WORKING GROUP ON PATHOLOGY AND DISEASES OF MARINE ORGANISMS (WGPDMO; OUTPUTS FROM 2024 MEETING)

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International Council for the Exploration of the Sea
Conseil International pour l’Exploration de la Mer

H.C. Andersens Boulevard 44-46
DK-1553 Copenhagen V
Denmark
Telephone (+45) 33 38 67 00
Telefax (+45) 33 93 42 15
www.ices.dk
info@ices.dk

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Editors

Charlotte Axen • Anne Cooper • Richard Paley

Authors

Charlotte Axén • Miguel Bao • John Bignell • Ryan Carnegie • Deborah Cheslett • Paolo Cipriani • Annelies Declercq •Ana Maria Eriksson-Kallio • Nellie Gagné• Åse-Helen Garseth • Lucilla Giulietti • Ana Grade • Olga Haenen • Árni Kristmundsson • Arne Levsen • Lone Madsen • Stein Mortensen • Richard Paley • Magdalena Podolska • Paula Ramos • Neil Ruane • Nina Sandlund • Jörn Scharsack • Silvia Soares • Julia E. Storesund • Janet Whaley

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Contents

i Executive summary

The Working Group on Pathology and Diseases of Marine Organisms (WGPDMO) reviews and reports on the health challenges affecting wild and cultured marine species, including finfish, shellfish, and crustaceans, within the ICES area. This report highlights key disease trends based on data from 14 ICES Member Countries. The last hybrid meeting of this group was in 2023, they met online late in 2024. This report summarizes the information presented during the 2023 WGPDMO expert group meeting covering trend data for the calendar years 2021 and 2022 (ToRa) and notes progress on ToRs b to e (2022–2024).

Key findings highlighted in this report include the following:

Farmed Fish:

- Viral infections, such as recurring outbreaks of Infectious Salmon Anaemia Virus (ISAV) in the North Atlantic, continue to pose significant threats.
- In eastern Canada the first reported virulent ISAV with a full, undeleted highly polymorphic region (HPR0) was detected.
- The emergence of *Cyclopterus lumpus* virus in lumpfish highlights the growing complexity of aquaculture health management.
- Sea lice infestations and complex gill disease remain critical challenges, impacting productivity in salmon farming operations.
- Bacterial pathogens, including *Moritella viscosa* and *Aeromonas salmonicida*, have exhibited changing bacterial variants patterns. Bacterial infections are common secondary to delousing, and an increasing problem in Norway and Scotland.

Wild Fish:

- The geographic expansion of "red skin disease" in Atlantic salmon and the reappearance of Eel rhabdovirus in England signal ongoing threats to wild stocks.
- Increasing trends in parasitic infections, such as *Anisakis simplex* in herring, *Contracaecum osculatum* in cod and the presence of granulomas in cod livers suggest broader environmental and ecological impacts.
- The increase in observations of Black spot syndrome, a condition of unknown aetiology, resulting in dermal degradation in Rock cook (*Centrolabrus exoletus*) in Norway and occasional observations in other wrasse species (Goldsinny, corkwing and cuckoo), warrants further investigation.
- Similarly increased observations of granulomas in mackerel, some of which are associated with mycobacterial infection should be investigated to understand implications.

Molluscs and Crustaceans:

- Following its detection in blue mussels in France in 2020, *Francisella halioticida* has now been described in blue mussels undergoing mortality in the Netherlands. Work to address increasing concern from this is ongoing.
- Putative infection of European flat oysters in England by a novel herpes-like virus should be the focus of further study.

Recommendations

1. **Enhanced Surveillance:** Reduction across national budgets for marine surveillance and disease data collection is having an impact on ability to provide information and advice. Regular monitoring and pathogen characterization should be expanded to detect emerging threats promptly.

2. **Biosecurity Improvements:** Implementing stricter controls on the movement of aquatic species and farmed stock can mitigate the spread of diseases.
3. **Research and Development:** Increased focus on vaccine development and selective breeding for disease resistance, especially for bacterial and viral pathogens, affecting aquaculture species, is critical.
4. **Integrated Management Strategies:** Collaboration across ICES countries to develop holistic approaches addressing environmental factors, pathogen management, and species health is highly desirable.

These findings highlight the urgency of addressing disease challenges in marine environments to support sustainable aquaculture and wild stock conservation; underscoring the importance of continued surveillance, biosecurity, and coordinated efforts to address emerging diseases in marine organisms.

ii Expert group information

Expert group name	Working Group on Pathology and Diseases of Marine Organisms (WGPDMO)
Expert group cycle	Multiannual fixed term
Year cycle started	2022
Reporting year in cycle	3/3
Chairs	Richard Paley, UK
Meeting venues and dates	6–10 March 2023, ICES Secretariat, Copenhagen, Denmark
	16–19 December 2024, online

1 Progress report on workplan

ToR 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 is presented, using national reports and work from WGPDMO 2023 meeting covering data for the years 2021 and 2022. This is an annual ongoing ToR for WGPDMO and will provide information for ToRs b-f.

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

This is an ongoing annual ToR. Disease leaflets on Pancreas disease and Infectious salmon anaemia in Atlantic salmon were drafted in 2022–23.

ToR c) Continue to refine application of the Fish Disease Index (FDI).

External visible fish disease is one of the general biological effects included in the Joint Assessment and Monitoring Programme (JAMP) recommended by Convention for the Protection of the Marine Environment of the Northeast Atlantic (OSPAR) from 2003, however, this indicator is voluntary, and not all contracting parties include the assessment of fish disease in their monitoring programmes. The Fish Disease Index (FDI) is a tool developed with the aim to summarize a fish's disease status using a single number intended to assess over time the link between disease as a biological effect and areas of pollution. Werner Wosniak (University of Bremen) and Thomas Lang (Thünen Institute) of the ICES Working Group on Pathology and Diseases of Marine Organisms (WGPDMO) developed the FDI from a pilot study in 2005 and presented the tool at the 2008 ICES science conference (Lang and Wosniak, 2008). The FDI is calculated for each fish based on the presence, severity, and impact of nine observable diseases ICES TIMES no. 19 (Bucke *et al.*, 1996). The severity of each disease is assigned a weighting factor based on expert judgment. The FDI is adjusted to account for factors including sex, size, and the time of year then the FDI is compared against Background Assessment Criteria (BAC) and Environmental Assessment Criteria (EAC) to determine if the status of disease is at background levels or causing significant harm. This holistic approach was regarded as a strong tool for disease data analysis (Lang *et al.*, 2017b) and its use as an ecosystem health indicator identified a relationship between mercury concentrations and the health status of dab (Lang *et al.*, 2017a). The FDI was used to assess the disease status of dab (*Limanda limanda*) collected between 2010 and 2015 in England and Wales (Robinson and Bignell, 2018) and between 2010 and 2019 in Scotland (Marine Scotland, 2020) highlighting some geographical areas of concern.

