



## Review

## Crustacean diseases in European legislation: Implications for importing and exporting nations

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## ABSTRACT

EC Council Directive 2006/88/EC, adopted during 2008, has for the first time introduced controls for crustacean diseases to be applied across all Member States of the European Union. It lists three crustacean diseases, all of which are caused by viral pathogens and primarily associated with the production of marine penaeid shrimp: White Spot Disease (WSD) caused by the White Spot Syndrome Virus (WSSV), Yellowhead disease (YHD) caused by Yellowhead Virus (YHV) and Taura syndrome (TS) caused by Taura syndrome Virus (TSV). Under Directive 2006/88/EC, WSD is listed as 'non-exotic' to the EU while YHD and TS are listed as exotic. The listing of crustacean diseases in the Directive recognises the global potential for the transboundary movement of economically and ecologically significant pathogens with live animals and with aquatic animal products and in essence, aligns approaches to biosecurity of farmed and wild crustacean populations of Europe with measures in place for molluscan shellfish and for finfish. Here, we discuss the implications of Directive 2006/88/EC for European Union Member States (net importers) and for producer nations wishing to export live crustaceans and associated products into the European Union. These implications are further compared to recommendations from the World Organisation for Animal Health (OIE) for trading of live crustaceans and products arising from them.

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## 1. Context

### 1.1. Global crustacean production

Wild capture and farmed crustaceans form a significant proportion of global aquatic food production. In 2006, total crustacean production from these two sectors exceeded 10 million MT with a first sale value of almost \$40 bn. Total fisheries catches contributed approximately 60% by weight and 50% by value, with the aquaculture sector forming the remainder. Fisheries are dominated by the capture of marine shrimp (3.4 mMT, \$12 bn) and crabs (1.4 mMT, \$3.7 bn), with lesser amounts of lobsters (251,000 t, \$2.4 bn), freshwater crustaceans (415,000 t, \$1 bn) and other miscellaneous species (663,000 t, \$1.6 bn) (<http://www.fao.org>). In terms of aquaculture, marine shrimp form the majority of the sector with production exceeding 3 mMT and a first sale value of >\$12 bn. Freshwater crustaceans (1 mMT, \$4.7 bn), including crabs (225,000 t, \$657 m) and other miscellaneous species (42,000 MT, £95 m) contribute the remaining portions (<http://www.fao.org/fishery/statistics>). While accurate figures are difficult to obtain, crustaceans also form an important component of the approximate annual \$300 m global trade in ornamental aquatic species (Ploeg, 2008). As for crustaceans produced for human consumption via aquaculture, producer nations for ornamental species are widely distributed across tropical and subtropical regions of the globe and include nations in which diseases listed in Directive 2006/88 are endemic (see OIE, 2006).

### 1.2. Crustacean populations in Europe

In 2005, the European Union (EU) imported 600,000 MT of shrimp (\$2.3 billion). Approximately 140,000 MT (\$500 m) comprised farmed shrimp from several global production regions. This figure represents an increase in quantity of 45% since 1999 (source <http://ec.europa.eu>). Whilst capture fisheries, mainly for coldwater marine shrimp, constitute the majority of the current market, tropical marine shrimp form a significant proportion of imports with the main products being frozen shrimps of the genus *Penaeus* (hereafter referred to as shrimp product). The three major buyers within the EU are Spain, Italy and the UK. In contrast to finfish and molluscan shellfish, aquaculture production of crustaceans is currently limited within Europe, only accounting for around 200 MT/annum, with a total value of c. \$3 m. The FAO lists production areas for penaeid shrimp (mainly *Penaeus japonicus*) in France (40 MT/annum), Italy (19 MT/annum) and Spain (44 MT/annum) with a total value of c. \$2 m in 2004. A small culture of palaemonid prawns also occurs in Spain (63 MT/annum, c. \$200 k) while the remainder of crustacean aquaculture production concerns the farming of freshwater crayfish of the family Astacidae (47 MT/annum, c. \$660 k) (Source: <http://www.fao.org/figis>). In terms of value, the top producers of crustacean aquaculture animals in Europe are France (\$1.5 m), Spain (\$860 k) and Italy (\$425 k). Smaller producers include Sweden, Ukraine, Estonia and Russian Federation countries.

In contrast to a small aquaculture industry, the total fishery production of crustaceans from European waters totalled almost 400,000 MT in 2004, largely comprising marine shrimp (c. 200,000 MT), lobsters (c. 60,000 MT) and crabs (c. 85,000 MT). Freshwaters, capture fisheries are solely comprised of crayfish (c. 6000 MT). Wild fisheries for marine crustaceans are considered key resources in Europe and in many countries, such as the UK, are amongst the most valuable marine fisheries resources, ranking above most important finfish species in terms of production quantity and value. With increasing demand for fish products and the documented

reduction in supplies from natural fisheries, further stimulation for development of the aquaculture sector within Europe is predicted though in terms of crustaceans, it appears unlikely that production units in Europe could efficiently compete with other global regions, particularly for marine shrimp. Production units for *P. japonicus* in the Mediterranean are currently small compared with tropical regions and may be hampered by temperature-derived reductions in the length of the production season and labour costs within the EU and by bottlenecks in the production process (Lumare, F. pers. comm.). However, production of premium crustacean products (e.g. ethical, organic) could provide some competitive edge to ensure local sustainability. Potential also exists for the specific culture of freshwater crustaceans within central and eastern European countries particularly via a move towards more intensive farming methods and through the production of premium products such as freshwater crayfish.

