# Fish welfare during slaughter: the European Council Regulation 1099/09 application

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## Abstract

The Treaty of Lisbon states that animals are sentient beings. Fish species show physiological differences from terrestrial animals and are slaughtered and killed in a very different context. Many existing commercial killing methods expose fish to extensive suffering over a prolonged period of time, and some of the slaughtering practices they experience can cause pain and distress. This study highlights the limited feasibility of European Council Regulation 1099/09 requirements on welfare when killing cephalopods and crustaceans. Sentience is the animal's capacity to have positive (comfort, excitement) and negative (pain, anxiety, distress, or harm) feelings. Considerable evidence is now showing that the major commercial fish species, including cephalopods and crustaceans, possess complex neurological substrates supporting pain sensitivity and conscious experiences. In the legislation applied to scientific procedures, the concept of sentience in these species is important. Therefore, it would be appropriate to acknowledge current scientific evidence and establish reference criteria for fish welfare. For the welfare of fish species during slaughter, European Council Regulation 1099/09 applicability is limited. Fish welfare during slaughter is more than just an ethical problem. According to the One-Health approach, food safety should also include the concept of sentience for fish welfare. Pending studies that dispel all doubt, the precautionary principle of European Council Regulation 178/04 remains valid and should be applied to fish welfare.

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Key words: cephalopods, crustacean, invertebrate sentience, council regulation EC 1099/09.

Contributions: the authors contributed equally.

Conflict of interest: the authors declare no potential conflict of interest.

Funding: none.

Availability of data and materials: data and materials are available from the corresponding author upon request.

Received: 10 October 2022.
Accepted: 26 January 2023.
Early view: 12 July 2023.


*Italian Journal of Food Safety 2023; 12:10926*
*doi:10.4081/ijfs.2023.10926*



## Introduction

Killing animals may cause pain, distress, fear, or other forms of suffering to the animals themselves, even under the best available technical conditions. The Treaty of Lisbon states that animals are sentient beings, and the member states shall pay full regard to animal welfare requirements. The European Council Regulation 1099/2009 on the protection of animals during slaughter includes specific requirements for the slaughter of terrestrial species farmed for food. Fish species are slaughtered and killed in a very different context and show physiological differences compared to terrestrial animals (European Council, 2009). As fish are recognized as sentient beings, the welfare rule principle remains applicable: they shall be spared any avoidable pain, distress, or suffering during their killing and related slaughtering operations (Boyland and Brooke, 2017). Among the *taxa* of invertebrate species, the octopoda order, *Cephalopoda subphylum* (cephalopods), includes all species of octopus, squid, cuttlefish, and nautilus; the decapoda order, *Crustacean subphylum* (crustaceans), includes invertebrate species such as true crabs, lobsters, crayfish, and true shrimps (Wolfe *et al*., 2019). Many existing commercial killing methods expose them to substantial suffering over a prolonged period of time, and some of the slaughtering practices (*i.e.,* boiling) are the cause of preventable pain and distress. The percussive, spiking or coring, free bullet, and electrical stunning, followed by the kill method (gill cutting), can be enabled for slaughter (Boyland and Brooke, 2017). The European Commission has recommended research on stunning based on a scientific risk assessment for the slaughter and killing of fish, taking into account social, economic, and administrative implications. In addition, the identification of separate standards for the protection of farmed fish at killing has also been recommended (European Council, 2009). Because of the differences in physiology and slaughter context and a less developed understanding of fish stunning, commercial fish species remain excluded from many of the recommendations regulating animal welfare at the time of the killing. Ineffective stunning, inhumane slaughter methods, and the practice of processing living cephalopods and crustaceans are serious welfare concerns (Boyland and Brooke, 2017). This study aims to highlight the limited applicability of the requirements of Regulation 1099/09 on welfare in comparison to terrestrial mammals when killing cephalopods and crustaceans.

## The concept of sentience in cephalopods and crustaceans

The question of the sentience of invertebrates is based on a scientific consensus that humans are not the only conscious beings. Non-human animals, including all mammals and birds, possess complex enough neurological substrates to support sentience and conscious experiences (Cambridge Declaration, 2012). Both capacities are closely linked because feelings are conscious experiences in the most basic, elemental sense of consciousness (Birch *et al.*, 2021).