The ongoing utility of the FDI was reviewed during a 2021 research impact assessment of the Thünen Institute and recommendations to interrogate extended data series, assessing temporal and spatial relationships, were followed up within a MSc research project supervised by Jörn Scharsack. Calculated FDI data were analysed for 23 297 common dab collected across five locations in the North sea and one location in the Baltic sea over the years 2015 to 2020. In this data set, no changes of the FDI over time were highlighted; there was no correlation between FDI and distance from shoreline and no correlation with condition factor of fish. The same analyses were then undertaken at the level of each individual disease, where it was determined that an increase in the number of conditions observed in an individual fish does correlate with decreased condition factor. Further investigation indicated that comparing parasitic disease observations vs. bacterial and viral disease observations, this corelation applied only to bacteria and viruses and of these papilloma and hyperpigmentation correlated, whereas lymphocystis did not. The FDI may therefore inherently miss some of this granularity as it seeks to simplify disease status into a single number.

Routine monitoring of fish health in the North Atlantic has significantly decreased in many jurisdictions over recent decades due to reductions in funding for national government programs under fiscal constraints. This trend seems to persist. Nevertheless, national and international authorities still require the capability to address policy questions and provide guidance on the optimal use of natural resources, taking into account the impact of disease on environmental quality, wild fish stocks, aquaculture efficiency, and other related issues. Understanding baselines – that is, what constitutes "normal" with regard to disease across our seas and oceans – is crucial. This knowledge is necessary for explaining perturbations such as the effects of pollution (both acute and chronic events), climate change (including temperature, salinity, and more extreme weather events), and natural ecological stock cycles that lead to both long-term and acute mass mortality events. WGPDMO advise that a drive for more rather than less data is critical. Options to facilitate this could be a review of novel alternative data and collection methods for the next decades (e.g. environmental DNA); the international sharing of research cruises; and collaboration across ICES Working Groups to better utilize sampled fish.

ToR d) 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 requests from the ICES Data Centre. No data or advice requests were made this year. Fish disease data for monitoring of Dab (*Limanda limanda*) for the years, 2021, 2022 and 2023 from UK-England and Wales is pending upload. Sweden has monitoring data for dab, flounder (*Platichthys flesus*) and cod from 2020-2023. There remains a pending decision on a harmonized nomenclature term for the level of pathology disease observed (stage/grade).

ToR e) Develop a synthesis integrating pathogen life history and ecology and the approaches to, and effectiveness of, management of different pathogens.

This ToR did not progress beyond initial first feasibility assessment. Available information is presented in conjunction with ToR a.

2 Summary of new and emerging disease trends in wild and cultured fish, molluscs and crustaceans based on national reports (ToR a) for the Years 2021 and 2022

2.1 Farmed fish

2.1.1 Viral infections

2.1.1.1 Infectious Hematopoietic Necrosis Virus in rainbow trout

In May 2021, Infectious Hematopoietic Necrosis Virus (IHNV) was detected in Denmark for the first time in farmed rainbow trout. During the epidemiological investigation, six fish farms and three put-and-take lakes were found to be infected in the period between May to September. The IHN-free status was lifted on 10 December 2021. At that time, 28 farms were approved as IHN free and one farm is in an eradication program to become an IHN free compartment. Epidemiological investigation points towards one introduction into Denmark followed by a rapid dispersion among affected farms and put-and-take lakes. The source of the outbreak could not be identified with certainty. In spring/early summer of 2022, another outbreak of IHN developed and nine freshwater farms (including one put-and-take lake connected to one of the farms) and nine saltwater farms were found to be infected. One additional saltwater farm was found to be infected in October. Based on G-gene sequencing, the same isolate as in 2021 was circulating. The isolate appeared to be genetically different from known circulating IHNV strains in Europe, but isolate databases are not necessarily complete.

To investigate virulence and host susceptibility an experimental challenge trial was conducted. Preliminary results indicated that rainbow trout are more susceptible to the infection than Atlantic salmon

In May 2021, Finnish authorities were alerted due to recent importation of trout from Denmark to two cage farms located in the island province of Åland. Sampling was conducted and IHN was confirmed on 27 May. The disease spread to three other cage farms, either by water or human activities. In 2022, a RAS farm on Åland was also confirmed to be infected with the "Danish" IHNV, but here the infection source is unclear. No fish had been moved from the Finnish cage farms and the geography doesn't allow transfer via water. Fish had been brought to the farm from one IHN-free Danish farm but also from other European countries (Source Finnish Food Authority homepage). All rainbow trout from the infected establishments were euthanized or slaughtered and the establishments have been washed, disinfected and fallowed to eradicate the infection. The Finnish Food Authority established two restricted zones around the infected sites, and an eradication program is in force in the same area. A two-year intensified surveillance will be carried out in the zones to restore IHN free status.

2.1.1.2 Infectious salmon anaemia virus in Atlantic salmon

Infectious salmon anaemia virus (ISAV; *Isavirus salaris*) outbreaks have resulted in significant losses of farmed salmon, and there are phenotypically distinct variants of ISAV, with divergent disease outcomes, associated regulations, and control measures. In November 2021, ISAV HPRΔ was detected for the first time in Iceland. Fish showing macroscopic clinical signs, suggestive of

ISAV, were detected during routine health surveillance at one site and subsequently confirmed with PCR, sequencing, and histopathology. In subsequent screening all samples were ISAV-negative until April 2022 when the virus was detected at two other farming sites in the same fjord. In May 2022, ISAV was also detected in two farming sites in a nearby fjord. Phylogenetic analysis of detected ISAV strains, i.e. both ISAV HPR0 and ISAV HPRΔ, strongly suggested that the source of infection was deletion in the HE gene of a native "wild type" strain and all were phylogenetically linked to the primary outbreak in 2021.

In Norway which experiences ISA outbreaks annually the number of outbreaks in 2021 was notably high (25 in 2021 and 15 in 2022, as compared to 1–15 in the previous 12 years).

In eastern Canada, the number of notifications for ISAV on Atlantic salmon farms was almost nil from 2007 to 2011, and has increased steadily since 2012, with a peak of 43 notifications in 2021, and 34 notifications in 2022. The breakdown of cases confirmed for 2021 was 12 HPR0 ISAV, and 31 HPRΔ, with 6 genotypes in circulation, H24.17 North American being the most detected. In 2022, 17 HPR0 (EU type) were confirmed, compared to 13 HPRΔ ISAV cases with 11 different HPRΔ genotypes involved, with a majority of those of the North American type.

In 2021, an ISAV outbreak was caused by a strain that had a full HPR, was cultured on ASK, and had segment 5 characteristic of virulent forms of ISAV (Ditlecadet *et al.*, 2021). The strain was named HPR0-like and was not detected at any other location afterward. This is the first report of a virulent ISAV with a full HPR.

2.1.1.3 Cardiomyopathy syndrome in Atlantic salmon

Cardiomyopathy syndrome outbreaks caused by infection with piscine myocarditis virus (PMCV) continued to be a significant issue for the Irish salmon industry, with frequent clinical disease and high mortality in 2021 similar to the previous year. The clinical impact was moderate in all sites affected but there were no sites that detected PMCV in 2021 that did not subsequently develop clinical disease. In 2022, the impact was low compared to 2021. Only three sites were clinically affected and only one site with significant mortality when the fish were approaching harvest size.

