may end up in an unsuitable habitat.[163]

4.4. Conclusion

The capture of octopuses is accompanied by numerous welfare issues, including oxygen deprivation, fatigue and exhaustion, injuries, and exposure to air and light. These problems occur both with net fishing and the use of fixed gillnets, pots, and traps.

Some octopuses arrive on board already dead due to these stress factors. Other octopuses are still alive when they come on board. No specific slaughter method is applied to octopuses that come on board alive, which means these octopuses, in practice, die on board from suffocation (and/or freezing). Although more humane practices exist (e.g., percussive stunning by a trained crew member), the application of this method on a large scale is considered practically and economically unfeasible.

160 CareFish/catch Consortium, Carefish report, Welfare assessment in pots and traps fisheries (2023) 7.
161 "Octaplegic" means that all eight limbs of an octopus are non-functional or paralysed.
162 CareFish/catch Consortium, Carefish report, Welfare assessment in pots and traps fisheries (2023) 7.
163 H. Van de Vis (n 3), 55.

VI

OCTOPUSES IN AQUACULTURE

VI. OCTOPUSES IN AQUACULTURE

1. Overview

Octopuses are attractive for commercial aquaculture due to their high economic value, rapid growth, high protein content, and fertility.[164] Octopuses are currently not farmed in Europe. Nueva Pescanova, a Spanish multinational seafood company, has applied to construct Europe's first commercial octopus farm in the port of the Canary Island of Las Palmas.[165]

Octopus aquaculture is not compatible with high welfare standards and leads to various welfare issues. Moreover, the environmental damage posed by the proposed *Octopus vulgaris* aquaculture farm poses significant risks to the marine environment. In captivity, the spread of diseases and pathogens occurs at a much faster rate. Consequently, the use and discharge of antibiotics – or other chemicals –, even in small amounts, along with discharges of feed remnants and faeces, would lead to a degradation in water quality, negatively impacting marine wildlife[166].

2. Welfare issues

2.1. Capture and storage

Breeding octopuses in captivity is difficult. Therefore, this form of aquaculture has typically consisted of "*ranching*" or "*rearing*", where young animals are captured in the wild and then raised in sea nets or tanks. As indicated in this report, all capture and storage techniques have a negative impact on the welfare of octopuses.

2.2. Feeding

Inadequate nutrition is a major problem in large-scale aquaculture. Currently, there is a lack of understanding around the metabolism and nutritional needs of octopuses to replicate a complete diet in captivity.[167] Octopuses that do not respond well to the provided food sources can face various health problems, such as hunger, eating disorders, and metabolic diseases.[168]

164 G.J. Pierce (n 9) 67.
165 Eurogroup for Animals en Compassion in world farming, Uncovering the horrific reality of octopus farming, 2021, 3.
166 Natali , M., & Gisie, L. (2024). Bienestar y legislación de los cefalópodos en la acuicultura industrial: exploración de la irrelevancia de los proyectos de cría de pulpo. *DALPS (Derecho Animal-Animal Legal and Policy Studies)*, *2*, 124–153.
167 Ibid. 63.
168 Ibid. 63.

2.3. Lack of cognitive stimulation

Jacquet et al. (2019) expressed concern about the lack of cognitive stimulation for farmed octopuses. The "*tightly controlled and monotonous environments*" typical of intensive farming provide insufficient cognitive stimulation, which is essential for their psychological well-being. In captivity, octopuses often show signs of stress, such as irregular swimming patterns, depression, agitation, and anorexia.[169] These symptoms can become so severe that they lead to autophagy (consuming their own limbs).[170]

In captivity, octopuses often show signs of stress, such as irregular swimming patterns, depression, agitation, and anorexia.

2.4. Lack of shelter

Octopuses are vulnerable to predators and typically require shelter and quick retreat strategies. When these are not available, as is often the case in captivity, it can cause anxiety, depression, anorexia or even major losses linked to cannibalism. Therefore, it is essential that octopuses have sufficient shelters available, such as caves or hiding places.[171]

2.5. Skin Injuries

A common fear response in octopuses is to quickly 'jet away' from a threat. In captivity, this can lead to collisions with the sides of the aquarium, causing injuries to the soft skin of the octopus. These wounds often heal poorly and can become infected, which can lead to permanent damage, the spread of infections to other tissues, and even death.[172] The 'jetting away' behaviour can be reduced by providing sufficient hiding places and visual barriers, and by handling octopuses carefully to minimise fear responses.[173]

