Import risk analysis: Fish food

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Biosecurity New Zealand
Ministry of Agriculture and Forestry
Wellington
New Zealand

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Biosecurity New Zealand

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1. Executive Summary

Commodities imported into New Zealand under the existing import health standard for use as fish food have included:

- Rendered poultry products including poultry meal, poultry feather meal, poultry oil, and poultry blood meal
- Rendered fishmeal
- *Artemia salina* and *Artemia franciscana*
- Zooplankton other than *Artemia salina* and *Artemia franciscana* (including *Daphnia* spp., Krill, and Mysida shrimps)
- Blood worms (Chironomid midge larvae)

This is a qualitative analysis of the risks associated with the import of these commodities from all countries for use in both commercial aquaculture and for domestic purposes (e.g. aquaria and fish ponds). Following a request from a manufacturer, the risks associated with the importation of rendered ruminant meals for use in fish food have also been considered. In addition, as fish oil may also be included in fish food, this commodity is also included here.

The key findings of this risk analysis and options discussed for the effective management of identified risks include:

- For rendered products derived from poultry which have not been slaughtered for disease control purposes and have been subject to the time/temperature conditions described in section 3.1 of this risk analysis (or equivalent conditions described in appendix 3), no hazards have been identified.

- No hazards have been identified in rendered fishmeal and fish oil which are derived from fish which have not been slaughtered for disease control purposes and manufactured under initial cooking conditions of at least 80°C for a period of no less than 20 minutes.

- No hazards have been identified associated with dried viable *Artemia salina* and *Artemia fransicana* eggs, and consignments containing only these species could be permitted without the need for risk management measures.

- Imported non-viable zooplankton species may be associated with hazards including potentially zoonotic bacteria, a number of viruses, and marine parasites, although a clear definition of these hazards is not possible due to a lack of data. Irradiation doses of at least 2.5 Mrads (25 kGy) or 4.5 Mrads (25 kGy) may be appropriate to effectively manage the risk.

- Similarly, limited data is available to clearly define hazards associated with freeze-dried non-viable Chironomid larvae although potentially

zoonotic bacteria have been associated with these organisms. Irradiation doses of at least 2.5 Mrads (25 kGy) or 4.5 Mrads (25 kGy) may be appropriate to effectively manage the risk.

- Imported ruminant meals derived from animals which have not been slaughtered for disease control purposes may contain infectivity for both Bovine Spongiform Encephalopathy (BSE) and Scrapie. It may be appropriate to limit the importation of ruminant meals to countries recognised as being free of scrapie and having a negligible BSE risk.

2. Introduction

Manufacturers import a number of products for use as fish food. An examination of imports into New Zealand has indicated that the following materials have been imported under the existing import health standard for this purpose:

- Rendered poultry products including poultry meal, poultry feather meal, poultry oil, and poultry blood meal
- Rendered fishmeal
- *Artemia salina* and *Artemia franciscana*
- Zooplankton other than *Artemia salina* and *Artemia franciscana* (including *Daphnia* spp., Krill, and Mysida shrimps)
- Blood worms (Chironomid midge larvae)

In addition to the above commodities, a manufacturer has expressed an interest in importing rendered ruminant meals (ovine blood meal, meat meal, bone meal, and casing meal, and bovine blood meal, meat meal, and bone meal) for use in fish food. Fish oil may also be included in fish food so this commodity is also included here.

Ingredients imported from all countries into New Zealand for use in the manufacture of fish food for both commercial aquaculture and domestic purposes (i.e. aquaria and fish ponds) will be considered here.

This risk analysis examines the biosecurity risks posed by the importation of each of these listed ingredients individually using the guidelines set out Biosecurity New Zealand's *Risk Analysis Procedures – Version 1*[1] (adapted from Murray, 2002) and in section 1.3 of the *OIE Terrestrial Animal Health Code* (OIE, 2006). For each ingredient the commodity is first defined then a preliminary hazard identification lists those hazards possibly associated with the commodity. A risk assessment is consequently carried out where:

1) An agent identified on the preliminary hazard list is unlikely to have been destroyed by the processing conditions described for the commodity; **and**
2) it is exotic to New Zealand but likely to be present in exporting countries; **or**
3) if it is present in New Zealand;
    a) it is "under official control" which could be by government departments, by national or regional pest management strategies, or by a small-scale programme; **or**
    b) more virulent strains are known to exist in other countries; **or**
    c) the arrival of the organism in association with this pathway would increase the current exposure to the organism in New Zealand.

If the conclusion of this risk assessment is non-negligible, then options for effective management of the risks are discussed.

[1] See: www.biosecurity.govt.nz/files/pests-diseases/surveillance-review/risk-analysis-procedures.pdf

2.1 RISK ASSESSMENT

Under the MAF Biosecurity New Zealand and OIE methodologies, risk assessment consists of:

a) Release assessment - the likelihood of the organism being imported in a commodity.

b) Exposure assessment - the likelihood of animals or humans in New Zealand being exposed to the potential hazard.

c) Consequence assessment - the consequences of entry, exposure, establishment, or spread of the organism.

d) Risk estimation - a conclusion on the risk posed by the organism based on the release, exposure, and consequence assessments.
If the risk estimate is non-negligible, then the organism is classified as a hazard.

It is important to understand that not all of the above steps may be necessary in all risk assessments. The MAF Biosecurity New Zealand and OIE methodologies make it clear that if the likelihood of release is negligible for a potential hazard, then the risk estimate is automatically negligible and the remaining steps of the risk assessment need not be carried out. The same situation arises where the likelihood of release is non-negligible but the exposure assessment concludes that the likelihood of exposure to susceptible species in the importing country is negligible, or where both release and exposure are non-negligible but the consequences of introduction are concluded to be negligible.

2.2 RISK MANAGEMENT

Risk management consists of:

a) Risk evaluation - a determination is made as to whether sanitary measures are necessary.

b) Option evaluation - the options that *could* be used for managing the risk are identified, and risk reduction effects are considered.

Where a non-negligible risk has been identified, options are presented for the effective management of the risk associated with the commodity. Recommendations for the appropriate sanitary measures to effectively manage the identified risks are not made in this document. These will be determined when an import health standard is drafted.

2.3 RISK COMMUNICATION AND EVALUATION OF VETERINARY SERVICES

MAF has standard procedures for consultation with the public and interested parties on all risk analyses. Therefore risk communication, the final step of a complete risk analysis, is not part of this risk analysis.

The OIE *Terrestrial Animal Health Code* also includes evaluation of veterinary services, zoning and regionalisation and surveillance and monitoring of animal health (OIE, 2006). These considerations apply to individual countries and are not covered in this risk analysis which is written for all countries. They will be considered by MAF at the time of writing any import health standards for these commodities.

3. Rendered Poultry Products

3.1 COMMODITY DEFINITION

Rendered animal by-products including poultry meal, poultry feather meal, poultry oil, and poultry blood meal are considered here.

All rendering processes involve the application of heat, the extraction of moisture, and the separation of fat. Raw material is ground to a consistent particle size before cooking. Cooking occurs by either a continuous or a batch procedure using steam. In the United States, cooking temperatures vary between 118°C and 143°C for periods of time from 40 to 90 minutes depending on the system type (Pearl, 2004).

In the European Union, the processing of animal by-products not intended for human consumption is regulated by EC 1774/2002[2]. Under this regulation, the heat treatment of poultry products intended for use as animal feed must be carried out by one of the methods shown in table 1.

Table 1: Cooking conditions specified under EC 1774/2002

Cooking method	Temperature	Time
Method 1	>133°C	>20 minutes
Method 2	>100°C	>125 minutes
	Including >110°C	>120 minutes
	Including >120°C	>50 minutes
Method 3	>100°C	>95 minutes
	Including >110°C	>55 minutes
	Including >120°C	>13 minutes
Method 4	>100°C	>16 minutes
	>110°C	>13 minutes
	>120°C	>8 minutes
	>130°C	>3 minutes
Method 5	>80°C	>120 minutes
	>100°C	>60 minutes

Under article 19 of EC 1774/2002 processed animal protein and other processed products that could be used as feed material are limited to 'Category 3' material which excludes by-products derived from animals which have been killed to eradicate an outbreak of disease.

Therefore, for the purposes of this risk analysis, rendered poultry products are defined as material derived from poultry which have not been slaughtered for disease control purposes and have been exposed to one of the cooking conditions described above.

[2] See: www.defra.gov.uk/animalh/by-prods/publicat/en_2002R1774_do_001.pdf

3.2 HAZARD IDENTIFICATION

A number of hazards may be associated with rendered poultry meals. It is assumed that complex multi-cellular organisms (acanthocephalan worms, cestodes, ectoparasites or nematodes) would not survive the processing conditions associated with rendering and are therefore not considered further in this risk analysis. The preliminary hazard list for poultry meals is shown in appendix 1.

Diseases/organisms on the preliminary hazard list are not considered to be potential hazards in this risk analysis if;

- the disease agents are known to be present in New Zealand, and are either not under official control, or their arrival in New Zealand in association with the pathway would not increase existing exposure; **or**
- the organisms are inactivated by the processing conditions defined for the commodity.

3.2.1 Disease agents present in New Zealand

3.2.1.1 Viral agents present in New Zealand

Avian encephalomyelitis virus, avian nephritis viruses types 1-3, avian pox virus, egg drop syndrome 76 virus, infectious laryngotracheitis virus, and reovirus (viral arthritis) are recognized as being present in New Zealand (Howell, 1992) and are therefore not considered to be potential hazards in the commodities.

Chicken infectious anaemia virus is present in New Zealand poultry (Anon[a], 2005) and therefore requires no further consideration here. Serological investigations indicate that, although clinical disease is unusual in New Zealand poultry, infection with reticuloendotheliosis virus is widespread (Howell et al, 1982). Rotaviruses have been recovered from poultry in New Zealand (Saifuddin et al, 1989). Therefore, these agents are not considered to be potential hazards in this risk analysis.

3.2.1.2 Bacterial agents present in New Zealand

Avian tuberculosis (*Mycobacterium avium-intracellulare*) is known to be present in New Zealand poultry (Anon[b], 2005). Exotic serovars of *Mycobacterium avium-intracellulare* may exist although no difference in pathogenicity between these and endemic strains has been reported. This agent is not considered to be a potential hazard.

Psittacosis is known to be present in New Zealand and is thought to be endemic with a reservoir maintained in wild birds (Black, 1997) although exotic (possibly more pathogenic) strains of *Chlamydophila psittaci* may be found overseas and these require further consideration.

Campylobacteriosis has also been documented in New Zealand poultry (Black, 1997) although the quinolone-resistant forms that have been documented overseas have not been seen in this country and should be considered further.

Colibacillosis of poultry is recognized in New Zealand (Black, 1997), although overseas strains may be associated with virulence factors not recognized in this country and require further consideration in this risk analysis.

Erysipelas is known to occur in New Zealand (Black, 1997; Alley[a], 2002). Gangrenous dermatitis, necrotic enteritis, streptococcosis, enterococcosis, staphylococcosis, and ulcerative enteritis have all been recognized in New Zealand (Black, 1997). *Acholeplasma laidlawii* is known to be present in New Zealand and is commonly recovered from sheep and goats (Belton, 1990). Surveillance of wild birds has confirmed the presence of aspergillosis and botulism in this country (Alley[a], 2002). These agents are not considered to be potential hazards in this risk analysis.

Aegyptianella spp., *Bacillus anthracis, Brucella* spp., *Coxiella burnetti, Francisella tularensis,* and *Mycobacterium avium* subsp *paratuberculosis* (exotic strains) are listed in MAF's unwanted organisms register and should therefore be considered further. The presence or absence of the other miscellaneous bacteria associated with poultry disease is summarised in appendix 2. From published literature, *Planococcus* spp., *Coenonia anatine,* and *Borrelia* spp. are exotic to New Zealand and should also be further considered.

Mycoplasma gallisepticum and *Mycoplasma synoviae* are recognised in New Zealand poultry (Black, 1997). Other *Mycoplasma* spp. are not documented in this country and require further consideration.

3.2.1.3 Other agents present in New Zealand

Candida spp. have a worldwide distribution and disease associated with these organisms occurs secondary to immunological compromise or disruption of commensal microflora (Kunkle, 2003). Candidiasis has been reported affecting a variety of avian species in New Zealand including wood pigeons (Johnstone and Cork, 1993) and ostriches (Anon[a], 2004). *Candida spp*. are, therefore, not considered to be potential hazards associated with this commodity.

Cryptosporidiosis has been reported in a number of species in New Zealand including cattle, sheep, pigs, goats, deer, possums, caged birds, reptiles, and man (Vickers, 1988). Although disease in domestic poultry had not been recognised in 1997 (Black, 1997), later studies identified the presence of cryptosporidiosis in New Zealand chickens (Anon, 1999). Cryptosporidiosis requires no further consideration.

Coccidiosis is recognised in New Zealand poultry and avian coccidia should not be considered a potential hazard (Black, 1997).

Dactylariosis due to *Dactylaria gallopava* does not appear to have been previously reported in New Zealand. However, as this is an environmental fungal organism

which causes sporadic opportunistic infections, and is found in New Zealand[3], *Dactylaria gallopava* should not be considered a potential hazard.

Although there are no reports of disease in turkey poults due to *Hexamita meleagridis*, suspect *Hexamita* spp. have been associated with ostriches in New Zealand (Anon, 1999). Histomoniasis is recognised in gallinaceous birds in New Zealand (predominantly turkeys) and requires no further consideration here (Black, 1997). Sarcocystosis, toxoplasmosis, and trichomoniasis are recognised in New Zealand birds (McKenna, 1998) and should not be considered as potential hazards in association with this commodity.

3.2.1.4 Summary

From the preliminary hazard list (appendix 1), the following require further consideration:

Viruses
Adenoviridae
Astroviridae
Birnaviridae
Coronaviridae
Flaviviridae
Herpesviridae
Orthomyxoviridae
Paramyxoviridae
Parvoviridae
Picornaviridae
Polyomaviridae
Reoviridae
Retroviridae
Togaviridae

Bacteria
Aegyptianella spp.
Bacillus spp.
Bordetella avium
Borrelia spp.
Brucella spp.
Campylobacter spp.
Chlamydophila psittaci
Coenonia anatine
Coxiella burnetii
E. coli 0111, 0157:H7 and others
Francisella tularensis
Haemophilus paragallinarum
Microsporum gallinae
M. avium intracellulare
M. avium subsp *paratuberculosis*
Mycoplasma spp.
Ornithobacterium rhinotracheale
Pasteurella multocida
Planococcus spp.
Riemerella anatipestifer
Salmonella spp.

