Invertebrate sentience and sustainable seafood

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Octopuses, crabs and lobsters are probably sentient, yet their welfare needs are poorly protected in the food system. Upholding animal welfare in the seafood industry presents challenges and more research is needed to address humane capture, housing and slaughter.

Every year, humans consume billions of cephalopod molluscs (including octopus, squid, and cuttlefish) and decapod crustaceans (including crabs, lobsters, crayfish, and shrimp) (**Figure 1**). Billions more of these invertebrate animals are slaughtered than the combined total of cows, sheep, pigs, and chickens[1] – and are frequently slaughtered using methods that would not be allowed for livestock. Caught octopuses may be asphyxiated or clubbed to death; live crabs are dismembered; and lobsters are boiled alive[1].

Is there a welfare problem?

Sentience is the capacity to have feelings. It is more than just the capacity to feel pain, although pain and distress raise the most urgent ethical issues. In most countries, animal welfare legislation does not protect cephalopods or decapods. The UK's Animal Welfare Act 2006, for instance, only covers vertebrates as invertebrates have often been viewed as not sentient. If we could be confident that octopuses, crabs and lobsters feel nothing when processed and slaughtered, it might be reasonable to leave them out of animal welfare laws. However, a growing body of evidence points the other way.

The UK government commissioned us to evaluate the evidence for sentience in cephalopods and decapods, to determine whether their welfare should be enshrined in legislation. We developed eight criteria for sentience, which encompass both whether the animal's nervous system can support sentience, and whether its behaviour indicates sentience[2,3]. In our report, which reviewed over 300 scientific studies, we found strong and diverse evidence for sentience in both cephalopods and decapods[2]. We found no clear evidence that either group failed any criteria. Where criteria were not shown to be satisfied, this was invariably due to a lack of evidence rather than clear evidence of absence.

Differences in the strength of evidence between species also tended to reflect biases in scientific attention. Octopuses and true crabs have received sustained scientific attention, leading to abundant evidence for sentience, whereas shrimps (for example) have barely been studied, leading to less evidence. To prevent these disparities in scientific attention from disproportionately affecting legislation, we advised against restricting the scope of protection to just some cephalopods (e.g., octopuses) or some decapods (e.g., true crabs).

The UK government subsequently amended the Animal Welfare (Sentience) Bill, expanding it to cover all cephalopod molluscs and all decapod crustaceans. The bill recently became law, and the Animal Welfare (Sentience) Act 2022 now legally recognises these invertebrates as sentient. Invertebrates also receive some legal protection in a handful of other countries, including Switzerland, New Zealand and Norway. But what are the implications for pathways to sustainable seafood? And how can industry minimise potential animal welfare issues?

Welfare risks for cephalopod molluscs

Cephalopods caught from the wild usually die during capture and landing, unlike decapods (which are often transported live before slaughter). Welfare issues are similar to those for wild-caught fish.

Nets and poorly designed tanks can injure or cause abrasions to cephalopods' soft skin, leading to infections which are often fatal. Fishing nets can also cause cephalopods to suffocate or be crushed under the weight of other animals. Little research has sought to address these risks, although promising interventions may include softer netting materials and alternative capture methods[4].

Traps present other problems such as cannibalism, which has been observed in some commonly studied species of octopus, squid, and cuttlefish[5]. Cannibalism has been linked to high densities and frequency of encounters between individuals, so rates are higher when decapods are trapped together. Furthermore, fights increase stress, which can contribute to self-cannibalism (i.e., individuals eating their own arms[6]).

Cephalopods have some attractive qualities for commercial aquaculture: high economic value, growth rate, protein content, and fecundity. However, current cephalopod aquaculture is incompatible with good welfare[7] and leads to a range of welfare issues. Conspecific aggression, including cannibalism, is a frequent problem when housing octopus in groups, particularly the commonly-used *Octopus vulgaris*[7,8]. Live prey is typically needed to avoid poor nutrition, especially for larval stages[4,8]. As this prey is most often decapod crustaceans (crabs and brine shrimp), there are additional welfare problems for the prey animals themselves.