2.6. Inadequate housing

Inadequate housing can significantly affect the health and well-being of octopuses. The quality of the water in which they can live is of crucial importance. Octopuses are not well-equipped to adapt to changes in their water environment and therefore require strict monitoring of oxygen, pH, CO_2, nitrate, and salinity levels. The prompt removal of ink is also essential. Poor water quality can lead to health issues, infections,

169 Ibid. 63.
170 Ibid. 63.
171 Ibid. 63.
172 Ibid. 64.
173 Ibid. 64.

respiratory problems, agitation, increased incidents of inking and jetting, and even death.[174]

In addition to water quality, other aspects of housing, such as lighting, temperature, and the presence of noise and vibrations, can affect the well-being of octopuses. Octopuses have unique sensory abilities, such as the ability to see polarised light and mechano- and chemosensory reception,[175] which lead to specific environmental requirements.[176]

One important aspect is temperature, as it influences feeding, growth, and lifespan. It is also important to consider the size of the social groups in which octopuses are housed. Octopuses are solitary and should be housed individually to prevent aggression and cannibalism resulting from overcrowding. Overcrowding can also increase stress and reduce rest and feeding times.[177]

2.7. Disease

Disease can arise from various factors, such as stress, poor water quality, or inadequate nutrition. Animals under stress have a weakened immune system, which can result in bacterial, viral, and fungal infections. Knowledge of the immune system of octopuses is limited, and there is insufficient knowledge about pain management in octopuses that suffer injuries or must undergo medical procedures.[178]

2.8. Slaughter methods

The humane slaughter of octopuses is recommended by administering a lethal overdose of anaesthesia followed by the destruction of the brain. However, this method is considered unsuitable for octopuses intended for human consumption. Mechanical methods, such as cutting or piercing the brain, are time-consuming and require expertise to be performed correctly, making them commercially unfeasible on a large scale.

Currently, there is no reliable, humane slaughter method for commercially farmed octopuses, a problem that also applies to wild-caught octopuses.[179]

174 Ibid. 64.
175 Mechanoreception and chemosensory reception in squid refer to their ability to perceive changes in their environment. Mechanoreception refers to the ability to sense physical changes, such as touch or pressure, while chemosensory reception refers to the ability to detect chemical changes, such as smell or taste.
176 J. Birch (n 7) 64.
177 Ibid. 64.
178 Ibid. 64.
179 Ibid. 64.

VII

LEGISLATION

VII. LEGISLATION

1. Europe

There is a noticeable inconsistency at the European level regarding the recognition of octopuses as sentient beings. Although the sensitivity and the ability of octopuses to experience pain and stress are acknowledged scientifically, this recognition is not reflected in the regulations governing the capture and slaughter of octopuses.

1.1. The European Slaughter Regulation

The European Slaughter Regulation 1099/09 is not applicable to octopuses,[180] which causes serious welfare issues during their slaughter. There is no requirement to stun octopuses before slaughter. The inhumane method of suffocating octopuses by exposure to air is not prohibited by the Slaughter Regulation. Although less cruel methods exist – such as percussive blows to the head, spiking or coring, captive bolt –,[181] they are not used because they are not considered commercially and/or practically feasible.[182]

To ensure a higher level of welfare for octopuses, the application of the Slaughter Regulation must be extended, and specific parameters for the slaughter of octopuses must be developed, taking into account scientific evidence of their sensitivity.[183]

1.2. The European Animal Testing Directive

In 2010, the European Union expanded legislation on animal testing to include the class Cephalopoda, which includes octopuses. This recognition is based on scientific evidence that octopuses are capable of experiencing pain, suffering, stress, and lasting harm. In accordance with Directive 2010/63/EU, all scientific procedures likely to have adverse effects on octopuses must meet certain conditions.[184]

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180 R. Mercogliano en D. Dongo, 'Fish welfare during slaughter: the European Council Regulation 1099/09 application (2023) 12 Italian Journal of Food Safety 10926.
181 N. Boyland en P. Brooke, Farmed fish welfare during slaughter (2017) Aquaculture Advisory Council (AAC) Report <https://aac-europe.org/wp-content/uploads/2018/06/Slaughter_report__AAC_report.pdf> 8-10.
182 Ibid.
183 R. Mercogliano en D. Dongo, 'Fish welfare during slaughter: the European Council Regulation 1099/09 application (2023) 12 Italian Journal of Food Safety 10926.
184 J.A. Smith et al., 'Cephalopod research and EU Directive 2010/63/EU: requirements, impacts and ethical review' (2013) 447 Journal of Experimental Marine Biology and Ecology 31; Directive 2010/63/EU: Recital 8, European Parliament and Council of the European Union, 2010.