3.2.2 Organisms inactivated by the processing conditions

Of the organisms considered either unwanted or exotic to New Zealand, any that are likely to survive the processing conditions associated with rendering (as described in the commodity definition) should be regarded as potential hazards requiring further risk analysis.

[3] See: http://nzfungi.landcareresearch.co.nz/html/mycology.asp

3.2.2.1 Viral agents

Coronaviridae, Flaviviridae, Herpesviridae, Orthomyxoviridae, Paramyxoviridae, Picronaviridae, Retroviridae, and *Togaviridae* are all sensitive to heat inactivation (Fauquet et al, 2005)[4].

Of the other exotic viral agents (*Adenoviridae, Astroviridae, Birnaviridae, Parvoviridae, Polyomaviridae,* and *Reoviridae*), infectious bursal disease virus (IBDV) (*Birnaviridae*) is recognised to be particularly hardy with a marked stability against physical and chemical agents[5] (Lukert and Saif, 2003). Using the MAF CS88 predictive model of the effect of heat on the inactivation of IBDV in chicken tissue[6], the results shown in table 2 are obtained.

Rendering under any of the conditions described is likely to achieve a >4D reduction[7] in the amount of IBDV present in poultry meals (i.e. >99.99% of virus destroyed). As the poultry meal under consideration here is to be used as an ingredient in fish food, a >4D reduction in the amount of any IBDV present is considered sufficient to provide a high level of protection. Other time/temperature combinations sufficient to achieve >4D reduction in IBDV (using the MAF CS88 predictive model) are listed in appendix 3 of this risk analysis.

[4] Further details of temperature sensitivity of these viruses are shown in appendix 6.

[5] See appendices 1 and 2 of MAF's 1999 import risk analysis for chicken meat and chicken meat products – see: www.biosecurity.govt.nz/files/pests-diseases/animals/risk/chicken-meat-ra.pdf.

[6] The CS88 predictive model is based on the findings of a study carried out by VLA Weybridge on behalf of the Australian Chief Veterinary Officer (Quality Control Unit 1997). This is discussed in further detail in appendix 1 of MAF's 1999 import risk analysis for chicken meat and chicken meat products – see: www.biosecurity.govt.nz/files/pests-diseases/animals/risk/chicken-meat-ra.pdf.

[7] D-values (decimal reduction times) refer to the amount of time taken at a certain temperature to kill 90% of the organisms being studied.

Table 2: IBD reduction associated with rendering conditions using the MAF CS88 model

Rendering conditions	Temperature	Time	Reduction in IBDV
Method 1 (EU1774/2002)	>133°C	>20 minutes	>12D
Method 2 (EU1774/2002)	>100°C Including >110°C Including >120°C	>125 minutes >120 minutes >50 minutes	>9D
Method 3 (EU1774/2002)	>100°C Including >110°C Including >120°C	>95 minutes >55 minutes >13 minutes	>7D
Method 4 (EU1774/2002)	>100°C >110°C >120°C >130°C	>16 minutes >13 minutes >8 minutes >3 minutes	>7D
Method 5 (EU1774/2002)	>80°C >100°C	>120 minutes >60 minutes	>4D
Pearl 2004	>118°C	>40 minutes	>8D

Exotic viral agents are not considered to be potential hazards in rendered poultry products that have been processed under the conditions described above or using the equivalent conditions described in appendix 3.

3.2.2.2 Bacterial agents

Of the bacterial agents listed, *Bacillus* spp. are spore-forming organisms and are therefore more likely to survive exposure to high temperatures than other bacteria. A review of literature published regarding the inactivation of *Bacillus anthracis* spores (Whitney et al, 2003) demonstrated that exposure of spores to a moist heat of 100°C for 10 minutes is sufficient for inactivation. Exotic bacterial agents should therefore not be considered potential hazards in rendered poultry products as defined here.

3.2.2.3 Summary

It is concluded that, given the time/temperature conditions described for rendered poultry products, no potential hazards have been identified in rendered products derived from poultry which have not been slaughtered for disease control purposes.

4. Fishmeal And Fish Oil

4.1 COMMODITY DEFINITION

Fishmeal and fish oil may be manufactured from fish caught solely for rendering, by-catches from another fishery, and from fish offcuts and offal from the consumption industry. Material used in the manufacturing process may be derived from Gadoids (cod-like fishes), Clupeids (the herrings), Scombrids (the mackerels and tunas), Elasmobranchs (sharks and rays), Salmonids (salmon and related fish), and Crustaceans (especially carapaces and shells).

The main steps used in fish rendering include:

- cooking for coagulation of protein and liberation of water and oil
- pressing the cooked material to produce a presscake, oil, and press liquor
- centrifugation of liquor into oil and stickwater
- evaporation of the stickwater to recover solids which are added to the presscake
- dehydration and milling of the presscake to produce stable meal

A review published by the United Nations Food and Agricultural Organisation (FAO, 1986) describes the initial cooking of material at temperatures of 95°C to 100°C for 15 to 20 minutes with the dehydration phase carried out at temperatures not exceeding 90°C to achieve a moisture content of less than 12%.

Manufacturer discussions have indicated that fishmeal likely to be imported in New Zealand is currently manufactured using cooking conditions of 85°C for 15 minutes or 80°C for 20 minutes.

As described in section 3.1, under EU legislation processed animal protein and other processed products that could be used as feed material are limited to ‘Category 3’ material which excludes by-products derived from animals which have been killed to eradicate an outbreak of disease.

Therefore, for the purposes of this risk analysis, fishmeal and fish oil are defined as material derived from those fish families listed above, which have not been slaughtered for disease control purposes and which have been manufactured under initial cooking conditions of at least 80°C for a period of no less than 20 minutes.

4.2 HAZARD IDENTIFICATION

Given the variety of host species, a large number of possible hazards may be associated with material used to manufacture fishmeal and fish oil. These are listed in the preliminary hazard list (appendix 4). As with poultry meal, it is assumed that complex multi-cellular organisms would not survive the rendering process and these will not be considered further here.

Diseases/organisms on the preliminary hazard list are not considered to be potential hazards in this risk analysis if;

- the disease agents are known to be present in New Zealand, and either are not under official control, or their arrival in New Zealand in association with the pathway would not increase existing exposure; **or**
- the organisms are inactivated by the processing conditions defined for the commodity**.**

4.2.1 Disease agents present in New Zealand

Nocardiosis has been described in a number of species in New Zealand and will not be considered further here (Orchard, 1979).

Examination of salmonids over the period 1977 to 1995 indicated the presence of a limited number of pathogens including *Flexibacter* sp, *Streptococcus* sp., *Vibrio ordalii, Yersinia ruckeri,* and *Myxobolus cerebralis* in New Zealand (Anderson, 1996). These agents are not considered potential hazards.

A survey of 1,796 freshwater fish carried out in 2002 failed to identify any significant disease in these fish indicating that the majority of preliminary hazards identified should be considered exotic to New Zealand (Duignan and Hine, 2003).

4.2.1.1 Summary

A limited number of studies have been published regarding the infectious agents that currently affect fish in New Zealand. However, the material that is available indicates a very limited number of fish pathogens are present in this country and this is consistent with the absence of reported epizootic mortality amongst New Zealand fish.

4.2.2 Organisms inactivated by the processing conditions

Of the organisms considered either unwanted or exotic to New Zealand, any that are likely to survive the processing conditions associated with rendering (exposure to greater than 80°C for no less than 20 minutes as described in the commodity definition) are considered to require further analysis.

4.2.2.1 Viral agents

Iridoviridae are inactivated at 55°C, *Rhabdoviridae* at 56°C, *Ronavirdae* (Okavirus) at 60°C, and *Togaviridae* at 58°C. *Baculoviridae, Bunyaviridae, Herpesviridae, Orthomyxoviridae*, and *Picronaviridae* are all sensitive to heat (Fauquet et al, 2005)[8].

Of the other exotic viral agents listed (*Birnaviridae, Dicistroviridae, Nimaviridae, Nodaviridae, Parvoviridae*, and *Reoviridae* (including Aquareovirus)), the aquabirnaviruses (*Birnaviridae*) are noted to show considerable resistance to heat (Whipple and Rohovec, 1994). The most extensively studied of all the aquabirnaviruses is infectious pancreatic necrosis virus (IPNV). Studies of the thermal stability of IPNV have indicated that it may survive exposure to 65°C for a period of 3 to 4 hours (Munday, 2002). Experimental studies by Whipple and

[8] Further details of temperature sensitivity of these viruses are shown in appendix 6.

Rohovec demonstrated that IPNV will be destroyed by exposure to 80°C for a period of 10 minutes (Whipple and Rohovec, 1994).

Therefore, given the rendering conditions described above, IPNV is not be considered a hazard associated with rendered fishmeal and fish oil.

4.2.2.2 Bacterial agents

Of the non-viral agents identified, *Renibacterium salmoninarum* is recognised as showing considerable resistance to heat (Humphrey, 1995; Whipple and Rohovec, 1994). *R. salmoninarum* is able to survive >15 minutes at 65°C although heating for 10 minutes at 71°C followed by 10 minutes at 82°C was shown to be effective in destroying *R. salmoninarum* (Whipple and Rohovec, 1994). Given this, it is thought unlikely that *R. salmoninarum* would survive exposure to a temperature of greater than 80°C for a period of no less than 20 minutes.

4.2.2.3 Summary

The viral and non-viral agents considered to be most resistant to heat treatment are likely to be inactivated by rendering at a temperature of at least 80°C for a period of no less than 20 minutes.

Therefore, it is concluded that no potential hazards have been identified in fishmeal and fish oil which have been manufactured using an initial cooking temperature of at least 80°C for a period of no less than 20 minutes.

5. Artemia Salina And Artemia Franciscana

5.1 COMMODITY DEFINITION

Artemia salina and *Artemia franciscana* are members of the Family: Artemiidae, Class: Branchipoda, and Phylum: Arthropoda.

Two species of *Artemia* are known to be present in New Zealand. *Artemia salina* has been established in this country for many years and *Artemia franciscana* was determined to be not a new organism by the Environmental Risk Management Authority (ERMA) on 30th December 2002.

The commodity under consideration is farmed *Artemia salina* and *Artemia franciscana*, imported as dried metabolically-inactive (although viable) cyst-like eggs which can be hatched by incubation in saline to produce live nauplii (larvae) for feeding to fish (Treece, 2000). Exotic *Artemia* spp. are not considered in this risk analysis.

5.2 HAZARD IDENTIFICATION

No pathogens associated with farmed *Artemia* spp. have been described in published literature. Furthermore, *Artemia* spp. have been imported into New Zealand without sanitary measures since July 1998, which suggests a low likelihood of significant hazards being associated with this commodity.

Importation of viable *Artemia* spp. could be associated with the introduction of exotic species of *Artemia* with possible consequences for established aquatic ecosystems. Applications for the introduction of exotic *Artemia* spp. would require consideration by ERMA New Zealand and will therefore not be considered further here.

5.2.1 Summary

Artemia salina and *Artemia fransicana* are both known to be present in New Zealand. No hazards have been identified associated with farmed *Artemia* spp., so consignments containing only these species could be permitted without the need for risk management measures.

6. Zooplankton Other Than Artemia Salina And Artemia Franciscana

6.1 COMMODITY DEFINITION

Zooplankton previously imported into New Zealand for use as fish food has included *Daphnia* sp., Krill (Order: *Euphausiacae*), and Mysida shrimps (Family: *Mysidae*). These zooplankton species imported into New Zealand are freeze-dried and non-viable.

Over 6,800 species of marine zooplankton are currently recognised and the ongoing census of marine zooplankton[9] is expected to describe at least that number of new species.

This risk analysis examines the risks associated with non-viable imported species of zooplankton intended for use as fish food.

6.2 HAZARD IDENTIFICATION

A number of bacterial pathogens have been associated with zooplankton, including *Enterococcus faecalis* (Signoretto et al, 2005), *Campylobacter jejuni* (Schallenberg et al, 2005), *Vibrio* spp. (Heidelberg et al, 2002), and *Helicobacter pylori* (Cellini et al, 2004). Many viruses are recognised to play a role in phytoplankton-zooplankton systems although the exact nature of this relationship is not yet understood (Singh et al, 2004). Of particular interest here is a study by Kitamura et al (2003) reporting the identification of marine birnavirus DNA in zooplankton by a PCR technique and the demonstration that Krill can act as a reservoir for white spot syndrome virus (Supamattaya et al, 1998).

Life cycles of marine parasites are poorly understood although a study by Jackson et al (1997) demonstrated that Mysida shrimps were hosts to the larval nematodes *Pseudoterranova decipiens* (sealworm), *Hysterothylacium aduncum*, and *Paracuaria adunca* (parasites of seals, fish and birds respectively), and to the digean fish parasite *Hemiurus levinseni*.

Given the number of species of zooplankton (both described and unknown), and the (likely) large number of potential pathogens associated with these organisms, it is not possible to compile a comprehensive preliminary hazard list for this commodity and it is reasonable to assume that a significant proportion of these hazards would be exotic to New Zealand Because of these uncertainties, it has been decided to consider all possible hazards together.

[9] See: www.cmarz.org

6.3 RISK ASSESSMENT

6.3.1 Release assessment

Published studies have indicated that zoonotic bacteria, viral pathogens and marine parasites have been associated with zooplankton. A number of these are likely to be exotic to New Zealand. The release assessment is non-negligible.

6.3.2 Exposure assessment

Imported zooplankton is most likely to be fed to ornamental fish. There is a high likelihood that humans may be exposed to any potentially zoonotic exotic bacteria present in the commodity. However, because of disinfection procedures used in municipal sewerage systems, the likelihood of viable hazardous pathogens entering the aquatic environment from sewerage following use in ornamental fish aquaria is considered to be negligible.

Imported zooplankton may also be required for use in finfish hatcheries as feed for larval stages. Use of the commodity in this environment would be associated with a risk of introducing exotic hazards into the aquatic environment.

The exposure assessment is non-negligible.

6.3.3 Consequence assessment

Exposure of fishkeepers to exotic zoonotic bacteria associated with zooplankton may result in human disease. Introduction of hazards into the environment following use of zooplankton in finfish hatcheries may cause exotic disease in native fish populations. The consequences are therefore considered non-negligible.