2.1.1.4 Salmonid alphavirus in Atlantic salmon

In 2022, Ireland experienced a higher impact of salmonid alphavirus (SAV) infections causing pancreas disease (PD) than in the previous four years. SAV, or antibodies to SAV, were detected on 10/12 of the commercial marine sites that were in operation and the impact was moderate to high in 5/12 of these cases. There was increased mortality in some sites directly associated with acute infection, but chronic effects were more common, in the form of extensive ill thrift and loss in body condition. As usual, most sites were vaccinated against SAV including the five most impacted. It was not clear why the impact of SAV infection was higher than average this year.

2.1.1.5 Salmon gill pox virus in Atlantic salmon

Salmon gill pox virus has a significant impact on juvenile salmon production in Iceland, and the problem is increasing. It is proposed to be commonly associated with suboptimal environment – e.g. chronic supersaturation/gas bubble disease. In Ireland, the virus was detected at low levels in several marine sites and one freshwater site during routine screening in 2022, but these findings were not associated with clinical disease.

2.1.1.6 Piscine orthoreovirus in Atlantic salmon

There is generally a high prevalence of Piscine orthoreovirus (PRV1) causing heart and skeletal muscle inflammation (HSMI) in both juveniles in freshwater and in sea cages in Iceland. This causes significant losses per se, and in association with other infectious agents (salmon gill pox virus; SGPV (freshwater)), *Moritella*, *Tenacibaculum* and *Parvicapsula pseudobranchicola.*

2.1.1.7 *Cyclopterus Lumpus* virus in lumpfish

In September 2021, a site in Dorset, Southwest England, hatching and on-growing imported lumpfish ova (*Cyclopterus lumpus*) reported increased mortalities of stocks (1–3% daily, up to 30% in total across four recirculating aquaculture units). Notifiable disease was ruled out, no viral pathogens were detected by culture, and no significant fish pathogens were detected by bacteriology. *Cyclopterus Lumpus* Virus (CLuV)-like pathology was observed by histological screen. The flavivirus *Cyclopterus Lumpus* Virus (CLuV) was detected by real-time RT-qPCR in all samples at high copy number. Consistent with the clinical signs observed CLuV was concluded as the cause of the mortality. This is the first observation of CLuV in the UK (Edwards *et al.*, 2024). Sequencing data shared 99.63% similarity to lumpfish flavivirus sequence from Norway (NC_040555.1). It is currently not clear if the virus originated from imported eggs or from the local environment. Fish size and stocking densities were abnormally high and the pre nursey had suffered from a blocked filter and increased dissolved organic content prior to the outbreak.

In January 2022, a second CLuV detection was made at a lumpfish hatchery on the North Wales coast epidemiologically linked to the first. Mortality rates were lower, not all compartments were affected and environmental or management factors were implicated again.

2.1.2 Bacterial infections

There is a general increased impact of bacterial diseases on aquaculture, mainly during the sea cage phase and potentially linked to mechanical delousing strategies (Norway) and or environmental change. Direct links to climate change are difficult to decipher but it is a likely candidate here.

2.1.2.1 *Moritella viscosa* in Atlantic salmon

Moritella viscosa is an increasing problem in sea cage reared salmon in Iceland, and with an apparent recent change in strain types. Outbreaks used to be caused exclusively by a "variant" type, but the classical strain is now dominant. An ongoing research program is working on further identification of the strains present in Icelandic aquaculture, to hopefully provide a basis for the development of a more effective vaccine. There are speculations as to whether chronic supersaturation in the juvenile production might cause micro erosions in the skin epithelium, making Moritella infections more common. Co-infection with *Vibrio wodanis* and *Tenacibaculum dichentrachi*/ *finnmarkensis* is common. Of interest is that in Norway a similar switch of *Moritella* strain type causing winter ulcers has been noted but in the opposite direction to that in Iceland (classical to variant). In Ireland, there has been a decreasing trend for *Moritella viscosa* since 2019. In 2021, one site had a moderate mortality due to *Moritella viscosa* infection. This site was the only site in Ireland that did not receive a vaccine with an *M. viscosa* component in 2021.

2.1.2.2 *Aeromonas salmonicida salmonicida* in salmonids

The impact of *Aeromonas salmonicida salmonicida* (ASS), the bacterium associated with furunculosis, on farmed salmon is increasing in Ireland and Norway. In Ireland, the bacterium was detected in three sites in fish vaccinated against the pathogen in 2021. This occurred shortly after transfer in two sites, and one year post transfer in the third site. Despite occasional isolation of ASS from fish in the first two sites, mortalities attributed to it were low. In the third site, there was low-level mortality coinciding with a stressful husbandry event. In 2022, outbreaks were observed in multiple seawater sites, three of which required antibiotic treatment. Sporadic infections were also detected on other marine sites with typical clinical presentation for the disease in the absence of elevated mortality suggesting vaccination is largely effective still. This pattern illustrates there is ongoing widespread prevalence of ASS in the marine environment, with vaccine protection likely preventing major clinical outbreaks. There were also significant problems at the freshwater stage of production. In Norway, there has been a good health situation regarding furunculosis, but now there is an increased detection rate, especially in lumpfish/cleaner fish. In Iceland, *Aeromonas salmonicida* ssp. atypical (ASA) seems to have intensified and increasingly affects Arctic charr. In Scotland, *A. salmonicida* was diagnosed on four Atlantic salmon marine sites in 2022, an increase in number compared to previous years.

2.1.2.3 *Piscirickettsia salmonis* in Atlantic salmon

Piscirickettsia salmonis, the causal agent of salmonid rickettsial septicaemia (SRS) is emerging as one of the major health challenges in marine salmon farming in Ireland, with the yearly number of cases requiring antibiotic treatment increasing steadily. Almost all sea sites in Ireland in 2022 experienced some level of *P. salmonis* challenge and clinical SRS was diagnosed on most, with impact ranging from mild to high. In Scotland *P. salmonis* was diagnosed on three Atlantic salmon marine sites in 2022. Mortality levels on sites associated with *P. salmonis*, but also where co-infections of other diseases such as complex gill disease (CGD), CMS and PD were detected, varied between 10.5% to 7.2%. This is an increase compared with previous years.

2.1.2.4 *Tenacibaculosis* in salmon and sea bass

Tenacibaculosis was widespread in Ireland in 2022, most notably following exposure to *Muggiaea atlantica* and other harmful jellyfish species. An unusual presentation was observed with *Tenacibaculum* infection around the oral cavity and teeth in marine salmon in some sites. Affected fish were observed spitting out pellets during feeding, most likely from oral discomfort. This presentation occurred on two sites, but sporadic localized *Tenacibaculosis* cases were ubiquitous. In Portugal, *Tenacibaculum maritimum* is known to appear in European sea bass. In Scotland *Tenacibaculum* sp. was diagnosed on three Atlantic salmon marine sites in 2022 associated with clinical signs and mortality observed.