Following capture, significant movements of live marine crustaceans (e.g. *Nephrops norvegicus*, *Cancer pagurus*, *Homarus gammarus*) occur between European Member States, for resale and consumption. Although some restrictions are in place for these movements, the trade is currently relatively uncontrolled with losses in transport remaining unrecorded and morbid or dead animals potentially finding their way back into the aquatic environment in receiving countries or *en route* to market. In addition, water used for transporting animals may be released accidentally or purposefully to local waterways or drains. The dearth in knowledge of pathogens of our major commercially exploited species and their potential for transmission to other commercially exploited and reservoir species identify these as potentially high risk practices. Live transport of animals to distant markets when coupled with a possibly high potential for transmission of pathogens to new hosts is cause for concern (Stentiford and Shields, 2005).

When considering implications for implementation of Directive 2006/88 in Europe, it is important to consider not only the fact that crustacean stocks are exploited commercially in the region but also that crustaceans are considered as keystone elements of most aquatic ecosystems. They form a fundamental component of food chains, and therefore comprise a significant element of the diet of many fish species. In some cases, they are afforded protected status under internationally recognised legislation. In UK freshwaters for instance, the white claw crayfish (*Austropotomobius pallipes*) is considered endangered and therefore protected under UK and European legislation (including the IUCN Red Data list, the Wildlife and Countryside Act 1981 and the EC Habitats Directive 1992). The listing of crustaceans in such Acts acknowledges a requirement for improved understanding of threats to remaining populations and in addition, highlights the necessity for national governments within the European Union to protect not only commercially exploited and farmed animals but also the wildlife species that populate their natural aquatic systems. In the implementation of Directive 2006/88, the potential for the listed diseases to establish within these stocks and to negatively affect populations is acknowledged. As stated above, crustaceans are also an important component of the global trade in ornamental aquatic species, though accurate statistics for volume, value and species traded by this industry are difficult to acquire.

In this paper we compare obligations on EU MS as members of the World Organisation for Animal Health (OIE) with legal requirements laid down in EU legislation (EC Directive 2006/88). The implications of EU legislation for the movement of live crustaceans and products thereof into the EU and between MS is considered alongside additional risk mitigation measures that are allowed under international guidelines (i.e. the OIE code).

## 2. Listed diseases in Directive 2006/88

### 2.1. Background

EC Council Directive 2006/88/EC adopted during 2008 introduces controls for crustacean disease at community level for the first time. It lists three crustacean disease which are to be controlled at EU level: White Spot Disease (WSD) caused by the White Spot Syndrome Virus (WSSV), Yellowhead disease (YHD) caused by Yellowhead Virus (YHV) and Taura syndrome (TS) caused by Taura syndrome Virus (TSV). WSD is currently listed as a 'non-exotic' pathogen to the EU based upon its reported occurrence in penaeid shrimp farms in Southern Europe (see Stentiford et al., 2009) while YHD and TS are listed as exotic due to their absence from the EU. The listing of these diseases is in recognition of their global importance in causing significant economic losses and the potential for their international transfer via the transboundary trade in live animals and their products. A representation of the pathology caused by these listed pathogens is provided in Fig. 1.

### 2.2. Susceptibility of European hosts to listed diseases

The potential for transfer of disease agents around the globe, either via movement of live animals for farming (e.g. broodstock and larvae) or as contaminating agents in aquatic animal products (e.g. frozen shrimp) has been amply demonstrated by the pandemic nature of several important diseases of marine shrimp, including WSD, TS and YHD (Flegel, 1997; Lotz, 1997). While movements of live aquatic animals offers the most efficient means for global distribution of such pathogens, several studies have also demonstrated at least the potential for disease introduction to novel hosts in new geographic regions via aquatic animal products, particularly where climatic regimens in receiving countries are suitable for pathogen survival and replication (Durand et al., 2000, 2003; Reville et al., 2005; Hasson et al., 2006). Despite major markets for tropical shrimp products in temperate regions (e.g. Europe) and the potential for establishment of infection in new hosts, relatively little research has investigated the susceptibility of European species to the relevant pathogens. Furthermore, little information is available on potential release and exposure pathways for these agents, or their environmental tolerance or ability to establish infection and disease in non-commercial hosts, should they be introduced. Available data are especially lacking for European crustaceans, particularly those that exist at temperatures that may be considered outside the normal range experienced by these viruses in endemic zones in Asia and South America (Stentiford et al., 2009). However, studies by Corbel et al. (2001) have demonstrated susceptibility to WSSV in a range of marine and freshwater decapods endemic to Europe, while others have demonstrated disease susceptibility in freshwater crayfish at temperatures normal for European aquatic habitats (Jiravanichpaisal et al., 2001, 2004; Du et al., 2008). Stentiford et al., 2009 have stated that improved knowledge of natural and experimental host range to listed pathogens and an understanding of environmental tolerance will lead to a better appreciation of likely and actual disease threats from aquatic animal products imported primarily for human consumption. These authors also provide an up to date review of susceptible species to WSD, TS and YHD based upon criteria developed by the European Food Safety Authority (EFSA). By addressing issues of susceptibility, alongside those associated with potential release and exposure pathways for the listed pathogens, it is likely to be possible to conduct well-informed import risk assessments (IRA) such that trade in aquatic animal products are maintained without posing unnecessary risks of pathogen transfer to the receiving nation.

