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Report of the Working Group on Pathology and Diseases of Marine Organisms (WGPDMO)

13–17 February 2018

Riga, Latvia

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Contents

Executive summary

The Working Group on Pathology and Diseases of Marine Organisms (WGPDMO) met on 13–17 February 2018 at the University of Agriculture, Riga, Latvia. The meeting was chaired by Ryan Carnegie, USA, and attended by eleven participants, representing eleven ICES member countries.

The agenda included several topics related to diseases and pathology in wild and farmed fish and shellfish. The group produced a report on new disease trends in the ICES area based on national reports from fifteen member countries. Notable reports for wild fish included observations of salmonid alphavirus SAV6 and *Photobacterium damsellae* in ballan wrasse, underscoring the need for disease surveillance in wrasse used as cleaner fish in salmonid aquaculture; the first observations of parasites *Ichthyobodo salmonis* and *Desmozoon lepeophtherii* in Pacific salmon from western Canada; high prevalences of *Loma branchialis* and increasing prevalences of *Contracaecum osculatum* in Baltic cod from the eastern Baltic Sea; and increasing prevalence of M74/thiamine deficiency in salmon yolk sac fry in Sweden. The considerable number of new and emerging disease trends in wild fish, all relevant to important fisheries, highlight the urgent need to continue disease monitoring of wild fish populations in the ICES region.

Reports for farmed fish included the first cases of heart and skeletal muscle inflammation (HSMI) caused by piscine orthoreovirus (PRV) in Atlantic salmon in western Canada; the first report of infectious haematopoietic necrosis virus (IHNV) in Finland, in rainbow trout; the first report of *I. salmonis* in Atlantic salmon in Canada, in aquaculture in British Columbia; widening geographic distribution and increased effects on younger salmon of cardiomyopathy syndrome (CMS) caused by piscine myocarditis virus (PMCV) in Scotland and Ireland; and increasing cases of complex gill disease (CGD) in Atlantic salmon in Scotland. Complex gill disease is an increasing concern among ICES member countries, and better understanding and developing strategies to mitigate CGD will be a new focus of WGPDMO effort.

Notable reports for shellfish included the first observation of acute hepatopancreatic necrosis caused by *Vibrio parahaemolyticus* in the USA, in Pacific white shrimp; observations of *Mikrocytos* parasites in association with mortality of Pacific oysters in The Netherlands and tellins in France; major mortalities in pen shells in Spain caused by a novel haplosporidian parasite; mortalities in flat oyster larvae in Sweden associated with a non-microvar form of the virus OsHV-1; and a widening geographic distribution of summer mortality, of unknown aetiology, of eastern oysters in the USA.

Work on additional documents included a summary of the role of *Vibrio* pathogens contributing to mortalities in shellfish aquaculture, a synthesis on the contemporary status of oyster pathogen *Bonamia ostreae*, a synthesis on amoebic gill disease in salmon, and a compilation of pathogen screening in wild salmonids. The present status of the Fish Disease Index and plans for its continued development in the upcoming cycle were also discussed, as were several new ToRs.

Four new ICES Identification Leaflets for Diseases and Parasites of Fish and Shellfish were published, and an additional new leaflet is in press. Eleven new leaflets are proposed for completion in the upcoming cycle.

1 Administrative details

Working Group name
Working Group on Pathology and Diseases of Marine Organisms (WGPDMO)
Year of Appointment within current cycle
2016
Reporting year within current cycle (1, 2 or 3)
3
Chair(s)
Ryan Carnegie, USA
Meeting venues and dates
17–20 February 2016, Gloucester Point, USA (9 participants)
14–18 February 2017, Gdynia, Poland, (7 participants)
13–17 February 2018, Riga, Latvia (12 participants)

2 Terms of Reference

ToR a) Summarize new and emerging disease trends in wild and cultured fish, molluscs and crustaceans based on national reports;

ToR b) Deliver leaflets on pathology and diseases of marine organisms;

ToR c) Synthesize information on the spread and impact of *Bonamia ostreae* in flat oysters in the ICES area;

ToR d) Summarise the role of *Vibrio* sp. pathogens contributing to mortalities in shellfish aquaculture;

ToR e) Prepare a report describing the occurrence and spread of amoebic gill disease (AGD) in marine salmonid farming in the ICES area;

ToR f) Compile information on pathogen screening of wild salmonids in the ICES member states;

ToR g) Evaluate applicability of the Fish Disease Index (FDI) by using the R package following newly developed guidelines;

ToR h) Provide expert knowledge and management advice on fish and shellfish diseases, if requested, and related data to the ICES Data Centre;

ToR i) Generate a standard reporting template to improve data collection concerning sample sizes and pathogen prevalences.

3 Summary of Work plan

ToR a) New disease conditions and trends in diseases of wild and cultured marine organisms will be reviewed. This is an annual, ongoing ToR for WGPDMO and will provide information for ToRs c-f.

ToR b) A number of ICES publications currently in preparation will be reviewed by WGPDMO. This is an ongoing, annual ToR.

ToR c) *Bonamia ostreae* is a major pathogen of European flat oysters that has expanded its range in recent years. The present distribution, recent trends in parasite prevalence and infection intensity, and the effectiveness of contemporary management strategies will be summarized, with a perspective on the related species *Bonamia exitiosa*, recently documented in oysters from some ICES member countries.

ToR d) *Vibrio* bacteria have long been associated with larval production problems in shellfish hatcheries, but the potential impacts of vibriosis in sub-market and market-sized Pacific oysters in European production areas has become an important emerging concern. This ToR will synthesize the current knowledge on *Vibrio* impacts and highlight critical gaps in our understanding of these species.

ToR e) Amoebic gill disease (AGD) has emerged as a significant issue for salmon farming in the Atlantic. This ToR will produce a report describing the spread and impact of this disease and current measures being used to mitigate its effects. It will identify knowledge gaps and future areas for research.

ToR f) Many ICES member countries screen wild broodstock used for restocking purposes for disease pathogens. This ToR will produce a report compiling information on diseases and methods used in order to prepare a common approach to screening and assess the effectiveness of current practices.

ToR g) This ToR will produce an assessment of the applicability of the Fish Disease Index based on its trial use by participants from among the group.

ToR h) This is an annual ToR in compliance with a requests from the ICES Data Centre.

ToR i) This ToR will allow improved resolution of disease trends in ICES member countries.

4 Summary of Achievements of the WG during 3-year term

- Annual reports on new disease trends in wild and farmed fish and shellfish in ICES Member Countries, which are the only annual expert reports available on this topic;
- Publication of five new and three revised ICES Disease Leaflets, including:

  No. 24: *Mytilicola intestinalis* parasitism (Bignell, revised leaflet)

  No. 37: Furunculosis (Bruno, revised)

  No. 42: Infection with *Exophiala salmonis* (Bruno, revised)

  No. 64: Francisellosis of Atlantic cod (Alfjorden and Ruane, new leaflet)

No. 65: Brown ring disease: a vibriosis affecting clams *Ruditapes philippinarum* and *R. decussatus* (Paillard, new)

No. 66: Bonamiosis of oysters caused by *Bonamia exitiosa* (Carnegie, new)

No. 67: Disseminated neoplasms in bivalves (Renault and Ford, new)

No. 68: X-cell disease in common dab (*Limanda limanda* L.) caused by *Xcellia lamelliphila* (Perkinsea) (Feist and Bass, new leaflet)

- Submission of a new ICES Disease Leaflet on Gonadal neoplasia in bivalves (Bruno);
- Publication of the ICES Cooperative Research Report titled New trends in important diseases affecting farmed fish and molluscs in the ICES areas (Ruane and Carnegie, editors, ICES reference no. 2013/1/SSGHIE06;
- Report of the Workshop to address the NASCO request for advice on possible effects of salmonid aquaculture on wild Atlantic salmon populations in the North Atlantic (WKCULEF), co-authored by Jones, WGPDMO representative to the workshop.

5 Final report on ToRs, workplan and Science Implementation Plan

5.1 Summarize new and emerging disease trends in wild and cultured fish, molluscs and crustaceans based on national reports (ToR a)

The update in the following sections is based on national reports for 2017 submitted by Canada, Denmark, England & Wales, Finland, France, Germany, Ireland, Latvia, The Netherlands, Norway, Poland, Russia, Scotland, Sweden and the USA. It documents significant observations and highlights the major trends in newly emerging diseases and in those identified as being important in previous years. The scientific names for each species mentioned can be found in Annex 5.

Wild Fish

Viruses

Salmonid alphavirus - Isolated from a pooled sample of five ballan wrasse from Ireland, and presumptively identified as the SAV6 sub-type by RNA sequencing. This is the first isolation of SAV in wrasse and the first isolation of SAV6 in Ireland since 1996.

Bacteria

Acute/healing skin ulcerations - There is a general decreasing trend in acute/healing skin ulcerations in dab in the Humber/Wash region, particularly the central Dogger Bank and German Bight, where prevalence has decreased from 22% in 2001 to 1.3% in 2017.

Photobacterium damsellae: Ballan wrasse without clinical signs, from the south coast of England and northwest Ireland (Lough Swilly), were examined for the presence of disease agents. Infection with the bacterium associated with tissue and organ pathology was detected in one female fish of 47 sampled from England.

Parasites

Protists

Ichthyobodo salmonis **–** This flagellate protist was recognised in histological gill preparations and confirmed by qPCR in 223/560 Pacific salmon (chum salmon: 140/344, 40.7%); pink salmon: 69/188, 36.7%; chinook salmon: 12/19, 63.2%; coho salmon: 2/9, 22.2%). This report provides the first evidence of *I. salmonis* in Pacific salmon from Western Canada.

Microsporidia

Desmozoon lepeophtherii **(syn *Paranucleospora theridion*) –** The parasite is associated with proliferative gill inflammation in Norway and was previously reported from salmon lice (*Lepeophtheirus salmonis*) in Western Canada. It was detected by qPCR in the gills of 55/560 juvenile Pacific salmon (chum salmon: 33/344, 9.6%; pink salmon: 16/188, 8.5%; chinook salmon: 4/19, 21.1%; coho salmon: 2/9, 22.2%). This is the first report of this parasite in Pacific salmon.

Loma branchialis **(= *morhua*)** - Based on macroscopic examination, prevalence continues to be very high in Baltic cod from the eastern Baltic Sea (Bornholm Basin, 94.8% and Gulf of Gdansk, 85.1%) compared to fish from the western Baltic Sea.

Nematoda

Contracaecum osculatum - Prevalence and intensity of infections in the liver of cod from the eastern Baltic Sea (ICES Subdivisions 25 and 26) have increased and are associated with a decline in Fulton's condition factor. There is concern that an increase in natural mortality may result.