2.1.2.5 *Photobacterium damselae subsp. piscicida* in sea bream and sea bass and sole

Photobacteriosis or *pasteurellosis* caused by *Photobacterium damselae* subsp. *Piscicida* has been a growing problem for ICES countries since the early 1960s. In Portugal, *Photobacterium damselae* ssp. *Piscicida* impacts in gilthead sea bream (*Sparus aurata*), sea bass (*Dicentrarchus labrax*), and sole (*Solea senegalensis* and *Solea solea*) are typically expressed in winter, and although somewhat controlled by vaccination, it continues to cause mortality in outgrowing marine fish production.

2.1.2.6 *Pasturellosis* in Atlantic salmon

Pasturellosis, caused by *Pasturella "atlantica genomovar salmonicida*" (working name) has recently increased in Norwegian aquaculture. It has been an emerging health issue in the region Vestlandet since 2018, and the number of sites where the bacterium was identified increased from 45 in 2021 to 52 in 2022. The disease commonly affects large salmon (2–5 kg) and is associated with reduced welfare and mortality. Sometimes the bacterium is found in association with other bacterial infections, or outbreaks of viral infections (PD, CMS, HSMI). *Pasturella "atlantica genomovar cyclopteri"* (working name) is commonly associated with bacterial infections in lumpfish.

2.1.2.7 *Vibrio anguillarum* and *Vibrio harveyi*

Vibrio anguillarum can infect many species of freshwater and marine fish, bivalves and crustaceans. Although *V. anguillarum* is somewhat controlled by vaccination in Portugal, it continues to cause mortality in outgrowing marine fish production.

2.1.3 Fungal infections

No new trends

2.1.4 Parasite infections

2.1.4.1 *Parvicapsula pseudobranchicola* in Atlantic salmon

Parvicapsula pseudobranchicola was detected for the first time in Iceland in 2019. A research project has shown that the prevalence is very high (up to 100%) in salmon in sea cages. Smolt become infected shortly after transfer to sea cages. Whether it is more common now is not clear as data from before 2019 are missing.

2.1.4.2 *Neoparamoeba perurans* in Atlantic salmon

Amoebic gill disease, caused by *Neoparamoeba perurans*, is currently endemic on all sites in Ireland and Norway, and many in Scotland and is controlled to some extent with no new trends.

2.1.4.3 Lepeophtheirus salmonis in Atlantic salmon

The salmon louse, *Lepeophtheirus salmonis*, infestation affected most Irish marine sites in 2022, but the levels of lice observed, and the fish health impacts, were notably reduced compared with previous years. Wrasse and lumpfish were widely used as a tool for lice control. Salmon louse infestation is also a problem in Norway, where mechanical de-lousing treatments is a major cause of mortalities.

2.1.5 Other diseases

2.1.5.1 Phytoplankton in Atlantic salmon

There was a significant noxious phytoplankton bloom in October 2021 in the southwest region of Ireland, with a species previously undescribed in Irish waters (tentative *Pseudochattonella verruculosa*). This led to acute high mortalities on two sites and a lower impact on one other site in the southwest. In 2022, phytoplankton blooms that impacted fish occurred in spring, summer and autumn. These blooms were frequently made up of a mixture of species, making it difficult to assess harmful levels. 2022 saw multiple sites around the country reporting impacts from phytoplankton in the form of bleeding gills elevated mortality. Chronic gill pathology, consistent with plankton exposure, was a constant feature on histology samples from most marine sites. This gill pathology, even if not severe, was likely to have exacerbated the impact of other diseases and adverse events.

2.1.5.2 Zooplankton in Atlantic salmon

Harmful zooplankton was a significant issue in Ireland in 2022. Extremely high levels of *Muggiae atlantica* were detected in bays from the southwest and the northwest of the country. Levels greater than (>2000 *M. atlantica* per cubic meter) associated with severe gill pathology in Atlantic salmon.

2.1.5.3 Jellyfish in Atlantic salmon

Larger jellyfish, such as the Compass and Lion’s mane, were implicated in causing significant skin damage in several Irish sites in summer/autumn of 2022.

2.1.5.4 Haemorrhagic smolt syndrome in Atlantic salmon

Atlantic salmon smolts (from pre-to post-smolt), with clinical signs of haemorrhagic smolt syndrome (HSS) have been identified in Norway for some time (Nylund *et al.,* 2003). It was identified for the first time in Iceland in 2022. HSS is a condition of unknown aetiology.

2.1.5.5 Gas bubble disease/supersaturation issues in Atlantic salmon

There are also environmental problems associated with juvenile production: In parallel with increasing production, supersaturation issues have increased. Supersaturation levels (mainly nitrogen) are mostly low and chronic, leading to a constant low-grade gas bubble disease affecting gills and numerous other organs. The decreased access to oxygen caused by gas thrombosis makes the fish more susceptible to infections with e.g. SGPV.

2.1.5.6 Complex gill disease (CGD) in Atlantic salmon

CGD in the marine environment continues to be a highly significant issue within Scottish salmon aquaculture. Twenty-one CGD diagnostic cases were reported in 2022. The following pathogens have been implicated with clinical outbreaks along with various environmental insults: *Neoparamoeba perurans* (causative agent of amoebic gill disease, AGD), Salmon gill poxvirus (SGPV), *Paranucleospora theridion*, *Candidatus 'Branchiomonas cysticola'* (epitheliocystis), *Candidatus 'Syngnamydia salmonis'* (epitheliocystis).

2.1.5.7 New myocardial pathology in Atlantic salmon

In Scotland, only in a single fish, histopathology displayed identical features to those described by Poppe *et al.,* 2021. This included multifocal areas in the stratum compactum with lighter stained cardiomyocytes and granular or vacuolated cytoplasm. Popes' findings were typically observed in salmon impacted in conjunction with non-medical treatments (thermal or mechanical) against sea lice (*Lepeophtheirus salmonis*).

2.2 WILD FISH

2.2.1 Viral infections

2.2.1.1 Anguillid herpes virus

No new trends

2.2.1.2 Screening of wild broodstock for restocking purposes

A number of countries working with restocking programs for salmonids screen the broodstock after stripping in order to rule out presence of different infections in the parents. This is especially important for infections such as infectious pancreatic necrosis (IPN) and bacterial kidney disease (BKD) that are known to be vertically transmitted. Viral screening is generally done by cell culture or molecular diagnostic methods. BKD analysis is generally done by ELISA or PCR.

Sweden samples all broodstock females, generally 2000–3000 per year, for Epizootic hematopoietic necrosis virus (EHNV), Viral haemorrhagic septicaemia virus (VHSV), Infectious hematopoietic necrosis virus (IHNV), Infectious pancreatic necrosis virus (IPNV) and Bacterial kidney disease (BKD). In 2022, one female Atlantic salmon broodstock out of 2420 females was positive for IPNV genogroup 5. The female was stripped and sampled at a restocking facility on the west coast. This was the first detection of any of these pathogens in Swedish wild broodstock since 2016.