## 3. Implications of Directive 2006/88 for importing nations

### 3.1. Import and trade controls

Directive 2006/88 lays down the animal health requirements to be applied for the placing on the market, the importation and the transit

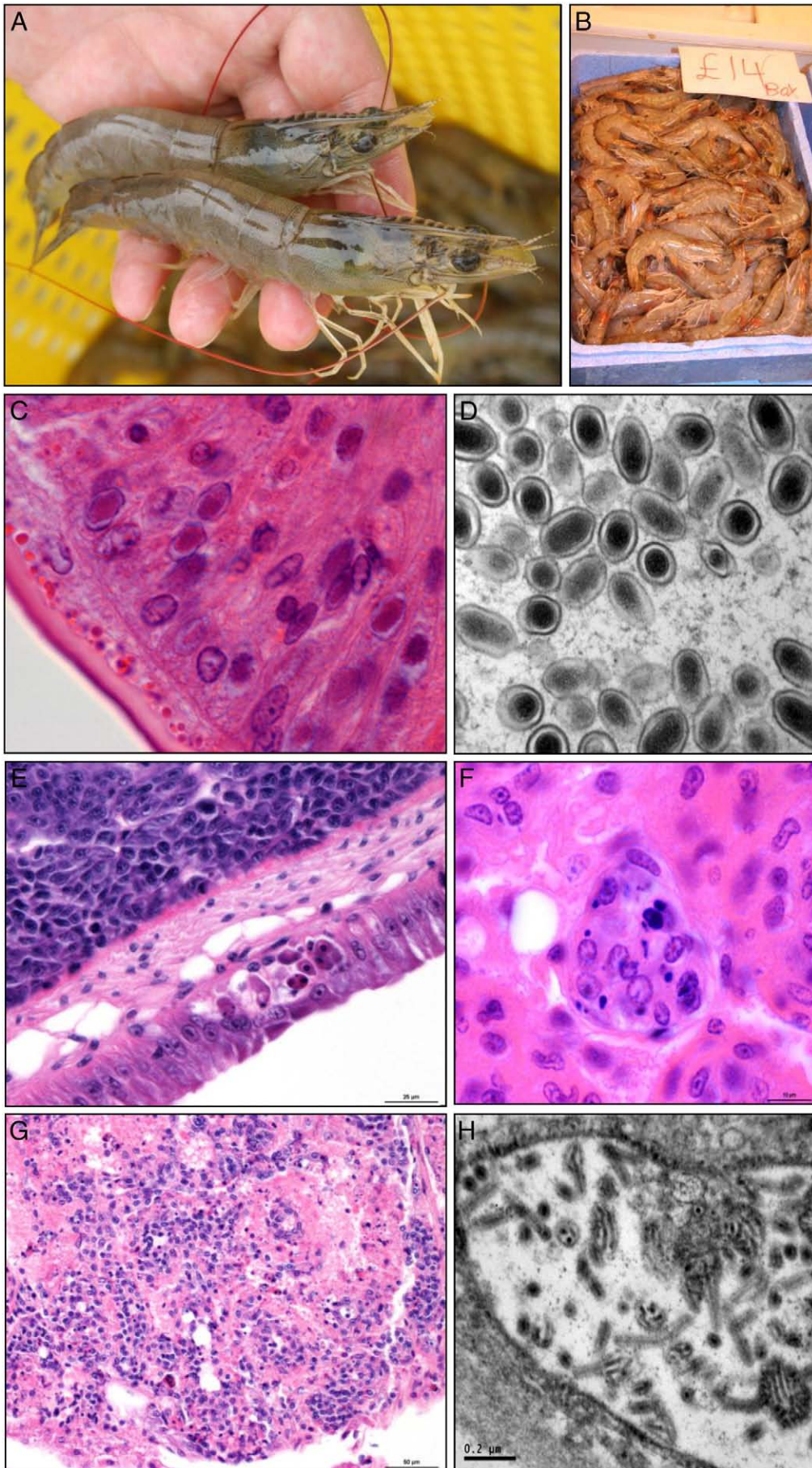
of aquaculture animals and products thereof, into, within and through European Union Member States. It provides information on the minimum preventative measures for dealing with the listed pathogens and further, the control measures to be applied in the event of an outbreak. Since the Directive covers a broad industry, it is useful to consider the specific animals and products covered and those that fall outside of its scope. The Directive applies to all crustaceans belonging to the subphylum Crustacea. It defines an 'aquaculture animal' as any aquatic animal at all of its life stages, reared in a farm (including those originally obtained from the wild and on-grown within a farm environment). The term 'farm' is defined as 'premises, areas or installations in which aquaculture animals are reared with a view to their being placed on the market'. It specifically excludes facilities where wild crustaceans are held temporarily without being fed (i.e. so-called 'vivier' facilities which hold live crustaceans after capture). Article 2 of the Directive lists those animals and products that fall out with its scope. These exceptions include ornamental aquatic animals reared in non-commercial aquaria, aquatic animals caught for the sole purpose of production of fish feeds, meal and oils etc., and wild aquatic animals harvested or caught for direct entry into the human food chain. Wild crustaceans fall within the scope of the Directive only where they are caught for introduction to aquaculture, including where they are fed in holding facilities for only short periods prior to sale for consumption, or where the environmental situation means they may impinge on the health status of aquaculture animals within the Community. Member States wishing to protect wild crustacean stocks from introductions of disease from imported wild crustaceans, which are to be released into the wild, must do so under national legislation as this element sits out with the Directive.