6.3.4 Risk estimation

Since the likelihood of release and exposure and the consequences of exposure are estimated to be non-negligible, the risk is considered to be non-negligible.

6.4 RISK MANAGEMENT

6.4.1 Risk evaluation

Since the risk estimate is non-negligible, measures could be introduced to effectively manage the risk.

6.4.2 Risk management objective

The objective is to effectively manage the risk associated with the commodity.

6.4.3 Risk management options

Three options are presented for the effective management of the identified risk. It is suggested that option i. is associated with the highest level of protection with options

ii. and iii. associated with a decreasing level of protection. As stated in section 2.2, recommendations for the appropriate sanitary measures to effectively manage the identified risks are not made in this document. These will be determined when an import health standard is drafted.

i. Given the (likely) large number of potential pathogens possibly associated with imported zooplankton and the uncertainties discussed in section 6.2, it might be considered that importation of this commodity could be prohibited. However, as other options are available for the effective management of the identified risk, prohibition of importation is likely to be regarded as excessively risk averse in this case.

ii. The current import health standard for this commodity requires that imported zooplankton be subject to high-dose irradiation of 5 Mrads (50 kGy). The WHO technical report, 'High-dose Irradiation: Wholesomeness of Food Irradiated With Doses Above 10 kGy' (WHO, 1997), indicates that most vegetative bacterial cells have D values in the range of 0.04 to 0.86 kGy, radiation-resistant vegetative bacteria have D values in the range of 2.73 to 20.4 kGy, foodborne parasites have D values in the range of 0.1 to 10 kGy, and bacterial spores have D values in the range of 0.6 to 3.4 kGy. Viruses are regarded as more radiation resistant than bacteria although this resistance varies depending on a number of factors, especially the concentration of organic material in the suspending medium, the temperature during irradiation, and the degree of dehydration. As a guide, it is estimated that foot and mouth disease virus can be eliminated from a carcase with a dose of 20 kGy. This WHO technical report concludes that, using the target of achieving a 10^{12}-fold reduction in the number of the most radiation-resistant spore-forming bacteria (*Clostridium botulinum*) in a foodstuff, a dose of 45 kGy may be required. In light of the data presented in the WHO report outlined above, and the number of uncertainties concerning the hazards possibly associated with the importation of zooplankton, a risk management measure of exposing imported zooplankton to an irradiation dose of at least 4.5 Mrads (45 kGy) could be applied.

iii. Studies on pathogenic strains of an avibirnavirus, infectious bursal disease virus (IBDV), demonstrated that viral titres were unaffected following exposure to 5 kGy of gamma irradiation. This study also demonstrated a 1.6 to 2.0 D reduction in IBDV vaccine strains exposed to 10 kGy (Jackwood et al, 2007). Marine birnaviruses are likely to show a similar level of resistance to irradiation as avibirnaviruses and these findings suggest that the D value for this group is likely to be around 6.25 kGy. It would be reasonable to suggest that exposure to 25 kGy would be required to achieve a 4D reduction of marine birnaviruses present in zooplankton. Therefore, exposure of imported zooplankton to an irradiation dose of at least 2.5 Mrads (25 kGy) could be considered as a risk management measure.

Heat treatment of imported zooplankton is unlikely to be an acceptable risk management option for this commodity as heating such material at temperatures above 50°C has a deleterious effect on protein quality (Garcia-Ortega et al, 2000).

7. Blood Worms (Chironomid Midge Larvae)

7.1 COMMODITY DEFINITION

Members of the family *Chironomidae* (Order: Diptera, Class: Insecta) form a significant portion of the foodbase for other wildlife in aquatic and wetland environments and >2000 species of Chironomids have been described worldwide. Over 130 Chironomid species have been described in New Zealand (Stark and Winterbourn, 2006). However, taxonomic identification of Chironomid larvae is often difficult.

Imported Chironomid larvae considered in this risk analysis are freeze-dried and non-viable.

7.2 HAZARD IDENTIFICATION

A literature review has identified two potential bacterial hazards that may be associated with Chironomid larvae; *Vibrio cholerae* (Broza and Halpern, 2001) and *Salmonella* spp. (Moore et al, 2003). Limited literature has been published concerning the viral hazards associated with these insects although a member of the *Poxviridae* family (Chironomus luridus entomopoxvirus) has been described in Chironomids (Fauquet et al, 2005). As with zooplankton, because of these uncertainties, it has been decided to consider all likely hazards together in this risk analysis.

7.3 RISK ASSESSMENT

7.3.1 Release assessment

Zoonotic bacterial hazards including *Salmonella* spp. and *Vibrio cholerae* have both been associated with Chironomids although the frequency of isolation of these pathogens from harvested Chironomids is unknown. Based on the available literature, there is a non-negligible likelihood that imported Chironomid larvae will be associated with pathogens exotic to New Zealand.

7.3.2 Exposure assessment

Imported bloodworms are most likely to be fed to ornamental fish and it is extremely unlikely that they will be used in commercial aquaculture. There is a high likelihood that humans owning ornamental fish may be exposed to any zoonotic agents present in the commodity so the exposure assessment is considered non-negligible.

However, because of disinfection processes used in municipal sewerage systems, the likelihood of viable bacterial and viral pathogens entering the marine or freshwater environments following use of Chironomids in ornamental fish aquaria is likely to be negligible.

7.3.3 Consequence assessment

Exposure of fishkeepers to zoonotic agents associated with bloodworms may result in human disease. The consequences are therefore considered non-negligible.

7.3.4 Risk estimation

Since the likelihood of release and exposure, and the consequences of exposure are estimated to be non-negligible, the risk is considered to be non-negligible.

7.4 RISK MANAGEMENT

7.4.1 Risk evaluation

Since the risk estimate is non-negligible, management measures could be introduced to effectively manage the risk.

7.4.2 Risk management objective

The objective is to effectively manage the risk associated with the commodity.

7.4.3 Risk management options

Three options are presented for the effective management of the identified risk. It is suggested that option i. is associated with the highest level of protection with options ii. and iii. associated with a decreasing level of protection. As stated in section 2.2, recommendations for the appropriate sanitary measures to effectively manage the identified risks are not made in this document. These will be determined when an import health standard is drafted.

i. As was discussed with regard to imported zooplankton, given the (likely) large number of potential pathogens possibly associated with Chironomids and the uncertainties discussed in section 7.2, it might be considered that importation of this commodity could be prohibited. However, as irradiation provides an option for the effective management of the identified risk, prohibition of importation is likely to be regarded as excessively risk averse in this case.

ii. A study of *V.cholerae*-infected oysters recommended a radiation dose of 1.41 kGy for the elimination of viable *V.cholerae* (deMoraes et al, 2000) and a study of *Salmonella*-infected eggs has recommended a dose of 1.5 kGy to achieve a 10^4 reduction in *Salmonella* counts (Serrano et al, 1997). However, limited literature is available regarding the bacterial and viral pathogens possibly associated with Chironomids and it would not be unreasonable to suspect that a number of hazards associated with this commodity have not been identified to date. It could therefore be appropriate to adopt the recommendations of the WHO outlined in section 6.4.3 of this risk analysis and subject imported Chironomids to high-dose irradiation of 4.5 Mrads (45 kGy), consistent with the dose discussed for imported zooplankton.

iii. Alternatively, given the available data which suggests that exposure to 25 kGy is likely to achieve a 4D reduction of birnaviruses (Jackwood et al, 2007), and the

estimate that foot and mouth disease virus can be eliminated from a carcase with a dose of 20 kGy (WHO, 1997), exposure of imported Chironomids to an irradiation dose of at least 2.5 Mrads (25 kGy) could be considered as a risk management measure.

As was discussed for imported zooplankton, heat treatment is unlikely to be an acceptable risk management option for this commodity because of the deleterious effect on Chironomid protein quality.

8. Rendered Ruminant Meals

8.1 COMMODITY DEFINITION

Ovine blood meal, meat meal, bone meal, and casing meal and bovine blood meal, meat meal, and bone meal are considered here. These animal by-products are produced from rendering entire bodies, or parts of animals, or products of animal origin. The rendering process is outlined in section 3.1 of this document.

As described previously, in the United States, cooking temperatures vary between 118°C and 143°C for periods of time from 40 to 90 minutes depending on the system type (Pearl, 2004).

As with poultry meal, under EC 1774/2002, it is possible for ruminant material to be rendered using any one of the five time/temperature methods described previously in table 1.

Under article 19 of EC 1774/2002 processed animal protein and other processed products that could be used as feed material are limited to 'Category 3' material which excludes by-products derived from animals which have been killed to eradicate an epizootic disease.

Therefore, for the purposes of this risk analysis, rendered ruminant meals are defined as material derived from ruminants which have not been slaughtered for disease control purposes and has been exposed to one of the cooking conditions described above.

8.2 HAZARD IDENTIFICATION

A number of hazards may be associated with rendered ruminant meals. As with rendered poultry and fish material, it is assumed that complex multi-cellular organisms would not survive the processing conditions associated with rendering and these are therefore not considered in this risk analysis. The preliminary hazard list for ruminant meals is shown in appendix 5.

Diseases/organisms are not considered to be potential hazards in this commodity if;

- the disease agents are known to be present in New Zealand, and either are not under official control, or their arrival in New Zealand in association with the pathway would not increase existing exposure; **or**
- the organisms are inactivated by the processing conditions defined for the commodity.

8.2.1 Disease agents present in New Zealand

8.2.1.1 Viral agents present in New Zealand

A serological study of 272 dairy farms carried out in 1998 indicated that infections with infectious bovine rhinotracheitis, parainfluenza type 3, bovine respiratory syncytial virus, and bovine coronavirus were widespread in all major dairy cattle farming regions in New Zealand and should not be considered potential hazards (Motha and Hansen, 1998). However, abortifacient strains of bovine herpesviruses have not been recognised in New Zealand and require further consideration.

Bovine viral diarrhoea virus type 1 (BVDV1) is a common pathogen in New Zealand, with bulk tank ELISA results indicating an active infection in approximately 15% of dairy herds in the Waikato, Bay of Plenty, and Northland regions (Thobokwe et al, 2004). BVDV2 is considered exotic to New Zealand. Border disease virus has been associated with neurological disorders of sheep in New Zealand (Hartley and Rofe, 2002). BVDV1 and border disease virus are not potential hazards. BVDV2 requires further consideration.

Bovine adenoviruses and bovine papular stomatitis virus are known to be widespread in New Zealand (Vermunt and Parkinson, 2000) and are not considered to be potential hazards.

Caprine arthritis-encephalitis virus is known to be present in the New Zealand goat population (Thompson, 2001) and requires no further consideration.

Contagious pustular dermatitis (contagious ecthyma or orf) is very common in this country (Familton, 1984; Robinson, 1983). This disease requires no further consideration in this risk analysis.

Pseudocowpox (associated with a similar parapoxvirus) is also widespread in New Zealand with confirmation of the viral aetiology being first recorded in 1968 (Carter et al). Bovine ulcerative mammilitis associated with bovine herpesvirus 2 has also been identified in New Zealand cattle (Horner and Raynel, 1988). These agents are not potential hazards.

A control scheme to eradicate enzootic bovine leucosis (EBL) from New Zealand has been in place since 1998 and the annual EBL herd prevalence is now below 0.2%. It is anticipated that this country will be classified as EBL-free in the near future (Voges, 2005). Therefore, in anticipation of this, EBL requires further consideration.

Malignant catarrhal fever (MCF) was first suspected in New Zealand in 1954 and confirmed in 1955 (MacKinnon and LeSouef, 1956). This disease is now common in cattle and deer in New Zealand and has also been described in swamp buffalo (Hill et al, 1993) and therefore requires no further consideration.

Rotaviral infections are recognised as commonly contributing to diarrhoea in lambs (Horner 1988) and calves (Schroeder et al, 1983) in New Zealand and are not considered to be potential hazards.

8.2.1.2 Bacterial and other agents present in New Zealand

Neurological disorders of sheep in New Zealand have been associated with *Toxoplasma gondii*, *Escherichia coli*, *Pasteurella haemolytica*, *Staphylococcus aureus*, *Fusobacterium necrophorum*, *Corynebacterium pyogenes* (*Arcanobacterium pyogenes*), and *Listeria monocytogenes* infections (Hartley and Rofe, 2002). These agents are not classed as potential hazards.

Infectious agents commonly associated with pneumonia in sheep in New Zealand include *Pasteurella haemolytica*, *Pasteurella multocida*, and *Mycoplasma ovipneumoniae* (Alley[b], 2002) so these organisms are not considered to be potential hazards.

Bacteroides nodosus is recognised as a common pathogen associated with hoof disorders of a number of species in New Zealand including sheep, cattle, goats, and deer (Skerman, 1983). This agent requires no further consideration in this risk analysis.

A review of infectious diseases of goats in New Zealand identified infections with *Corynebacterium pseudotuberculosis* (*ovis*), *Dermatophilus congolensis*, *Bacteroides* (*Dichelobacter*) *nodosus*, *Fusobacterium necrophorum*, *Mycobacterium avium* subsp. *paratuberculosis*, and *Yersinia enterocolitica* (Thompson, 2001). These agents are not considered to be potential hazards.

A voluntary flock accreditation scheme for *Brucella ovis* is in place in New Zealand (Anon[b], 2004) and infection of rams with this organism is recognised in this country (Kittelberger et al, 1996). *Brucella ovis* is not considered to be a potential hazard.

Campylobacter fetus fetus is commonly associated with ovine abortion in New Zealand (West, 2002) and is not considered a potential hazard.

Campylobacter fetus subsp *venerealis* was last reported in New Zealand in 1993 (Loveridge and Gardner, 1993). A recent survey of beef cattle indicated that this infection was not widespread in New Zealand although it did not provide evidence that this organism should now be considered absent from the country and is therefore not a potential hazard (McFadden et al, 2005).

Results of a study of 185 dairy calves from 24 farms in New Zealand published in 2005 identified widespread infection with *Cryptosporidium parvum* (21.2% of calves sampled) and *Campylobacter jejuni* subsp *jejuni* was also recovered from 6.8% of calves (Grinberg et al, 2005). Therefore these organisms are not considered to be potential hazards.