Other diseases

Macroscopic liver neoplasms - A relatively high prevalence (17%) of macroscopic liver neoplasms (tumours) was histologically confirmed in dab sampled at the periphery of a dumpsite for conventional munitions in Kiel Bight. Prevalence of tumours in other regions in the Baltic Sea is generally less than 5%.

Hyperpigmentation - Recently increasing in prevalence in dab from the North Sea. The aetiology of this condition remains unknown.

M74/Thiamine deficiency in salmon yolk sac fry - Increasing in prevalence (percent of females producing thiamine-deficient roe) in Baltic salmon, to 31% in 2017, from 21% in 2016 and 1–6% in 2011–2015, based on data from seven stocking farms from different rivers in Sweden. The cause of this increase in prevalence is not understood.

Conclusions

- The occurrences of SAV6 and *P. damsellae* highlight the need for greater disease surveillance amongst stocks of ballan wrasse used as cleaner fish in salmon aquaculture.
- The prevalence and intensity of infection with *C. osculatum* in Baltic cod continues to increase and causes a reduction of Fulton's condition factor of fish. Potential population effects of *C. osculatum* infection warrant further study.

- The prevalence of hyperpigmentation in dab is again increasing in the North Sea. Causes are unknown.
- The prevalence of M74/thiamine deficiency in Atlantic salmon from Sweden is again increasing. The cause of the increase is unknown.
- From the national wild fish disease reports received, there is evidence of a considerable number of new and emerging disease trends, the effects of which in relation to population dynamics, disease transfer between wild and farmed fish and the safety of seafood for human consumers are largely unknown. It is also in many cases not clear to what extent these findings reflect the impact of natural and anthropogenic factors on the health status of wild fish. WGPDMO, therefore, concluded that research on and monitoring of wild fish diseases need to be continued. This, unfortunately, contrasts the development in some ICES Member Countries, where wild fish disease monitoring programmes have been cut considerably.

Recommendation

WGPDMO recommends that ICES Member Countries should be encouraged to continue funding of fish disease research and monitoring programmes; or, in cases where no such programmes have been implemented, make a commitment to fund such programmes to sustain fish health surveillance of wild stocks. Information obtained is of vital importance in relation to the assessment of population effects of diseases, the risk of disease transfers between wild and farmed fish and of possible effects on seafood safety. Furthermore, data obtained based on quality assured ICES/BEQUALM methodologies are required for integrated assessments of the health of marine ecosystems, e.g. in relation to environmental monitoring and assessment programmes under the EU, OSPAR and HELCOM.

Farmed Fish

Viruses

Piscine Orthoreovirus (PRV) – The first case of heart and skeletal muscle inflammation (HSMI) in Canada was described from Atlantic salmon in British Columbia in 2013–2014, which we report for the first time here. Characteristic histological lesions were present in 80%-100% of sampled fish. Clinical signs were mild and there was no HSMI-specific mortality. The prevalence of PRV was statistically correlated with the occurrence and severity of histopathological lesions in the heart. In Denmark, PRV3 (formerly also known as virus Y and PRV-om) was found at two rainbow trout farms in connection with mortalities and with no other pathogens present.

Infectious haematopoietic necrosis virus (IHNV) – In Finland, the virus was diagnosed by RT-qPCR and confirmed by cell culture in apparently healthy rainbow trout. These infections were detected at two production farms in the Bothnian Bay (0.3% salinity) and at a freshwater broodstock farm. The two affected production sites, which contained 80 000 kg, and the broodstock facility, containing 150 000 kg, were depopulated. This is the first report of IHNV in Finland, and the OIE has been notified.

Piscine myocarditis virus (PMCV) – In Scotland, the incidence of cardiomyopathy syndrome (CMS) increased to 8 cases in 2017 from 3 a year earlier. Two sites in particular underwent large mortality events with peak mortality of 2.8% per week (30 015 Atlantic salmon). Reports from Scotland and Ireland suggest the clinical presentation of CMS is changing. Historically, CMS affected harvest sized Atlantic salmon (>4 kg), but in Scotland clinical outbreaks now occur in much younger fish (<2 kg) and the disease appears to have a larger geographical distribution than previously reported. A similar trend was reported in Ireland where the disease at one site was chronic, with persistent low mortalities, and occurred in younger salmon three to four months post-transfer.

Bacteria

Piscirickettsia salmonis – In Western Canada, the number of Atlantic salmon testing positive by PCR declined from 29/117 (25%) in 2016 to 15/120 (13%) in 2017. Three farms were treated for salmonid rickettsial septicaemia in 2017, down from six that required treatment in 2016.

Pasteurella skyensis – In Scotland, mortality events attributed to the bacterium occurred on two Atlantic salmon sites in 2017. Approximately 125 000 4-kg fish, totaling 500 tonnes, were lost during the outbreaks. Antibiotic treatments were effective.

Parasites

Desmozoon lepeophtherii – The microsporidian was detected by qPCR in gills from 157/165 (95%) apparently healthy Atlantic salmon on three farms in Western Canada. Severity of the infection increased during a mortality event that was evidently triggered by exposure to a harmful algal bloom (median Ct-healthy: 28.9; median Ct-moribund: 19.0).

Ichthyobodo salmonis – The flagellated protist was detected by qPCR in 56/165 gill samples (34%) from apparently healthy Atlantic salmon on three farms in British Columbia. This is the first evidence of *I. salmonis* in Atlantic salmon in Canada.

Other diseases

Complex gill disease – In Scotland, there has been an increase in the number of cases over the past three years, from 8 in 2015 to 25 in 2017. The disease typically begins in July and August in association with rising sea temperatures, and lasts until January. The name of this disease reflects an aetiology believed to result from a complex interaction of environmental, host and infectious factors.

Conclusions

- HSMI was reported for the first time in Atlantic salmon in Western Canada;
- Infection with PRV-3 was associated with elevated mortality in rainbow trout in Denmark;
- Infection with *Pasteurella skyensis* was associated with elevated mortality in Atlantic salmon in Scotland;
- CMS in Atlantic salmon in Scotland and Ireland occurred in younger fish than previously reported;

- Infections with *Ichthyobodo salmonis* were reported for the first time in Canada on gills of Atlantic salmon in British Columbia;
- Complex gill disease is increasing in importance as a health issue in marine Atlantic salmon aquaculture in Scotland.

Wild and farmed molluscs and crustaceans

Viruses

Oyster Herpes Virus - Potential virus-caused mortalities in European flat oyster larvae have occurred on the west coast of Sweden, with mortality rates as high as 99% in hatcheries and farms that capture wild larvae. The mortalities have been ongoing for several years, and at least two variants of OsHV-1, though not OsHV-1 microvars, have been identified through DNA sequencing from affected larvae. OsHV-1 variants believed to be microvars continue to cause mortalities in Pacific oyster spat in France, with observed mortalities in 2017 ranging from 25–82%.

Bacteria

Vibrio splendidus - In France, vibrios belonging to the *V. splendidus* group were detected at 12% prevalence by PCR in Mediterranean mussels from a mortality event in Vendée, an indication that bacterial infection may underlie at least some of the widely observed recent mortality in mussels.

Vibrio parahaemolyticus - Acute hepatopancreatic necrosis associated with infection with a *V. parahaemolyticus* variant was reported in Pacific white shrimp in Texas, the first occurrence of this disease in the USA. A report was made to the OIE.

Bacterial black spot disease in brown shrimp - Long-term data on the occurrence and prevalence of bacterial black spot disease in brown shrimp from the German Bight, North Sea, since the early 1990s have been analysed for manuscript submission. The data indicate an average prevalence of 10% across the period with a maximum prevalence of 30% in the early 2000s, as well as correlations with environmental factors such as pollution and water temperature.

Parasites

Bonamia ostreae **-** In France, detected in >2 year old European flat oysters in Brittany displaying 75% mortality. In Denmark, the parasite has been found by qPCR and cytology for the first time in the Nissum Bredning, the western part of Limfjorden, although at very low prevalence, 1/40 oysters from one zone and 2/60 oysters from another.

Mikrocytos mimicus - In the Netherlands, observed by histopathology and DNA sequencing in Pacific oysters displaying 90% mortality in May near the island Schiermonnikoog in the Wadden Sea. This is the first observation of this parasite from the Netherlands.

***Mikrocytos* sp. in tellins** - In France, *Mikrocytos* sp. parasites were identified by DNA sequencing in wild tellins from the bay of Audierne, Brittany, a first observation in this species. Mortality events have been observed in 2008, 2010 and 2011 in tellins from several sites including bays of Audierne and Douarnenez in Brittany and Oleron Island in Charente Maritime in association with *Mikrocytos*-like parasite detection.

Marteilia refringens - In France, detected in Mediterranean mussels of <1 year old from Brittany in March that were displaying 25% mortality, and in European flat oysters of mixed age from the same area in December with percent mortality not defined. In Norway, parasite type "M" was detected by histology and PCR in 2016 in 13/30 wild blue mussels in an oyster poll. During 2017 a study involving regular sampling (April, July, August, October) of blue mussels and flat oysters was initiated. At each sampling *Marteilia* was found in mussels, whereas the oysters from the same poll only were positive by PCR in October, at the same time that the mussels were found to harbor mature, sporulating parasites.

***Haplosporidium nelsoni* -** In the USA, mean autumn prevalence of the parasite in eastern oysters from Virginia waters of Chesapeake Bay decreased from 3.7% to under 2%, as a minor epizootic waned. Mean prevalence in Maryland waters of Chesapeake Bay similarly decreased, from 11% to less than 3%. Despite this general decrease, the parasite was still the likely cause of a spring mortality event in wild and aquacultured oysters around the lower Rappahannock River in Virginia. In Delaware Bay, the parasite was associated with mortality on aquaculture leases in higher-salinity waters. In the UK, an October sample of Pacific oysters from the Camel Estuary was found to have low prevalence (1/30) of sporulating *H. nelsoni*, a first observation of the parasite in this location.

***Perkinsus marinus* –** In the USA, mean prevalence in eastern oysters in Virginia waters of Chesapeake Bay increased from 58% in 2016 to 65% in 2017, based on autumn analyses of 25 oysters from each of 29 oyster reefs. Mean prevalence still remained below the long-term mean for the system. Similarly, mean prevalence in Maryland oysters from 45 oyster reefs in the upper part of Chesapeake Bay increased from 63% to 69%. Mean infection intensities in both lower and upper Chesapeake Bay were unchanged despite the prevalence increase. Infection levels have increased in higher salinity waters of Delaware Bay as well, though not with an increase in host mortality. In New York, USA, the parasite caused unusual and severe early-season (July-August) oyster mortality among aquacultured oysters from two bays on the south shore of eastern Long Island, as evidenced by high parasite prevalences (100% and 93%, respectively) and proportions of advanced infections (100% and 40%).