### 3.2. Member state surveillance for disease freedom

Under Directive 2006/88 EU Member States are required to control, and eradicate where possible, any outbreaks of listed exotic diseases, such as YHD and TS. Member States are additionally required to designate their status for the non-exotic pathogen causing WSD. Five categories are listed in Annex III of the Directive: I (disease free), II (under a surveillance programme to establish disease freedom), III (undetermined), IV (under an eradication programme) or V (infected). Designation into one of these five categories will directly affect where Member States may trade live animals within the EU, will affect the type and frequency of surveillance required to maintain or improve this status within the State (see Section 3.4), and will ultimately govern the certification requirements of live animals and aquatic animal products imported into the State from 3rd countries (i.e. those outside of the EU). The key principle is that movements of live aquaculture animals take place only between areas of equal status, or from an area of higher status to an area of lower status. Freedom from listed diseases can be recognised at country, zone or compartment levels, in line with OIE principles.

In order to implement such controls Member States must appoint a Competent Authority (CA), which is required to put in place effective disease monitoring, investigation, diagnosis and reporting systems. They must also carry out a programme of inspection and monitoring of authorised aquaculture production businesses, which include farms, certain processing plants, and open ornamental facilities. A major requirement is that the EU listed pathogens are made statutorily notifiable and a system is in place for the early detection of an incursion. Aquatic animal health professionals must be trained to recognise clinical signs associated with notifiable diseases. Conditions, determined by Directive 2006/88 and discussed below, must be placed on intra-community trade and imports to prevent the introduction of the listed pathogens into the Member State.

Member States are currently in the process of designating status for WSD, and we examine below some of the factors that a Member State may wish to take into account when deciding how best to



manage this disease within its territory. For those Members wishing to declare disease freedom (category I) for WSD, or to obtain freedom via categories II or IV, an epidemiological survey, including targeted surveillance of crustacean farming facilities and, in the absence of crustacean farms, from wild stocks, is required. Requirements for such a survey are laid down in Annex V to Directive 2006/88/EC and more detailed requirements on the diagnostic methods to be used, the number of samples taken etc. are currently under development in a Diagnostic Manual (Draft Decision EC 6084). Once a Member state has declared its status in respect of WSD it will be required to implement a risk-based programme of inspection of authorised aquaculture sites, based on guidance issued at A III Part B of the Directive, and will be required to implement appropriate controls on movements of susceptible and vector species to and from its territory as detailed in Annex III Part A of the Directive. The EU trade regulations regarding the declaration of and maintenance of WSD-free status are compatible with OIE guidelines (see most recent OIE code — OIE, 2009). The OIE Code listed certain safe aquatic animal products which can be imported irrespective of the status of the exporting countries (e.g. canned, or boiled products or other treatments that inactivate the agent). Live aquatic animals originating from areas with a lower health status must be held in biosecure facilities, isolated from the environment.

Control measures to be taken in the event of an outbreak of WSD in an area previously approved as free (i.e. category 1) are provided in Section 3 of Directive 2006/88/EC and are elaborated upon in the Diagnostic Manual (Draft Decision EC 6084). Stock on the infected farm(s) have to be destroyed. A containment area based on tidal excursion in coastal zones and river catchments in freshwater must be established. Stock on all farms in the area immediately surrounding the farm (i.e. within one tidal excursion) must be sampled (10 animals per farm) and tested. To re-establish freedom, surveillance must be conducted in the containment area over four years. In the absence of a sufficient number of farms, wild animals must be sampled and tested. The current guidance is written with outbreaks of disease in farmed animals in mind, re-establishing freedom if the disease is established in a wild population is clearly more problematic. Attempts to eliminate an infected wild population are likely to be unsuccessful and possibly environmentally unacceptable, depending on the method used.

