ALI

OUR POLICY REQUESTS AND RECOMMENDATIONS

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CROSTACEI

INTRODUCTION

Science and the legislation of various national legal systems have been recognising the sentience of decapod crustaceans (crustaceans belonging to the order Decapoda, literally meaning ‘ten-footed’) for years, as well as their ability to feel pain and suffering; in Italy, however, these animals do not receive adequate protection from the law. Article 9 of the Italian Constitution delegates to the Parliament the identification of the ‘*ways and forms of animal protection*’.

It is urgent to implement a law that, following the most recent and reliable scientific evidence, aims at protecting decapod crustaceans,. Not all the problems considered, however, currently present a feasible solution or are backed up by sufficient scientific evidence to make timely requests. In particular, several welfare issues, such as the appropriate storage temperatures per species, lack data from scientific studies; others, such as the need for these animals to be kept away from direct light, are of difficult application.

With this in mind, we make the following requests and recommendations, divided by production phase: catching, transport/storage, and slaughter. The requests represent solutions to specific problems, supported by scientific literature which can offer a sufficient number of studies to demonstrate their adequate implementation. The recommendations, on the other hand, represent solutions to address problems which, due to partial or complete lack of scientific literature to support them and/or difficulties in applying them, are currently non-binding, although we do have the confidence to recommend their application.

Some of the requests and recommendations made are already included in the regulations of a few countries. Two examples are the ban on keeping live decapod crustaceans in direct contact with ice, already established in Switzerland, and the obligation to stun these animals before slaughter, already implemented in Switzerland and New Zealand.

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    - Ask: In the absence of new scientific evidence demonstrating the effectiveness of additional mechanical slaughter methods, for lobsters, 'whole-body splitting' (cutting down the entire longitudinal midline on the underside of the animal) and for crabs, 'double spiking' (the destruction of the two nerve centres in rapid succession by means of a pointed object), are the only two methods of mechanical slaughter permitted. These methods must be performed by experienced personnel and they must not take more than 10 seconds.
    - Ask: In the absence of new scientific evidence that guarantees that the death of the animal by means of other techniques occurs whilst still unconscious, electrocution with adequate equipment, according to parameters based on the characteristics of the single species involved, leading to the death of the animal in less than 10 seconds is the only non-mechanical method of slaughter allowed and must be performed by suitably trained personnel.
    - Ask: A ban of the following stunning and slaughter methods: water chilling, high salt solution, chemical anaesthetics, CO_2 gassing, air chilling, boiling, freshwater immersion, dismemberment, and high-pressure processing.

Capture

Problem: Declawing is a harmful practice that causes suffering and can result in death in decapods.

Evidence: European Union regulation No 850/98 allows 1% by weight of a catch of brown crabs (*Cancer pagurus*) made by pots or creels to consist of detached crab claws. Declawing, the practice of removing one of both of the claws from a crustacean, has been found to result in a loss of competitive advantage in brown crabs (*Cancer pagurus*), such as lower chances of mating (McCambridge et al., 2016) and diminished ability to feed on bivalves in brown crabs (*Cancer pagurus*) (Patterson et al., 2009) and stone crabs (*Menippe* spp.) (Duermit et al., 2015), for which death was found to occur within a few days if the wound was greater than 7mm. A study also found that the process induces considerable stress in brown crabs (*Cancer pagurus*), which displayed a physiological stress response following declawing, which was more severe for manual declawing than for induced autotomy (Patterson et al., 2007). McCambridge et al. (2016) also observed that brown crabs (*Cancer pagurus*) that had been declawed would tend their wound and shield it. Based on this evidence, the practice of declawing is very likely to cause suffering in decapods.

Ask: Ban on declawing.

Transport/Storage

Problem: Storing live decapods in direct contact with ice can cause suffering and is a health hazard.

Evidence: Because of the relatively high concentration of magnesium ions in their haemolymph, most crustaceans become inactive at a temperature of or below 2°C, and their joints become immobile (Frederich et al., 2002); this reduced status of activity is termed 'torpor'. Although research on the effects of cold temperatures on pain in crustaceans is lacking, most crustaceans do not inhabit polar regions and thus never experience temperatures of or below 2°C, and fishing industry reports suggest that sudden cold can stress and kill decapods (Jacklin & Combes, 2005). Furthermore, there is some evidence that these animals may possess cold-sensitive neurons (Tani & Kuramoto, 1998). Some countries, such as Italy and Switzerland, have forbidden the display or transport of live decapods on ice or ice water. Given such considerations, and the lack of scientific literature on the matter, it is sensible not to expose these animals to such cold conditions.

Ask: Storing live decapods directly on ice or in ice water must not be allowed.

Problem: Live-sale of crustaceans, including online delivery, is a welfare risk for the animals.

Evidence: The delivery of live decapods to private homes is a practice that does not ensure the effective handling, storage, and slaughter of the animals (Birch et al., 2021).