***Perkinsus beihaiensis*-** In the USA, observed for the first time and in a new host, Olympia oysters from San Diego Bay, California, in June 2016. Prevalence as determined using histopathology was 1/60. By PCR, 3/15 pools of four oysters were positive. Sequence similarity to a GenBank-deposited *P. beihaiensis* sequence was 100%.

Minchinia mytili - In England, a novel haplosporidian parasite of blue mussels was found distributed throughout connective tissues of 6/309 mussels in the Tamar estuary, Devon.

Haplosporidian in pen shells - In Spain, widespread mortalities that in places exceeded 90% were observed in noble pen shells from areas of the western Mediterranean Sea, beginning in September 2016. A haplosporidian parasite sporulating in host digestive tubule epithelium was found in association with this mortality. *Bonamia*-generic and *Haplosporidium nelsoni*-specific PCR assays on affected individuals were negative, suggesting that the parasite may be a novel *Haplosporidium* species. The contribution of the haplosporidian to the mortality as well as the potential significance of other factors such as elevated seawater temperatures and infection by pathogenic *Vibrio* bacteria remain to be fully resolved.

Fungi

Microsporidian sp.

Halioticida noduliformans - In England, recorded for the first time in European lobsters, collected from the south coast. The parasite infected lobster eggs at 6.5% prevalence (21/323 individuals) and was subsequently also found to be associated with gill tissues. Pathology of the egg mass may lead to reduced fecundity.

Other diseases

Epizootic shell disease in American lobsters - Mean prevalence of this disease in the Gulf of Maine, USA, has increased from 0.5% to 1.2% over the last eight years, with observed prevalences as high as 2–3% off southern Maine. An *Aquimarina* sp. bacterium is a putative causative agent.

Summer mortality in eastern oysters - In the USA, continued to be observed in Virginia waters of Chesapeake Bay, with reports in 2017 extending observations from the upper, Maryland part of Chesapeake Bay to Alabama waters of the Gulf of Mexico. The phenomenon continues to be found exclusively in domesticated oyster lines used for aquaculture, with no evidence of such mortality in wild oysters. Evidence increasingly suggests a heightened susceptibility of triploid oysters relative to diploids.

Conclusions

- Mortality of larval flat oysters was associated with a non-microvariant OsHV-1 in Sweden;
- Acute hepatopancreatic necrosis disease in shrimp associated with a *Vibrio parahaemolyticus* variant was reported in the USA for the first time;
- *Mikrocytos mimicus* was associated with 90% mortality in Pacific oysters in the Netherlands, a first observation of this pathogen in the Netherlands;
- *Marteilia refringens* was detected in blue mussels in Norway for the first time;
- *Perkinsus beihaiensis* was observed in a new host and location, Olympia oysters in California, USA;
- *Minchina mytili* was described as a new pathogen of blue mussels;
- A novel haplosporidian parasite was associated with major pen shell mortality in Mediterranean waters of Spain;
- *Halioticida noduliformans* was identified as a parasite of eggs and gill of European lobsters in England, a first observation in this host and location;
- Summer mortality of eastern oysters in the USA was increasingly widespread with new reports from Maryland waters of Chesapeake Bay and Alabama waters of the Gulf of Mexico.

5.2 Deliver leaflets on pathology and diseases of marine organisms (ToR b)

The WGPDMO plans to update all disease leaflets on an annual basis and to increase the visibility and relevance of the leaflets.

The assistance of Lise Crone (ICES Secretariat) in updating the ICES webpage for the leaflet series was much appreciated. The link to the new page is: http://ices.dk/publications/our-publications/Pages/ID-masterlist.aspx (linked to the button "view ID leaflets for diseases and parasites for fish and shellfish).

Since the 2017 meeting four new leaflets have been published:

No. 65: Brown ring disease: a vibriosis affecting clams *Ruditapes philippinarum* and *R. decussatus* (Paillard) (http://doi.org/10.17895/ices.pub.1924 -- the very first ICES product with a DOI number)

No. 66: Bonamiosis of oysters caused by *Bonamia exitiosa* (Carnegie)

No. 67: Disseminated neoplasms in bivalves (Renault & Ford)

No. 68: X-cell disease in common dab (*Limanda limanda* L.) caused by *Xcellia lamelliphila* (Perkinsea) (http://doi.org/10.17895/ices.pub.3320)

The following revised and new leaflets are currently with the editor and will be published during 2018:

Gonadal neoplasia in bivalves (Renault)

It remains important for the WGPDMO to continue to propose titles of new leaflets and to suggest potential authors for these so that the series remains current with up to date and relevant information. In addition, the editor has contacted selected authors for production of further revised leaflets, which are to be submitted during 2018. As part of the ongoing task to update all remaining leaflets more than ten years old the WGPDMO reviewed the list of published leaflets and identified members to either take responsibility to produce a revised leaflet or to propose an alternative author to the editor.

The current editor of the leaflet series (S.W. Feist) did not decide to reapply for editorship after 13 years in the role. As such, a new editor of the series is in place as of January 1, 2018. WGPDMO member Neil Ruane received this appointment.

The current list of emerging disease conditions that should generate a new disease leaflet is provided below:

1) *Mikrocytos* spp. (Carnegie)
2) Ostreid herpesvirus (Cheslett)
3) Infectious salmon anaemia (ISA) (Falk)
4) Pancreas disease (PD) (Taksdal)
5) *Haematodinium* (Stentiford)
6) Vibriosis in oysters (Renault)
7) Tenacibaculosis in farmed fish (Jones)
8) Vibriosis in farmed salmonids (Lillehaug)
9) *Sphaerothecum* in dab (Feist and Paley)

10) Mycobacteriosis in wild fish (Madsen)
11) QPX in hard clams (Smolovitz)

Further leaflet titles with authors to be determined include:

1) Marteilia cochillia
2) Ganglioneuritis in Haliotis (infection with abalone herpesvirus)
3) Nocardiosis
4) Withering syndrome in abalone
5) Perkinsus olseni
6) Steinhausia

5.3 Synthesize information on the spread and impact of *Bonamia ostreae* in flat oysters in the ICES area (ToR c)

The disease bonamiosis has had a significant impact on flat oyster production in Europe since its emergence in 1979. It is a disease notifiable to both the OIE and the EU (under Directive 2006/88/EC), and it has expanded its distribution over the last decade particularly in the north of Europe, where it has been observed in new locations in Norway, the United Kingdom, and Denmark.

New *B. ostreae* observations have typically not included the very high levels of mortality characteristic of new outbreaks in the 1980s. Areas where the parasite has long been present, such as Ireland and Maine, USA, have also been characterized by only modest disease and mortality. These observations raise questions not only about the present status of pathogen distributions and the influences on them but also about the evolutionary dynamics between *B. ostreae* and its oyster host that may be producing disease states and impacts on oyster populations that are relatively low by historical standards.

Data regarding spread of disease, mortality rates, human activities in an area, climate change, density of oyster populations as well other aspects of, and influences on, *B. ostreae* epizootiology exist in many countries where bonamiosis has had an impact, often in non-published forms. The aim of this ToR is to produce a review of the present status and distribution of *B. ostreae* in the ICES area now nearly four decades after its initial emergence, and to use data including parasite prevalence, infection intensities, and host mortality to gain insight into the nature of contemporary *B. ostreae*-oyster interactions. The purpose of the review involving several authors within the shellfish area, both WGPDMO members as well as shellfish experts outside the group, will be to synthesize information on the spread and impact of *B. ostreae* in flat oysters in the ICES area, both from published papers but also from grey literature and surveillance programs in different countries. The headings for the review will cover current distribution, changes in distribution with human activities and changing climate, indications of adaption or not, and long-term prevalence, intensity and mortality data. The product will be a review paper made available in 2019/2020.

5.4 Summarise the role of *Vibrio* sp. pathogens contributing to mortalities in shellfish aquaculture (ToR d)

Vibrio bacteria pathogenic to Pacific oysters and other bivalve molluscs have been increasingly documented in WGPDMO national reports from the last several years. Whilst it is becoming increasingly apparent that particular species such as *V. aestuarianus* and *V. splendidus* are involved in mortalities observed in aquacultured bivalves in natural waters, additional species have been reported as pathogens in hatchery and nursery environments, for example in 2015 in Spain. Still, there exists a lack of clarity in relation to the pathogenic role of different vibrios, particularly where multiple species or other pathogens such as the OsHV-1 μVar are detected in a single event. At the same time human pathogens such as *V. parahaemolyticus* and *V. vulnificus* are increasingly a concern as oceans warm and as more shellfish are eaten raw in the summer as mollusc aquaculture expands, but the influences on the epidemiology of these vibrios are also not completely understood. The WGPDMO will provide a synthesis on the current state of knowledge relating to these pathogens through a review of the existing literature and data from events which have occurred in recent years, with a view toward identifying key knowledge gaps to be addressed through future research. The group's objective will be to elucidate the established roles of different *Vibrio* species in mortalities in both wild and aquaculture populations. Concurrently, a new EU project "Vivaldi" (*Preventing and mitigating farmed bivalve diseases*) includes among its aims an examination of the roles of the pathogens OsHV-1 and *Vibrio* species and their interactions. Relevant Vivaldi participants will be included as collaborators in the review being undertaken by the WGPDMO to ensure that the review is informed by results from the Vivaldi project. The product of this ToR will be a journal article completed in 2019/2020.

5.5 Prepare a report describing the occurrence and spread of amoebic gill disease (AGD) in marine salmonid farming in the ICES area (ToR e)

Amoebic gill disease (AGD), caused by infection with the parasitic amoeba, *Neoparamoeba perurans*, (Young *et al.* 2007; Crosbie *et al.* 2012), has emerged as a significant issue for salmonid farming in the North Atlantic Ocean. The disease was first reported in the mid-1980s in salmonids farmed in Washington state, Western USA and in Tasmania, Australia (Kent *et al.* 1988). AGD outbreaks have also been reported from non-salmonid farmed species including ballan wrasse (*Labrus bergylta*) (Karlsbakk *et al.* 2013), lumpsucker (*Cyclopterus lumpus*), turbot (*Scophthalmus maximus*) (Dyková & Novoa 2001; Mouton *et al.* 2013) ayu (*Plecoglossus altivelis*) (Crosbie *et al.* 2010) and blue warehou (*Seriolella brama*) (Adams *et al.* 2008). *Neoparamoeba* species have also been implicated in an occurrence of AGD in farmed olive flounder (*Paralichthys olivaceus*) (Kim *et al.* 2005). Other species known to be susceptible to AGD are European seabass (*Dicentrarchus labrax*) and sharp-snout seabream, (*Diplodus puntazzo*) (Dyková & Novoa 2001; Dyková *et al.* 2005; Steinum *et al*. 2008).