In 2021-2022, Danish authorities screened a total of 205 wild Atlantic salmon broodstock for EHNV, IPNV, IHNV, VHSV, ISAV, SAV, PMCV, PRV-1, PRV-3 and BKD. Three samples from three different rivers systems, tested positive for PRV-1 in 2021.

In 2021–2022, Norway screened 812 wild Atlantic salmon broodstock and 472 wild sea trout broodstock from 14 rivers for BKD, IPN, PRV and ISA by PCR, and for bacterial infections by cultivation. In 2021, IPN was identified in one sea trout, PRV-1 in 55 salmons and PRV-3 in 50 sea trout. In 2022, PRV-1 was identified in 12 out of 359 salmons from 2 out of 21 rivers and PRV-3 in 43 out of 270 sea trout from 12 out of 14 rivers. No primary bacterial pathogens detected.

Finland monitors their wild-caught broodstock for VHS, IHN, IPN, salmonid alphavirus (SAV) and BKD. In 2021, approximately 800 fish were sampled and the corresponding number for 2022 was approximately 1000 fish. None of the investigated pathogens were detected.

Scotland undertakes passive surveillance on wild returning salmon broodfish where appropriate. 17 fish, returning ahead of spawning, from 6 different rivers were investigated during 2021 and 2022 for the presence of IHNV, VHSV, ISAV and GS, none of which were detected.

2.2.2 Bacterial infections

2.2.2.1 Mycobacteriosis

Mycobacterium infection in fish is a well-known disease problem globally. Presumptive mycobacteriosis has previously been observed in Atlantic mackerel (*Scomber scombrus*). Recently, mycobacteriosis was identified in Atlantic mackerel caught south of the Shetlands Isles, North of Scotland and in the Northern part of the Norwegian Sea, between 2018–2020. (Sandlund *et al.*, 2023). Since 2018, there has been an increase in reports of granulomatous kidney disease in Atlantic mackerel with the suspicion of this being mycobacteriosis. Little is known about the prevalence, distribution, and the effects such infections have on Atlantic mackerel.

2.2.3 Fungal infections

No new trend.

2.2.4 Parasite infections

2.2.4.1 *Kudoa thyrsites* and *Ichthyophonus* sp in Atlantic mackerel

In Norway, prevalence of clinical signs of infection decreased from 3.4% in 2020 to 1.3% in 2021.

The prevalence of *Ichthyophonus* sp. infections in Atlantic mackerel remained at an average of around 50% in mackerel from the northern North Sea and Norwegian Sea. Prevalence was assessed by macroscopic and microscopic screening of heart, kidney and spleen and red muscle tissue for resting spores. In comparison the prevalence in North Sea herring and Spring-spawning herring remained low at around 1%. The comparatively high prevalence in mackerel highlights the need for continued monitoring due to the parasite's potential to cause mortalities in wild marine fish stocks including herring from the North Atlantic. SSU rDNA gene sequencing and histological examinations indicate both a DNA sequence divergence and significant size difference between *Ichthyophonus* sp. detected in herring and mackerel.

2.2.4.2 Parvicapsula pseudobranchicola

This parasite was first identified in wild salmonids in Iceland in 2021 but had first been identified in farmed salmon two years earlier. It has been found in a low prevalence in anadromous Arctic charr (*Salvelinus alpinus*) and sea trout (*Salmo trutta*). While it is absent in many areas, in close vicinity to sea cages the prevalence it high.

2.2.4.3 Gill worms

A parasitological survey of gills of hornfish (*Belone belone*) caught in the Baltic Sea close to Bornholm revealed the finding of *Axine belones* (the hornfish gill worm). Danish investigations revealed that in total three gill worms were found on 12 hornfish, which shows that the gill worm, which is normally found at higher salinities, could be found in salinities at 7–8 per mille.

2.2.4.4 Parasitic nematodes

In Norwegian Gadiformes samples from the Barents Sea ecoregion, a 100% prevalence of *Anisakis simplex* (s.s.) is found in Arctic cod (*Boreogadus saida*), with most of the larvae found in viscera, but also present in muscle. Similarly, *Contracaecum osculatum* sp. B is very common in cod, showing a 100% prevalence in the viscera, however it was never found in the fillets. The species *C. osculatum* sp. A was only rarely recorded in viscera. Infection by *Pseudoterranova* spp. was less common in viscera and muscle (prevalence <20%). The species *P. decipiens* (s.s.), *P. krabbei* and *P. bulbosa* were identified. Remarkably, sealworm infections were considerably higher, both in fillets and viscera, when comparing coastal cod from Vesterålen/Lofoten area compared to Artic cod samples. As regards to Arctic saithe, a 100% prevalence was recorded for *A. simplex* (s.s.), both in viscera and muscle, and for *C. osculatum* sp. *B in viscera*. However, *Pseudoterranova* spp. larvae was very rarely recorded in this fish. Finally, *A. simplex* (s.s.) was very abundant in tusk, showing 100% prevalence in muscle and viscera, not just in the belly flap area but also in the anterior dorsal fillet of the fish. *Contracaecum osculatum* (s.l.) larvae were much less abundant in the viscera than *A. simplex* (s.s.), but still showing high prevalence. *Pseudoterranova* larvae were often observed in the flesh with different infection levels.

Blue whiting (*Micromesistius poutassou*) specimens from waters west of British Isles have been inspected annually for >10 years during the fishery season (i. e. early spring) for the presence of anisakid larvae. *A. simplex* (s.s.). was very abundant, particularly in viscera but also in flesh, especially considering the relatively small size of this commercial fish, reaching virtually a 100% overall prevalence. High prevalence of *A. simplex* (s.s.) is also commonly found in Norwegian Spring-spawning and North Sea herring (*Clupea harengus*) as well as in Atlantic mackerel.

Increasing trends in the prevalence and intensity of Anisakis simplex sensu lato infections in herring were reported for the period of 2019–2022 in the Polish EEZ (ICES Subdivisions 25 and 26). Anisakis was also present in a wide variety of fish and fishery products in Portugal, which resulted in discarded and unmarketable fish products. The presence of endoparasites in dab in the Greater North Sea Ecoregion seem to be common. Anisakis sp. is monitored in Belgian waters, and the prevalence in dab was 0.6% for dab caught close to the shore vs. 0.2% for dab caught offshore in 2020. In 2022, Belgian authorities reported a prevalence in dab as 0% for dab caught close to the shore compared to 1.2% for dab caught offshore. There is no specific trend, prevalence varies a bit from year to year, but there was a peak 3.1% prevalence in dab caught close to the shore in 2019.

Contracaecum osculatum sensu lato nematode larvae were found in livers of cod sampled in the Polish EEZ (ICES Subdivisions 25 and 26), and there was an increasing trend in the level of infection from 2011 to 2022. The prevalence of infection exceeded 96% of cod at length of ≥ 35 cm, that were sampled in the Eastern Baltic in Q1 of 2021.