### The concept of sentience

The animal welfare law issue is focused on two main concepts: sentience and nociception. Sentience (from the Latin *sentire*, to feel) is the animal's capacity to have positive (comfort, excitement) and negative (pain, anxiety, distress, or harm) feelings (European Council, 2009; Birch *et al*., 2021). Nociception is the detection of actual/potentially noxious stimuli achieved through nociceptors (sensory receptors of the peripheral somatosensory nervous system) that are capable of transducing and encoding noxious stimuli (Broom, 2019). Although the concepts of sentience and nociception are different, they are not unrelated. States of anxiety, fear, hunger, thirst, coldness, discomfort, and boredom are recognized as negatively valenced affective states. All negative feelings are sources of concern relevant to questions of sentience since they have the potential to contribute to poor welfare (Birch *et al.*, 2021).

A recent report has evaluated the evidence of sentience in cephalopods and crustaceans based on the satisfaction of 8 established criteria (Birch *et a*l., 2021). For each criterion, 5 confidence levels have been used to communicate the strength of the evidence that the invertebrates under discussion satisfy or fail the criterion (Tables 1 and 2).

### Criteria for evidence of sentience in cephalopods

Octopods, in particular cephalopods, possess seven of the eight criteria of physiological sentience. The application of the criteria of sentience in cephalopods has shown that they possess afferent sensory neurons differentially responding to noxious stimuli (very high confidence levels). After exposure to noxious stimuli, sensory neurons undergo sensitization showing spontaneous activation (criterion 1). There is also high-quality evidence: octopods possess molecular markers of nociceptors in their arms. Cephalopods possess centralized brains capable of integrating different types of information, including nociceptive. The vertical lobe is the brain center responsible for learning and memory (criterion 2). In addition, they possess relevant endogenous neurotransmitters and receptors, including enkephalins, estrogen, and serotonin (criterion 4). It has been hypothesized that they are aware of their injuries and change their priorities accordingly. However, this is also compatible with the hypothesis that injury directly produces increased sensitivity to threat (criterion 5). The strongest evidence of wound grooming and guarding is shown in cephalopods. Individuals have been shown to curl their adjacent arms around the injured site or attempt to scrape away a noxious stimulus when injured (criterion

**Table 1.** List of the 8 criteria for evidence of sentience. Modified from Birch *et al.* (2021).

| | |
|---|---|
| 1) | The animal possesses receptors sensitive to noxious stimuli (nociceptors). |
| 2) | The animal possesses integrative brain regions capable of integrating information from different sensory sources. |
| 3) | The animal possesses neural pathways connecting the nociceptors to the integrative brain regions. |
| 4) | The animal's behavioral response to a noxious stimulus is modulated by chemical compounds affecting the nervous system in either or both of the following ways:<br>a. the animal possesses an endogenous neurotransmitter system that modulates (in a way consistent with the experience of pain, distress, or harm) its response to threatened or actual noxious stimuli;<br>b. putative local anesthetics, analgesics (such as opioids), anxiolytics, or anti-depressants modify an animal's responses to threatened or actual noxious stimuli in a way consistent with the hypothesis that these compounds attenuate the experience of pain, distress, or harm. |
| 5) | The animal shows motivational trade-offs, in which the disvalue of a noxious or threatening stimulus is weighed (traded-off) against the value of an opportunity for reward, leading to flexible decision-making. Enough flexibility must be shown to indicate centralized, integrative processing of information involving an evaluative common currency. |
| 6) | The animal shows flexible self-protective behavior (e.g., guarding, grooming, rubbing) of a type likely to involve representing the bodily location of a noxious stimulus. |
| 7) | The animal shows associative learning in which noxious stimuli become associated with neutral stimuli, and/or in which novel ways of avoiding noxious stimuli are learned through reinforcement. Note: habituation and sensitization are not sufficient to meet this criterion |
| 8) | The animal shows that it values putative analgesic and anesthetic when injured in one or more of the following ways:<br>a. The animal learns to self-administer putative analgesics and anesthetics when injured.<br>b. The animal learns to prefer, when injured, a location at which analgesics and anesthetics can be accessed.<br>c. The animal prioritizes obtaining these compounds over other needs (such as food) when injured |