Left untreated, AGD can cause up to 10% mortality in the farmed population per week (Munday *et al.* 2001). Additional costs are incurred through the reduction in fish growth rate and the removal and disposal of mortalities. In addition, freshwater baths are an effective but costly treatment (Nowak 2012), particularly in regions where there is significant expense in establishing the infrastructure and labour required, as well as sourcing of sufficient freshwater (Adams *et al.* 2012).

In addition to the USA and Australia, AGD has also been reported in South Africa, Chile, western Canada, Norway, Scotland, Faroe Islands and Ireland (Rodger & McArdle 1996; Steinum *et al.* 2008; Bustos *et al.* 2011; Mouton *et al.* 2013). Onset of AGD in numerous geographic locations suggests that the causative agent is ubiquitous in coastal waters (Oldham *et al.*, 2016). However it has been very difficult to consistently detect the amoeba in samples of water, wild fish or their ectoparasites, near to affected salmon aquaculture sites or elsewhere in coastal waters and reservoirs of the infection have not been identified (Stegg *et al.*, 2015; Oldham *et al.*, 2016). The risk of developing AGD is associated with elevated seawater temperature and salinity (Clark and Nowak, 1999).

The purpose of this report is to describe the pathology, diagnosis and treatment of AGD and to document trends in the occurrence of the disease within ICES member countries. Knowledge gaps and areas for future research are also identified. The reader is also referred to two recent reviews on the *Paramoeba* and disease caused by these opportunistic parasites (Oldham *et al.*, 2016; Nowak and Archibald, 2018).

Pathology

AGD is characterised by localised host tissue responses including epithelial oedema, hyperplasia of the epithelial cells and mucous cells, fusion of lamellae and the development of interlamellar vesicles (Clark & Nowak 1999). In addition to the pathological lesions, the case definition includes the observation of amoebae in wet preparations or observed in histological examination. At least one *Perkinsiella*-like organism (PLO) should be observed in stained preparations (Adams *et al.*, 2004; Bustos *et al.* 2011). Functional gill surface area can be severely reduced due to the filamental hyperplasia which inhibits the exchange of carbon dioxide, leading to persistent respiratory distress (Powell *et al.* 2000). Further complications can arise as hypertension develops, causing circulatory collapse (Powell *et al.* 2002). Some cases in Scotland and Ireland have observed significant liver histopathology, which presents as multifocal necrosis (Rodger 2014). Importantly, the mechanism(s) by which *N. perurans* initiates the host response are not fully understood (Nowak *et al.* 2014). In transmission electron microscopy (TEM) analysis, enlarged swellings have been observed in affected gill filaments with fusion of adjacent lamellae, in addition to spherical amoebae which appeared to be embedded within the epithelium, which subsequently left indentations with visible fenestrations (Wiik-Nielsen *et al.* 2016). These fenestrated structures appeared to correspond with the presence of pseudopodia, which were observed to penetrate the epithelium.

Diagnosis of AGD

Currently the most financially viable non-destructive means for the diagnosis of AGD on a commercial scale is through gross pathological assessment (Adams *et al.* 2004) using various gill scoring methods (Taylor *et al.* 2009). Gross pathological assessment and gill scoring methods have been utilised as a quantitative measure of the severity of amoebic gill disease in several studies and used as a monitoring tool on farms. With the recurrence of AGD in Europe, gill scoring has quickly been adapted as the preferred method for monitoring of the disease. Development of the disease can be quite rapid, particularly in the summer months, with the majority of farms performing gill checks on a weekly basis in conjunction with sea lice counts (Rodger 2014). Using tools such as gill scoring determines the severity of the AGD infection and the frequency of treatment (Nowak *et al.* 2014).

Figure 1. Atlantic salmon gill during gill scoring with established thickened mucus patches associated with AGD (Credit: Richard Taylor, CSIRO, Agriculture and Food).

It is, however, a presumptive means by which to confirm the presence of AGD, and is open to misinterpretation. The detection of lesions and patches (Figure 1) only indicates an altered gill condition but lacks the ability to identify the causative agent (Adams *et al.* 2004). As the reactions of gills are very few and look similar, lesions created by amoebae are difficult to distinguish from other pathogens or irritants, with the technique and experience of the observer also influencing the diagnosis (Adams *et al.* 2004). Lesions and patches on the gills do not always coincide with AGD in salmon and are less reliable in the early stages of an infection (Clark & Nowak 1999). Additionally, in species such as the lumpsucker, gill scoring is not practical due to a small operculum opening. The severity of the lesions that are used to assess gill scores has been suggested to be related to the number of amoebae present on the gills, with the degree of amplification in the PCR analysis showing correlation with the level of infection (Bridle *et al.* 2010). Gross gill assessment is currently the primary means by which farms identify AGD and the severity of the disease.

While clinical diagnosis is accepted at farm level as a monitoring tool, further investigation through histological and/or molecular means is required for accurate diagnosis of the causal agent, particularly in new locations or species (Nowak *et al.* 2002). Histology has been one of the primary methods of identification and diagnosis of the causal agent, and it has also been utilised in the investigation of host response (Clark & Nowak 1999; Nowak *et al.* 2014). Mitchell *et al.* (2012) developed a histopathological gill scoring method, which assigned a score of 0 to 3 for each parameter associated with changes in gill health, including lamellar oedema, lamellar hyperplasia, lamellar fusion and circular anomalies (necrosis and sloughing). While both the gross and histological screenings have provided a valuable tool to the industry for the regulation of AGD, they are still limited in their capacity to identify the infectious agent (Young *et al.* 2008). Currently histology is an invaluable tool in relation to case definition, but it cannot illustrate all aspects of the host response – this is most clearly evident in artefactual loss of mucous and a certain portion of amoebae during tissue fixation and histology processing (Nowak *et al.* 2014).

A number of laboratory techniques were developed to confirm AGD in presumptively diagnosed fish, including immunofluorescent antibody test (IFAT) or immuno-dot blot, using polyconal antisera raised against *N. pemaquidensis* (Douglas-Helders *et al.* 2001; Nowak *et al.* 2002, Young *et al.* 2008). Additionally a quick dip haematology stain was utilised on gill smears for rapid confirmation of AGD outbreaks on farms known to be affected by the disease (Zilberg *et al.* 1999). Other studies confirmed AGD by establishing cultures of the pathogens, which were then identified on the basis of morphology (Dyková *et al.* 2000). However, further analysis of morphological features suggested that this is not suitable for routine discrimination between *Neoparamoeba spp.,* and that PCR and phylogenetic analysis are more applicable (Wong *et al.* 2004).

In recent years, the development of such highly sensitive and species-specific methods of detection such as *in situ* hybridisation and PCR have become available since the discovery of *N. perurans* and are routinely performed in research and diagnostics. Following the identification of *N. perurans,* Young *et al.* (2008) developed a PCR assay which amplified a 636bp region of the 18s rRNA gene. Further investigation allowed for the development of *in situ*-hybridisation using oligonucleotides that bind with the 18s rRNA gene and this was utilised to confirm that *N. perurans* was the predominant aetiological agent of AGD in Tasmania, despite other amoebae species previously being associated with the disease (Young *et al.* 2008). This assay was found to be specific and highly sensitive for the detection of *N. perurans* in gill samples and isolates of non-cultured gill-derived amoebae.

Bridle *et al.* (2010) developed and validated a real-time PCR assay using SYBR® Green chemistry and iQ5 Real-Time PCR detection system (Bio-Rad NSW, Australia). The primers used in this assay amplified a 146bp portion of the 18s rRNA gene from base 677 to 822 of *N. perurans*. A quantitative duplex real-time TaqMan®-based PCR was developed for the detection of *N. perurans* in Atlantic salmon and rainbow trout, using a set of primers and probes to amplify a 139-bp fragment specific to the *N. perurans* 18s rRNA gene (Fringuelli *et al.* 2012).

Treatment of AGD

Although there has been significant research into treatments since AGD was first recorded, freshwater bathing remains one of the most effective and essential methods for the removal of the majority of amoebae that cause AGD (Parsons *et al.* 2001; Adams & Nowak 2004; Adams *et al.* 2012; Oldham *et al.* 2016). It was first documented in 1988 that a simple freshwater bath for 2–3 hours would provide immediate relief and recovery from AGD (Foster & Percival 1988). Current treatment strategies in Australia involve monitoring by gross gill lesions and prophylactic freshwater baths (Taylor *et al.* 2009). Re-infection of the gills can occur relatively quickly, varying from 1 to 2 weeks post freshwater bath, and increases in severity by 4 weeks (Clark *et al.* 2003; Adams & Nowak 2004). Since initial outbreaks in Australia in the 1980s, farms have seen a requirement for an increase in the frequency of treatments, with some fish being treated up to 15 times a year (Parsons *et al.* 2001; Rodger 2014). The mechanism by which freshwater bathing treats AGD is by osmotic effect, removing the excess mucus and the associated amoebae, thereby promoting healing of the gills (Clark *et al.* 2003). It was noted by Findlay *et al.* (2000) that fish placed in water with reduced salinity for an extended period of 4 weeks, allowing gills to fully recover, showed significant resistance to re-infection, which perhaps suggests the stimulation of non-specific immune response to AGD.

Treatments are generally triggered when farms observe 30 to 40% of fish with gill scores of 2 or above (Rodger 2014). While freshwater bathing is effective in significantly reducing amoeba gill load, with an 86+/-9.1% reduction in the amount of live amoebae observed, the remaining amoebae could potentially cause a re-infection within a week (Clark *et al.* 2003). It has also been observed that water hardness had a noticeable effect on the efficacy of freshwater bathing, with soft fresh water (19.3–37.4mg$L^{-1}CaCO_3$) proving to be more effective at reducing the numbers of viable amoebae (73.9 to 40.9% of total count) (Roberts & Powell 2003). The physiological effects on salmon of freshwater bathing have also been investigated and it was found that freshwater bathing as a treatment posed very little risk of side effects (Powell *et al.* 2001). However, any form of bathing treatment can be problematic as it requires the fish to be confined by tarpaulin, cage skirt or transferred to a well-boat which imposes a handling effect, causing acute stress to the fish (Powell *et al.* 2015).

During the emergence of AGD in Australia, research focused on establishing an alternative chemotherapeutic agent; however, much of this research was relatively unsuccessful. The results of these endeavours were summarised in a review of AGD research by Hardy-Smith & Humphrey (2011) and further reviewed by Oldham *et al.* (2016).