Ask: Ban of the sale of live decapod crustaceans, including online delivery to private homes.

Problem: Nicking in crabs causes suffering and is a welfare risk.

Evidence: In the fishing industry, the claws of decapods such as lobster (*Homarus* spp.) are generally immobilised by banding; this is done in order to reduce the likelihood of injuries that can occur as the animals fight, as well as potential injuries to the handlers (Birch et al., 2021). It is however said that the sloped morphology of the claws of brown crab (*Cancer pagurus*) make banding impractical for this species (Welsh et al., 2013), therefore most brown crabs undergo a process called 'nicking', where the tendon of both of their claws are severed, effectively preventing the animal from using them (Welsh et al., 2013). This practice has been shown to increase the amount of glucose and lactate in the haemolymph of the animals, as well as the risk of muscle necrosis and pathology (Welsh et al., 2013); the level of haemolymph phenoloxidase activity, which is important in immunity and wound healing, and mortality, were also found to increase following nicking – all these results were found to increase when nicking was performed at warmer temperatures (Johnson et al., 2016). This evidence shows that the practice of nicking is a serious health and welfare risk for brown crabs, especially when performed in warm temperatures, although it is by no means a necessary practice. In Norway, the claws of these animals are sometimes restrained using elastic bands (Woll et al., 2010), and Haefner (1971) has shown that in blue crabs (*Callinectes sapidus*) a small block could be inserted between the two claw dactyls, which would in turn allow for the claw to open slightly and for the slope to accommodate for a band.

Ask: Ban on nicking.

Slaughter

Problem: The slaughter of conscious decapod crustaceans, in the absence of stunning practices that render them insensitive to pain, causes severe suffering for the animals involved.

Evidence: As stated by Birch et al. (2021), '*from a welfare perspective, crustaceans should be stunned before slaughter*'. Stunning decapod crustaceans, thus rendering them insensible to pain, can in fact minimise the potential amount of pain and distress felt during slaughter. Electrical stunning has come forward as one of the most efficient and quick methods for stunning decapods. British company Mitchell & Cooper Ltd produces an electrical stunning device called Crustastun™, developed for the humane stunning and killing of decapods. Roth & Øines (2010) investigated electrical stunning for brown crabs (*Cancer pagurus*), finding that electricity could render the crabs insensible within one second using electric field strengths of 400 V/m and more. Roth & Grimsbø (2013) stated that in order to successfully stun brown crabs (*Cancer pagurus*) within one second, the direct exposure must be 220 V/m; however, due to the high resistance of the animals, they recommended an exposure of 10 seconds. A subsequent study by Roth & Grimsbø (2016) recommended the use of electrical stunning used in combination with a thermal shock to stun the animals instantaneously. Whilst the most appropriate current and duration of procedure is likely to be dependent on species and size, electrical stunning offers the possibility to render the animals unconscious to pain within a few seconds, and must therefore be practised before any method of slaughter.

Ask: In the absence of new scientific evidence demonstrating the effectiveness of additional stunning methods, the use of electrical stunning techniques tailored to the characteristics of the species involved and capable of causing instant insensitivity (within one second) to the pain before any slaughter method is mandatory. Unconsciousness must be maintained until the moment of death, and the practices must be adopted by adequately trained personnel.

Problem: The use of inappropriate mechanical slaughter techniques for large decapod crustaceans such as lobsters and crabs, adopted by inadequately trained personnel, causes serious suffering for the animals involved.

Evidence: Unlike vertebrates that have a centralised nervous system with one single brain, lobsters have a decentralised nervous system with 13 interconnected nerve clusters (ganglia) down their ventral nerve cord, which means that dismantling only the brain does not necessarily kill the animal (Roth & Øines, 2010). The only way to confidently kill the animal is if all 13 ganglia are dismantled. This can be done by severing down the whole longitudinal midline of the animal with a knife, a process known as 'complete splitting' or 'whole-body splitting'; only splitting the head ('head splitting') leaves the posterior ganglia intact and thus can result in the survival of the animal. It is advocated by Birch et al. (2021) that to reduce suffering, complete splitting should be performed by a skilled practitioner and take less than 10 seconds.

Crabs have a decentralised nervous system with two ganglia: the main cerebral ganglion, and a second thoracic ganglion. Destroying only one of the two ganglia, generally the cerebral ganglion (known as 'single spiking'), is a common procedure that does not necessarily result in the death of the animal (Roth & Øines, 2010). A more effective procedure called 'double spiking' involves piercing the underside of the animal with a spike in rapid succession at the two points corresponding to the locations of the ganglia; this effectively dismantles both ganglia and kills the animal. This method was recommended by the Universities Federation for Animal Welfare (UFAW) as the most human method for slaughtering crabs (Birch et al., 2021).