### 3.3. Certification requirements for intra-community trade and imports

The animal health certification requirements for live crustaceans and products thereof, traded within or entering the EU, are found in two EC Regulations (EC 1250/2008 and EC 1251/2008). Council Regulation EC 1251/2008 outlines the animal health requirements relevant for the placing on the market within the Community, and the import into the Community, of live crustaceans for farming, for the ornamental trade, and for release to the wild (re-stocking). Such imports of crustaceans can only be made from countries listed in Annex III of the Regulation. This Regulation requires that all such imports of crustacean species susceptible to the listed exotic diseases TS and YHD must originate from a source declared free of these diseases, as must any listed vector species, where these originate from a farm holding susceptible species. Live wild susceptible species may be imported for farming from areas not declared disease free, where they have been subject to, or are destined for, quarantine according to Commission Decision 2008/496/EC. Equivalent rules apply to the import and trade within the EU of species susceptible to, or vectors of,

the non-exotic disease WSD, where such imports are destined for parts of the EU declared free of, or seeking freedom for, that disease.

At the time of writing, only one country (USA) is listed in Annex III of the Regulation, enabling the export of live crustaceans to the EU for farming or re-stocking. In addition, a number of Pacific island states are able to export live crustaceans only for keeping in closed ornamental facilities. Article 12 of Regulation EC 1251/2008 requires that live crustaceans imported for human consumption must originate from countries that are listed according to Article 11(1) of Regulation EC 854/2004. Imported consignments must be accompanied by the joint public health/animal health certification using the model certificate from Regulation 2074/2005, as amended by Regulation (EC) No 1250/2008. Animal health certification is required only for crustaceans of aquaculture origin, which are susceptible to TS, YHD or WSD and the health attestations parallel those for imports for aquaculture. As observed in Directive 2006/88 and stated above, there are however a number of exemptions to these certification requirements for certain types of crustacean product. Firstly, crustaceans intended for further processing, without prior storage, and those imported in 'retail-sale' packages, for direct human consumption are exempt from animal health certification provided they are packaged and labelled in accordance with EC Regulation 853/2004. Furthermore, live crustaceans are also exempt if they are consigned to processing establishments or to dispatch centres authorised in accordance with the Directive and equipped with suitable effluent treatment facilities that prevent viable pathogens reaching natural waters. Finally, there is an exemption for 'non-viable' live crustaceans; though in practice there is no trade in such animals (the term non-viable was introduced to describe bivalve molluscs which are traded with one valve removed). Taken together, these exemptions mean that crustacean products (i.e. live or frozen crustaceans for human consumption) do not need to originate from countries free from the pathogens listed in Directive 2006/88, even where they are entering areas recognised to be free of those pathogens. It is therefore important that EU Member States wishing to remain free of these pathogens consider whether post-import restrictions are required to control the risk posed by the growing trade in potentially infected crustacean products. This also raises a wider issue of how Member States may wish to balance costs against potential benefits when making decisions of whether to, or how best to implement controls for WSD, and further, how to obtain the minimal risk/cost ratio for their mandatory controls for YHD and TS, which we discuss below.

### 3.4. Crustacean disease infrastructure within the EU

Under Directive 2006/88, the European Commission has designated the first Community Reference Laboratory (CRL) for crustacean diseases. The designation of the CRL aligns the requirements of Member States to deal with listed crustacean diseases with measures already in place for dealing with fish and mollusc diseases. In this context, Member States are also required to designate a National Reference Laboratory (NRL) to fulfil diagnostic requirements for crustacean diseases as laid down in the Directive. These laboratories, overseen by the CRL, will be responsible for carrying out specific diagnostics for the listed exotic and non-exotic crustacean diseases in the Directive within Member States and for the official reporting of their occurrence. In addition they may also be responsible for carrying out surveillance for WSD in order to define the appropriate status within the country. The functions and duties of the CRL and the Member State NRLs is provided in Parts I–III of Annex VI of the Directive and on the website: <http://www.crustaceancrl.eu>.

**Fig 1.** Pathology of diseases listed in EC Directive 2006/88 (WSD, TS and YHD). (A) Farmed Pacific white shrimp (*Penaeus vannamei*) from South America; (B) commodity *P. vannamei* at a European fish market; (C) histopathology of WSD in cuticular epidermis of *P. vannamei*; (D) transmission electron micrograph of WSSV virions infecting *P. vannamei*; (E) histopathology of TS in cuticular epidermis of *P. vannamei*; (F) histopathology of TS forming a lymphoid organ spheroid in *P. vannamei*; (G) histopathology of YHD in lymphoid organ of *P. vannamei*; and (H) transmission electron micrograph of YHV virions infecting gill epithelia of *P. vannamei*.

#### 4. Implications of Directive 2006/88 for exporting nations

Countries wishing to export live crustaceans or their products to EU Member States, must comply with the conditions imposed by the relevant legislation described in Section 3.3. Those requirements will vary significantly depending on the nature of the trade they wish to establish. A country wishing to export live animals, for aquaculture or restocking, to the EU for aquaculture would have to have in place a crustacean disease control system akin to that described for an EU member state in Section 3.2, with a Competent Authority in place, appropriate surveillance for listed notifiable disease, and import controls to ensure that the health status of the country, or parts thereof is protected. They could then make a case to the European Commission for inclusion on the list of countries able to give animal health attestations for crustaceans. Their trade to the EU would then only be constrained by the specific disease attestations they could give relative to the requirements of individual EU Member States. If however a country wishes only to export crustaceans for human consumption, then the requirements are potentially significantly different, since it is possible to consign such animals and products to EU Member States without any animal health certification. The country must establish facilities which comply with the human health/food hygiene requirements laid down in Regulation EC 854/2004, and make a case for listing those facilities under Article 11 of that Regulation. Once this is achieved, they are able to freely export live crustaceans and their products from such facilities to the EU for consumption, without any animal health certification, providing they are packaged appropriately (see above).