There was an increasing trend in Baltic cod sampled by Sweden as well, with 100% prevalence of *Contracaeum* sp. in livers 2022 compared to 42% in 2021. In addition, the parasite burden of individual fish had increased: in 2021, 1 of 26 (4%) infected livers contained <10 parasites compared to 30 of 58 (52%) in 2022. There was a negative correlation between parasite burden and Fulton’s condition factor. The cod was sampled in ICES Subdivisions 24, 25, 27 and 28 in 2021, and subdivisions 25 and 25 in 2022.

2.2.5 Other diseases

2.2.5.1 Impacts on cod, flounder, and dab in the Baltic Sea

The health of cod and flounders/dabs, especially in the Baltic Sea needs to be continuously monitored.

In 2020, Swedish monitoring of cod in the Baltic Sea identified 7% of sampled cod with abnormal gonads. No such deviations were discovered in 100 cod sampled in 2021, but in 1/100 cod sampled in 2022. Since 2020, flounder with renomegaly have been seen during health monitoring in the Hanö Bay (Swedish southeast coast) and further out at sea. Obtaining proper samples has been challenging, and thus the aetiology has not been determined. Histopathology of one fish (2021) showed glomerulinephritis, whereas histopathology of three flounders 2022 showed more advanced disease with complete destruction of nephrons. Histopathology to be done of all flounders and dabs from the surveys, BITS and IBTS 2022 (n=200, whereof 20 had swollen kidneys).

Cod that were sampled from the Kattegat and Skagerrak in 2022 showed a lot of parasitic or bacterial granulomas in the livers of young fish (liver weight appr.1 g).

2.2.5.2 Black spot syndrome in wrasse

In recent years, there has been an increasing number of observations of a black spot syndrome in rock cook (*Centrolabrus exoletus*) in the area around Austevoll in Norway (ICES Greater North Sea Ecoregion). The black spots have been characterized into three categories or types of lesions: type 1 and 2 abnormalities on head and fins and type 3 on skin with scales. Histopathological examination of type 1 and 2 lesions are characterized by absence of epidermis, and degradation dermis. In dermis a matrix of connective tissue with infiltration of inflammatory cells and granulomas are seen. Type 3 lesions showed infiltration of inflammatory cells and melanomacrophages in both epidermis and dermis (Aga, 2019). Since 2017 occasional observations of this syndrome have also been seen in goldsinny wrasse (*Ctenolabrus rupestris*), corkwing wrasse (*Symphodus melops*), and cuckoo wrasse (*Labrus mixtus*). The aetiology of this condition is unknown, and no pathogen has been detected in the cases reported here. A more detailed description of this syndrome can be found in Aga (2019).

Following the Nord Stream sabotage in October 2022, SVA (Sweden) obtained samples of cod from a number of trawlings in SLU:s BIAS operation. The point closest to the leak was 7 nautical mile away, and sampling was performed 2 weeks after the leaks were closed. Notably, there was a high prevalence of S-curved/wire-looped gill filaments. This was also noted in other sampling points than the one closest to Nord Stream, but in less fish and gills were not as affected (less curving and a lower degree of curving). It is unclear if the findings are actually associated with the leaks or if there is another aetiology. Acute nephrosis was also seen, but at an approximately equal prevalence at the Nord Stream point and other sampling points.

2.2.5.3 Impacts on Atlantic salmon in the Baltic Sea, red skin disease and saprolegniosis

Sweden and Finland monitor salmon health each year in a joint project covering the Torne river, that constitutes the border between the two countries. In addition, Sweden monitors salmon health in 3-4 other river systems, of which Vindelälven and Luleälven belongs to the Baltic Sea, Ätran belongs to the Northern Sea/Atlantic Ocean and Klarälven is and inland river with landlocked salmon.

Red skin disease and summer mortalities in salmon is continuing but has caused less problem in 2021 and 2022 compared to the previous seven years. Testing for a midichloria-like organism (MLO) previously associated with red mark syndrome in Rainbow trout was performed on skin lesion samples from 2020-2022. The MLO was not detected but several samples showed indication of a related organism, and investigations are ongoing.

Fungal/oomycete infestations of salmon and trout in autumn season are also continuing at unaltered high rates, and potentially result in fewer spawning couples.

2.2.5.4 M74 syndrome

Sweden reported a slightly increasing trend for M74, from 0% in 2020 to 10% in 2022. There was a variability of its occurrence among hatcheries (from 0 to 22% in the 2022 hatch). M74 is still low compared to a peak in 2016–2107 (20–30%) and there is a natural fluctuation in the occurrence of the syndrome over time (see Figure 3.1).

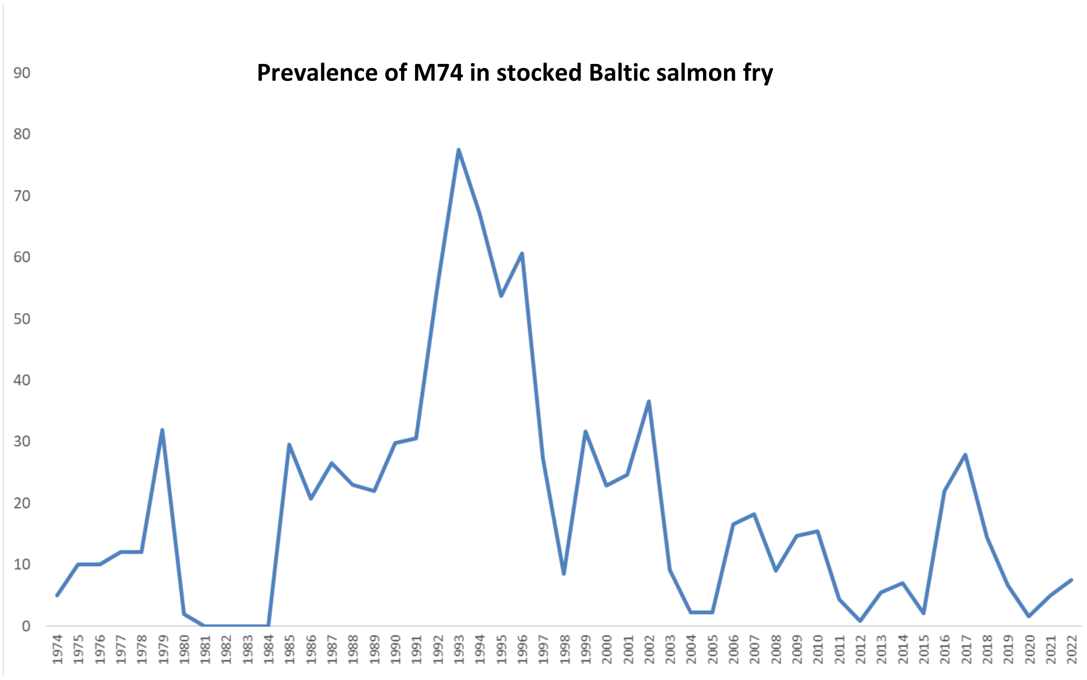

Figure 3.1 Annual overall prevalence of suspected M74 % (proportion of females affected) in Swedish salmon hatchery stocks during the period 1974-2022. Data are provided for the year of hatching.