Clostridial infections/intoxications have been recognised in New Zealand for many years including diseases due to *Clostridium septicum*, *Clostridium novyi*, and *Clostridium welchii* (Hartley and Boyes, 1964), *Clostridium tetani* and *Clostidium perfringens* (Wallace, 1962), *Clostidium botulinum* (Martinovich et al, 1972), *Clostridium haemolyticum* (Marshall, 1959), and *Clostridium chauvoei* (Buddle, 1952). These bacteria are, therefore, not considered to be potential hazards.

Eleven species of bovine coccidia have been identified in New Zealand, including the most pathogenic species *Eimeria bovis* and *Eimeria zuernii* (Jones-Gaddam et al, 2004). Limited work has been published on ovine coccidiosis in New Zealand, although a small study of 25 lambs was able to identify natural infection with eleven different species of ovine coccidia (Mason, 1976). *Eimeria* spp are not considered to be potential hazards.

Eperythrozoonosis due to *Eperythrozoon ovis* was first recognised in New Zealand sheep in 1967 (Sutton, 1970) and sporadic cases of this disease are still noted (Gill, 1999). *Eperythrozoon wenyoni* has been recorded in New Zealand cattle (Sutton et al, 1977). These organisms therefore require no further consideration.

Although reports of disease due to *Haemophilus somnus* are not common in the published literature, a study of bovine uteri identified growths of this organism in 5% of examined uteri, indicating that this organism is present in New Zealand and is not regarded as a potential hazard (McDougall, 2005).

Neospora caninum is recognised as a common cause of bovine abortion in both dairy and beef cattle in many countries and is known to be a significant problem in New Zealand (Thornton et al, 1991) and requires no further consideration.

Johne's disease is recognised as being endemic in cattle and sheep in New Zealand and is spreading through the farmed deer population (de Lisle, 2002). *Mycobacterium avium* subsp. *paratuberculosis* is not considered to be a potential hazard.

Eight serovars of pathogenic leptospires have been identified in New Zealand whereas internationally, around 180 serovars are recognised within the seven species of pathogenic leptospires (Marshall and Manktelow, 2002). Exotic leptospira serovars therefore require further consideration.

Serological surveys of New Zealand livestock have detected no evidence of exposure to *Mycoplasma bovis* or *Mycoplasma mycoides* subsp. *mycoides* SC in cattle, no evidence of exposure to *Mycoplasma agalactiae*, *Mycoplasma capricolum* subsp. *capricolum*, or *Mycoplasma mycoides* subsp. *mycoides* LC in goats, and no evidence of exposure to *Mycoplasma agalactiae*, *Mycoplasma capricolum* subsp. *capricolum*, or Mycoplasma *mycoides* subsp. *mycoides* LC in sheep (Reichel et al, 1999). These mycoplasma species must therefore be considered exotic to New Zealand and require further consideration.

Salmonella has been identified in New Zealand livestock since 1934 although the list of serovars that have been isolated to date is limited. Also, in New Zealand, antibiotic resistance among *Salmonella* spp. is relatively rare (Clark et al, 2002). Exotic serovars of salmonella or isolates with exotic antimicrobial resistance phenotypes must therefore be considered further.

A survey of 30 New Zealand dairy herds indicated that *Streptococcus dysgalactiae* was associated with around 10% of cases of clinical mastitis in the herds and is, therefore, not a potential hazard (McDougall and Compton, 2005).

Theileria orientalis has been identified in New Zealand cattle (James et al, 1984) although pathogenic *Theileria* spp. (including *Theileria parva* and *Theileria annulata*) have not been described and should be considered further. Serological surveys have confirmed that New Zealand is free of *Anaplasma* spp. (MacDiarmid et al, 1984; Kelly et al, 2005) and *Ehrlichia* spp. (Kelly et al, 2005) and these require further consideration.

Trichomonas foetus is recognised in New Zealand and is sporadically reported in the literature with cases documented in 1972 (Anon, 1972) and 1982 (Bruere, 1982). This organism is not considered to be a potential hazard.

Tuberculosis is present in cattle and deer in New Zealand although a national control programme has been in place for a number of years which includes testing and culling (Livingstone, 2005). *Mycobacterium bovis* therefore requires further consideration.

Ureaplasmas have been identified in cattle in New Zealand (Hodges and Holland, 1980) although there is no evidence for the presences of these organisms in the sheep population of this country. Therefore, ureaplasmas associated with sheep are considered exotic to New Zealand and require further consideration.

Candida spp., *Erysipelothrix rhusiopathiae, Aspergillus* spp. (including) *Aspergillus fumigatus,* Dermateaceae fungi, *Actinobacillus lignieresii, Geotrichum candidum, Listeria monocytogenes, Nocardia asteroides, Fusobacterium necrophorum, Corynebacterium* spp. (including *Corynebacterium renale*), *Streptococcus agalactiae, Streptococcus uberis, Staphylococcus aureus*, *Escherichia coli, Klebsiella* spp., *Pseudomonas aeruginosa*, *Dermatophilus congolensis*, and *Trichophyton* spp. (including *Trichophyton verrucosum*) are all listed as organisms that are known to be present in New Zealand on the NZFUNGI database of New Zealand Fungi (and Bacteria)[10]. These organisms are not considered to be potential hazards.

8.2.1.3 Summary

From the initial list of hazards possibly associated with rendered ruminant meals (appendix 4), the following require further consideration as they are considered either exotic to New Zealand or are under official control in New Zealand:

[10] See: nzfungi.landcareresearch.co.nz/html/mycology.asp

TSEs
BSE prion
Scrapie prion

Viruses
Bornaviridae
Bunyaviridae
Caliciviridae
Coronaviridae
Flaviviridae
Herpesviridae
Paramyxoviridae
Parvoviridae
Picornaviridae
Poxviridae
Reoviridae
Retroviridae
Rhabdoviridae
Togaviridae

Bacteria
Actinomyces bovis
Anaplasma spp.
Babesia spp.
Bacillus anthracis
Besnoitia besnoiti
Borrelia burgdorferi
Brucella abortus
Brucella melitensis
Chlamydophila spp.
Coccidioides immitis
Cowdria ruminatium
Coxiella burnetti
Ehrlichia ondiri
Ehrlichia phagocytophilia
Epizootic bovine abortion agent
Francisella tularensis
Exotic *Leptospira* spp.
Mycobacterium bovis
Exotic *Mycoplasma* spp.
Pasteurella multocida serotypes 6:B and 6:E
Rhinosporidium seeberi
Exotic *Salmonella* spp.

Others
Theileria spp.
Trypanasoma spp.
Ureaplasma spp.

8.2.2 Organisms inactivated by the processing conditions

Of the organisms considered exotic to New Zealand (or under official control in New Zealand), any which are likely to survive the processing conditions associated with rendering should be regarded as potential hazards requiring further risk assessment.

8.2.2.1 Prions

The prion agents associated with scrapie and bovine spongiform encephalopathy (BSE) are notoriously difficult to inactivate. Some prion infectivity may survive standard autoclaving conditions and the BSE agent is known to be particularly thermostable. Under dry heat conditions, infectivity shows even greater survival properties, e.g. some infectivity may survive temperatures of 200°C or more (Somerville, 2003). Rendering cannot be relied upon to inactivate the prion agents associated with BSE and Scrapie and these should, therefore, be considered potential hazards in this risk analysis.

8.2.2.2 Viral agents

Bornaviridae, Bunyaviridae, Coronaviridae, Flaviviridae, Herpesviridae, Paramyxoviridae, Picronaviridae, Poxviridae, Retroviridae, Rhabdoviridae, and *Togaviridae* are all sensitive to heat inactivation and/or dessication (Fauquet et al, 2005)[11].

Rotavirus haemagglutinating activity is lost rapidly at 45°C (Estes, 1996) and orbiviruses are inactivated within seconds to minutes by heating at 56°C (Monath and Guirakhoo, 1996). *Reoviridae* are not considered to be potential hazards.

Caliciviridae are described in Fauquet et al (2005) as relatively heat stable although Duizer et al (2004) were able to demonstrate a 3D reduction in both feline and canine caliciviruses following exposure to 71.3°C for 1 minute, indicating that *Caliciviridae* are likely to be inactivated by rendering and should not be considered potential hazards.

Bovine parvovirus has been demonstrated to have a marked resistance to heat. In one study (Roberts and Hart, 2000) exposure to 80°C for 72 hours was shown to bring about a 1.3D reduction in viral titre. Rendering cannot be relied upon for inactivation of bovine parvovirus and this should be considered a potential hazard.

8.2.2.3 Bacterial and other agents

Of the bacterial and other agents listed, only *Bacillus anthracis* is a spore-forming organism which is therefore more likely to survive exposure to high temperatures than the other agents listed. A review of literature published regarding the inactivation of *Bacillus anthracis* spores (Whitney et al, 2003) demonstrated that exposure of spores to a moist heat of 100°C for 10 minutes is sufficient for inactivation. Exotic bacterial and other agents should therefore not be considered potential hazards in rendered ruminant meals.

8.2.2.4 Summary

It is concluded that, given the time/temperature conditions described, prion agents associated with BSE and Scrapie, and bovine parvovirus are potential hazards which may be present in rendered ruminant material and require risk assessment.

[11] Further details of temperature sensitivity of these viruses are shown in appendix 6.

8.3 BSE AND SCRAPIE

8.3.1 Hazard identification

8.3.1.1 Aetiology

BSE and Scrapie are neurodegenerative disorders included within the group of transmissible spongiform encephalopathies (TSEs). These disorders are associated with prions, proteinaceous infectious particles that lack nucleic acids. Prions (in mammals) are composed of an abnormal pathogenic isoform of the normal cellular prion protein, PrP. This pathogenic isoform may be denoted by PrP^{Sc}. The pathogenic isoform of PrP associated with BSE is $BoPrP^{Sc}$ and the pathogenic isoform of PrP associated with Scrapie is $OvPrP^{Sc}$ (Fauquet et al, 2005).

8.3.1.2 OIE list

Both BSE and Scrapie are included in the OIE list of notifiable diseases.

8.3.1.3 New Zealand status

New Zealand is free from Scrapie and is recognised by the OIE as a country with a negligible BSE risk.

8.3.1.4 Epidemiology

Under natural circumstances, the most significant route of transmission of BSE is through feed contamination. The only common feature of all the initial cases of BSE investigated in the UK was the use of compound feed containing meat and bone meal (Wilesmith et al, 1988). This conclusion was further supported by the fact that the incidence of BSE in dairy herds was much greater than in beef suckler herds, consistent with the use of compound feeds in these two types of herd. A subsequent study of calf feeding practices and meat and bone meal inclusion in proprietary concentrates supported this finding (Wilesmith et al, 1992). It is unclear what the initial source of the BSE agent in feed was although it is likely that changes to rendering procedures in the 1970s/1980s allowed the infectious agent to survive during rendering of animal by-products into meat and bone meal and so enter cattle feed (Wilesmith et al, 1991).

To date, no evidence exists supporting the hypothesis of direct horizontal transmission of BSE. There has been a study showing some evidence for horizontal transmission up to three days after calving, but there was no evidence of transmission to the cow's own calf, (Hoinville et al, 1995). However, the results of this study are generally considered statistically insufficient to suggest that horizontal transmission was occurring.

Vertical transmission of BSE is also unlikely. Experimental transmission of BSE has been attempted using semen, seminal vesicles and prostate of bulls confirmed to have

BSE, but no infectivity was detected in these samples (Wilesmith, 1994). A revised epidemiological analysis published by Imperial College in 2002 estimated the risk of maternal transmission of BSE to be less than or equal to 1% during the last six months of the maternal incubation period (Donnelly et al, 2002).

Similarly, the nature of the agent which causes scrapie is not fully understood, and although the way in which the disease spreads is also unclear, it is well established that the scrapie agent can persist for some years in the environment and that it is relatively resistant to most disinfectants. In sheep it is suspected that a significant route of transmission of this disease is the ingestion of placental material from infected ewes at lambing.

8.3.1.5 Conclusion

Both $BoPrP^{Sc}$ and $OvPrP^{Sc}$ are potential hazards in rendered ruminant material and require risk assessment.

8.3.2 Risk assessment

8.3.2.1 Release assessment

Australia, New Zealand, Argentina, Singapore, and Uruguay are the only countries currently recognised by the OIE as having a negligible BSE risk.

Scrapie has a worldwide distribution including the United Kingdom, Ireland, several European countries, USA, Canada, India, and Japan.

Legislation is in place in many countries (e.g. EU 1774/2002) to reduce the risk of specified risk material (those parts of a carcase thought most likely to contain infectivity for either BSE or Scrapie) or carcases of animals clinically affected by either BSE or Scrapie being included in rendered ruminant meals intended for animal consumption. However, cross-contamination may occur at feed mills and both of these diseases are characterised by clinically inapparent long incubation periods.

The release assessment is considered non-negligible.

8.3.2.2 Exposure assessment

Although ruminant meals imported for use as fish food are unlikely to be used as ruminant feed, and The Biosecurity (Ruminant Protein) Regulations 1999 forbid the feeding of ruminant protein to ruminant animals, the possibility of accidental exposure of ruminants to this material cannot be excluded entirely. As the consequences of establishment of BSE or Scrapie in New Zealand would be devastating (see below), it is considered that even this low chance of exposure must be considered non-negligible.

8.3.2.3 Consequence assessment

New Zealand is free of both BSE and Scrapie and the livestock industry is heavily export oriented. We export about 95% of our dairy produce, 90% of lamb, 80% of mutton and 80% of beef. If BSE or Scrapie were to occur in this country, this is likely to have devastating consequences for these export markets as well as a marked negative effect on the national economy.

8.3.2.4 Risk estimation

As the release, exposure and consequence assessments are all considered non-negligible, the risk assessment is non-negligible and BSE and Scrapie agents are hazards in this commodity that require risk management.

8.3.3 Risk management

8.3.3.1 Risk evaluation

Since the risk estimate is non-negligible, management measures could be introduced to effectively manage the risk.

8.3.3.2 Risk management objective

The objective is to effectively manage the risk associated with the commodity.

8.3.3.3 Risk management options

As discussed above in section 8.2.2.1, thermal treatment cannot be used reliably to ensure that the agents of BSE and Scrapie are inactivated in imported ruminant meals.

To ensure ruminant meal is free of the agents of BSE and Scrapie, only material that has originated from animals in flocks and herds in countries known to be free of scrapie and recognised as having a negligible BSE risk could be considered acceptable for importation.