Given that the vast majority of crustacean imports into the EU are animals or products for consumption, it is clear that the Directive places almost no restriction on current trade and the disease risks associated with that trade, but places significant burdens on EU Member States to ensure that they detect and control any disease introductions arising from such trade. It is likely that EU Member States will need to seek information about the likely pathogen status of imported products, if they are to make appropriate decisions about the post-import control of crustacean products. In this context it is useful to consider the responsibilities of exporting countries as laid down in the OIE Aquatic Animal Code 2009, particularly with regard to the exportation of aquatic animal products (such as frozen, uncooked shrimp) (OIE, 2009). The OIE code states that exporting countries should, on request, supply the following to importing countries: a. information on the aquatic animal health situation and national aquatic animal health information systems to determine whether that country is free or has zones or compartments free from OIE-listed diseases (in the case of Directive 2006/88, WSD, TS and YHD), including regulations and procedures in place to maintain free status; b. regular and prompt information on the occurrence of listed diseases; c. details of the country's ability to apply measures to control and prevent OIE-listed diseases; d. information on the structure of the Competent Authority and the authority that they exercise; and, e. technical information, particularly on biological tests applied in all or part of the country. In addition, Competent Authorities in exporting countries should have official procedures for the authorization of certifying officials, (defining functions, duties and discipline procedures), ensure that relevant training is provided to these officials, and a requirement to monitor the activities of the officials to verify their integrity and impartiality. In essence, the Competent Authority of the exporting country is ultimately accountable for certification used in international trade. A combination of the relative freedom of aquatic animal product movements allowed by the Directive as stipulated above, combined with the measures to promote safe movement of these products by the OIE, highlights the role of the Competent Authority, and wider, that of producers within exporting countries, in assisting with global biosecurity associated with disease agents potentially present within these products.

#### 5. Conclusions and summary

##### 5.1. Member States application of controls

EC Directive 2006/88 introduces controls to prevent the import of exotic pathogens of crustaceans to the European Community, through the aquaculture industry and provides Member States the opportunity to apply import controls for live crustaceans likely to introduce other listed pathogens into the developing crustacean aquaculture industry or to other valuable crustacean populations within the community. It does however place a significant burden on EU Member States to equip themselves to control the exotic pathogens of crustaceans and does not totally address the risk that such pathogens can be moved into the EU through trade in aquatic animal products intended for human consumption. Member States must therefore assess how far and to what extent they need to apply the available controls and any additional controls they may have to introduce internally to address any residual risks.

It is important to note that the choice by a Member State to seek disease free status for WSD is not straightforward. It will depend on a range of factors, including the extent of any crustacean industry (farmed or wild capture), the presence and relative importance of crustaceans as a component of wildlife, the scale, types and sources of imports of live crustaceans and their products entering the State and the likelihood that the designated status will be maintained by future trading of crustaceans into the state according to the EC Regulations, or whether additional national controls on the fate of uncertified products will be necessary. Furthermore, the extent of any export industry of live crustaceans and their products to third countries will also be an important consideration since trading partners may similarly demand that imports originate from countries designated as 'disease free'. For EU Member States with no aquaculture industry, protection of an export trade may be the most important reason to seek disease free status for WSD, as it is possible that non-EU countries may require wild or farm sourced products to be declared disease free, once they implement crustacean import controls to facilitate their own exports to the EU.

##### 5.2. Assessing what is to be protected

Stentiford et al. (2009) reviewed the host ranges of WSD, TS, YHD and highlighted those species that are present in European marine, brackish and freshwater habitats. They also defined species as either economically important (farmed or fished), ecologically important (e.g. protected under international legislation), or incidental (no current economic value and not protected by legislation). In the context of global trade, it is likely that those species considered as economically important pose the greatest risk of pathogen transfer. For importing nations, those with stocks of ecologically and economically important species are likely to be at highest direct risk of effect from imported pathogens, while those with only incidental species may still be subject to the indirect effects of introduction (e.g. by alterations in food chain structure by the disease) though these effects may only be observed at different levels in the food chain (e.g. loss of predators) and may not be easily attributable to any obvious cause. Stentiford et al. (2009) proposed that individual European Member States may be broadly categorised into 3 regional types. Type 1 states being those with coldwater marine borders, estuaries and freshwaters (e.g. Northern Europe); Type 2 states those with warmer water marine borders, estuaries and rivers (e.g. Mediterranean); and Type 3 states those that are landlocked and only contain freshwaters (e.g. Central and Eastern Europe). Each type may or may not support commercially significant susceptible species (e.g. lobsters, crabs, and crayfish) and ecologically significant susceptible species (e.g. crayfish), while all are likely to contain susceptible incidental species (at least to WSD).