Another commonly used treatment in the aquaculture industry is hydrogen peroxide (H_2O_2), which is utilised in the treatment of many external parasites and gill infections as well as fungal, bacterial and protozoan infections, including sea lice infestations (Gaikowski *et al.* 1999; Schreier *et al.* 1996; Bruno & Raynard 1994). *In vitro* testing of hydrogen peroxide efficacy against *N. perurans* initially seemed to show promising results (Adams *et al.* 2012). Farms in Ireland and Scotland have good experience with using hydrogen peroxide for the treatment of sea lice, and had some success in treating cases of AGD in 2011 and 2012 at dosage levels between 1000 and 1400 mg/l for 18 to 22 minutes (Rodger 2014). However, a major disadvantage of hydrogen peroxide for the treatment of AGD is that there is a narrow safety margin and at temperatures >13.5°C its use becomes hazardous (Bruno & Raynard 1994, Rodger 2014). The effects of hydrogen peroxide on Atlantic salmon gills were investigated in relation to sea lice treatments and it was determined that exposure to 2.58gL^{-1} for 20 minutes causes complete mortality (Kiemer & Black 1997).

The implementation of beneficial health management and husbandry practices has been highlighted as having the potential to reduce the impact and improve survival of fish infected with AGD (Nowak 2012). Included in such fish health management plans:

1) Reduced stock density

2) Net fouling/changing management

3) Mortality removal

4) Fallowing of site

In particular, fallowing of sites and cage rotation have been identified as having an effect on AGD, with fewer freshwater baths being required and increased growth rates observed where management practices were adjusted (Douglas-Helders *et al.* 2004). Novel strategies currently being investigated to mitigate against sea lice, such as snorkel cages, which encourage the fish to spend greater time at various depths (Frenzl *et al.* 2014, Stien *et al.* 2016), or light and feed manipulation (Bui *et al.* 2013) have also been suggested as alternative approaches for the management of AGD.

Emergence of AGD within the ICES area

Table 1 summarises the emergence of AGD within the ICES area. Among member countries, there is a range of over 20 years between the first recorded occurrence in Ireland in 1995 and the Faroes in 2015. Detailed information from Ireland provides some insight into the establishment of the infection and possible relationship with environmental factors in that country. The first case occurred in Ireland in the autumn of 1995 in S1 Atlantic salmon transferred to sea in the spring of that year, with a total of 10 sites showing pathology and associated amoeba (Rodger & McArdle 1996; Palmer *et al.* 1997). Of ten sites with confirmed disease, two recorded mortality exceeding 10%, while three others had less than 5% mortality, with the remaining sites experiencing no significant mortality (Rodger & McArdle 1996). Between the years 1995 and 2010, there were sporadic and relatively minor outbreaks of AGD (Figure. 2). Thought initially to be confined to warm dry summers, more widespread and sustained infections are now common (Rodger & McArdle 1996; Nowak *et al.* 2014, Rodger 2014) with approximately 50% of sites in Ireland affected in 2016, however the highest frequency of outbreaks coincides with elevated seawater temperatures in June, July and August (Hamish Rodger, pers. comm.). Similar increases in the numbers of cases have been reported from Norway and Scotland in the same interval. In addition, AGD outbreaks in Norway and Scotland have been associated with higher water temperatures (Steinum *et al.* 2008), suggesting a link to common environmental processes. More recent data indicate that positive seawater temperature anomalies contribute to a greater risk of AGD, since most recent outbreaks in several global localities have followed shortly after periods of unusually high surface seawater temperatures (Oldham *et al.*, 2016). In Chile, an AGD epizootic coincided with record low rainfall compared to a 15-year average (Bustos *et al.* 2011). Although severe outbreaks appear to be associated with elevated temperatures and high salinity, once an elevated infection pressure with *N. perurans* is established in a region, disease outbreaks may occur under conditions of lower temperature and salinity, such as in Tasmania at temperatures of 10.6°C and salinity of 7.2 (Clark & Nowak 1999).

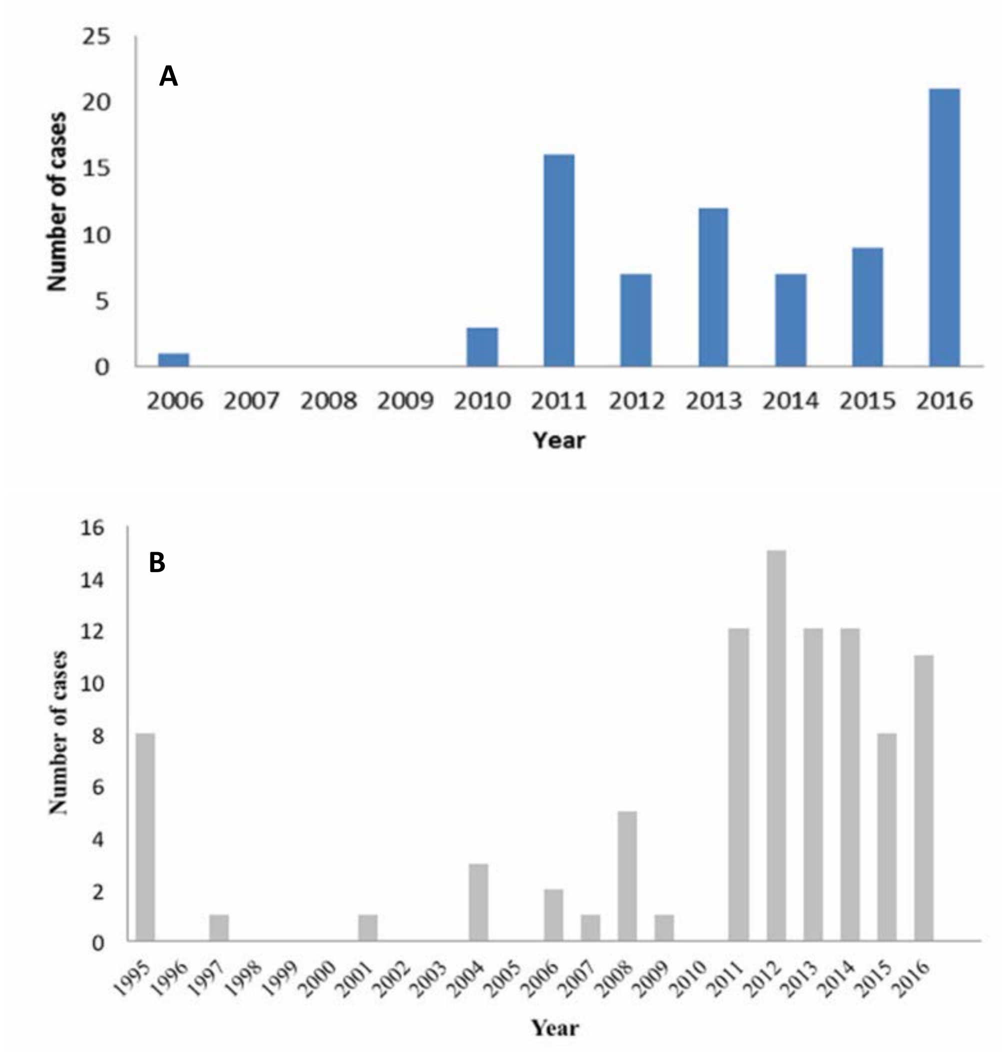

Figure 2. Amoebic gill disease (AGD) trends in two ICES member states. A. Confirmed new cases in Ireland, 1995–2016 (source: Fish Vet Group). B. New cases in Scotland reported to the Marine Laboratory, Aberdeen, 2006–2016.

Knowledge Gaps and Future Research

There is considerable evidence that the incidence and severity of AGD is linked both to infection with the opportunistic amoeba *Neoparamoeba perurans* and to severe environmental conditions, particularly elevated temperatures and salinities. Research linked to improved forecasting of coastal ocean conditions is essential to develop predictive tools for AGD. The application of sensitive diagnostic tools to farmed salmon should be encouraged as a means of early detection of infection. More research is required to identify natural reservoirs of *N. perurans*.

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Table 1. Summaries of amoebic gill disease or the detection of *Neoparamoeba perurans* reported to the WGPDMO between 2005 and 2017.

OCCURRENCE YEAR	SCOTLAND	IRELAND	NORWAY	FAROES	CANADA
2005	NR	NR	NR	NR	NR
2006	AGD first report	NR	AGD first report	NR	NR
2007	40% loss, Sep-Nov	NR	NR	NR	NR
2008	NR	NR	NR	NR	NR
2009	NR	NR	NR	NR	NR
2010	NR	NR	NR	NR	NR
2011	6% of cases; 2–47% mort	9 clinical cases; 5 w >20% mort	NR	NR	NR
2012	39% of cases v 6% in 2012	15 cases	5 cases	NR	NR
2013	9% cases	10 cases; avg 15% mort	52 cases; negl – 50% mort	AND	NR
2014	Reduction in cases, H2O2 tx	14 cases, var mortality, FW bathing	63 cases; spread western to mid; OS	First report, no elevated mortality	First report; 3 cases
2015	Similar to last year	8 cases; 1–13% mort; H2O2 or FW tx	47 cases	NR	Geographic spread; increased mortality
2016	NR	10 cases	NR	NR	AND
2017	NR	10 cases	NR	NR	AND

NR, data not reported; AND, amoeba infection, no disease; OS, other species (lumpsuckers 5 cases, Ballan wrasse 1 case.

5.6 Compile information on pathogen screening of wild salmonids in the ICES member states (ToR f)

Interactions between farmed and wild fish may play a role in the spread of important diseases within the aquaculture industry. Aquaculture can create conditions of increased host population density, leading to a higher prevalence of pathogens that can have limited impacts on wild fish but can emerge as serious diseases in aquaculture. These pathogens can become amplified in populations of farmed fish and may cause spillback to wild populations, particularly to those populations in close proximity to the fish farms. Likewise, reservoirs of infection can also be created in wild fish populations that have the potential to spread the infection to other aquaculture areas.

There is limited data available in the published literature on the prevalence of aquatic pathogens in wild fish due to the fact that the majority of wild fish have been screened as pathogen negative. The goal of this report is to utilise both published and unpublished reports to compile data on wild fish screening, describe the screening methods used, pathogens screened for and results to determine the practicalities of adopting a common approach to screening.

Canada

The Canadian Food Inspection Agency is responsible for the design and implementation of official surveillance. In 2012–2013 in British Columbia, 8,006 anadromous salmonids were screened by qRT-PCR for ISAV (8006), IPNV (6734) and IHNV (1272). All samples were negative.

2016 – New Brunswick: anadromous Atlantic salmon (255), landlocked Atlantic salmon (30), brook charr (240): PRV negative.

New Brunswick: SGPV: Atlantic salmon (12/213), brook charr (0/90)

Western Canada: sockeye salmon (41.2% positive) IHNV by cell culture.

Canadian Food Inspection Agency, 2014. Status update on the surveillance of wild and enhanced anadromous salmonids in British Columbia. 23 pp.