Ask: In the absence of new scientific evidence demonstrating the effectiveness of additional mechanical slaughter methods, for lobsters, 'whole-body splitting' (cutting down the entire longitudinal midline on the underside of the animal) and for crabs, 'double spiking' (the destruction of the two nerve centres in rapid succession by means of a pointed object), are the only two methods of mechanical slaughter permitted. These methods must be performed by experienced personnel and they must not take more than 10 seconds.

Problem: The use of inadequate non-mechanical slaughter techniques, adopted by inadequately trained personnel, causes serious suffering for the animals involved.

Evidence: Electrical stunning has come forward as one of the most efficient and quick methods for killing decapod crustaceans, being deemed by Roth and Øines (2010) as the most humane method for slaughtering brown crabs (*Cancer pagurus*). With the Crustastun^{TM}, the decapod crustaceans can be stunned in a saline solution by a 110 V electrical charge, which

can stun the animal within 10 seconds. In two studies by Neil (2010, 2012), Crustastun™ used for 10 seconds ended all detectable neural activity in lobster (*Homarus gammarus*), langoustine (*Nephrops norvegicus*), and brown crab (*Cancer pagurus*); the animals did not autotomise (self-amputate), move their limbs, eyes, or antennules, or recover. For two shore crabs (*Carcinus maenas*), some neuronal recovery in one of the three legs tested was detected, but none in the central nervous system. A study by Albalat et al. (2008) also found that Crustastun™ reliably killed langoustine (*Nephrops norvegicus*), and that the device improved the quality of the meat when compared to the meat of the animals killed on ice. There are conflicting evidences on the effects of Crustastun™ on stress levels (Lorenzon et al., 2007; Barrento et al., 2011; Neil & Thompson, 2012), which means that there is no definitive evidence as to whether this process is painless (Birch et al., 2021). The process has been found to induce a seizure-like state in European lobsters (*Homarus gammarus*) and occasional seizure-like states in crayfish (*Astacus astacus* and *Astacus leptodactilus*), and it was concluded that Crustastun™ paralyses the animals and leads to a reversible decline of nerve system activity after seizure (Fregin & Bickmeyer, 2016). The process was shown by Weineck et al. (2018) to immobilise and reduce the heart rate of red swamp crayfish (*Procambarus clarkii*) and whiteleg shrimp (*Litopenaeus vannamei*). A study by Roth & Grimsbø (2016) showed that in brown crabs (*Cancer pagurus*) an exposure to 220 V resulted in swift stunning and death within 10 seconds, and that neither pre-chilling or keeping in air or ice water after stunning resulted in the survival of the animals. Also, the loss of claws or legs was relatively minor (3 to 6%) and appeared to be independent of voltage or exposure time. It was concluded that electrical stunning was a humane method for stunning and slaughtering decapods in large-scale commercial settings (Roth & Grimsbø, 2016). Taking into account these studies, Birch et al. (2021) recommended electrical stunning as a human method for slaughtering decapods, as long as it kills the animal within 10 seconds. A recent study by Neil et al. (2022) done on brown crab (*Cancer pagurus*) concluded that:
'*Electrical stunning with the Crustastun™ can rapidly arrest spontaneous activity within the central nervous system, with an accompanying loss of sensory responsiveness and a failure in neuromuscular activation. In effect this stunning induces rapid anaesthesia, which renders the animals insensible within 10 s. Moreover, as judged by indicative biochemical measures, it imposes no more physiological stress than does brief handling of the animal. This stun is also irreversible, leading to the death of all 18 of the crabs that were stunned. For all these reasons*

this procedure may meet the criteria for being a humane method of slaughter for C. pagurus'. Based on these results, electrical stunning can be considered the most human method available for stunning and slaughtering decapods, especially when performed by a tested instrument like the Crustastun^{TM}.

Ask: In the absence of new scientific evidence that guarantees that the death of the animal by means of other techniques occurs whilst still unconscious, electrocution with adequate equipment, according to parameters based on the characteristics of the single species involved, leading to the death of the animal in less than 10 seconds is the only non-mechanical method of slaughter allowed and must be performed by suitably trained personnel.

Problem: The following methods of stunning before slaughter or methods of slaughter are not suitable due to their ineffectiveness and/or for causing prolonged suffering to decapod crustaceans: chilling, boiling alive (including slowly raising the temperature of the water), any other form of live dismemberment (separation of the abdomen from the thorax, separation of the head from the thorax), freshwater immersion (osmotic shock), high salt solution (salt baths), the use of chemical anaesthetics, and CO_2 gassing.

Evidence (by type):

Stunning

Water chilling: Birch et al. (2021) concluded that this method at present cannot be recommended, as '*nervous system activity continues after chilling, melting slush-ice can cause osmotic shock, and death is slow*', taking into account a study by Gardner (2004). Given the lack of evidence as to whether this method causes suffering, it cannot be recommended.