For Type 1 states, known susceptible marine species include shore crab (*Carcinus maenas*), edible crab (*Cancer pagurus*), swimming crab (*Liocarcinus depurator*), velvet crab (*Liocarcinus puber*), brown shrimp (*Crangon crangon*) and lobster (*Homarus gammarus*) while susceptible freshwater species include several crayfish species (*Pacifastacus leniusculus*, *Astacus leptodactylus*, *Orconectes limosus*). Given the apparent relatively narrow range of susceptible species for TS and YHD, Type 1 States may be at greatest risk from the introduction of WSD (which has a wide host range). For Type 2 states, additional susceptible marine species include farmed and wild penaeid shrimp species (e.g. *P. japonicus*, *P. kerathurus*, *P. semisulcatus*, *Metapenaeus* spp.). In these states, farmed and wild stocks may be potentially at risk from introduction of the pathogens affecting penaeids, YHD and TS, in addition to WSD.

Type 3 states (containing only freshwaters) will only support crayfish species and other susceptible incidental hosts and as such, introduction of WSD poses the greatest risk in these cases. As stated in Section 3.3, any risk assessment carried out at the Member State level will depend on a range of factors, including the extent of any domestic or export crustacean industry (farmed or wild capture) within the State, the presence and relative importance of crustaceans as a component of wildlife, the scale and types of imports of crustaceans and their products entering the State and the likelihood that the designated status may be breached by future trading of crustaceans into the state.

### 5.3. Actions to address uncontrolled risk

Since Directive 2006/88 does not impose any significant restriction on the importation of crustacean products into the EU, it is therefore important for Member States to consider the potential for such products to contain viable pathogens and also the potential for these pathogens to establish in native European species if release were to occur. The presence of listed pathogens in uncooked frozen products from penaeid shrimp has been shown in a number of studies (Lightner et al., 1997; Durand et al. 2000; Soto et al., 2001; McColl et al., 2004; Reville et al., 2005; Hasson et al., 2006). Furthermore, transmission trials utilising these contaminated products have demonstrated that pathogens such as WSSV can remain viable and further are able to be transmitted to susceptible hosts, at least in laboratory settings (Durand et al. 2000; Hasson et al. 2006; Nunan et al. 1998).

However, the view that virus contaminated shrimp products may pose a significant risk of disease transmission to susceptible hosts with which the contaminated product comes into contact has recently been challenged by Flegel (2009) who states that while trials such as those carried out above do indeed demonstrate viability of viral pathogens, their probability of successful transmission and establishment has not been amply demonstrated, and further, appears unlikely given the historic global trade in commodity products and the lack of evidence for any significant detrimental effect on wild crustacean fisheries in receiving countries. Flegel (2009) also suggests that uncooked frozen shrimp products do not possess any unique characteristics in terms of disease risk over similar products from fish or molluscan shellfish; a statement currently being assessed by an *ad hoc* group of the OIE aimed at addressing the risks posed (in terms of pathogen transfer) by fish, mollusc and crustacean products (Oidtmann, B. Pers. Comm.). Given the potential negative effects on the aquaculture industry of restricting the import of virus contaminated products and the balance between the potential for significant negative impact of a disease such as WSD (WSSV) becoming endemic within European aquatic habitats, it is timely that import risk assessments are carried out to assess the risk of moving fish, mollusc and crustacean products. As suggested by Flegel (2009), such an assessment will highlight evidence gaps to support mitigation of this issue and will ensure that net exporting and importing nations

maintain trade in these commodities while improving the health status of animals and products produced.

Since Directive 2006/88 and associated import certification does not preclude the importation of products from countries in which the listed diseases have been reported, responsibility for such risk assessment and gap analysis rests with the importing nation (EU Member State). However, as stated above, OIE member countries may wish to refer to guidelines provided in the OIE Aquatic Animal Code (OIE, 2009) that lists responsibilities for the importing country with regard aquatic animal products (e.g. frozen shrimp). In this context, the OIE states that products introduced into the importing country should comply with OIE standards and also that importing countries restrict their certification requirements to those necessary to achieve the national appropriate level of protection. Given the fact that crustacean products are not precluded from entry into the EU by Directive 2006/88, European Member States are likely to require risk assessment for the release, exposure and consequence associated with these products coming into contact with populations of farmed and wild crustaceans in the receiving country, particularly if Member States propose to demonstrate freedom from WSD (see 3.3 and 3.4 above).

### 5.4. Impacts on exporting countries

While it would appear that the Directive 2006/88 introduces very little restriction on current trade, it is far from clear that this will remain so in the longer term. Where EU Member States carry out risk assessments on product imports, they may impose conditions on businesses dealing with potentially infected animals. The operators of such businesses may then be required to make decisions on whether to introduce adequate measure to eliminate the risk of pathogen release from the operation or to take the decision to source animals only from disease free stocks. This, perhaps more than the formal obligations laid down in the OIE code (discussed above), may provide an impetus for exporting nations to produce products which are deemed as 'lower risk' by consumer nations (such as EU Member States) in order to protect their trade in these crustacean products. In an increasingly competitive market it is likely that producers able to provide product with a low risk of transferring controlled pathogens may have a competitive advantage in trading with areas subject to stringent animal health controls.