8.4 BOVINE PARVOVIRUS

8.4.1 Hazard identification

8.4.1.1 Aetiology

Family: Parvoviridae; Genus *Parvovirus*, bovine parvovirus

8.4.1.2 OIE list

Not listed.

8.4.1.3 New Zealand status

New Zealand status is unknown although this virus is likely to have a universal distribution.

8.4.1.4 Epidemiology

Bovine parvovirus has been isolated in the USA (Barnes et al, 1982), Canada (Sandals et al, 1995), Australia (Durham[a] et al, 1985), and Japan (Inaba et al, 1973). On three epidemically infected farms, calves became infected and seroconverted soon after birth but this was associated with a post-weaning diarrhoea on only one of these farms (Durham[a] et al, 1985). Experimental infection of calves has been associated with a mild to moderate diarrhoea (Durham[b] et al, 1985). In 29 herds in Canada, the seroprevalence was found to be 82% in cattle and herd prevalence was 100% (Sandals et al, 1995).

Reports on clinical disease associated with the virus are rare and generally the literature is dated. Even experimental infections are generally mild and antibody occurs widely in clinically normal animals. It has been stated that there is uncertainty as to the pathogenic potential of the virus in cattle and that the virus may be ubiquitous (Thomson, 2004).

8.4.1.5 Conclusion

This virus occurs commonly in healthy cattle and is likely to have little or no pathogenic significance. The occurrence of this virus in New Zealand is unknown and there have been no reported surveys to demonstrate the presence of (or seroconversion to) bovine parvovirus in this country. This virus is therefore not considered to be a hazard in this risk analysis.

9. References

Abdel Gabbar KM, Dewani P and Junejo BM (1995) Possible involvement of *Planococcus halophilus* in an outbreak of necrotic hepatitis in chickens. *Veterinary Record.* 136(3), p74.

Alley[a] MR (2002) Avian wildlife diseases in New Zealand: current issues and achievements. *New Zealand Veterinary Journal* 50(3) Supplement, pp118-20.

Alley[b] MR (2002) Pneumonia in sheep in New Zealand: an overview. *New Zealand Veterinary Journal* 50(3) Supplement, pp99-101.

Anderson C (1996) Distribution of salmonid diseases in New Zealand. *Surveillance* 23 (4), pp23-4.

Anon (1972) Case reports and disease investigations, Ministry of Agriculture and Fisheries, Animal Health Division, Animal Health Laboratories, June-July, issue 5-6.

Anon (1999) Quarterly review of diagnostic cases - January to March 1999. *Surveillance* 26(2), pp14-8.

Anon[a] (2004) *Libyostrongylus douglassii* in New Zealand ostriches. *Surveillance* 31(3), p14-6.

Anon[b] (2004) *Brucella ovis* flock accreditation scheme. *Surveillance* 31(2), p25.

Anon[a] (2005) Quarterly review of diagnostic cases - October to December 2004. *Surveillance* 32(1), pp11-5.

Anon[b] (2005) Poultry health surveillance. *Surveillance* 32(2), p27.

Barnes MA, Wright RE, Bodine AB and Alberty CF (1982) Frequency of bluetongue and bovine parvovirus infection in cattle in South Carolina dairy herds. *American Journal of Veterinary Research* 43(6), pp1078-80.

Belton D (1990) Mycoplasmas of sheep and goats in New Zealand. *Surveillance* 17(2), pp18-9.

Bishop DM and Heath ACG (1998) Checklist of ectoparasites of birds in New Zealand. *Surveillance* 20(Special Issue), pp13-31.

Black A (1997) Bacterial and parasitic diseases of New Zealand poultry. *Surveillance* 24(4), pp3-5.

Broza M and Halpern M (2001) Chironomid egg masses and *Vibrio cholerae*. *Nature* 412, p40.

Bruere SN (1982) *Trichomonas foetus* infection in a beef herd. *New Zealand Veterinary Journal* 30, pp15-6.

Buddle MB (1952) A note on penicillin treatment of experimental *Clostridium chauvoei* infection in sheep. *New Zealand Veterinary Journal* 1, pp13-4.

Calneck BW and Adldinger HK (1971) Some characteristics of cell free preparations of Marek's disease virus. *Avian Diseases* 15, pp508-7.

Carter ME, Brookbanks EO and Dickson MR (1968) Demonstration of a pseudo-cowpox virus in New Zealand. *New Zealand Veterinary Journal* 16, pp105-8.

Cellini L, DelVecchio A, DiCandia M, DiCampli E, Favaro M, and Donelli G (2004) Detection of free and plankton-associated *Helicobacter pylori* in seawater. *Journal of Applied Microbiology* 97(2), pp285-92.

Clark RG, Robinson RA, Alley MR, Nicol CM, Hathaway SC and Marchant RM (2002) Salmonella in animals in New Zealand: the past to the future. *New Zealand Veterinary Journal* 50(3) Supplement, pp57-60.

Coats LM (1998) An outbreak of *Pseudomonas* mastitis. *New Zealand Veterinary Journal* 46(1), p39.

Dietzschold B, Rupprecht CE, Fu ZF and Koprowski H (1996) Rhabdoviruses in: Fields BN, Knipe DM and Howley PM et al (eds): Fields Virology Volume 1. Lippincott-Raven, Philadelphia, p1140.

de Lisle (2002) Johne's disease in New Zealand: the past, present and a glimpse into the future. *New Zealand Veterinary Journal* 50(3) Supplement, pp53-6.

deMoraes IR, Del Mastro NL, Jakabi M and Gelli DS (2000) Radiosensitivity of *Vibrio cholerae* O1 incorporated in oysters to (60)Co. *Rev Saude Publica* 34(1), pp29-32.

Donnelly CA, Ferguson NM, Ghani AC and Anderson RM (2002) Implications of BSE infection screening data for the scale of the British BSE epidemic and current European levels. *Proceedings of the Royal Society of London* 269, pp2179-90.

Dougherty RM (1961) Heat inactivation of Rous sarcoma virus. *Virology,* 14, pp371-372

Duignan PJ and Hine PM (2003) Disease surveillance in freshwater fish from the lower North Island. *Surveillance* 30(3), pp6-8.

Duizer E, Bijkerk P, Rockx B, de Groot A, Twisk F and Koopmans M (2004) Inactivation of caliciviruses. *Applied and Environmental Microbiology* 70 (8), pp4538-43.

Durham[a] PJ, Johnson RH, Isles H, Parker RJ, Holroyd RG and Goodchild I (1985) Epidemiological studies of parvovirus infections in calves on epidemically infected properties. *Research in Veterinary Science* 38(2), pp234-40.

Durham[b] PJ, Lax A and Johnson RH (1985) Pathological and virological studies of experimental parvoviral enteritis in calves. R*esearch in Veterinary Science* 38(2), pp209-19.

Estes MK (1996) Rotaviruses and their replication. In: Fields BN, Knipe DM and Howley PM et al (eds): Fields Virology Volume 2. Lippincott-Raven, Philadelphia p1632.

Familton AF (1984) Diseases of the skin and wool of sheep. *Proceedings of the Society of Sheep and Beef Cattle Veterinarians of the New Zealand Veterinary Association* 14, pp79-91.

FAO (1986) FAO Fisheries Technical Paper 142, The production of fish meal and fish oil, 1986, http://www.fao.org/documents.

Fauquet CM, Mayo MA, Maniloff J, Desselberger U and Ball LA (2005) Virus taxonomy - eighth report of the international committee on taxonomy of viruses. Elsevier Academic Press, California.

Garcia-Ortega A, Verreth J, Van Hoornyck A and Segner H (2000) Heat treatment affects protein quality and protease activity in decapsulated cysts of *Artemia* when used as starter food for larvae of African catfish *Clarias gariepinus* (Burchell). *Aquaculture Nutrition* 6, pp25-31.

Gelb J (1989) Infectious bronchitis. In: Purchase HG et al (eds): A Laboratory manual for the isolation and identification of avian pathogens 3rd edition. Dubuque, Kendall/Hunt publishing Co, pp124-7.

Gill J (1999) Diseases of East Friesian sheep. *Surveillance* 26(2), pp6-7.

Gonzalez-Scarano F and Nathanson N (1996) Bunyarviridae in: Fields BN, Knipe DM and Howley PM et al (eds): Fields Virology Volume 1. Lippincott-Raven, Philadelphia, p1476.

Graham C (1998) *Bacillus* species and non-spore-forming anaerobes in New Zealand livestock. *Surveillance* 25(4), p19.

Grinberg A, Pomroy WE, Weston JF, Ayanegui-Alcerreca A and Knight D (2005) The occurrence of *Cryptosporidium parvum*, *Campylobacter* and *Salmonella* in newborn dairy calves in the Manawatu region of New Zealand. *New Zealand Veterinary Journal* 53(5), pp315-20.

Hartley WJ and Boyes BW (1964) Incidence of ovine perinatal mortality in New Zealand with particular reference to intra-uterine infections. *New Zealand Veterinary Journal* 12, pp33-6.

Hartley WJ and Rofe JC (2002) Neurological diseases in sheep in New Zealand. *New Zealand Veterinary Journal* 50(3) Supplement, pp91-2.

Heidelberg JF, Heidelberg KB and Colwell RR (2002) Bacteria of the subclass *Proteobacteria* associated with zooplankton in Chesapeake Bay. *Applied and Environmental Microbiology*, 68(11), pp5498-507.

Hill FI, Arthur DG and Thompson J (1993) Malignant catarrhal fever in a swamp buffalo (*Bubalus bubalis*) calf in New Zealand. *New Zealand Veterinary Journal* 41, pp35-8.

Hodges RT and Holland JTS (1980) The recovery of ureaplasmas from the semen and prepuce of bulls. *New Zealand Veterinary Journal* 28, pp89-90.

Hoinville LJ, Wilesmith JW and Richards MS (1995) An investigation of risk factors for cases of bovine spongiform encephalopathy born after the introduction of the 'feed ban'. *Veterinary Record* 136, pp312-8.

Horner GW (1988) Viral infections of the gastrointestinal tract of lambs. *Proceedings of the Society of Sheep and Beef Cattle Veterinarians of the New Zealand Veterinary Association* 18, pp70-3.

Horner G and Raynel P (1988) Serological evidence of bovine herpesvirus 2 in northern New Zealand. *New Zealand Veterinary Journal* 36, pp44-5.

Howell J, Bagust TJ and Alexander AM (1982) Serological investigations of infectious bursal disease virus and reticuloendotheliosis virus infections in New Zealand chickens. *New Zealand Veterinary Journal* 30, p128.

Howell J (1992) Viral diseases in the New Zealand poultry industry. *Surveillance* 19(2), pp15-7.

Humphrey JD (1995) Australian quarantine policies and practices for aquatic animals and their products - a review for the scientific working party on aquatic animal quarantine. Part 1: review and annexes. Bureau of Resource Sciences, Canberra.

Inaba Y, Kurogi H, Takahashi E, Sato K and Tanaka Y (1973) Isolation and properties of bovine parvovirus type I from Japanese calves . *Archiv fur die gesamte Virusforschung* 42(1), pp54-66.

Jackson CJ, Marcogliese DJ and Burt MDB (1997) Role of hyperbenthic crustaceans in the transmission of marine helminth parasites. *Canadian Journal of Fisheries and Aquatic Sciences* 54, pp815-20.

Jackwood DJ, Sommer-Wagner SE and Pharo HJ (2007) The use of gamma irradiation for the inactivation of infectious bursal disease viruses. *Avian Diseases* 51, pp606-8.

James MP, Saunders BW, Guy LA, Brookbanks EO, Charleston WAG and Uilenberg G (1984) *Theileria orientalis*, a blood parasite of cattle. First report in New Zealand. *New Zealand Veterinary Journal* 32, pp154-6.

Johnstone AC and Cork SC (1993) Diseases of aviary and native birds in New Zealand. *Surveillance* 20(3), pp35-6.

Jones-Gaddam M, Pomroy WE and Scott I (2004) Coccidiosis in calves around weaning and the use of Toltrazuril. Proceedings of the *Society of Sheep and Beef Cattle Veterinarians of the New Zealand Veterinary Association* 34, pp53-61.

Julian AF, Smits B, Clark G, Gill J, Fairley RA and Bailey K (2002) Quarterly review of diagnostic cases - July to September 2002. *Surveillance* 29(4), pp21-6.

Kelly PJ, Midwinter AC, Rolain JM and Raoult D (2005) Polymerase chain reaction (PCR) survey for rickettsias and bartonellas in ticks from New Zealand. *New Zealand Veterinary Journal* 53(6), pp468-9.

Kitamura S, Kamata S, Nakano S and Suzuki S (2003) Detection of marine birnavirus genome in zooplankton collected from the Uwa Sea, Japan. *Diseases of Aquatic Organisms* 54(1), pp69-72.

Kittelberger R, Laybourn BJ, Reichel MP, Ross GP, de Lisle GW and Joyce MA (1996) Attempted definition by immunoblotting of the causes of reactivity in suspected false-positive sera in the *Brucella ovis* complement fixation test. *New Zealand Veterinary Journal* 44, pp170-4.

Kunkle RA (2003) Aspergillosis. In: Saif YM (ed). *Diseases of Poultry. Ed 11*. pp883-95. Iowa State Press, Iowa.

LeBlanc BD and Overstreet RM (1991) Effect of desiccation, pH, heat, and ultraviolet irradiation on viability of *Baculovirus penaei*. Journal of invertebrate pathology 57, p277-86.

Livingstone P (2005) Reports from national pest management strategies – bovine tuberculosis. *Surveillance* 32(2), pp22-3.

Loveridge R and Gardner E (1993) *Campylobacter fetus venerealis* infection in cattle. *Surveillance* 20(4), pp26-7.

Lukert PD and Saif YM (2003) Infectious Bursal Disease. In: Saif YM (ed). *Diseases of Poultry. Ed 11*. p162. Iowa State Press, Iowa.

MacDiarmid SC, Durham PJK and Jones DL (1984) Survey confirms freedom from anaplasmosis. *New Zealand Veterinary Journal* 32, pp156-7.

MacKinnon MM and LeSouef DH (1956) Bovine malignant catarrhal fever in New Zealand. *New Zealand Veterinary Journal* 4, pp86-9.

Marshall RB and Manktelow (2002) Fifty years of leptospirosis research in New Zealand: a perspective. *New Zealand Veterinary Journal* 50(3) Supplement, pp61-3.