High salt solution: This method involves placing the animal in a strong salt solution (35%) for a minute or less prior to boiling, as a way to partially stun the animal prior to slaughter (Conte et al., 2021). Baker (1955), however, reported that brown crabs (*Cancer pagurus*) that had been previously placed in a high salt solution, when immersed in boiling water began to autotomise, which shows clear distress (Birch et al., 2021). Similar results were observed by Roth & Øines (2010) using a 17% NaCl or 5% KCl solution to stun brown crabs (*Cancer pagurus*); when the animals were then immersed in boiling water they displayed vigorous attempts to escape, and were still responsive to touch after 3 minutes. Based on the evidence, immersing decapods in a high salt solution prior to slaughter does not result in diminished suffering, and as such cannot be deemed as a humane stunning method.

Chemical Anaesthetics: These products, the most studied representatives being clove oil and AQUI-S (a clove oil-based product), are known to induce paralysis in different species of crustaceans (Gardner, 1997; Morgan et al., 2001; Coyle et al., 2005; Cowing et al., 2015; Waterstrat & Pinkham, 2005; Ghanawi et al., 2019). The behavioural signs that were used to assess their effects, however, do not distinguish between paralysis and anaesthesia, and thus they cannot be considered as humane stunning methods that lead to a reduction of suffering (Birch et al., 2021).

CO_2 gassing: This method works by increasing the concentration of carbon dioxide in the water. A study by Gardner (2004) found that crabs exposed to this method showed extremely aversive behaviour, including tearing at their own sternums with their claws and exposing their internal organs (Gardener, 2004; Yue, 2008). A study by Roth & Øines (2010) suggested that this method was unsuitable for humane stunning in brown crabs (*Cancer pagurus*) because these animals showed behavioural signs of sensibility.

Slaughter

Air chilling: This method is reportedly very slow, taking over one hour to kill decapods (Roth & Øines, 2010), and causes autotomy, which is a clear indicator of distress (Birch et al., 2021). As such, this slaughter method cannot be considered humane.

Boiling: This method of slaughter is very commonly practised, but has been found to elicit various behavioural and physiological symptoms of distress (Birch et al., 2021). A study by Baker (1955) reported that brown crabs (*Cancer pagurus*) that were immersed in boiling water autotomised and showed clear behavioural signs of distress, such as uncoordinated movements and escape attempts. Another study by Fregin & Bickmeyer (2016) showed that after the immersion of lobsters in boiling water, intense neural activity continued for up to 150 seconds; this suggests 2.5 minutes of continuous sentience (Birch et al., 2021). Immersing decapods in cold water and slowly raising the temperature has been suggested as a valid alternative, however this method was shown in two studies on brown crab (*Cancer pagurus*) and red swamp crayfish (*Procambarus clarkii*) to induce behaviours such as escape attempts, uncoordinated movements, and autotomy (Baker, 1955; Adams et al., 2019). Adams et al. (2019) recorded heartbeat alterations in response to touch and sensory neuron recovery in red swamp crayfish (*Procambarus clarkii*) at water temperatures of up to 44 °C, indicating a functional nervous system. Based on the evidence, boiling can be deemed as an inhumane method of slaughtering decapods which can cause extreme suffering.

Freshwater immersion: This method consists of placing salt-water crustaceans in freshwater, where they are usually left for several hours; this effectively causes them to die slowly from the loss of salts from their hemolymph (Yue, 2008). A study by Baker (1955) on brown crab (*Cancer pagurus*) showed that these animals displayed signs of distress, such as uncoordinated movement and increased respiration. A study by Gardner (1997) on Australian giant crabs (*Pseudocarcinus gigas*) reported these animals autotomising at their legs and abdomen after 10 minutes of freshwater immersion, all clear signs of extreme distress.

Dismemberment: These methods cannot be recommended as they do not successfully dismantle the ganglia of the decapods (Birch et al., 2021) and as such do not ensure the quick death of the animals.

High-pressure processing: High-pressure processing is a slaughtering method that is common in the United States. It involves exposing crustaceans to very high water pressure and is claimed to successfully kill crustaceans in less than six seconds. Birch et al. (2021) however do not recommend it, having failed to find any robust scientific evidence confirming the claim.

Based on the available literature, all the stunning and slaughtering methods listed above cannot be considered humane and suitable for protecting crustaceans from suffering serious suffering.

Ask: A ban of the following stunning and slaughter methods: water chilling, high salt solution, chemical anaesthetics, CO_2 gassing, air chilling, boiling, freshwater immersion, dismemberment, and high-pressure processing.