Norway

The Norwegian Veterinary Institute and the Institute of Marine Research monitor the health of wild anadromous salmonids on behalf of the Norwegian Food Safety Authority. Samples of sea trout, wild, hatchery-reared and escaped Atlantic salmon screened by qPCR for ISAV, IPNV, SAV, PRV, PMCV.

Madhun, A.S., Isachsen, C.H., Omdal, L.M., Einen, A.C.B., Maehle, S., Wennevik, V., Niemelä, E., Svåsand, T. & Karlsbakk, E. 2017. Prevalance of piscine orthoreovirus and salmonid alphavirus in sea-caught returning adult Atlantic salmon (*Salmo salar* L.) in northern Norway. Journal of Fish Diseases doi: 10.1111/jfd.12785

Garseth, A.H., Madhum, A.S., Gjessing, M., Moldal, T., Gjevre, A.G., Barlaup, B. & Karlsbakk, E. 2017. Annual report on health monitoring of wild anadromous salmonids in Norway 2016. Norwegian Veterinary Institute Report No. 15–2017, 15 pp.

Madhum, A.S., Garseth, A.H., Einen, A.C.B., Fiksdal, I.U., Sindre, H., Karlsson, S., Biering, E., Barlaup, B. & Karlsbakk, E. 2016. Annual report on health monitoring of wild anadromous salmonids in Norway 2015. Norwegian Veterinary Institute Report No. 7–2016, 27 pp.

Garseth, A.H., Madhum, A.S., Biering, E., Isachsen, C.H., Fiksdal, I., Einen, A.C.B., Barlaup, B. & Karlsbakk, E. 2015. Annual report on health monitoring of wild anadromous salmonids in Norway 2015. Norwegian Veterinary Institute Report No. 10–2015, 16 pp.

USA

NOAA National Marine Fisheries Service (NMFS) Northeast Salmon Team (NEST): 2003–2005 Maine region, screened 3,580 fish species – BKD, ISAV, VHSV

Gustafson, L.L., Creekmore, L.H., Snekvik, K.R., Ferguson, J.A., Warg, J.V., Blair, M., Meyers, T.R., Stewart, B., Warheit, K.I., Kerwin, J., Goodwin, A.E., Rhodes, L.D., Whaley, J.E., Purcell, M.K., Bentz, C., Shasa, D., Bader, J. & Winton, J.R. 2017. A systematic surveillance programme for infectious salmon anaemia virus supports its absence in the Pacific Northwest of the United States. Journal of Fish Diseases doi: 10.1111/jfd.12733

Purcell, M.K., Powers, R.L., Evered, J., Kerwin, J., Meyers, T.R., Stewart, B. & Winton, J.R. 2017. Molecular testing of adult Pacific salmon and trout (*Oncorhynchus* spp.) for several RNA viruses demonstrates widespread distribution of piscine orthoreovirus in Alaska and Washington. Journal of Fish Diseases doi: 10.1111/jfd.12740

UK

Wallace, I.S., McKay, P. & Murray, A.G. 2017. A historical review of the key bacterial and viral pathogens of Scottish wild fish. Journal of Fish Diseases 40: 1741–1756 doi: 10.1111/jfd. 12654

An epidemiological investigation of wild fish in Shetland in 2009 for the presence of ISAV. 2009. Report by Marine Scotland Science.

Ireland

Ranched Atlantic salmon broodstock are screened annually for IPNV, VHSV and IHNV by cell culture and BKD by ELISA. One IPNV positive pool was detected in 2009 in asymptomatic fish, all other results have been negative.

IPN virus and its impact on the Irish salmon aquaculture and wild fish sectors. 2007. Report by the Marine Institute.

Finland

Report of BKD in one Atlantic salmon broodfish returning to spawn from the Bothnian Bay region – WGPDMO report for 2013 (2014 report).

Sweden

Wild returning salmonids (wild and ranched) have been monitored for IPN, IHN, VHS and BKD since 1986 (see Table 2 for recent data). Fish are sampled at spawning or shortly thereafter. Only females are sampled and for salmon and trout (seatrout or brown trout) all the females are tested while for whitefish (*Coregonus* sp.), a selection of females are tested. Initially, 50% of the samples were ovarian fluid and 50% were internal organs consisting of heart, spleen and kidney. Only internal organs have been used since 2005.

Virus: Screening by viral cell culture BF-2 + FHM. Pooling of samples from 1–10 females, depending on how many roe batches the farmer pool.

BKD: antigen ELISA in individual fish. Kidney. In some threatened strains ovarian fluid is sampled.

Overall for Sweden:

5 isolations of IPN virus: coastal zone: 1992, 1995, 1999, 2005 (IPN 2 or 5); inland zone 2016 (IPN 6).

6 positive for BKD: coastal zone: 1998, 2008; inland zone 1994, 1995, 2009, 2015.

Denmark

Piscine reovirus (PRV) was found in wild salmon in 2014. In total 176 *Salmo salar* were investigated by qPCR. Eleven of the salmon (6.3 %) were found to harbour PRV. Eight wild brown trout and 120 rainbow trout from aquaculture were found to be negative for the virus. Eggs from the PRV-positive salmon broodfish were transferred to laboratory facilities, where the eggs were disinfected and hatched. PRV could later be found in the salmon fry – WGPDMO 2016 Report.

Surveillance of wild caught Atlantic salmon targeted several pathogens: ISA HPR0, SAV, CMS (PMCV), IPN, BKD, PRV, PRV2. None of the pathogens were found – WGPDMO 2017 Report.

Table 2. Recent IPN, IHN, VHS, and BKD results from salmonids from Sweden.

YEAR	SPECIES	NO OF FISH SAMPLED	NO OF POS IPN	NO OF POS IHN	NO OF POS VHS	NO OF POS BKD
2017	Salmon	839	0	0	0	0
	Trout	487	0	0	0	0
	Whitefish	0	0	0	0	0
2016	Salmon	731	0	0	0	0
	Trout	545	1 (gen. 6)	0	0	0
	Whitefish	60	0	0	0	0
2015	Salmon	820	0	0	0	0
	Trout	531	0	0	0	1 (ov. fluid)
	Whitefish	0	0	0	0	0
2014	Salmon	982	0	0	0	0
	Trout	458	0	0	0	0
	Whitefish	120	0	0	0	0

5.7 Evaluate applicability of the Fish Disease Index (FDI) by using the R package following newly developed guidelines (ToR g)

The present version of the R package is able to perform following actions: read rawfish disease data (ICES format or user-supplied), calculate descriptive statistics, calculate disease prevalence including confidence limits (per area, over time), calculate FDI values (raw and standardized, per individual and per population), do assessment of FDIs based on BAC and EAC in a traffic light fashion, display the assessment on a map, do a long-term trend assessment. Standard versions of the FDI for common dab (*Limanda limanda*), cod (*Gadus morhua*) and flounder (*Platichthys flesus*), are included in the package. The package also contains features to define new FDI and to derive new BAC and EAC. User input to the programme is done via an Excel spreadsheet into which all necessary inputs are entered. At present, this spreadsheet has to be stored and subsequently the user has to start the R programme manually. This procedure will be simplified by allowing users to start the programme directly from the Excel interface. The programme will subsequently be circulated to volunteering WGPDMO members for testing.

5.8 Provide expert knowledge and management advice on fish and shellfish diseases, if requested, and related data to the ICES Data Centre (ToR h)

Members of the WGPDMO continue to provide support to the ICES Data Centre in relation to the clarification of details concerning the submission of data.

5.9 Generate a standard reporting template to improve data collection concerning sample sizes and pathogen prevalences (ToR i)

Lack of consistency in the format of national disease data reports has long been recognized as presenting a challenge for the WGPDMO. Incomplete data with regard to sample sizes, prevalences, and intensities of infection, for example, can make it difficult to gauge the significance of reported observations, or to conduct meta-analyses across member countries and years. Ultimately, the group declined to mandate the use of a standard reporting template, in part out of concerns that this would be counterproductive, potentially serving as a disincentive or barrier to reporting, more than an encouragement. Rather, in annual solicitations we will simply encourage use of a template to be provided on the SharePoint site, and provide guidelines to steer reporting toward the most useful content. This guidance was originally produced by the WGPDMO at its Lisbon, Portugal, meeting in 2012. It is as follows:

Standards and guidelines for the reporting of pathogens and diseases in National Reports – S.R.M. Jones, author

Background

Members are tasked each year with the preparation of National Reports, which document significant observations and major trends in newly emerging diseases or those identified in previous reports as being important. The collation of data from the National Reports into a single document including conclusions and recommendations is an important part of the advice to ICES delivered by the WGPDMO.

While it is encouraged that National Reports address significant, major or important events, the definition of these terms has been vague and in the absence of clear guidelines, a wide range in information content and styles of data analysis or presentation is evident among reports. It is acknowledged that each national context differs in such a way that what is important in one country or region may be trivial in another. Despite this, the purpose of this document is to elicit discussion on the establishment of Guidelines and Standards which will attempt to ensure the clarity, uniformity and ultimately the value of the data upon which advice to ICES is generated.

Standards and Guidelines

1) Terms and Definitions: National data should be reported by using published and accepted terms and definitions as used in epizootiology (e.g. Bush *et al.* 1997; http://www.cdc.gov/training/products/ss1000/ss1000-ol.pdf, http://www.cs.columbia.edu/digigov/LEXING/CDCEPI/gloss.html).

2) Sample sizes must be reported for each case.

3) The age and/or size class of the host must be reported.

4) Sample locations must be unambiguous (e.g. lat-long coordinates) or a recognised reference point (e.g. Dogger Bank).

5) National Reports should be drafted using a standardised template, located on the Sharepoint (WGPDMO_National Report_Template.doc).

6 Cooperation

Cooperation with other WG

WGPDMO has strong links with the European Association of Fish Pathologists (EAFP) with members of WGPDMO serving on the EAFP Executive, as national Branch Officers and on the editorial board of the EAFP Bulletin.

WGPDMO has strong links to the National Reference Laboratories of ICES member countries, with WGPDMO members employed by NRLs and/or EU Reference Laboratories for finfish, molluscan and crustacean diseases.

The WGPDMO provided feedback on a manuscript in preparation by the Working Group on Application of Genetics in Fisheries and Aquaculture (WGAGFA). Additionally, the WGPDMO with the WGAGFA and the Working Group on Social and Economic Dimensions of Aquaculture (WGSEDA) proposed an aquaculture-related session, which was accepted, to be held at the 2018 Annual Science Conference in Hamburg. The session description is as follows:

Working Toward an Ecosystem Approach to North Atlantic Marine Aquaculture

ICES core values that focus our work include the statements that "We value marine ecosystems, the sustainable use of their resources, and the protection of the natural environment in all our endeavours" and "We are proactive, responsive and sensitive to the needs of society". These values are also at the heart of ecosystem-based management of all types of human activity, including marine aquaculture.