2.2.5.5 Cyanobacteria

No new trend

2.3 Wild and farmed molluscs and crustaceans

2.3.1 Viral infections

2.3.1.1 Ostreid herpesvirus 1 in Pacific oysters

A re-occurrence of OsHV-1 was confirmed in juvenile Pacific oysters (*Magallana gigas*) at an aquaculture production business (APB) in North Kent, England, in June 2021, during investigation into a report of >80% mortality. The isolate in this case had not previously been detected in the United Kingdom but has been known in France since 2009. The affected site has imported stock from several French oyster hatcheries.

For the third consecutive year there were no reports of oyster mortalities associated with OsHV-1μVar in Ireland in 2022.

OsHV-1 was found in Pacific oysters in samples were collected in the Wadden Sea between 2013 and 2019. This is the first detection of the virus in oysters sampled in Danish waters.

2.3.1.2 Viral detection in association with mortality in European flat oysters

In July 2022, mortality estimated at up to 50% was reported in *Ostrea edulis* held in an intertidal farm located in northeast England. The mortality was observed in juvenile (two-year-old) oysters only and occurred at a time of adverse environmental conditions, high temperatures and prolonged air exposure from spring tides as these juveniles were held relatively high on the shore. Histological examination was negative for pathogenic protists but revealed a potential virus infection with enlarged nuclei and possible viral inclusions in 7 of 30 oysters. Samples were negative for OsHV-1 by PCR but electron microscopy and metagenomic analyses indicated presence of a herpes-like virus, which is now under characterization. Similar observations have been previously reported in flat oysters in Spain (Villalba *et al.*, 2010) but the identity of the virus remains undetermined. The extent to which this virus is a direct or indirect cause of mortality is unknown.

2.3.1.3 Unknown mortalities in edible crabs

In the Netherlands in 2021, live *Cancer pagurus* imported from Ireland showed 50% mortality. The crabs were in poor condition with numerous granulomas observed in two of the three crabs submitted for analysis. One crab displayed pathology consistent with a viral infection, although no virus was identified and whether this could have been the cause of the mortality could not be determined.

2.3.1.4 CsRV1 in blue crabs

A recent genetic analysis (Zhao *et al.*, 2023) provided new insight into *Callinectes sapidus Reovirus* 1 dynamics, via examination of genetic variation of the pathogen from Massachusetts, USA, to Uruguay. One of the observations was that genotypes of CsRV1 from Louisiana, USA, in the Gulf of Mexico are more similar to those in the Chesapeake Bay, USA, than would be predicted by gene flow along the coast. Chesapeake Bay and Louisiana virus genotypes were revealed to be more like each other than Louisiana genotypes are to those from Florida, USA, or elsewhere in the southeastern United States.

This observation is consistent with the movement of virus genotypes by interstate transport of live crabs between the two areas, which have the two largest blue crab fisheries in North America. In the cooler months, when the Chesapeake Bay fishery is closed, live crabs from the Gulf of Mexico are transported to the Chesapeake Bay area to meet market demand. Some fishers in the Chesapeake Bay region also have businesses that import crabs from out of state. It is anecdotally reported that the crabs that inevitably die in transport are discarded into estuary waters. These results underscore the risk of disease introductions with transfers of crab fishery products and the importance of improving control to mitigate potential disease impacts.

2.3.2 Bacterial infections

2.3.2.1 *Vibrio aestuarianus* in Pacific oysters

This pathogen continues to be the predominant cause of mortality in Pacific oysters in Ireland. In 2021, two cases of mortality in spat were attributed to the presence of *V. aestuarianus*, with a further 12 cases in adult and half-grown oysters. In 2022, reports of increased mortalities associated with Pacific oysters were reported from 11 different production bays. Mortality reports were associated with all age classes of Pacific oysters (spat = 3, juvenile = 4, and adult = 4). *Vibrio aestuarianus* was present in all 13 samples collected during the mortality events. The three cases of spat mortality were associated with imported stock from a hatchery in France. Subsequent investigations revealed that a number of other operators in other production bays had also experienced problems with batches received in April, and that there had also been mortality at the source site. Issues at the source hatchery coincided with a rapid rise in water temperatures. Additional samples of oyster seed from the same hatchery collected from other operators also tested positive for *V. aestuarianus* both prior to and after deployment in Irish waters. Bacteria belonging to the *Vibrio splendidus* clade were additionally detected in Pacific oysters during mortality events in Ireland in two bays in 2021 and five bays in 2022.

In Denmark, *Vibrio aestuarianus* has been detected in Pacific oysters sampled in the Limfjorden between 2016 and 2021 as part of the national project "Development of mitigation strategies for control of Pacific oysters". In 2019 and 2020 the pathogen was additionally detected by qPCR in cockles *Cerastoderma edule* and *C. glaucum* in the Limfjorden, along with *B. ostreae* (the cockles were negative for *Marteilia* parasites). The implications of these observations for control of oyster pathogens warrants further attention.

Nineteen mortality events affecting principally commercial size Pacific oysters, in Aveiro lagoon and Formosa lagoon in the Algarve, Portugal, were recorded over the 2021–2022 period. No cause was initially identified for the mortality, however a subset of the samples collected during these events were subsequently screened for the presence of *V. aestuarianus* and 9/17 oysters tested were shown to be positive for *Vibrio aestuarianus*.

2.3.2.2 *Francisella halioticida* in blue mussels

The bacterium was detected in mussels in the Netherlands undergoing mortality in May 2022. It was not detected in either Common cockles (*Cerastoderma edule*) or the Pullet carpet shell (*Venerupis corrugata*) from the same mortality event.

It was also detected in archival blue mussel (*Mytilus edulis*) samples collected from 2013–2019 from a wild population in the Tamar estuary (Cornwall, Southwest England) in which declines in mussel abundance have been noted in the last decade. Seven percent of mussels collected in 2013, and 18% in 2019, presented large granulomas and haemocytic infiltration in the interstitial tissue of the digestive gland. Four samples were selected for 16S rRNA gene Nanopore sequencing, and consensus sequence of 1449 bp was produced that showed nucleotide similarities of 99.93–100% to published sequences of *F. halioticida*. In situ hybridization (ISH) confirmed the presence of *F. halioticida* DNA within individual granulocytes in granulomas and also in prokaryotic-like inclusion bodies within the digestive epithelial cells.

2.3.3 Parasite infections

2.3.3.1 *Bonamia ostreae* in European flat oysters

The Limfjorden in Denmark lost its Bonamia-free status in March 2015 after the finding of *Bonamia ostreae* in flat oysters in autumn 2014 sampling. Limfjorden surveillance dating to 2000 was discontinued in 2018. In 2020, mortalities among flat oysters were observed at several places in Limfjorden, prompting new sampling. It was shown that *Bonamia ostreae* could be detected at high prevalence in different zones of the Limfjorden. Currently, only flat oysters potentially used as broodstock in a hatchery are screened for Bonamia.