POLICY RECOMMENDATIONS

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- Capture
    - Recommendation: Creel bottoms should be in plastic without netting, and creels should include escape gaps or a large mesh net to allow bycatch to escape and to discourage fighting and limbs getting trapped.
    - Recommendation: Establishment of managing/handling guidelines to enforce the following practices – handling of decapods should be kept to a minimum, tossing and throwing the animals should not be allowed, and the handling of decapods should only be performed by experienced and trained personnel in order to minimise the risk of injury to the animals. The personnel should be responsible for thoroughly checking each animal for injuries, and promptly removing the dead ones.
- Transport/Storage
    - Recommendation: Transport and storing containers should be resistant to crushing, prevent limbs from becoming caught, and only contain a limited amount of animals to prevent the weight of the ones above from crushing the ones underneath. Bags should be avoided as they can trap limbs and result in injury or dismemberment, and only sturdy containers should be employed for the storage and transport of the animals. Lobsters should be packed with their tails curled under them, all placed to be facing in the same direction.
    - Recommendation: Live animals in restaurant and retail shops should be kept away from direct light sources.
    - Recommendation: Ensure low stocking densities, based on the species, in display tanks for decapods to avoid social stress.
    - Recommendation: Decapods in both damp storage and flowing water storage conditions must be kept below the maximum temperature threshold appropriate for their species.

Capture

Problem: Creel base netting is a health hazard, and creels without escape gaps cause trapping of bycatch.

Evidence: Brown crabs (*Cancer pagurus*) tend to cling onto the creel netting, and removing the animals from the creed can result in them tearing off their limbs (Birch et al., 2021). As suggested by Jacklin & Combes (2005), the insertion of smooth plastic material at the base of the creels may help reduce this. Also, aggression and stress can occur among decapods when many animals are trapped in the same creel (Jacklin & Combes 2005). The employment of bycatch reduction devices (BRDs), widely studied for example for the reduction of bycatch of the aquatic turtle diamondback terrapin (*Malaclemys terrapin*) in pots used for catching blue crabs (*Callinectes sapidus*) in the United States (Roosenburg & Green (2000); Morris et al., 2011), could allow bycatch to escape. In this regard, Jacklin & Combes (2005) recommend the use of creels with a second chamber built in, with escape gaps, or a large mesh net.

Recommendation: Creel bottoms should be in plastic without netting, and creels should include escape gaps or a large mesh net to allow bycatch to escape and to discourage fighting and limbs getting trapped.

Problem: Uncareful handling of decapods is a health hazard.

Evidence: Uncareful handling of decapods by unexpert or untrained personnel can result in substantial damage to the bodies of decapods, as well as death in the worst cases. Although careful handling is in the interest of the industry as injured animals count as damaged goods, and is therefore emphasised as good practice in industry guidance (Jacklin & Combes, 2005), unexpert and untrained personnel can still inflict substantial damage to the animals. The most common injuries that decapods are subjected to are cracked carapaces, damaged antennae, and loss of limbs; these can cause haemolymph to quickly start leaking from the cracks, resulting in the death of the animal. The industry generally responds to this risk by instructing personnel to remove damaged limbs via autotomy (Jacklin & Combes, 2005). In general, the handling of decapods causes physiological stress (Jacklin & Combes, 2005), and there is an increased risk of injury or loss of vigour when the animals are thrown or tossed into containers (Lavallee et al., 2000; Barrento et al., 2010), as opposed to more gentle, mindful, and appropriate handling. Careless and rough handling should be avoided as it can cause stress and physical injuries that can lead to prolonged pain, suffering, and death.

Recommendation: Establishment of managing/handling guidelines to enforce the following practices – handling of decapods should be kept to a minimum, tossing and throwing the animals should not be allowed, and the handling of decapods should only be performed by experienced and trained personnel in order to minimise the risk of injury to the animals. The personnel should be responsible for thoroughly checking each animal for injuries, and promptly removing the dead ones.

Transport/Storage

Problem: Containers generally used for the transport or storage of decapods are a health hazard.

Evidence: Containers that are currently being used for transporting or storing live crustaceans are a health hazard for the animals. With the animals positioned above risking to crush the ones below, specific attention should be placed on the way these animals are packed, with all of them positioned as to face in the same direction, and kept at a density that supports stability, all without pressing the animals too tightly together (Birch et al., 2021). In fact, brown crabs (*Cancer pagurus*) that were at the bottom of tanks were reported as having more missing limbs than the ones at the top of the tanks (Barrento et al., 2010). Specific attention should be given to lobsters, which should be packed with their tails curled under them to protect their ventral surface from puncture (Basti et al., 2010). Containers should also be resistant enough as to be bend-proof, in order to prevent the outside pressure from crushing the animals.

Recommendation: Transport and storing containers should be resistant to crushing, prevent limbs from becoming caught, and only contain a limited amount of animals to prevent the weight of the ones above from crushing the ones underneath. Bags should be avoided as they can trap limbs and result in injury or dismemberment, and only sturdy containers should be employed for the storage and transport of the animals. Lobsters should be packed with their tails curled under them, all placed to be facing in the same direction.

Problem: Shelter-free tanks for keeping live lobsters and crabs cause stress in decapods and are a health hazard.