Marine aquaculture is expanding very rapidly. While we are still debating the ways and extent to which ecosystem based management can be applied to aquaculture, there is some agreement that such an approach is desirable in terms of sustainability. In some respects, we might argue that marine aquaculture in the ICES region is rooted in an ecosystem approach from the onset, as societal values and perceptions have shaped the scope and degree of the industry. Many of the societal concerns have been about potential impacts on the environment, thus having often acted as something of an impediment to further expansion of aquaculture. Socially acceptable sustainability criteria for marine aquaculture that could underpin an ecosystem approach have not yet found consensus. To date, various definitions of an ecosystem approach to aquaculture put emphasis on the following components:

1) It is applied in a geographically specified area;

2) It contributes to the sustainability of the ecosystem;

3) It recognizes the physical, biological, economic, and socio-cultural interactions among the affected aquaculture and non-aquaculture related components of the social-ecological system;

4) It seeks to optimize benefits among a diverse set of societal goals.

Papers which address any aspect of these topical foci are welcome. Following each set of presentations, time will be allowed for discussion designed to answer the question "Is aquaculture an example of ecosystem based management?" If so, why? If not, then what would need to happen to make it ecosystem based management?"

Cooperation with Advisory structures

In this cycle, WGPDMO member Simon Jones participated in a workshop to address the NASCO request for advice on possible effects of salmonid aquaculture on wild Atlantic salmon populations in the North Atlantic [WKCULEF], Copenhagen, Denmark, 1–3 March 2016. WKCULEF met to consider a question posed to ICES by the North Atlantic Salmon Conservation Organisation (NASCO): *Advise on possible effects of salmonid aquaculture on wild Atlantic salmon populations focusing on the effects of sea lice, genetic interactions and the impact on wild salmon production*.

This question was originally included among a suite of questions developed by NASCO, and due to be addressed by the annual meeting of the Working Group on North Atlantic Salmon (WGNAS). However, given that the question was pertinent to other Expert Groups at ICES, particularly the Working Group on Aquaculture (WGAQUA), the Working Group on Pathology and Diseases of Marine Organisms (WGPDMO) and the Working Group on the Application of Genetics in Fisheries and Mariculture (WGAGFM), it was recommended that the question would be best addressed by means of a Workshop, independent of the Working Groups. WKCULEF enabled experts in aquaculture effects, wild Atlantic salmon, disease transmission and genetic interaction to share and discuss relevant information and recent findings, in order to meet the objectives and timeline of the request.

The terms of reference were addressed though a comprehensive review of the recent peer-reviewed literature. This was facilitated by a range of presentations from participants, by reviewing working documents prepared ahead of the meeting as well as the development of documents and text for the report during the meeting. The report (ICES, 2016) is structured in two main sections, one focusing on the effects of sea lice and the other on genetic interactions. The third issue specified in the question from NASCO, namely the impact of salmon farming on wild salmon production, has been relatively poorly researched and most information derives from attempts to evaluate population level effects related to sea lice infestation and genetic introgression. This information has therefore been reported in the sea lice and genetics sections of the report, respectively.

Reference

ICES. 2016. Report of the Workshop to address the NASCO request for advice on possible effects of salmonid aquaculture on wild Atlantic salmon populations in the North Atlantic (WKCULEF), 1–3 March 2016, Charlottenlund, Denmark. ICES CM 2016/ACOM:42. 44 pp.

7 Summary of Working Group self-evaluation and conclusions

The full copy of the self-evaluation is given in Annex 4.

Annex 1: List of participants

Name	Institute	Country (of institute)	Email
Charlotte Axén	National Veterinary Institute, 751 89, Uppsala, Sweden	Sweden	charlotte.axen@sva.se
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Neil Ruane	Marine Institute, Rinville, Oranmore, Co. Galway, Ireland	Ireland	neil.ruane@marine.ie
Janet Whaley	NOAA Office of International Affairs and Seafood Inspection, Office of Aquaculture, 1315 East West Highway, 5th Floor, Office Space 5302, Silver Spring, MD, USA	USA	janet.whaley@noaa.gov
Werner Wosniok	University of Bremen, Institute of Statistics, P.O. Box 330 440, 28344 Bremen, Germany	Germany	wwosniok@math.uni-bremen.de

Annex 2: Recommendations

Recommendation	Adressed to
1. WGPDMO recommends that the ICES Secretariat strongly encourage Member Countries to continue funding of fish disease research and monitoring programmes; or, in cases where no such programmes have been implemented, make a commitment to fund such programmes to sustain fish health surveillance of wild stocks. Information obtained is of vital importance in relation to the assessment of population effects of diseases, the risk of disease transfers between wild and farmed fish and of possible effects on seafood safety. Furthermore, data obtained based on quality assured ICES/BEQUALM methodologies are required for integrated assessments of the health of marine ecosystems, e.g. in relation to environmental monitoring and assessment programmes under the EU, OSPAR and HELCOM.	ICES Secretariat

Annex 3: WGPDMO draft resolutions

Workshop proposal

A **Workshop on Emerging Mollusc Pathogens** (WKEMP), chaired by Janet Whaley and Ryan Carnegie, USA, will meet in Copenhagen in June 2019 to:

a) Identify practical concerns needing to be addressed with regard to maintaining biosecurity and responding to outbreaks by emerging as well as established pathogens;

b) Consider lessons learned from recent experience with OsHV-1 microvariants in Europe, Australia and New Zealand;

c) Develop a framework for coordinated international response to emerging diseases.

WKEMP will report by 1 August 2019 (via Aquaculture SG) for the attention of ACOM and SCICOM.

Supporting Information

Priority	The current activities of the WGPDMO will lead ICES into a consideration of how best to mitigate the impacts of emerging diseases on important fishery and aquaculture industries. Consequently, these activities are considered to have a very high priority.
Scientific justification	OsHV-1 microvariants are the most significant mollusc pathogens within the ICES area because of their present and potential future impacts on globally important Pacific oyster industries. Their rapid spread throughout Europe suggests inadequacies with regard to international aquatic animal health management. At the same time, their continued absence from major production areas in North America underscores the importance of identifying flaws in the framework for managing emerging aquatic diseases, and finding ways to correct them. Our continuing battle with these viral pathogens represents an ideal foundation for discussions concerning the international response to this and other future emerging diseases. While the immediate focus of this workshop relates to mollusc health, the results will largely transcend this phylum and apply to aquatic animal health management more generally.
Resource requirements	The research programmes which provide the main input to this group are already underway, and resources are already committed. The additional resource required to undertake additional activities in the framework of this group is negligible.
Participants	The WKEMP is anticipated to be attended by 20–25 members and guests.
Secretariat facilities	Meeting space at ICES Headquarters is requested for this workshop.
Financial	No financial implications.
Linkages to advisory committees	ACOM/SCICOM workshop
Linkages to other committees or groups	Considerations of pathogen detection and characterisation and host resistance breeding would directly relate to interests of the Working Group on Application of Genetics in Fisheries and Aquaculture (WGAGFA).
Linkages to other organizations	The work of this group is closely aligned with World Organisation for Animal Health (OIE) interests.

WGPDMO draft resolution 2019–2021

A **Working Group on Pathology and Diseases of Marine Organisms** (WGPDMO), chaired by Ryan Carnegie, USA, will work on ToRs and generate deliverables as listed in the Table below.

	Meeting dates	Venue	Reporting details	Comments (change in Chair, etc.)
Year 2019	5–9 February	Copenhagen, Denmark	1 April	
Year 2020	TBD	Rekjavik, Iceland	1 April	
Year 2021	TBD	TBD	1 April	Election of new chair

ToR descriptors

ToR	Description	Background	Science Plan topics addressed	Duration	Expected Deliverables
a	Summarize new and emerging disease trends in wild and cultured fish, molluscs and crustaceans based on national reports	New disease conditions and trends in diseases of wild and cultured marine organisms will be reviewed. This is an annual, ongoing ToR for WGPDMO and will provide information for ToRs b-i	1, 2, 3, 4, 6	3 years	Summary in annual reports
b	Deliver leaflets on pathology and diseases of marine organisms	A number of ICES publications currently in preparation will be reviewed by WGPDMO. This is an ongoing, annual ToR	1, 2, 3, 4, 6	3 Years	Publication in ICES Identification Leaflets for Diseases and Parasites of Fish and Shellfish
c	Synthesize information on the spread and impact of *Bonamia ostreae* in flat oysters in the ICES area	*Bonamia ostreae* is a major pathogen of European flat oysters that has expanded its range in recent years. The present distribution, recent trends in parasite prevalence and infection intensity, and the effectiveness of contemporary management strategies will be summarized, with perspective on the related species *Bonamia exitiosa*, recently documented in oysters from some ICES member countries. This is a continuing ToR from the previous cycle	1, 2, 3, 4, 6	2 Years	Publication in the peer-reviewed literature
d	Summarise the role of *Vibrio* pathogens contributing to	*Vibrio* bacteria have long been associated with larval production problems in shellfish hatcheries, but	1, 2, 3, 4, 5, 6	3 Years	Peer-reviewed journal article

	mortalities in shellfish aquaculture and to seafood-associated disease risks in humans	the potential impacts of vibriosis in sub-market and market-sized Pacific oysters in European production areas has become an important emerging concern. Likewise, concerm about *Vibrio* risks to human consumers has also grown. This ToR will synthesize the current knowledge on *Vibrio* highlight critical gaps in our understanding of these species. This is a continuing ToR from the previous cycle			
e	Synthesize perspective on complex gill disease (CGD) in salmon and identify strategies for mitigation	Complex gill disease (CGD) is an emergent, economically important health issue that limits productivity in salmon aquaculture. CGD is believed to results from a complex interaction of environmental, host and infectious factors. The performance and survival of affected fish is influenced by the severity of the gill lesions. Environmental factors associated with CGD include exposure to harmful algae, jellyfish, low dissolved oxygen and elevated water temperatures. Relevant infectious agents include Atlantic salmon paramyxovirus, salmonid gill poxvirus, *Candidatus Piscichlamydia salmonis* and the microsporidian *Desmozoon lepeophtherii*. This ToR will describe the causes and consequences of CGD in salmon aquaculture in ICES member countries and identify mitigation strategies in the context of climate change	1, 2, 3, 4, 6	3 Years	Peer-reviewed journal article
f	Integrate perspective on emerging health issues affecting wild salmon populations of Baltic member countries	National reporting in recent years has revealed an array of disease concerns in Baltic salmon populations, with elevated mortality being widely reported. Determining similarities and differences in patterns of disease and mortality and gaining insight into potential aetiological factors is urgent for effective management of salmon health in the region. This ToR will involve coordination among representatives of member countries around the Baltic to consolidate information concerning	1, 2, 3, 4, 6	3 Years	Peer-reviewed journal article