Marshall SC (1959) The isolation of *Clostridium heamolyticum* from cattle in New Zealand. *New Zealand Veterinary Journal* 7, pp115-9.

Martinovich D, Carter ME, Woodhouse DA and McCausland IP (1972) An outbreak of botulism in wild waterfowl in New Zealand. *New Zealand Veterinary Journal* 20, pp61-5.

Mason P (1976) Naturally acquired coccidian infection in lambs in Otago. *New Zealand Veterinary Journal* 25, pp30-3.

McDonald S (1999) Proceedings of the New Zealand society for parasitology inc. *New Zealand Journal of Zoology* 26, p7.

McDougall S (2005) Gross abnormalities, bacteriology and histological lesions of uteri of dairy cows failing to conceive or maintain pregnancy. *New Zealand Veterinary Journal* 53(4), pp253-6.

McDougall S and Compton C (2005) Bacteriology, cure rate and herd level risk factors for clinical mastitis in dairy herds. *Proceedings of the Society of Dairy Cattle Veterinarians of the New Zealand Veterinary Association* 22, pp17-32.

McFadden AM, Heuer C, Jackson R, West DM and Parkinson TJ (2005) Investigation of bovine venereal campylobacteriosis in beef cow herds in New Zealand. *New Zealand Veterinary Journal* 53(1), pp45-52.

McKenna PB (1998) Checklist of helminth and protozoan parasites of birds in New Zealand. *Surveillance* 20 (Special Issue), pp3-12.

Melnick JL (1996) Enteroviruses: Polioviruses, Coxsackieviruses, Echoviruses, and Newer Enteroviruses in: Fields BN, Knipe DM and Howley PM et al (eds): Fields Virology Volume 1. Lippincott-Raven, Philadelphia, p658.

Midwinter A and Fairley R (1999) Spirochaetes in New Zealand. *Surveillance* 26(3), pp10-2.

Monath TP and Guirakhoo F (1996) Orbiviruses and Coltiviruses. In: Fields BN, Knipe DM and Howley PM et al (eds): Fields Virology Volume 2. Lippincott-Raven, Philadelphia, p1737.

Monath TP and Heinz FX (1996) Flaviviruses in: Fields BN, Knipe DM and Howley PM et al (eds): Fields Virology Volume 1. Lippincott-Raven, Philadelphia, p964.

Moore BC, Martinez E, Gay JM and Rice DH (2003) Survival of *Salmonella* Enterica in freshwater sediments and transmission by the aquatic midge *Chironomus tentans* (Chironomidae: Diptera). *Applied and Environmental Microbiology* 69(8), pp4556-60.

Motha MXJ and Hansen MF (1998) Prevalence of IBR, PI 3, BRS and BCV infections in the dairy cattle population of New Zealand. *New Zealand Veterinary Journal* 46, pp239-40.

Munday BL (2002) Scientific review of significant disease agents carried by non-viable, non-salmonid freshwater and estuarine finfish and their products. Biosecurity Australia (http://www.daff.gov.au/corporate_docs/publications/word/market_access/biosecurity/animal/munday_report.doc).

Murray N (2002) Import risk analysis: Animals and animal products. New Zealand Ministry of Agriculture and Forestry, Wellington, New Zealand.

OIE (2006) Risk analysis. In: OIE (ed). *Terrestrial Animal Health Code.Chapter 2.3.8 http://www.oie.int/eng/normes/MCode/en_chapitre_2.3.8.htm*. OIE, Paris.

Orchard VA (1979) Nocardial infections of animals in New Zealand, 1976-78. *New Zealand Veterinary Journal* 27(8), pp159-60,165.

Orr MB (1995) Animal Health Laboratory Network review of diagnostic cases - July to September 1995. *Surveillance* 22(4), pp3-6.

Pearl GG (2004) Rendering 101: Raw material, rendering process, and animal by-products. *Render Magazine* (http://www.rendermagazine.com), August 2004, pp30-8.

Quality Control Unit (1997) Study report: heat inactivation of infectious bursal disease virus strain CS88. Study number CVLS/06/97, Contract number FT0517. Central Veterinary Laboratory, United Kingdom.

Quinn PJ, Carter ME, Markey B and Carter GR (1994) *Clinical Veterinary Microbiology*, Mosby International Ltd, p88.

Reichel M, Nicholas RAJ, Ross GP and Penrose ME (1999) Survey results for exotic Mycoplasma infections in cattle, goats, and sheep. *Surveillance* 26(3), pp12-3.

Ritchie BW and Carter K (1995) Avian Viruses: Function and Control, Wingers Publishing Inc, Lake Worth, Florida, p 417.

Roberts PL and Hart H (2000) Comparison of the inactivation of canine and bovine parvovirus by freeze-drying and dry-heat treatment in two high purity factor VIII concentrates. *Biologicals* 28(3), pp185-8.

Robinson AJ (1983) Prevalence of contagious pustular dermatitis (orf) in six million lambs at alsughter: a three-year study. *New Zealand Veterinary Journal* 31, pp161-3.

Saifuddin Md., Wilks CR, Christensen NH and Rice M (1989) Isolation of a reovirus from a broiler chicken flock with high early mortality. *New Zealand Veterinary Journal* 37, pp12-4.

Sandals WC, Povey RC and Meek AH (1995) Prevalence of bovine parvovirus infection in Ontario diary cattle. *Canadian Journal of Veterinary Research* 59(2), pp81-6.

Schallenberg M, Bremer PJ, Henkel S, Launhardt A and Burns CW (2005) Survival of *Campylobacter jejuni* in water: effect of grazing by the freshwater crustacean *Daphnia carinata* (Cladocera). *Applied and Environmental Microbiology* 71(9), pp 5085-8.

Schroeder BA, Kalmakoff J, Holdaway D and Todd BA (1983) The isolation of rotavirus from calves, foals, dogs and cats in New Zealand. *New Zealand Veterinary Journal* 31, pp114-6.

Serrano LE, Murano EA, Shenoy K and Olson DG (1997) D values of *Salmonella* Enteritidis isolates and quality attributes of shell eggs and liquid whole eggs treated with irradiation. *Poultry Science* 76(1), pp202-6.

Signoretto C, Burlacchini G, Pruzzo C and Canepari P (2005) Persistence of *Enterococcus faecalis* in aquatic environments via surface interactions with Copepods *Applied and Environmental Microbiology* 71(5), pp2756-61.

Singh BK, Chattopadhyay J and Sinha S (2004) The role of virus infection in a simple phytoplankton zooplankton system**.** *Journal of Theoretical Biology* 231(2), pp153-66.

Skerman TM (1983) Isolation of *Bacteroides nodosus* from hoof lesions in a farmed red deer (*Cervus elaphus*). *New Zealand Veterinary Journal* 31, pp102-3.

Smits B, Clark G, Gill JM, Varney K and Julian AF (2002) Quarterly review of diagnostic cases - April to June 2002. *Surveillance* 29(3), pp24-8.

Somerville RA (2003) In: Overview of the BSE risk assessments of the European Commission's scientific steering committee (SSC) and its TSE/BSE *ad hoc* group adopted between September 1997 and April 2003. Eds P. Vossen, J. Kreysa and M. Goll, p154. (europa.eu.int/comm/food/fs/sc/ssc/out364_en.pdf).

Staples P (2000) *Aeromonas* , *Plesiomonas* and *Vibrio* bacteria isolated from animals in New Zealand. *Surveillance* 27(1), pp3-4.

Stark JD and Winterbourn MJ (2006) Guide to the Aquatic Insects of New Zealand, 4th Edition, *Bulletin of the Entomological Society of New Zealand* 14, p76.

Stone M (2005) Quarterly report of investigations of suspected exotic diseases. *Surveillance* 32(4), pp20-3.

Supamattaya K, Hoffmann RW, Boonyaratpalin S and Kanchanaphum P (1998) Experimental transmission of white spot syndrome virus (WSSV) from black tiger shrimp *Penaeus monodon* to the sand crab *Portunus pelagicus*, mud crab *Scylla serrata* and krill *Acetes sp*. *Diseases of Aquatic Organisms* 32(2), pp79-85.

Sutton RH (1970) *Eperythrozoon ovis* – a blood parasite of sheep. *New Zealand Veterinary Journal* 18(8), pp156-64.

Sutton RH, Charleston WAG and Collins GH (1977) *Eperythrozoon wenyoni* – a blood parasite of cattle. A first report in New Zealand. *New Zealand Veterinary Journal* 25(1-2), pp8-9.

Swayne DE and Beck JR (2004) Heat inactivation of avian influenza and Newcastle disease viruses in egg products. *Avian Pathology*, 33, pp512-8.

Thobokwe G, Heuer C and Hayes DP (2004) Validation of a bulk tank antibody ELISA to detect dairy herds likely infected with bovine viral diarrhoea virus in New Zealand. *New Zealand Veterinary Journal* 52(6), pp394-400.

Thompson J (1999) Important infectious diseases of cats in New Zealand. *Surveillance* 26(2), pp3-5.

Thompson K (2001) Infectious diseases of goats in New Zealand. *Surveillance* 28(2), pp3-7.

Thomson GR (2004) Bovine parvovirus infection. In: Coetzer JAW and Tustin RC (eds). *Infectious Diseases of Livestock* pp 815-6. Oxford University Press, Oxford.

Thornton RN, Thompson EJ and Dubey JP (1991) *Neospora* abortion in New Zealand cattle. *New Zealand Veterinary Journal* 39(4), pp129-33.

Treece GD (2000) *Artemia* production for marine larval fish culture. *Southern Regional Aquaculture Center*, Publication Number 702.

Vandamme P, Vancanneyt M, Segers P, Ryll M., Kohler B, Ludwig W and Hinz KH (1999) *Coenonia anatina* gen. *nov.*, sp. *nov.*, a novel bacterium associated with respiratory disease in ducks and geese. *International Journal of Systemic Bacteriology* 49, pp867-74.

Varney[a] K (2004) Quarterly review of diagnostic cases - July to September 2004. *Surveillance* 31(4), pp31-4.

Varney[b] K (2004) Quarterly review of diagnostic cases - April to June 2004. *Surveillance* 31(3), pp21-5.

Varney[a] K (2005) Quarterly review of diagnostic cases – July to Sept 2005. *Surveillance* 32(4), pp14-9.

Varney[b] K (2005) Quarterly review of diagnostic cases - October to December 2004. *Surveillance* 32(1), pp11-4.

Varney K and Gibson I (2006) Quarterly review of diagnostic cases – October to December 2005. *Surveillance* 33(1), pp11-6.

Vermunt JJ and Parkinson TJ (2000) Infectious diseases of cattle in New Zealand - Part 2 - adult animals. *Surveillance* 27(3), pp3-9.

Vickers M (1988) Cryptosporidiosis in New Zealand. *Surveillance* 15(1), p19.

Voges H (2005) Reports from industry surveillance and disease control programmes – enzootic bovine leucosis eradication scheme. *Surveillance* 32(2), pp24-5.

Vogt PK (1965) Avian tumor viruses. *Advances in Virus Research*, 11, pp293-385

Wallace GC (1962) Immunization of lambs against pulpy kidney and tetanus. *New Zealand Veterinary Journal* 10, pp59-60.

West DM (2002) Ovine abortion in New Zealand. *New Zealand Veterinary Journal* 50 (3) Supplement, pp93-5.

Whipple, M.J. and Rohovec, J.S. (1994) The effect of heat and low pH on selected viral and bacterial fish pathogens. *Aquaculture* 123, pp179-89.

Whitney EAS, Beatty ME, Taylor TH, Weyant R, Sobel J, Arduino MJ and Ashford DA (2003) Inactivation of *Bacillus anthracis* spores. *Emerging Infectious Diseases*, 9(6), pp623-7.

WHO (1997) High-dose irradiation: wholesomeness of food irradiated with doses above 10 KGy, a joint FAO/IAEA/WHO study group. Geneva, Switzerland, 15-20 September 1997. http://www.who.int/entity/foodsafety/publications/fs_management/en/irrad.pdf.

Wilesmith JW, Wells GA, Cranwell MP and Ryan JB (1988**)** Bovine spongiform encephalopathy: epidemiological studies. *Veterinary Record* 123, pp638-44.

Wilesmith JW, Ryan JB and Atkinson MJ (1991) Bovine spongiform encephalopathy: epidemiological studies on the origin. *Veterinary Record* 128, pp199-203.

Wilesmith JW, Ryan JB and Hueston WD (1992) Bovine spongiform encephalopathy: case-control studies of calf feeding practices and meat and bonemeal inclusion in proprietary concentrates. *Research in Veterinary Science* 52, pp325-31.

Wilesmith JW (1994) Bovine spongiform encephalopathy and related diseases: an epidemiological overview. *New Zealand Veterinary Journal* 42, pp1-8.

Wilson PR (2002) Bacterial infections reported in New Zealand farmed deer. *Surveillance* 29(3), pp13-6.