Moreover, cephalopods have exacting environmental requirements. Oxygen, pH, CO_2, nitrate, salinity, and temperature must remain constant to prevent poor health and stress[9], and appropriate hiding places must be provided (shelters for octopus and soft substrate for cuttlefish). Small, barren tanks also fail to offer opportunities for exploration or cognitive stimulation, causing captive cephalopods to display indicators of stress[7].

Finally, in both fisheries and aquaculture, no commercial cephalopod slaughter methods are humane. Terminal overdose with anaesthetic is the only recommended welfare-friendly approach[10], but this is inappropriate for cephalopods destined for human consumption. Common slaughter methods include asphyxiation, clubbing, and reversing the body (mantle), all of which raise welfare concerns. Mechanical slaughter – cutting or puncturing the brain – requires careful and skilled operators to ensure it is performed correctly, and the level of suffering experienced is currently unknown[10,11]. For these reasons, it is not recommended in most cases, and seems particularly unlikely to be effective at a commercial scale.

Welfare risks for decapod crustaceans

Decapods represent the fastest growing major fishery worldwide, with hundreds of billions caught and farmed every year[12]. Commercially important examples include brown crab, langoustine, and shrimp. Best-practice guidelines, where they exist at all, tend to prioritise product quality rather than animal welfare[13]. Welfare concerns are, therefore, prevalent during decapod farming, capture, transport, and slaughter.

A common practice is declawing, the removal of one or both claws, which are harvested for human consumption. In edible crabs, twisting off even one claw induced a substantial stress response within 10 minutes, and approximately 17% mortality within 24 hrs[14]. For laboratory-housed stone crabs, removing one or both claws increased mortality, compared to control individuals[15]. Declawed edible crabs tended and shielded their wound[16], suggesting pain and suffering. If declawed crabs are returned to the ocean, relatively few are successfully re-fished and claw regrowth is very slow, suggesting limited commercial viability of this supposedly renewable practice (e.g.,[15]). Declawing was banned in the UK from 1986-2000; reinstating this ban may improve decapod welfare. If there is a perceived need to declaw, a possible higher-welfare alternative is inducing the animal to shed its claw (autotomy[14]).

Nicking, a practice associated with brown crab fisheries, involves cutting the tendons of a decapod's claw. This makes crabs safer to handle and limits aggression during transport. However, nicking elevates haemolymph glucose and lactate (potential signs of stress), as well as the risk of muscle necrosis and pathology[17]. Using individual transport containers or noninvasively immobilising claws are two possible alternatives.

During capture and transport, accidental physical injuries include cracked carapaces, damaged antennae, and limb loss. These are not just welfare issues: intact animals generally command higher prices than injured ones, which can spoil rapidly. Hence, industry best-practice guidelines already emphasise careful handling[13]. Means of avoiding injury vary between species. With langoustine, for example, creels (baskets) cause lower physiological stress, mortality, and physical damage than trawl nets[18].

Intact decapods may be transported and kept alive for days or even weeks before slaughter. Live crustaceans are also maintained in commercial aquaculture. To prevent both poor welfare and spoilage, their temperature must be carefully controlled. Salinity and oxygen levels should also be kept stable for immersed decapods[19], whilst constant humidity is important for “dry-stored” animals[20]. In addition, best-practice guidelines discourage displaying and transporting live decapods on ice or in icy water[13].

A common practice in global shrimp aquaculture is eyestalk ablation: severing the eyestalks of breeding females to induce egg production. Ablation causes whiteleg shrimp (marketed as king prawns) to recoil and swim erratically[21], and cauque river prawns to flick their tails and rub the uncovered wound site[22]. In both studies, the local anaesthetic lidocaine (branded Xylocaine) dampened these behavioural responses. It is, however, unclear whether the anaesthetic reduced pain or simply inhibited general responsiveness. There is a need for more evidence regarding sentience in shrimps, but we should take seriously the possibility that they can feel pain, and eyestalk ablation is therefore a severe welfare risk. Moreover, there is evidence that non-ablated whiteleg shrimp can produce more offspring, with better stress-resistance, than ablated shrimp[23].