		Baltic salmon health problems and identify strategies for better understanding and mitigating them			
g	Identify strategies to prevent further spread of ostreid herpesvirus OsHV-1 within the ICES region and mitigate impacts where it occurs	The emergence of 'microvar' variants of the ostreid herpesvirus OsHV-1, which have caused significant Pacific oyster mortality from Europe to Australia and New Zealand, is the most significant mollusc disease development in decades. Preventing further spread of these pathogens and mitigating damage in affected areas are twin challenges of OsHV-1 management today. This ToR will aim to identify strategies to prevent OsHV-1 microvariant dispersal to North American member countries, presently free of the microvars, and to maintain commercial production should an epizootic emerge. It will also more broadly consider the OsHV-1 microvar emergence as a case study in response to emerging viral and bacterial pathogens, to identify general strategies for future responses and potential pitfalls with regard to their application	1, 2, 3, 4, 6	3 Years	ICES Journal of Marine Science article
h	Complete assessment and refine application of the Fish Disease Index (FDI)	Results of assessment of the FDI will be reviewed, and data harmonisation and quality assurance will be addressed as refined guidelines are produced for FDI application	1, 2, 3, 4, 5, 6	3 Years	Publication in final WGPDMO report
i	Provide expert knowledge and management advice on fish and shellfish diseases, if requested, and related data to the ICES Data Centre	This is an annual ToR in compliance with a requests from the ICES Data Centre	6	3 Years	Ad hoc reports

Supporting information

Priority	The current activities of this Group will provide key perspective on disease impacts on fisheries and aquaculture, and on potential avenues for mitigation to promote sustainable industries. It will lead ICES into new areas of consideration with regard to aquaculture-environment interactions. Consequently, these activities are considered to have a very high priority.
Resource requirements	The research programmes which provide the main input to this group are already underway, and resources are already committed. The additional resource required to undertake additional activities in the framework of this group is negligible.

Participants	The Group is normally attended by some 10–15 members and guests.
Secretariat facilities	None.
Financial	No financial implications.
Linkages to ACOM and groups under ACOM	ACOM/ SCICOM group
Linkages to other committees or groups	There are clear linkages to the groups of ASG, WGSEDA and WGAGFA, that we will seek to develop.
Linkages to other organizations	OSPAR, HELCOM, EAFP, OIE

Annex 4: Copy of Working Group self-evaluation

1) Working Group name:

Working Group on Pathology and Diseases of Marine Organisms

2) Year of appointment:

2016

3) Current Chairs

Ryan Carnegie, USA

4) Venues, dates and number of participants per meeting

17–20 February 2016, Gloucester Point, USA (9 participants)

14–18 February 2017, Gdynia, Poland, (7 participants)

13–17 February 2018, Riga, Latvia (12 participants)

WG Evaluation

5) If applicable, please indicate the research priorities (and sub priorities) of the Science Plan to which the WG make a significant contribution.

The WGPDMO contributes to at least six of the seven priority areas highlighted by the Science Plan, which reflect the broad relevance of marine diseases as well as the broad interests and expertise of WG members.

Food from the Sea. The WGPDMO focuses primarily on diseases of marine organisms that are the focus of fisheries and aquaculture activities.

Understanding Ecosystems. WGPDMO contributes to improving our understanding of ecosystem function through its annual work describing trends in diseases in these systems. We cannot fully understand ecosystem function without understanding and appreciating parasitism and disease in ecosystems. It is no different than the "who is consuming whom" focus of fisheries, understanding energy flow in ecosystems by resolving trophic networks. In fact it is precisely the same, as parasites are micropredators that influence energy flow through their consumption of hosts, through the connectivity of different hosts determined by parasite life cycles, and through profound influences on host fish and shellfish population biology.

Impacts of Human Activities. Humans can create or exacerbate disease issues by translocating pathogens or susceptible hosts, by altering the density or demographics of host populations, and at least to some extent through myriad other anthropogenic environmental changes, including increasing ocean temperatures, raising sea levels to change estuarine salinity profiles, increasing eutrophication, and altering carbonate chemistry. Understanding these influences is fundamental to understanding and managing diseases. New ToRs e, f, and g will reflect WGPDMO activity on this front.

Observation and Exploration. Monitoring of fish and shellfish populations for diseases, and collation of national reporting on monitoring, is fundamental to WGPDMO descriptions of disease trends in the ICES area.

Emerging Techniques and Technologies. Integral to disease monitoring is the adoption and application, as appropriate, of new technologies. The WGPDMO provides perspective on the state of the art in diagnostics through its regular revision of the disease leaflet series. The utility of next-generation sequencing approaches for pathogen detection in environmental samples has been a focus of discussions in this cycle.

Conservation and Management. Providing essential perspective on aquatic animal health to promote more informed marine resource management is central to WGPDMO work.

6) In bullet form, list the main outcomes and achievements of the WG since their last evaluation. Outcomes including publications, advisory products, modelling outputs, methodological developments, etc. *

- Annual reports on new disease trends in wild and farmed fish and shellfish in ICES Member Countries, which are the only annual expert reports available on this topic
- Publication of five new and three revised ICES Disease Leaflets, including:
  - No. 24: *Mytilicola intestinalis* parasitism (Bignell, revised leaflet)
  - No. 37: Furunculosis (Bruno, revised)
  - No. 42: Infection with *Exophiala salmonis* (Bruno, revised)
  - No. 64: Francisellosis of Atlantic cod (Alfjorden and Ruane, new leaflet)
  - No. 65: Brown ring disease: a vibriosis affecting clams *Ruditapes philippinarum* and *R. decussatus* (Paillard, new)
  - No. 66: Bonamiosis of oysters caused by *Bonamia exitiosa* (Carnegie, new)
  - No. 67: Disseminated neoplasms in bivalves (Renault and Ford, new)
  - No. 68: X-cell disease in common dab (*Limanda limanda* L.) caused by *Xcellia lamelliphila* (Perkinsea) (Feist and Bass, new leaflet)
- Submission of a new ICES Disease Leaflet on Gonadal neoplasia in bivalves (Bruno)
- Publication of the ICES Cooperative Research Report titled New trends in important diseases affecting farmed fish and molluscs in the ICES areas (Ruane and Carnegie, editors, ICES reference no. 2013/1/SSGHIE06
- Report of the Workshop to address the NASCO request for advice on possible effects of salmonid aquaculture on wild Atlantic salmon populations in the North Atlantic (WKCULEF), co-authored by Jones, WGPDMO representative to the workshop

7) Has the WG contributed to Advisory needs? If so, please list when, to whom, and what was the essence of the advice.

See final bullet point just above regarding the response to a NASCO request.

8) Please list any specific outreach activities of the WG outside the ICES network (unless listed in question 6). For example, EC projects directly emanating from the WG discussions, representation of the WG in meetings of outside organizations, contributions to other agencies' activities.

The WGPDMO has strong links with the European Association of Fish Pathologists, members participating regularly at EAFP meetings and serving as national branch members, executive board members, and journal editors.

The WGPDMO also has strong links to the National Reference Laboratories of ICES member countries, with WGPDMO members employed by NRLs and/or EU Reference Laboratories for finfish, molluscan and crustacean diseases.

9) Please indicate what difficulties, if any, have been encountered in achieving the workplan.

Future plans

10) Does the group think that a continuation of the WG beyond its current term is required? (If yes, please list the reasons)

The WGPDMO should continue its work. The annual synthesis it provides of new and emerging diseases in wild and aquacultured fish and shellfish populations as well as the ever expanding disease leaflet series continue to be invaluable with regard to marine resource management within the ICES region. New and ongoing ToRs will provide deeper perspective on critical contemporary issues. The WGPDMO is central to renewed ICES focus on aquaculture, and particularly with regard to understanding influences on the health and production of aquatic animals and interactions between aquaculture and the environment.

11) If you are not requesting an extension, does the group consider that a new WG is required to further develop the science previously addressed by the existing WG.

Not applicable.

12) What additional expertise would improve the ability of the new (or in case of renewal, existing) WG to fulfil its ToR?

WGPDMO activity would be improved by broader participation among the members. Of a WG membership of over 30, typical meeting attendance for the last 4 years has averaged 9, meaning that discussions represent a narrower perspective than is ideal. Increasing attendance at annual meetings is a focus of present efforts, and the WG will seek assistance from Headquarters staff in effecting this.

13) Which conclusions/or knowledge acquired of the WG do you think should be used in the Advisory process, if not already used?

The aquaculture arena presents particularly strong opportunities for ICES Advisory contributions, and WGPDMO should be a key resource given its broad expertise in aquaculture health.

Annex 5: Common and scientific names of host species in the report

abalone	*Haliotis* spp.
ayu	*Plecoglossus altivelis*
charr, brook	*Salvelinus fontinalis*
clam, carpet shell	*Ruditapes decussatus*
clam, hard	*Mercenaria mercenaria*
clam, Manila	*Ruditapes philippinarum*
cod, Atlantic	*Gadus morhua*
cod, Baltic	*Gadus morhua*
dab, common	*Limanda limanda*
flounder, European	*Platichthys flesus*
flounder, olive	*Paralichthys olivaceus*
lobster, American	*Homarus americanus*
lobster, European	*Homarus gammarus*
lumpsucker	*Cyclopterus lumpus*
mussel, blue	*Mytilus edulis*
mussel, Mediterranean	*Mytilus galloprovincialis*
oyster, eastern	*Crassostrea virginica*
oyster, European flat	*Ostrea edulis*
oyster, Olympia	*Ostrea lurida*
oyster, Pacific	*Crassostrea gigas*
pen shell, noble	*Pinna nobilis*
salmon, Atlantic	*Salmo salar*
salmon, chinook	*Oncorhynchus tshawytscha*
salmon, coho	*Oncorhynchus kisutch*
salmon, chum	*Oncorhynchus keta*
salmon, pink	*Oncorhynchus gorbuscha*
salmon, sockeye	*Oncorhynchus nerka*
seabass, European	*Dicentrarchus labrax*
seabream, sharpsnout	*Diplodus puntazzo*
shrimp, brown	*Crangon crangon*
shrimp, Pacific white	*Litopenaeus vannamei*

tellin	*Donax trunculus*
trout, brown	*Salmo trutta*
trout, rainbow or sea	*Oncorhynchus mykiss*
trout, sea	*Oncorhynchus mykiss*
turbot	*Scophthalmus maximus*
warehou, blue	*Seriolella brama*
whitefish	*Coregonus* sp.
wrasse, ballan	*Labrus bergylta*