APPENDIX 1: PRELIMINARY HAZARD LIST (RENDERED POULTRY PRODUCTS)

Disease	Agent (hazard)	OIE notifiable	NZ status
Viral diseases			
Angara disease, quail bronchitis and other group I avian adenovirus infections	Group I avian adenoviruses (*Aviadenoviridae*)	No	Exotic
Avian adenovirus splenomegaly	Group II avian adenoviruses (*Siadenoviruses)*	No	Exotic
Avian encephalomyelitis	unassigned (*Picornaviridae*)	No	Present
Avian enteroviruslike viruses	*Picornaviridae*	No	Exotic
Avian influenza	Influenzavirus A (*Orthomyxoviridae*)	Yes	Exotic
Avian leukosis/sarcoma	Alpharetrovirus (*Retroviridae*)	No	Exotic strains
Avian nephritis types 1-3	unassigned (*Picornaviridae*)	No	Present
Avian paramyxovirus types 2 & 3	Rubulavirus (*Paramyxoviridae*)	No	Exotic
Avian pox virus	*Poxviridae*	No	Present
Big liver and spleen disease	Viral aetiology (not classified further)	No	Exotic
Chicken infectious anaemia	Gyrovirus (*Circoviridae*)	No	Present
Derzsy's disease (goose parvovirus infection)	Parvovirus (*Parvoviridae*)	No	Exotic
Duck hepatitis types 1 & 3	Unassigned (*Picornaviridae*)	Yes	Exotic
Duck hepatitis type 2	Astrovirus (*Astroviridae*)	Yes	Exotic
Duck viral enteritis (duck plague)	unassigned (*Herpesviridae*)	No	Exotic
Eastern equine encephalitis	Arbovirus (*Togaviridae*)	Yes	Exotic
Egg drop syndrome 76	Group III avian adenoviruses (Atadenoviruses)	No	Present
Goose herpesvirus	unassigned (*Herpesviridae*)	No	Exotic
Haemorrhagic enteritis	Group II avian adenoviruses (*Siadenoviruses)*	No	Exotic
Haemorrhagic nephritis enteritis of geese	Goose haemorrhagic polyomavirus (*Polyomaviridae*)	No	Exotic
Highlands J virus infection	Arbovirus (*Togaviridae*)	No	Exotic
Infectious bronchitis	Coronavirus (*Coronaviridae*)	Yes	Exotic strains
Infectious bursal disease	Avibirnavirus (*Birnaviridae*)	Yes	Exotic
Infectious laryngotracheitis	Herpes virus	Yes	Present
Israel turkey meningoencephalitis	Arbovirus (*Flaviviridae*)	No	Exotic
Marble spleen disease	Group II avian adenoviruses (*Siadenoviruses)*	No	Exotic
Marek's disease	*Herpesviridae*	Yes	Exotic strains
Muskovy duck reovirus	*Reoviridae*	No	Exotic
Newcastle disease, APMV-1	Rubulavirus (*Paramyxoviridae*)	Yes	Exotic
Poult enteritis and mortality syndrome	*Astroviridae*?	No	Exotic?
Reticuloendotheliosis	Gammaretrovirus (*Retroviridae*)	No	Present
Rotavirus infection	Rotavirus (*Reoviridae*)	No	Present
Turkey coronavirus enteritis	Coronavirus (*Coronaviridae*)	No	Exotic?
Turkey rhinotracheitis, swollen head syndrome and avian rhinotracheitis	Avian pneumovirus (*Paramyxoviridae*)	Yes	Exotic
Turkey torovirus infection	Torovirus (*Coronaviridae*)	No	Exotic?

APPENDIX 1 (CONTINUED)

Disease	Agent (hazard)	OIE notifiable	NZ status
Viral diseases (cont)			
Turkey viral hepatitis	Unidentified (*Picornaviridae*)	No	Exotic
Viral proventriculitis	Undetermined viral agent	No	Exotic?
Viral arthritis	Unassigned (*Reoviridae*)	No	Present
West Nile virus	Arbovirus (*Flaviviridae*)	Yes	Exotic
Other diseases			
Acholeplasmosis	*A. laidlawii*	No	Present
Arizonosis	*Salmonella arizonae* serovar $18Z_4Z_{32}$	No	Exotic
Aspergillosis	*Aspergillus* spp.	No	Present
Avian spirochaetosis	*Borrelia anserine*	No	Exotic
Avian tuberculosis	*Mycobacterium avium intracellulare*	No	Exotic strains
Bordetellosis (turkey coryza)	*Bordetella avium*	No	Exotic
Botulism	*Clostridium botulinum* and preformed exotoxin	No	Present
Campylobacteriosis	*Campylobacter jejuni* and others	No	Exotic strains
Candidiasis	*Candida* spp.	No	Present
Coccidiosis	*Eimeria* spp.	No	Present
Colibacillosis	*Escherichia coli* 0111, 0157:H7 and others	No	Exotic strains
Cryptosporidiosis	*Cryptosporidium* spp.	No	Present
Dactylariosis	*Dactylaria gallopava*	No	Present
Dermatophytosis	*Microsporum gallinae*	No	Exotic
Duck septicaemia	*Riemerella anatipestifer*	No	Exotic
Enterococcosis	*Enterococcus* spp.	No	Present
Erysipelas	*Erysipelothrix* spp.	No	Present
Fowl cholera	*Pasteurella multocida*	Yes	Exotic
Fowl typhoid	*Salmonella* Gallinarum	Yes	Exotic
Gangrenous dermatitis	*Clostridium septicum, Clostridium perfringens* and *Staphylococcus aureus*.	No	Present
Hexamitiasis	*Hexamita meleagridis*	No	Present
Histomoniasis (Blackhead)	*Histomonas meleagridis*	No	Present
Infectious coryza	*Haemophilus paragallinarum*	No	Exotic
Miscellaneous bacterial diseases	*Acinetobacter* spp.	No	Present
	Actinobacillus spp.	No	Present
	Arcanobacterium pyogenes	No	Present
	Aegyptianella spp.	No	Exotic
	Aeromonas spp.	No	Present
	Arcobacter spp.	No	Present
	Bacillus spp.	Yes	Exotic
	Bacteroides spp.	No	Present
	Borrelia spp.	No	Exotic
	Brucella spp.	Yes	Exotic
	Citrobacter spp.	No	Present
	Coenonia anatine	No	Exotic

APPENDIX 1 (CONTINUED)

Disease	Agent (hazard)	OIE notifiable	NZ status
Other diseases (cont)			
Miscellaneous bacterial diseases (continued)	*Coxiella burnetii*	Yes	Exotic
	Enterobacter spp.	No	Present
	Flavobacterium spp.	No	Present
	Francisella tularensis	No	Exotic
	Helicobacter spp.	No	Present
	Klebsiella spp.	No	Present
	Lactococcus spp.	No	Present
	Lawsonia intracellularis	No	Present
	Listeria monocytogenes	No	Present
	Megabacteria	No	Present
	Moraxella spp.	No	Present
	Mycobacterium avium subsp *paratuberculosis*	Yes	Exotic strains
	Neisseria spp.	No	Present
	Nocardia spp.	No	Present
	Peptostreptococcus spp.	No	Present
	Planococcus spp.	No	Exotic
	Plesiomonas spp.	No	Present
	Proteus spp.	No	Present
	Pseudomonas aeruginosa	No	Present
	Rothia spp.	No	Present
	Vibrio spp.	No	Present
Mycoplasmosis	*Mycoplasma gallisepticum*	Yes	Present
	M. meleagridis	No	Exotic
	M. synoviae	Yes	Present
	M. iowae	No	Exotic
	M. anseris	No	Exotic?
	M. cloacale	No	Exotic?
	M. gallinaceum	No	Exotic?
	M. gallinarum	No	Exotic?
	M. imitans	No	Exotic?
	M. pullorum	No	Exotic?
Necrotic enteritis	*Clostridium perfringens, Clostridium difficile.*	No	Present
Ornithobacteriosis	*Ornithobacterium rhinotracheale*	No	Exotic
Paratyphoid salmonellae	*Salmonella* Enteritidis, *Salmonella* Typhimurium and others	No	Exotic
Psittacosis	*Chlamydophila psittaci*	Yes	Exotic strains
Pullorum disease	*Salmonella* Pullorum	Yes	Exotic
Sarcocystosis	*Sarcocystis* spp.	No	Present
Staphylococcosis	*Staphylococcus* spp.	No	Present
Streptococcosis	*Streptococcus* spp.	No	Present
Toxoplasmosis	*Toxoplasma gondii*	No	Present
Trichmoniasis	Trichomonas gallinae	No	Present
Ulcerative enteritis (quail disease)	*Clostridium colinum*	No	Present

APPENDIX 2: MISCELLANEOUS BACTERIA ASSOCIATED WITH POULTRY DISEASE - PRESENCE IN NEW ZEALAND.

Organism	In NZ?	Reference
Acinetobacter spp.	Yes	Varney[a] 2005
Actinobacillus spp.	Yes	Wilson 2002
Arcanobacterium pyogenes	Yes	Varney[a] 2004
Aeromonas spp.	Yes	Julian et al 2002
Arcobacter spp.	Yes	McFadden et al 2005
Bacteroides spp.	Yes	McDougall 2005
Borrelia spp.	No	Midwinter and Fairley 1999
Citrobacter spp.	Yes	Julian et al 2002
Coenonia anatine	No	Vandamme et al 1999
Enterobacter spp.	Yes	Thompson 1999
Flavobacterium spp.	Yes	Ubiquitous – Quinn et al 1994
Helicobacter spp.	Yes	Varney and Gibson 2006
Klebsiella spp.	Yes	Varney[b] 2004
Lactococcus spp.	Yes	Stone 2005
Lawsonia intracellularis	Yes	Smits et al 2002
Listeria monocytogenes	Yes	Varney[a] 2005
Megabacteria	Yes	Varney[b] 2005
Moraxella spp.	Yes	Vermunt and Parkinson 2000
Neisseria spp.	Yes	Alley[b] 2002
Nocardia spp.	Yes	Orchard 1979
Peptostreptococcus spp.	Yes	Graham 1998
Planococcus spp.	No	Abdel et al 1995
Plesiomonas spp.	Yes	Staples 2000
Proteus spp.	Yes	Orr 1995
Pseudomonas aeruginosa	Yes	Coats 1998
Rothia spp.	Yes	Thompson 1999
Vibrio spp.	Yes	Staples 2000

APPENDIX 3: TIME/TEMPERATURE COMBINATIONS REQUIRED TO ACHIEVE >4D REDUCTION IN IBDV USING THE MAF CS88 PREDICTIVE MODEL

Temperature (°C)	Time (minutes)
80	1364
85	500
90	184
95	68
100	25
105	10
110	4
115	2
120	1

APPENDIX 4: PRELIMINARY HAZARD LIST (FISH MEAL AND FISH OIL)

Disease	Agent (hazard)	OIE notifiable	NZ status
Viral diseases			
Carp pox	CHV (*Herpesviridae*)	No	Exotic?
Channel catfish virus disease	CCV (*Herpesviridae*)	No	Exotic
Epizootic haematopoietic necrosis	*Iridoviridae*	Yes	Exotic
Golden shiner virus disease	GSV (Aquareovirus - *Reoviridae*)	No	Exotic?
Grass carp haemorrhagic disease	GCRV (*Reoviridae*)	No	Exotic?
Infectious haematopoietic necrosis	IHNV (*Rhabdoviridae*)	Yes	Exotic
Infectious pancreatic necrosis	IPNV (*Birnaviridae*)	Yes	Exotic
Dab ascites	Related *Birnaviridae*	No	Exotic?
Eel nephritis			
Eel stomatopapilloma			
Japanese flounder ascites			
Kumura shrimp disease			
Milkfish ulcer disease			
Seabass nephritis			
Spinning disease of menhaden			
Striped bass mortality			
Talbot haemopoietic necrosis			
Yellowtail ascites disease			
Infectious salmon anaemia	ISAV (*Orthomyxoviridae*)	Yes	Exotic
Oncorhynchus masou virus disease	OMV (*Herpesviridae*)	No	Exotic
Pancreas disease	SPDV (*Togaviridae*)	No	Exotic
Pike fry rhabdovirus disease	Pike Fry Rhabdovirus	No	Exotic
Red sea bream iridoviral disease	*Iridoviridae*	Yes	Exotic?
Spring viraemia of carp	SVCV (*Rhabdoviridae*)	Yes	Exotic
Viral encephalopathy and retinopathy	*Nodaviridae* (formerly barramundi picorna-like virus/striped jack nervous necrosis virus)	No	Exotic
Viral erythrocytic necrosis	ENV (*Iridoviridae*)	No	Exotic
Viral haemorrhagic septicaemia	VHSV (*Rhabdoviridae*)	Yes	Exotic
White sturgeon iridoviral disease	*Iridoviridae*	No	Exotic?
Other diseases			
Atypical lactobacillus disease	*Carnobacterium piscicola* *Vagococcus salmoninarum*	No	Exotic?
Bacterial gill disease	*Flavobacterium branchophilum*	No	Exotic?
Bacterial kidney disease	*Renibacterium salmonarium*	Yes	Exotic
Cold-water disease	*Flavobacterium psychrophilum*	No	Exotic?
Columnaris disease	*Flavobacterium columnare*	No	Exotic?
Dermocystidiosis	*Dermocystidium* spp.	No	Exotic?
Enteric bacterial diseases	*Proteus* spp. *Serratia* spp. *Citrobacter freundii* *Enterobacter agglomerans*	No	Present?

APPENDIX 4 (CONTINUED)

Disease	Agent (hazard)	OIE notifiable	NZ status
Other diseases (cont)			
Enteric redmouth disease	*Yersinia ruckeri*	No	Exotic
Enterococcosis	*Enterococcus seriolicida*	No	Exotic?
Enteric septicaemia of catfish	*Edwardsiella ictaluri*	No	Exotic
Epitheliocystis	*Chlamydophila*-like organisms	No	Exotic?
Epizootic ulcerative syndrome	*Ahpanomyces invadans*	Yes	Exotic?
Fish gangrene	*Edwardsiella tarda*	No	Exotic?
Emphysematous putrefactive disease of catfish Red disease of eels			
Furunculosis	*Aeromonas salmonicida*	No	Exotic
Ichthyophoniasis	*Ichthyophonus hoferi*	Yes	Exotic?
Marine columnaris	*Flexibacter* sp.	No	Present
Mycobacteriosis	*Mycobacterium* spp.	No	Present?
Nocardiosis	*Nocardia* spp.	No	Present
Other oomycete fungal infections	*Saprolegnia* spp. *Achlya* spp. *Aphanomyces* spp.	No	Exotic?
Piscirickettsiosis	*Piscirickettsia salmonis* (and other rickettsia-like organisms)	No	Exotic
Pseudotuberculosis or Fish Pasteurellosis	*Photobacterium damsela* subsp. *Piscicida*	No	Exotic?
Red fin disease	*Aeromonas hydrophila*	No	Exotic?
'Sekiten-byo' or Red-spot disease of Japanese eels	*Pseudomonas anguilliseptica*	No	Exotic?
Streptococcosis	*Streptococcus iniae*	No	Exotic?
Vibriosis	*Vibrio* spp.	No	*V. salmonicida* and *V. anguillaum* exotic
Whirling disease	*Myxobolus cerebralis*	No	Exotic
Further diseases/hazards specific to shellfish			
Tellina virus	*Birnaviridae*	No	Exotic?
Paralysis virus	*Reoviridae*	No	Exotic?
Baculovirus penaei	*Baculoviridae*	Yes	Exotic
Penaeus monodon type baculovirus		Yes	Exotic
Plebejus baculovirus		No	Exotic?
Baculovirus midgut-gland necrosis		No	Exotic?
Tau baculovirus		No	Exotic?
Tau 2		No	Exotic?
Infectious hypodermal and haematopoietic necrosis or runt-deforming syndrome	*Parvoviridae*	Yes	Exotic
Hepatopancreatic parvo-like virus		No	Exotic?
Spawner-isolated mortality virus		No	Exotic?
Chesapeake Bay virus	*Picornaviridae*	No	Exotic?