Evidence: Tanks used for keeping live lobsters and crabs in retail shops and restaurants are generally bare and without any shelters for the animals, which are in turn also exposed to bright lighting (Carder, 2017). However, in their natural environment these animals spend most of the time in dark conditions, generally under rocks or crevices. Barr & Elwood (2011) and Hamilton et al. (2016) showed that, given the choice between light areas and dark shelters, shore crab (*Carcinus maenas*) and striped shore crab (*Pachygrapsus crassipes*) pick the latter; red swamp crayfish (*Procambarus clarkii*) also strongly prefer dark areas to light areas (Fossat et al., 2015). As recommended by Jacklin & Combes (2005), stored live decapods should always be given access to shelters and dark areas.

Recommendation: Live animals in restaurant and retail shops should be kept away from direct light sources.

Problem: High stocking densities of decapods can be a welfare risk.

Evidence: Many commercially important decapod species, such as lobsters, spiny lobsters, and brown crabs, among others are solitary animals that are highly territorial, and placing them with other individuals, especially at high stocking densities, is against their nature and detrimental to their well-being. Bacqué-Cazenave et al. (2017), for example, showed that in red swamp crayfish (*Procambarus clarkii*) being on the receiving end of social aggression lead to an 'anxiety-like' state, characterised by high levels of serotonin. As shown by Barrento et al. (2010) in a survey conducted in Portugal, stocking densities of brown crabs (*Cancer pagurus*) can exceed recommendations and be extremely high, at 300kg/m^3. Carder (2017) reported how in display tanks in several UK food retailers lobsters were stored at very high densities, at times the animals being stored in two layers or more. Similar conditions are likely to be commonplace in other European countries.

Recommendation: Ensure low stocking densities, based on the species, in display tanks for decapods to avoid social stress.

Problem: Current allowable temperature storing conditions for decapods are a welfare risk.

Evidence: The likelihood of physiological stress, disease susceptibility, and mortality in decapods increase when the transport or storage of these animals happens at excessively warm temperatures (Lavallee et al., 2000; Jacklin & Combes, 2005). Several studies have shown the adverse effects that excessively high temperatures can have on decapods. In brown crabs (*Cancer pagurus*), storage at 12°C compared with 8°C and 4°C resulted in an increase in haemolymph values of lactate and glucose, as well as the risk of pathology and mortality (Johnson et al., 2016). In a study simulating the transport of brown crab (*Cancer pagurus*), all individuals transported at 16°C died, while most survived at 12°C if immersed in good quality seawater, or at 8°C if kept under damp conditions (Barrento et al., 2011). In another study by Woll et al. (2006), brown crabs (*Cancer pagurus*) in damp storage displayed signs of reduced vitality at temperatures of 15°C and 20°C, whilst the signs were not observed at 5°C and 10°C. Asian tiger prawns (*Penaeus monodon*) immersed in water that was warmer than their optimal water temperature showed stress responses such as reduced feeding, red colouration and altered gene expression (de la Vega et al., 2007). Finally, shrimp (*Pandalus borealis*) immersed in flowing water displayed 70% and 50% survival rates at 10°C and 15°C, respectively, versus a 95% survival rate at 2°C and 5°C (Larssen et al., 2013).

Recommendation: Decapods in both damp storage and flowing water storage conditions must be kept below the maximum temperature threshold appropriate for their species.

References

Adamn R., Stanley C.E., Piana, E., Cooper R.L. (2019) Physiological and Behavioral Indicators to Measure Crustacean Welfare. Animals 9(11):914.

Albalat A., Gornik S., Theethakaew C., Neil D. (2008) Evaluation of the Quality of Langoustines After Being Killed by the Crustastun Project Report. University of Glasgow, Glasgow, UK. Available at URL: https://www.wellbein-gintlstudiesrepository.org/agreports/vol2008/iss2008/5 [Last access: 8 June 2023].

Bacqué-Cazenave J., Cattaert D., Delbecque J. P., Fossat P. (2017) Social harassment induces anxiety-like behaviour in crayfish. Scientific Reports, 7(1):1-7.

Baker J. (1955) Experiments on the humane killing of crabs. Journal of the Marine Biological Association of the United Kingdom. 34:15–24.

Barr S. and Elwood R.W. (2011) No evidence of morphine analgesia to noxious shock in the shore crab, Carcinus maenas. Behavioural Processes 86(3):340-344.

Barrento S., Marques A., Vaz-Pires P., Nunes M.L. (2010) Live shipment of immersed crabs Cancer pagurus from England to Portugal and recovery in stocking tanks: stress parameter characterization. ICES Journal of Marine Science 67:435-443.

Barrento S., Marques A., Vaz-Pires,P., Leonor Nunes M. (2011) Cancer pagurus (Linnaeus, 1758) physiological responses to simulated live transport: In- fluence of temperature, air exposure and AQUI-S®. Journal of Thermal Bio- logy 36:128-137.