Wherever possible, effective stunning should precede decapod slaughter. Commercial devices can deliver electric shocks that induce a seizure-like state and (apparently) render large crustaceans insensible within one second[24]. Stunning devices are available for lobsters, crabs, and crayfish. Slaughter methods that would otherwise be inhumane can become humane if the animal is *effectively* stunned beforehand. Some electrical stunning devices may also be used to slaughter large crustaceans.

Without stunning, most decapod slaughter methods almost certainly entail substantial pain and suffering. Examples include boiling, chilling, tailing (twisting head from body), and any form of dismemberment. Large crustaceans dropped in boiling water routinely take over two minutes to die, likely in extreme suffering[24]. Whilst smaller crustaceans boil faster, they do not escape this severe welfare risk[25]. Chilling can paralyse and kill decapods, but it is unclear whether loss of sentience accompanies immobility, and whether chilling is painful[25].

Lobster and crab nervous systems are relatively decentralised: lobsters have a chain of 13 interconnected nerve clusters (ganglia) running down their bodies, whilst crabs have two main ganglia. Until the neural circuits that underpin sentience are precisely located, we ideally recommend rapidly destroying all these ganglia. This means slicing lobsters down the midline (whole-body splitting) and stabbing crabs through both ganglia (double-spiking). Even for these methods, however, it is unclear how many ganglia are typically destroyed by trained chefs.

Selling live animals to domestic consumers is a particular welfare concern. Live decapods can be ordered from online retailers and various supermarket chains without guidance on storage, handling, or slaughter. These animals are thus highly likely to suffer from poor handling, inhumane slaughter methods, and lack of oversight or accountability. Banning live decapod sales to private individuals would be a low-cost intervention to improve welfare.

Future Directions

Our full report developed a scientific framework to evaluate evidence of sentience, and we hope it is applied to other animal groups harvested for food. Insects and gastropod molluscs should be regarded as serious candidates for sentience, raising potential welfare concerns about farming insects and eating snails. Moreover, we found virtually no work on larval phases of cephalopods and decapods. Future studies should investigate the development of sentience and determine whether larvae satisfy our criteria.

To ensure acceptable cephalopod welfare, best-practice guidelines must be developed for their capture, housing, husbandry, and slaughter (see[10]). Cephalopod welfare research has, however, been very limited to date. For example, no slaughter methods are both humane and commercially viable. CephRes, a non-profit that promotes and disseminates cephalopod research, plans to evaluate different stunning methods – a positive step, especially since this organisation does not focus primarily on fisheries or welfare.

Decapods, meanwhile, are often kept alive during transport, storage, and aquaculture, so their long-term welfare needs safeguarding. This requires more research on appropriate stocking densities, environmental conditions, and methods to prevent aggression and injury. Improving health and welfare assessment is also important to allow early identification of suffering, injury, or disease.

Humane slaughter research is another decapod priority[25]. We tentatively recommend whole-body splitting, double-spiking, and electrocution as the best methods, but these can take 10-15 seconds and require specialist training and equipment. For splitting, research is also needed to determine whether the entire chain of ganglia is typically bisected.

The Humane Slaughter Association, a charity that promotes food animal welfare, is currently funding research into crustacean stunning and slaughter, including methods that may be feasible on vessels. Shrimp research is especially urgent, as very little is known about their welfare, and there is continuing uncertainty about their sentience. This is despite 210-530 billion shrimps and prawns being farmed in 2017, plus countless wild-caught individuals (http://fishcount.org.uk/fish-count-estimates-2/numbers-of-farmed-decapod-crustaceans).

Including cephalopods and decapods in the Animal Welfare (Sentience) Act 2022 was a milestone, but this law only leads to oversight of new legislation. Existing welfare laws must also be extended, including the Animal Welfare Act 2006 (which only protects vertebrates) and the Animals in Scientific Procedures Act 1986 (which only protects vertebrates and cephalopods). To date, the UK government has not amended either piece of legislation. We also hope that other countries recognise cephalopods and decapods as sentient, and take reasonable steps to protect their welfare.

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Conflicts of interest

The authors declare there are no conflicts of interest.