APPENDIX 4 (CONTINUED)

Disease	Agent (hazard)	OIE notifiable	NZ status
Further diseases/hazards specific to shellfish (cont)			
Taura syndrome	Picorna-like virus (*Dicistroviridae*)	Yes	Exotic
Yellow-head disease	Corona-like virus	Yes	Exotic
Gill-associated virus disease	(Okavirus – *Ronaviridae*)	No	Exotic?
Rhabdovirus A	*Rhabdoviridae*	No	Exotic?
Rhabdovirus B		No	Exotic?
Crab haemocytopenic virus	*Bunyaviridae*	No	Exotic?
White spot disease	Whispovirus (*Nimaviridae*)	No	Exotic
Necrotising hepatopancreatitis	Alpha-proteobacterium	No	Exotic?
Crayfish plague	*Aphanomyces astaci*	Yes	Exotic
Other fungal infections of shellfish	Misc. fungal species	No	Exotic?

Key: "Present?" and "Exotic?" indicate that literature specifically describing the presence or absence of the organism/disease in New Zealand could not be found. "Present?" indicates that the balance of probabilities suggests that the organism is likely to be present in this country, and 'Exotic?' indicates that the organism is unlikely to be present in New Zealand.

APPENDIX 5: PRELIMINARY HAZARD LIST (RUMINANT MEALS)

Disease	Agent (hazard)	OIE notifiable	NZ status
Spongiform encephalopathies			
Bovine spongiform encephalopathy	Prion agent	Yes	Exotic
Scrapie	Prion agent	Yes	Exotic
Viral diseases			
Akabane disease	Orthobunyavirus (*Bunyaviridae*)	No	Exotic
Aujeszky's disease	Varicellovirus (*Herpesviridae*)	Yes	Exotic
Adenoviral disease	Atadenovirus and Mastadenovirus (*Adenoviridae*)	No	Present
Bluetongue	Orbivirus (*Reoviridae*)	Yes	Exotic
Borna disease	Bornavirus (*Bornaviridae*)	No	Exotic
Bovine calicivirus disease	Vesivirus (*Caliciviridae*)	No	Unknown
Border disease	Pestivirus (*Flaviviridae*)	No	Present
Bovine parainfluenza	Respirovirus (*Paramyxoviridae*)	No	Present
Bovine parvovirus disease	Bocavirus (*Parvoviridae*)	No	Unknown
Bovine papular stomatitis	Parapoxvirus (*Poxviridae*)	No	Present
Bovine respiratory syncitial virus	Pneumovirus (*Paramyxoviridae*)	No	Present
Bovine rhinovirus disease	Rhinovirus (*Picornaviridae*)	No	Unknown
Bovine ulcerative mammillitis	Simplexvirus (*Herpesviridae*)	No	Present
Bovine viral diarrhoea/mucosal disease	Pestivirus (*Flaviviridae*)	Yes	Type 1 present Type 2 exotic
Caprine arthritis encephalitis	Lentivirus (*Retroviridae*)	Yes	Present
Contagious ecthyma / orf	Parapoxvirus (*Poxviridae*)	No	Present
Coronaviral disease	Coronavirus (*Coronaviridae*)	No	Present (cattle) Exotic (ovine)
Cowpox	Orthopoxvirus (*Poxviridae*)	No	Exotic
Crimean Congo haemorrhagic fever	Nairovirus (*Bunyaviridae*)	Yes	Exotic
Enzootic bovine leucosis	Deltaretrovirus (*Retroviridae*)	Yes	Present but eradication scheme in place
Ephemeral fever	Ephemerovirus (*Rhabdoviridae*)	No	Exotic

APPENDIX 5 (CONTINUED)

Disease	Agent (hazard)	OIE notifiable	NZ status
Viral diseases (cont)			
Foot and mouth disease	Aphthovirus (*Picornaviridae*)	Yes	Exotic
Goatpox	Capripoxvirus (*Poxviridae*)	Yes	Exotic
Infectious bovine rhinotracheitis / infectious pustular vulvovagintis	Varicellovirus (*Herpesviridae*)	Yes	BHV – 1.2b present BHV – 2 present BHV – 1.1, 1.2a and 5 exotic
Ibaraki disease	Orbivirus (*Reoviridae*)	No	Exotic
Jembrana disease	Lentivirus (*Retroviridae*)	No	Exotic
Louping ill	Flavivirus (*Flaviviridae*)	No	Exotic
Lumpy skin disease	Capripoxvirus (*Poxviridae*)	Yes	Exotic
Maedi visna	Lentivirus (*Retroviridae*)	Yes	Exotic
Malignant catarrhal fever	Rhadinovirus (*Herpesviridae*)	Yes	Present
Nairobi sheep disease	Nairovirus (*Bunyaviridae*)	Yes	Exotic
Palyam virus group diseases	Orbivirus (*Reoviridae*)	No	Exotic
Peste des petits ruminants	Morbillivirus (*Paramyxoviridae*)	Yes	Exotic
Progressive pneumonia	Lentivirus (*Retroviridae*)	Yes	Exotic
Pseudocowpox	Parapoxvirus (*Poxviridae*)	No	Present
Pulmonary adenomatosis / jaagsiekte	Lentivirus (*Retroviridae*)	No	Exotic
Rabies	Lyssavirus (*Rhabdoviridae*)	Yes	Exotic
Rhinderpest	Morbillivirus (*Paramyxoviridae*)	Yes	Exotic
Rift Valley fever	Phlebovirus (*Bunyaviridae*)	Yes	Exotic
Ross River disease	Alphavirus (*Togaviridae*)	No	Exotic
Rotaviral disease	Rotavirus (*Reoviridae*)	No	Present
Sheeppox	Capripoxvirus (*Poxviridae*)	Yes	Exotic
Tick borne encephalitis	Flavivirus (*Flaviviridae*)	No	Exotic
Vesicular stomatitis	Vesiculovirus (*Rhabdoviridae*)	Yes	Exotic
Wesselbron disease	Flavivirus (*Flaviviridae*)	No	Exotic
West Nile disease	Flavivirus (*Flaviviridae*)	Yes	Exotic

APPENDIX 5(CONTINUED)

Disease	Agent (hazard)	OIE notifiable	NZ status
Other diseases			
Actinobacillosis	*Actinobacillus lignieresii*	No	Present
Actinomycosis	*Actinomyces bovis*	No	Exotic
Anthrax	*Bacillus anthracis*	Yes	Exotic
Anaplasmosis	*Anaplasma* spp. *A. centrale* *A. marginale*	Yes	Exotic
Aspergillosis	*Aspergillus* spp. *A. fumigatus*	No	Present
Babesiosis	*Babesia bovis* *B. bigemina* *B. divergens* *B. microti* *B. ovata* *B. jakimovi* *B. motasi* *B. ovis*	Yes	Exotic
Benign and virulent foot rot	*Fusobacterium necrophorum* *Bacteroides nodosus*	No	Present
Besnoitiosis	*Besnoitia besnoiti*	No	Exotic
Bovine petechial fever / Ondiri disease	*Ehrlichia ondiri*	No	Exotic
Brucellosis	*Brucella abortus* *B. melitensis*	Yes	Exotic
Campylobacteriosis	*Campylobacter jejuni* *C. fetus* subsp. *fetus* *C. fetus* subsp. *Venerealis*	Yes (*C. venerealis* only)	Present
Candidiasis	*Candida* spp.	No	Present
Caseous lymphadenitis	*Corynebacterium pseudotuberculosis (ovis)*		Present
Chronomycosis	Fungi of the family Dermateaceae	No	Present
Coccidioidomycosis	*Coccidioides immitis*	No	Exotic
Coccidiosis	*Eimeria* spp.	No	Present
Colisepticaemia	Enterotoxigenic *E. coli*	No	Present
Contagious agalactia, contagious bovine pleuropneumonia and contagious caprine pleuropneumonia	*Mycoplasma agalactiae* *M. mycoides* subsp. *mycoides SC* *M. mycoides* subsp. *mycoides LC* *M. capricolum* subsp. *Capricolum*	Yes	Exotic
Clostridial diseases	*Clostridium novyi* *C. haemolyticum* *C. chauvoei* *C. perfringens* *C. septicum* *C. botulinum* *C. tetani* *C. welchii*	No	Present

APPENDIX 5 (CONTINUED)

Disease	*Agent (hazard)*	OIE notifiable	NZ status
Other diseases (cont)			
Cowdriosis (heartwater)	*Cowdria ruminatium*	Yes	Exotic
Cryptosporidiosis	*Cryptosporidium* spp.	No	Present
Dermatophilosis	*Dermatophilus congolensis*	No	Present
Dermatophytosis	*Trichophyton* spp. *T. verrucosum*	No	Present
Eperythrozoonosis	*Eperythrozoon* spp.	No	Present
Epizootic bovine abortion	Aetiology unknown (poss. Deltaproteobacterium)	No	Exotic
Erysipelas	*Erysipelothrix rhusiopathiae*	No	Present
Geotrichosis	*Geotrichum candidum*	No	Present
Haemophilosis	*Haemophilus somnus*	No	Present
Interdigital dermatitis	*Fusobacterium necrophorum* *Corynebacterium pyogenes*	No	Present
Leptospirosis	*Leptospira hardjo* *L. pomona* *L. grippotyphosa* *L. canicola* *L. icterohaemorrhagiae*	Yes	Exotic serovars
Listeriosis	*Listeria monocytogenes*	No	Present
Lyme disease	*Borrelia burgdorferi*	No	Exotic
Mastitis (organisms not listed elsewhere in table)	*Streptococcus uberis* *S. agalactiae* *S. dysgalactiae* *Staphylococcus aureus* *Escherichia coli* *Klebsiella* spp. *Pseudomonas aeruginosa* *Corynebacterium pyogenes*	No	Present
Necrobacillosis	*Fusobacterium necrophorum*	No	Present
Neosporosis	*Neospora caninum*	No	Present
Nocardiosis	*Nocardia asteroides*	No	Present
Other mycoplasma infections	*Mycoplasma* spp. *M. bovis*	No	*M.bovis* exotic
Ovine epididymitis	*Brucella ovis*	Yes	Present
Paratuberculosis/ Johnes disease	*Mycobacterium avium* subsp. *Paratuberculosis*	Yes	Present
Pasteurellosis	*Pasteurella multocida* *P. haemolytica*	*P. multocida* serotypes 6:B and 6:E notifiable: Haemorrhagic septicaemia	Present (notifiable serotypes exotic)
Q fever	*Coxiella burnetti*	Yes	Exotic
Rhinosporidiosis	*Rhinosporidium seeberi*	No	Exotic

APPENDIX 5 (CONTINUED)

Disease	Agent (hazard)	OIE notifiable	NZ status
Other diseases (cont)			
Salmonellosis	*Salmonella* spp.	(*S*.Abortus ovis – Yes)	Exotic or unwanted strains: *S*. Abortus ovis *S*. Arizonae *S*. Dublin *S*. Enteritidis *S*. Typhimurium pt44 *S*. Typhimurium pt104 Exotic *Salmonella* Spp.
Sporadic bovine encephalomyelitis, enzootic abortion, chlamydial polyarthritis / serositis	*Chlamydophila* spp.	Yes	Exotic
Theileriosis	*Theileria* spp. *T. parva* *T. annulata*	Yes	Exotic (non-pathogenic strain recognised)
Tick-borne fever	*Ehrlichia phagocytophilia*	No	Exotic
Toxoplasmosis	*Toxoplasma gondii*	No	Present
Trichomoniasis	*Trichomonas foetus*	Yes	Present
Trypanosomiasis	*Trypanosoma vivax* *T. congolense* *T. brucei*	Yes	Exotic
Tuberculosis	*Mycobacterium bovis*	Yes	Present under official control
Tularaemia	*Francisella tularensis*	Yes	Exotic
Ulcerative posthitis and vulvitis (pizzle rot); bovine cystitis and pyelonephritis	*Corynebacterium renale*	No	Present
Ureaplasmosis	*Ureaplasma* spp.	No	Present (cattle)
Yersiniosis	*Yersinia enterocolitica*	No	Present

APPENDIX 6: FURTHER INFORMATION REGARDING THERMAL INACTIVATION OF SELECTED VIRAL PATHOGENS.

Virus family	Thermal Sensitivity	Reference
Baculoviridae	Inactivated by 60°C for 10 minutes.	LeBlanc and Overstreet (1991)
Bornaviridae	Virus infectivity is rapidly lost by heat treatment at 56°C.	Fauquet et al (2005)
Bunyaviridae	Bunyaviridae are sensitive to 56°C.	Gonzalez-Scarano and Nathanson (1996)
Coronaviridae	Inactivated by 50°C for 15 minutes.	Gelb (1989) cited by Ritchie and Carter (1995)
Flaviviridae	At 50°C, 50% of infectivity is lost in 10 minutes. Total inactivation occurs within 30 minutes at 56°C.	Monath and Heinz (1996)
Herpesviridae	Inactivation follows exposure to 56°C for 30 minutes or 60°C for 10 minutes.	Calneck and Adldinger (1971)
Orthomyxoviridae	LPAI had a D-value of <20 seconds in homogenized whole egg at 61°C. HPAI had a D-value of <19 seconds in homogenized whole egg at 61°C.	Swayne and Beck (2004)
Paramyxoviridae	Newcastle Disease has D-values of <18 to <20 seconds in homogenized whole egg at 61°C.	Swayne and Beck (2004)
Picronaviridae	Rapid destruction following exposure to 50°C.	Melnick (1996)
Poxviridae	Sensitive to temperatures greater than 40°C.	Fauquet et al (2005)
Retroviridae	Half life at 37°C varying from 100 minutes to 540 minutes (average around 260 minutes). Avian retroviruses have been shown to be rapidly inactivated at high temperatures, with the Rous sarcoma virus having a half-life of 8.5 minutes at 50°C and 0.7 minutes at 60°C.	Vogt (1965) and Dougherty (1961)
Rhabdoviridae	Rapidly inactivated at 50°C.	Dietzschold et al (1996)
Togaviridae	Half-life at 37°C of 1 to 2 hours and a half-life at 58°C of 5-20 minutes.	Fauquet et al (2005)