Basti D., Bricknell I., Hoyt K., Chang E.S., Halteman W., Bouchard D. (2010) Factors affecting post-capture survivability of lobster Homarus americanus. Diseases of aquatic organisms 90:153-166.

Birch J., Burn C., Schnell A., Browning H., Crump A. (2021) Review of the evidence of sentience in cephalopod molluscs and decapod crustaceans.

Carder G. (2017) A preliminary investigation into the welfare of lobsters in the UK. Animal Sentience 2:19. Available at URL: https://www.wellbeingintlstu- diesrepository.org/ animsent/vol2/iss16/19/ [Last access: 8 June 2023].

Consiglio dell'Unione Europea (2011) Regolamento (CE) n . 850/98 del Consiglio del 30 marzo 1998 per la conservazione delle risorse della pesca attraverso misure tecniche per la protezione del novellame. Available at URL: https://eur-lex.europa.eu/legal-content/IT/TXT/PDF/?uri=CELEX:01998- R0850-20150601&from=FI [Last access: 8 June 2023].

Conte F., Voslarova E., Vecerek V., Elwood R.W., Coluccio P., Pugliese M., Passantino A. (2021) Humane slaughter of edible decapod crustaceans. Animals 11(4):1089.

Cowing D., Powell A., Johnson M. (2015) Evaluation of different concentration doses of eugenol on the behaviour of Nephrops norvegicus. Aquaculture 442: 78-85.

Coyle S.D., Dasgupta S., Tidwell J.H., Beavers T., Bright L.A., Yasharian D.K. (2005) Comparative efficacy of anesthetics for the freshwater prawn Macro- brachiurn rosenbergii. Journal of the World Aquaculture Society, 36(3), 282-290.

de la Vega E., Hall M.R., Wilson K. J., Reverter A., Woods R.G., Degnan B.M. (2007) Stress-induced gene expression profiling in the black tiger shrimp Penaeus monodon. Physiological Genomics, 31, 126-138.

Duermit E., Kingsley-Smith P.R., Wilber D.H. (2015) The consequences of claw removal on stone crabs Menippe spp. and the ecological and fishery implications. North American Journal of Fisheries Management, 35(5):895-905.

Fossat P., Bacqué-Cazenave J., De Deurwaerdère P., Cattaert D., Delbecque J.P. (2015) Serotonin, but not dopamine, controls the stress response and anxiety-like behavior in the crayfish Procambarus clarkii. Journal of Experimental Biology 218(17):2745-2752.

Frederich M., Sartoris F.J., Pörtner H.O. (2002) Distribution patterns of deca- pod crustaceans in polar areas: A result of magnesium regulation? In: W. E. Arntz & A. Clarke (Eds.), Ecological Studies in the Antarctic Sea Ice Zone: Results of EASIZ Midterm Symposium (pp 246-250). Berlin and Heidelberg: Springer-Verlag.

Fregin T. and Bickmeyer U. (2016) Electrophysiological investigation of different methods of anesthesia in lobster and crayfish. PLoS One 11(9):e0162894.

Gardner C. (1997) Options for humanely immobilizing and killing crabs. Journal of Shellfish Research 16(1):219-224.

Gardner C. (2004) Treating the prawn well on its way to the barbie: welfare of aquatic crustaceans. In: Jones B (ed.), Welfare Underwater: Issues with Aquatic Animals. Proceedings of the 2004 RSPCA Australia Scientific Seminar, Canberra, February 26 (Deakin West, Australia: RSPCA Australia Inc., pp. 21-4.

Ghanawi J., Saoud G., Zakher C., Monzer S., Saoud I.P. (2019) Clove oil as an anaesthetic for Australian redclaw crayfish Cherax quadricarinatus. Aqua- culture Research 50(12):3628-3632.

Haefner P.A. (1971) The use of elastrator rings for binding crab claws. Chesapeake Science, 12, 183-184.

Hamilton T.J., Kwan G.T., Gallup J., Tresguerres M. (2016) Acute fluoxetine exposure alters crab anxiety-like behaviour, but not aggressiveness. Scientific Reports 6:19850.

Jacklin M. and Combes J. (2005) The good practice guide to handling and storing live crustacea. Seafish report. Available at URL: https://www.sea-fish.org/document/?id=4b3b62 [Last access: 9 June 2023].

Johnson L., Coates C.J., Albalat A., Todd K., Neil D. (2016) Temperature-de- pendent morbidity of 'nicked' edible crab, Cancer pagurus. Fisheries Research 175:127-131.

Larssen W.E., Dyb J.E., Woll A., Kennedy J. (2013) Factors that affect vitality of Northern Shrimp (Pandalus borealis, Krøyer 1838) during capture and storage that are destined for live trade. Journal of Shellfish Research 32:807-813.

Lavallee J., Spangler E., Hammell K.L., Dohoo I.R., Cawthorn R.J. (2000) Analytical assessment of handling, fishing practices, and transportation risk factors on lobster (Homarus americanus) health in Prince Edward Island, Ca- nada. Journal of Shellfish Research 19:275-281.