2. Belgium

2.1. Flemish Animal Welfare Code

The Flemish Animal Welfare Code states that the Code will only apply to invertebrates after an evaluation. However, the Code does not explicitly mention that this evaluation will include an investigation into the ability of invertebrates, including octopuses to experience pain. Article 7 stipulates:

"Dit decreet is van toepassing op de gewervelde dieren.

In de volgende gevallen is dit decreet van toepassing op ongewervelde dieren:

1° als dit decreet het uitdrukkelijk bepaalt;

2° als de Vlaamse Regering op basis van een evaluatie bepaalt op welke ongewervelde dieren het van toepassing is en welke maatregelen erop van toepassing zijn."

Translation into English:

"This decree applies to vertebrate animals.

In the following cases, this decree applies to invertebrate animals:

1° if this decree explicitly stipulates it;

2° if the Flemish Government determines, based on an evaluation, which invertebrate animals it applies to and which measures are applicable to them."

2.1. Walloon Animal Welfare Code

The ability of invertebrate animals to experience pain is the decisive criterion in determining whether the Walloon Code applies. Article D§3.2 stipulates:

« §2. Le présent Code s'applique aux vertébrés. Il s'applique également à certains invertébrés déterminés :

1° lorsque les dispositions du présent Code le spécifient;

2° pour les dispositions du présent Code déterminées par le Gouvernement sur la base de recherches scientifiques menées quant à leurs capacités sensitives. »

Translation into English:

« §2. This code applies to vertebrates. It also applies to certain specified invertebrates:

1° when the provisions of this Code specify it;

2° for the provisions of this Code determined by the Government based on scientific research regarding their sensory capacities. »

VIII
CONCLUSION

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VIII. CONCLUSION

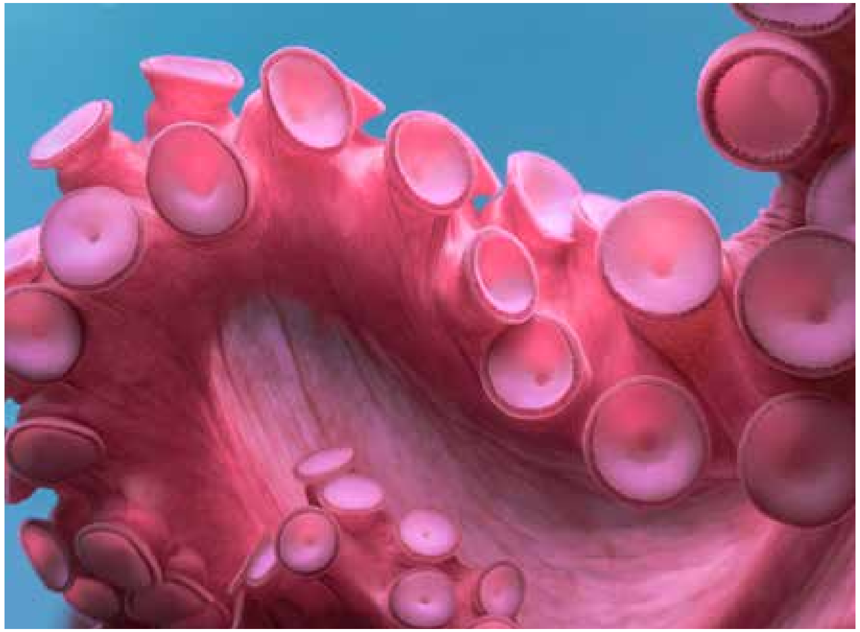
In conclusion, scientific research concludes that octopuses should be regarded as sentient beings, capable of conscious perception and experiencing subjective sensations. Despite this understanding, there are no policy or legal regulations requiring the use of humane methods for capturing and slaughtering them for commercial purposes.

In practice, octopuses suffer from being left for extended periods in capture devices such as traps and fixed nets. Moreover, they often die during capture in nets or, if they arrive alive on board, by suffocation (and/or freezing) on the vessels. Although, from an animal welfare perspective, it is necessary that octopuses be immediately stunned and slaughtered when brought on board, this practice is not followed. Despite evidence of their sentience and consciousness, practical and economic objections prevent the implementation of a humane slaughter method (e.g., immediately killing the octopus once on board by a trained crew member who delivers a percussive blow to the head with a knife or spike).

As a result, a complete ban on the capture and consumption of octopuses is the only viable solution currently available to ensure their welfare.

Retailers should remove octopuses and derivative products from their assortment, and consumers should stop eating octopuses.

Breeding octopuses in farms also offers no solution, as these intensive environments do not meet the complex needs of octopuses and thus would lead to immense pain and suffering.



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