**Table 2.** Five confidence levels to communicate the strength of the evidence of sentience. Modified from Birch *et al.* (2021).

| Confidence levels | Criteria | Evidence of sentience |
|---|---|---|
| Very high confidence | 7-8 criteria are satisfied | Very strong |
| High confidence | 5-6 criteria are satisfied | Strong |
| Medium confidence | 3-4 criteria are satisfied | Substantial |
| Low confidence | 2 criteria are satisfied | Some evidence |
| Very low | 0-1 criteria are satisfied | Unknown or unlikely sentience |

6). Cephalopods can learn to avoid noxious stimuli, which suggests they can differentially detect and process the inputs (criterion 7). They learn to prefer a chamber in which a local anesthetic can be accessed when they are exposed to a noxious stimulus (criterion 8) (Birch *et al*., 2021).

## Criteria for evidence of sentience in crustaceans

Among decapods, crustaceans possess 7 of the 8 criteria for physiological sentience. Nociceptors are also present in other arthropods, such as insects, and the ion channel families involved in nociception are highly evolutionarily conserved. Several homologous ion channel proteins are expressed in crustaceans such as crabs and lobsters. Together with the behavioral evidence, this suggests that nociceptors are present in crustaceans (criterion 1). Decapods possess brains that integrate information from different sensory sources: the central complex, the hemiellipsoid bodies, and the accessory lobes (criterion 2). Neural pathways connect other sensory receptors to integrative brain regions. Nociceptors are connected to the same brain regions (criterion 3). Crustaceans have endogenous neurotransmitter systems (endogenous opioid, serotonergic, dopaminergic, and octopaminergic). Dopamine and octopamine have a role in mediating learning from aversive and attractive stimuli (respectively), while serotonin mediates responses to stress in decapods (criterion 4). Some crustacean species show motivational trade-offs. They are capable of weighing the disvalue of a noxious stimulus against the value of an opportunity for reward, leading to flexible decision-making (criterion 5). Brachyura crabs are capable of targeting self-protective behaviors at the site of a noxious stimulus (*e.g*., claw, mouth, abdomen) (criterion 6). True crabs show associative learning (criterion 7) (Birch *et al*., 2021).

In brief, no dramatic differences in evidence of sentience have been observed in with respect to decapods. The evidence of sentience based on the number of satisfied criteria and the confidence levels of each criterion is considered very strong for octopods, strong for true crabs (infraorder brachyura), substantial for coleoid cephalopods (squid and cuttlefish) and other *taxa* (anomuran crabs, astacids, caridean shrimps).

# Discussion

There is a critical relationship between animal health and animal welfare. To assess animal welfare, quality parameters are extensively studied in terrestrial species. Indicators of metabolic stress (osmolality, glucose, lactate, cortisol) or physicochemical (pH, superoxide radical production) and histological parameters (glycogen reserve, muscle damage) are considered stress markers (Mercogliano *et al*., 2017; Prisco *et al*., 2021).

The study of the changes caused by stress in fish has become a topic of discussion relatively recently (Balasch and Tort, 2019; Ferrante *et al*., 2022), and the procedures of stunning and slaughter, which are the main issues of animal welfare, are still not well known as far as fish is concerned. General principles to ensure farmed fish welfare during stunning and killing were described by the World Organization for Animal Health (WOAH, 2010). At the moment, a scientific risk assessment evaluation for fish slaughter and killing by the European Food Safety Authority is still pending. Separate rules for fish welfare are not established; therefore, Regulation 1099/09 provisions applicable to fish welfare remain limited to the application of the welfare key principles (European Council, 2009).

According to current knowledge, cephalopods and crustaceans should be regarded as sentient within the scope of animal welfare legislation (Birch *et al*., 2021).