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### References

- Corbel, V., Zuprisal, Z., Shi, C., Huang, I., Sumartono, C., Arcier, J.M., Bonami, J.R., 2001. Experimental infection of European crustaceans with white spot syndrome virus (WSSV). *J. Fish Dis.* 24, 377–382.
- Du, H., Dai, W., Han, X., Li, W., Xu, Y., Xu, Z., 2008. Effect of low water temperature on viral replication of white spot syndrome virus in *Procambarus clarkii*. *Aquaculture* 277, 149–151.
- Durand, S.V., Tang, K.F.J., Lightner, D.V., 2000. Frozen commodity shrimp: potential avenue for introduction of white spot syndrome virus and yellow head virus. *J. Aquat. Anim. Health* 12, 128–135.
- Durand, S.V., Redman, R.M., Mohny, L.L., Tang-Nelson, K., Bonami, J.R., Lightner, D.V., 2003. Qualitative and quantitative studies on the relative virus loads of tails and heads of shrimp acutely infected with WSSV. *Aquaculture* 216, 9–18.
- Flegel, T.W., 1997. Special topic review: major viral diseases of the black tiger prawn (*Penaeus monodon*) in Thailand. *World J. Microb. Biol.* 13, 433–442.
- Flegel, T.W., 2009. Review of disease transmission risks from prawn products exported for human consumption. *Aquaculture* 290, 179–189.

- Hasson, K.W., Fan, Y., Reisinger, T., Venuti, J., Varner, P.W., 2006. White-spot syndrome virus (WSSV) introduction into the Gulf of Mexico and Texas freshwater systems through imported, frozen bait-shrimp. *Dis. Aquat. Org.* 71, 91–100.
- Jiravanichpaisal, P., Bangyeekhun, E., Söderhäll, K., Söderhäll, I., 2001. Experimental infection of white spot syndrome virus in freshwater crayfish *Pacifastacus leniusculus*. *Dis. Aquat. Org.* 47, 151–157.
- Jiravanichpaisal, P., Söderhäll, K., Söderhäll, I., 2004. Effect of water temperature on the immune response and infectivity pattern of white spot syndrome virus (WSSV) in freshwater crayfish. *Fish Shell. Immunol.* 17, 265–275.
- Lightner, D.V., Redman, R.M., Poulos, B.T., Nunan, L.M., Mari, J.L., Hasson, K.W., 1997. Risk of spread of penaeid shrimp viruses in the Americas by the international movement of live and frozen shrimp. *Rev. Sci. Tech Off. Int. Epizoot.* 16, 145–160.
- Lotz, J.M., 1997. Special topic review: viruses, biosecurity and specific pathogen-free stocks in shrimp aquaculture. *World J. Microbiol. Biotech.* 13, 405–413.
- McColl, K.A., Slater, J., Jeyasekaran, G., Hyatt, A.D., Crane, M.S.T.J., 2004. Detection of white spot syndrome virus and yellowhead virus in prawns imported into Australia. *Aust. Vet. J.* 82, 69–74.
- Nunan, L.M., Poulos, B.T., Lightner, D.V., 1998. The detection of white spot syndrome virus WSSV and yellowhead virus YHV in imported commodity shrimp. *Aquaculture* 160, 19–30.
- OIE, 2006. Manual of Diagnostic Tests for Aquatic Animals. OIE, Paris, p. 469.
- OIE, 2009. Section 9. Diseases of Crustaceans. OIE Aquatic Animal Health Code 2009. OIE, Paris. <http://www.oie.int>.
- Ploeg, A., 2008. The effect of the new EU import legislation on Asian exports of ornamental fish. *Ornament. Fish Int. J.* 58, 16–20.
- Reville, C., Al-Beik, J., Meehan-Meola, D., Xu, Z., Goldsmith, M.L., Rand, W., Alcivar-Warren, A., 2005. White spot syndrome virus in frozen shrimp sold at Massachusetts supermarkets. *J. Shell. Res.* 24, 285–290.
- Soto, M.A., Shervette, V.R., Lotz, J.M., 2001. Transmission of white spot syndrome virus (WSSV) to *Litopenaeus vannamei* from infected cephalothorax, abdomen, or whole shrimp cadaver. *Dis. Aquat. Org.* 45, 81–87.
- Stentiford, G.D., Shields, J.D., 2005. A review of the parasitic dinoflagellates *Hematodinium* species and *Hematodinium*-like infections in marine crustaceans. *Dis. Aquat. Org.* 66, 47–70.
- Stentiford, G.D., Bonami, J.R., Alday-Sanz, V., 2009. A critical review of susceptibility of crustaceans to Taura syndrome, yellowhead disease and white spot disease and implications of inclusion of these diseases in European legislation. *Aquaculture* 291, 1–17.