Lorenzon S., Giulianini P.G., Martinis M., Ferrero E.A. (2007) Stress effect of different temperatures and air exposure during transport on physiological profiles in the American lobster Homarus americanus. Comparative Biochemistry and Physiology Part A: Molecular & Integrative Physiology 147(1):94-102.

McCambridge C., Dick J.T., Elwood R.W. (2016) Effects of autotomy compared to manual declawing on contests between males for females in the edible crab cancer pagurus: implications for fishery practice and animal welfare. Journal of Shellfish Research 35(4):1037-1044.

Morgan J., Cargill C., Groot E. (2001) The efficacy of clove oil as an anesthetic for decapod crustaceans. Bulletin – Aquaculture Association of Canada 3:27-31.

Morris A.S., Wilson S.M., Dever E.F., Chambers R.M. (2011) A test of bycatch reduction devices on commercial crab pots in a tidal marsh creek in Virginia. Estuaries and Coasts 34:386-390.

Neil D. (2010) The effect of the CrustastunTM on nerve activity in crabs and lobsters. Project Report. University of Glasgow, Glasgow, UK. Available at URL: http://eprints.gla.ac.uk/81428 [Last access: 8 June 2023]

Neil D. (2012) The effect of the CrustastunTM on nerve activity in two commercially important decapod crustaceans: the edible brown Cancer pagurus

and the European lobster Homarus gammarus. Project Report. University of Glasgow, Glasgow, UK. Available at URL: http://eprints.gla.ac.uk/81430 [Last access: 8 June 2023].

Neil D. and Thompson J. (2012) The stress induced by the CrustastunTM process in two commercially important decapod crustaceans: the edible brown Cancer pagurus and the European lobster Homarus gammarus. Project Report. University of Glasgow, Glasgow, UK. Available at URL: http:// eprints.gla.ac.uk/81433/ [Last access: 8 June 2023].

Neil D.M., Albalat A., Thompson J. (2022) The effects of electrical stunning on the nervous activity and physiological stress response of a commercially important decapod crustacean, the brown crab Cancer pagurus L. Plos one 17(7):e0270960.

Patterson L., Dick J.T.A., Elwood R.W. (2007) Physiological stress responses in the edible crab, Cancer pagurus, to the fishery practice of de-clawing. Marine Biology 152:265–272.

Patterson L., Dick J.T.A., Elwood R.W. (2009) Claw removal and feeding ability in the edible crab, Cancer pagurus: Implications for fishery practice, Applied Animal Behaviour Science 116(204):302-305.

Roosenburg W.M. and Green J.P. (2000) Impact of a bycatch reduction device on diamondback terrapin and blue crab capture in crab pots. Ecological Applications 10(3):882-889.

Roth B. and Grimsbø E. (2016) Electrical stunning of edible crabs (Cancer pagurus): From single experiments to commercial practice. Animal Welfare 25(4):489-497.

Roth B. and Grimsbø M. (2013) Electrical Stunning of Edible Crabs. NOFIMA Report 18/2013. Available at URL: https://bora.uib.no/bora-xmlui/bitstream/handle/195610643/Rapport+18-2013.pdf?sequence=2 [Last access: 8 June 2023].

Roth B. and Øines S. (2010) Stunning and killing of edible crabs (Cancer pa- gurus). Animal Welfare 19(3):287-294.

Tani M. and Kuramoto T. (1998) Cool-sensitive neurons in the ventral nerve cord of crustaceans. Comparative Biochemistry and Physiology Part A: Molecular & Integrative Physiology 119(3):845-852.

Waterstrat P.R. and Pinkham L. (2005) Evaluation of Eugenol as an Anesthetic for the American Lobster Homerus americanus. Journal of the World Aquaculture Society 36(3):420-424.

Weineck K., Ray A.J., Fleckenstein L.J., Medley M., Dzubuk N., Piana E., Cooper R.L. (2018) Physiological changes as a measure of crustacean welfare under different standardized stunning techniques: Cooling and electro- shock. Animals 8(9):158.

Welsh J.E., King P.A., MacCarthy E. (2013) Pathological and physiological effects of nicking on brown crab (Cancer pagurus) in the Irish crustacean fishery. Journal of Invertebrate Pathology 112:49-56.

Woll A.K., Larssen W.E., Fossen I. (2010) Physiological responses of brown crab (Cancer pagurus Linnaeus 1758) to dry storage under conditions simulating vitality stressors. Journal of Shellfish Research 29:479-487.

Yue S. (2008) The Welfare of Crustaceans at Slaughter, Agribusiness Reports 2008(5). Available at URL: https://www.humanesociety.org/sites/default/fi- les/docs/hsus-report-animal-welfare-crustaceans-slaughter.pdf [Last access: 8 June 2023].