An important question on cephalopod welfare is whether a slow slaughter method can be accepted due to the time it takes for the animals to become unconscious (De la Rosa *et al*., 2022). Octopus and cuttlefish are caught using trawls, pots, traps, and nets (Pierce *et al*., 2010). In squid fisheries, the hand-jigging method is considered the most humane live-capture method for squids, but it may not be appropriate for all species. The problem is that cephalopods are usually brought aboard the vessel dead or nearing death. Capture techniques can result in physical trauma (*e.g*., rough handling causes the mantle to detach from the head) (Birch *et al*., 2021). When capture methods involve nets, the main welfare risk is that individuals might be pursued to exhaustion, then suffocate and crush under the weight of other animals. Collision with other animals or the side of the net routinely causes skin ulcerations, which promote bacterial growth or can lead to disease or death (Gestal *et al*., 2019). Skin and fin injuries become a welfare concern if individuals are left in nets for hours or days before landing and if undersized live animals are released back into the water with injuries (Birch *et al*., 2021). In addition, the confinement of octopods and cuttlefish within a small space (*e.g*., pot or trap) causes stress, resulting in fighting and cannibalistic tendencies between individuals that are not size-matched if insufficient food is provided (Aguado-Giménez and García, 2003; Pierce *et al*., 2010; Jacquet *et al*., 2019). Cephalopods are highly stenohaline and stenotherm species. Changes in salinity can result in discomfort, stress, and death (Fiorito *et al*., 2015; Birch *et al*., 2021). In conclusion, for commercial cephalopod fisheries, no reliably humane slaughter method performed commercially on a large scale can achieve the minimum amount of pain and distress. Alternatively, experimental methods of slaughter that involve an overdose of anesthetics (typically ethanol) are not suitable for human consumption. Mechanical methods that do not involve contamination (cutting, puncturing of the brain) require skilled handlers and are inefficient for large-scale practices (Birch *et al*., 2021).

The main issue with crustacean welfare is that they should be stunned before slaughter (Birch *et al*., 2021). In terms of crustacean welfare, electrical stunning is considered a humane method preferable to chilling, boiling, and gassing with $CO_2$. For crustaceans, researching reliable and humane methods of killing in less than ten seconds is a priority (Fregin and Bickmeyer, 2016). Electrical and (potentially) pharmacological stunning are the most promising approaches (Birch *et al.*, 2021). The humaneness of electrical stunning highly depends on the electrical parameters, which must be adjusted according to species, size, and developmental stage. Higher voltage and longer electric shocks applied to neural tissue can stun and kill crustaceans. This procedure has the potential to be the only effective method for slaughtering edible crabs (*Cancer pagurus*) in one second (Roth and Øines, 2010). Electrical stunning can induce in astacid lobsters and crayfish a seizure-like state that diminishes, without wholly abolishing, the nervous system's response to boiling water (Fregin and Bickmeyer, 2016). Nevertheless, more evidence is needed about the following issues: i) how electrical stunning affects other commercially important decapod species; ii) how smaller species (such as shrimps) can be effectively stunned; iii) how stunning technology might work on boats.

The existing data leaves open the possibility that cold-induced immobilization leaves crustaceans susceptible to pain from subse-

quent procedures (Birch *et al.,* 2021). The slaughtering methods that are most likely to be humane are double-spiking (for crabs), whole-body splitting (for lobsters), or electrocution until death using a specialist device designed and validated for that purpose. Moreover, even these methods may take 10-15 seconds and require specialist skills.

Stunning crustaceans with ice promotes hypothermia and seems to offer similar results to those associated with electrical stunning. They are ectotherms and rely on external heat to maintain their body temperature. When external temperatures drop below a certain threshold, crustaceans enter a state of torpor that renders them immobile, preventing autotomy and aggression between individuals. Torpor also facilitates nerve center destruction, allowing a faster and more humane dispatch, but it is unclear whether chilling-induced inactivity is associated with unconsciousness. Moreover, chilling in a home freezer has been considered an inhumane slaughter method since it takes more than one hour for animals to die (Birch *et al*., 2021), as well as asphyxia or carbon dioxide methods, as they are associated with more negative effects (De la Rosa *et a*l., 2022).

Some commercial practices also raise fish welfare issues. Immersion of decapods in boiling water is a common practice in restaurants and domestic kitchens for lobster, langoustine, small crabs, crayfish, shrimps, and prawns. Boiling (without prior stunning) is the most controversial slaughter method applied to large crustaceans since they may take over two minutes to die. Boiling elicits physiological symptoms of distress, such as uncoordinated movements and escape attempts, in edible crabs (*C. pagurus*). The practice involves less prolonged suffering for smaller crustaceans (*e.g*., shrimps), but for other crustaceans, boiling causes a period of up to 2.5 minutes of continued sentience and extreme suffering (Roth and Øines, 2010). In lobsters and cuttlefish, intense neural activity continues for up to 30-150 seconds after immersion (Fregin and Bickmeyer, 2016). The practice of gradually raising the water temperature (without prior stunning) is also considered an inhumane slaughtering method, inducing a serious risk of suffering over several minutes (Birch *et al*., 2021).

Currently, to formulate fish protection legislation, there must be statistically significant evidence (obtained by experiments that meet normal scientific standards) that species of particular orders are sentient. The proposed list of neurological and behavioral criteria of Birch *et al.* (2021) includes important indicators concerning animal pain, particularly: i) self-delivery of analgesics, whereby the animal learns to administer pain relief drugs such as opioids in an operant-conditioning setup; ii) motivational trade-offs, whereby the animal behaves as if weighing its preference to avoid a noxious stimulus against other preferences; iii) conditioned place avoidance, whereby the animal learns to avoid locations where it previously encountered noxious stimuli. These are good indicators of pain, as opposed to mere nociception, as they require the brain to integrate information about tissue damage with other kinds of information and to make that integrated information available to mechanisms of motivation, decision-making, memory, and learning (Birch *et al*., 2021).

Thus, the aim of the European policy should be to include within the scope of animal protection legislation all animals for which the evidence of sentience is sufficient according to established standards of sufficiency (Birch, 2017). The precautionary principle (European Parliament and Council, 2002 - Article 7) was established to ensure a high level of health protection, and it has been often invoked in debates about animal sentience. The idea is that when the evidence of sentience is inconclusive, we should give the animal the benefit of the doubt, using caution to formulate animal protection legislation (Birch, 2017). The components of good welfare for fish are different from those of good welfare for terrestrial animals. The precautionary principle's application implies that the methodological standards should be lowered since, at the moment, high-quality research in the field of animal sentience already meets this requirement (Birch, 2017). To serve as a reliable guide to animal protection legislation, statistically significant indicators of the sentience of a particular species order should be required. When the burden of proof is satisfied, the animal in question should be brought within the scope of animal protection legislation (Birch, 2017). Based on the precautionary principle, where there are threats of serious, negative animal welfare outcomes associated with a lack of full scientific certainty (such as invertebrate sentience), this should not be used as a reason for postponing cost-effective measures to prevent those outcomes (Birch, 2017). Moreover, the measures taken to prevent negative animal welfare outcomes must be proportionate and cost-effective in comparison to other feasible means (European Parliament and Council, 2002). Finally, the issue of the potential effects of stress conditions on food safety when the fish are caught, transported, stunned, and slaughtered should also be considered. Further information for a more comprehensive risk assessment should be collected to establish if the poor well-being of fish may represent a risk to human health.

## Conclusions

Fish welfare during slaughter is more than just an ethical problem. One of the main animal welfare objectives of the strategy Farm to Fork is to review European legislation. According to the One-Health approach, food safety should include the concept of the sentience of fish species.

The sentience concept is important in the legislation applied to scientific procedures. Cephalopods are already included in provisions for the protection of animals used for scientific purposes (European Parliament and Council, 2010). Live crustaceans are considered primary products included among the aquatic organisms resulting from any fishing activity or derived products (European Parliament and Council, 2013 - Annex I). At the moment, there is considerable evidence that cephalopods and crustaceans possess complex neurological substrates supporting pain sensitivity and conscious experiences. From the point of view of welfare rules, the most critical issue is the identification of specific parameters applicable during the slaughter and killing of different fish species. Pending studies that dispel all doubts, the precautionary principle of Regulation 178/04 remains valid. To extend the application of Regulation 1099/09 and to ensure a higher level of fish welfare, it would be appropriate to lay down reference criteria that include the current scientific evidence on sentience.

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