2.3.3.2 *Marteilia cocosarum* in common cockles

A 2022 publication (Skujina *et al.*, 2022) described this pathogen from *Cerastoderma edule* at several sites in Wales, UK, with prevalence of infection noted to range from 4.7% (2/42 positive) to 79.2% (19/24) depending on location and sample time. Samples from Ireland and northwest, southwest, and northeastern England were negative for the parasite. Though associated with areas showing cockle declines, *M. cocosarum* has also been detected at high prevalence in areas not reporting decline, thus the extent to which this parasite is responsible, either solely or in combination with other factors, for reported cockle declines and mortality events is unknown.

2.3.3.3 *Marteilia* sp in common cockles

A *Marteilia* sp. closely related to *M. cocosarum* was observed in the Wash, eastern England, in April and July 2021, in investigation of ongoing common cockle declines and increased mortality. Prevalence of the *Marteilia* sp. was significantly higher in moribund compared to buried cockles across three sampling sites (82 vs. 42%, 84 vs. 34%, and 22 vs. 10% in 50 animals sampled per group, 289 in total). Work is ongoing to characterize the parasite's potential link to cockle mortalities and declines and a paper is in preparation.

2.3.3.4 *Marteilia pararefringens* in mussels

In recent years the nomenclature of the *Marteilia* sp. affecting mussels and oysters has changed several times as knowledge of these parasites has grown. It is now generally understood that the parasite impacting flat oysters which was first described in the 1970s in France is *Marteilia refringens* and that affecting mussels (*Mytilus* sp.) is now termed *Marteilia pararefringens*. *Marteilia pararefringens* was detected for the first time in Norway in 2016 (Kerr *et al.*, 2018, Bøgwald *et al.*, 2022). This parasite has so far been found in wild blue mussels, *Mytilus* sp. at eight sites in Norway and in one mussel farm (Mortensen *et al.*, 2022 and 2023).

2.3.3.5 *Haplosporidium costale* in eastern oysters

An outbreak of this pathogen with associated Eastern oyster (*Crassostrea virginica*) mortality was observed on an oyster farm in Delaware, USA, in spring 2022. Histopathological analysis of samples of moribund and live oysters in June 2022 presented abundant haplosporidian infections, at 60% prevalence with advanced infections in the moribund group, and at 20% and 25% prevalence in two live oyster samples also with advanced infections. Subsequent PCR examination of a follow-up sample of live oysters revealed a 100% PCR presence of *H. costale* and only a 10% PCR prevalence of the co-occurring congeneric *Haplosporidium nelsoni*, evidence of some dual infections but with *H. costale* the likely cause of the mortality. The affected farm was located at a higher salinity site (~30 psu), within the range of salinities in which *H. costale* is known to occur in the region (>25 psu). Like most aquaculture broodstock in the region, the affected oysters were selectively bred in waters of intermediate salinity (~15–21 psu) for resistance to the endemic pathogens *H. nelsoni* and *Perkinsus marinus,* but not for resistance to *H. costale*, which does not occur in those mesohaline to polyhaline waters. Susceptibility to *H. costale* thus represents a vulnerability to disease that breeding interests in the US aquaculture industry should focus future attention on addressing.

2.3.3.6 Haplosporidium nelsoni in eastern oysters

Prevalence of this pathogen has increased in Chesapeake Bay waters of Virginia, USA, in annual Fall Survey sampling of adult oysters from 30 Virginia reefs (each n = 25). Mean prevalence across 29 reefs that were sampled in 2022 was 1.8%, with a maximum prevalence observed of 12% at one reef in the James River. Despite a recent increasing trend, *H. nelsoni* infection levels have been far below historical peaks, a mean of 16.8% prevalence in 1999, for example, and prevalences at individual reefs at times exceeding 40%. The generally decreasing impacts of *H. nelsoni* are likely due to increasing disease resistance in the oyster host.

2.3.3.7 Perkinsus marinus in eastern oysters

Mean prevalence of this pathogen in Chesapeake Bay waters of Virginia, USA, was 68.4% in 2022, the highest observed since 2012, based on annual Fall Survey sampling of adult oysters from 30 Virginia reefs (each n = 25). Despite the recent increase mean prevalence of *P. marinus* remained below the long-term (1989–2022) mean of 69.6% and well below the historical peak of 88.4% in

2001. Despite continued impacts of P. marinus in the Chesapeake Bay region oyster abundance has steadily improved, now reaching levels not seen since the 1980s.

2.3.3.8 *Perkinsus olseni* in Grooved carpet shell

As has happened in previous years, mortality events of *Ruditapes decussatus* took place in Ria Formosa lagoon, in the south coast of Portugal. Most of these episodes began in June and are related to the presence of the parasite *Perkinsus olseni*. Juvenile and adult samples were collected and analysed using the RFTM diagnostic techniques. Results indicated high levels of infection and a very high prevalence of that pathogen which associated with post-spawning stress, contributes to the high prevalence observed.

2.3.3.9 *Lagenidium callinectes* in European lobster

This oomycete was observed in September 2021 in a berried female lobster (*Homarus gammarus*) submitted for analysis following reports from fishers of increased incidence of discoloured eggs on berried female lobsters in the Eastern IFCA region of England. The parasite is responsible for larval mycosis of cultured penaeid shrimp and other crustacean larvae.

2.3.4 Other diseases

2.3.4.1 Transmissible Neoplasia in softshell clams

A 2022 paper (Giersch *et al.,* 2022) provided further evidence of the transmissibility of a disseminated neoplasia in *Mya arenaria* in the USA, the condition termed *Mya arenaria* bivalve transmissible neoplasia (MarBTN), finding environmental detection of MarBTN cells in aquaria holding affected clams, and MarBTN cell survival from several days to up to 8 weeks in artificial seawater.

Reference list

Aga, J. 2019. Beskrivelse av svarte flekker på hus til grasgylt (*Centrolabrus exoletus*) Master thesis, Department og Biology, UiB, Norway

Bøgwald M, Skår CK, Karlsbakk E, Alfjorden A, Feist SW, Bass D, Mortensen S (2022). The infection cycle of *Marteilia pararefringens* in blue mussels *Mytilus edulis* in a heliothermic marine oyster lagoon in Norway. Diseases of Aquatic Organisms 148: 153–166, https://doi.org/10.3354/dao03651

Ditlecadet, D., Gautreau, C., Boston, L., Liston, R., Johnsen, E., & Gagné, N. (2021). First report of successful isolation of a HPR0-like variant of the infectious salmon anaemia virus (ISAV) using cell culture. Journal of Fish Diseases, 00, 1–5. https://doi.org/10.1111/jfd.13556

Edwards, M., Bignell, J.P., Papadopoulou, A., Trani, E., Savage, J., Joseph, A.W., Wood, G. and Stone, D.M. 2022. First Detection of *Cyclopterus Lumpus* Virus in England, Following a Mortality Event in Farmed Cleaner Fish. *Bulletin of the European Association of Fish Pathologists* 43 (1): 28–37. https://doi.org/10.48045/001c.56559.

Giersch, R.M.; Hart, S.F.M.; Reddy, S.G.; Yonemitsu, M.A.; Orellana Rosales, M.J.; Korn, M.; Geleta, B.M.; Countway, P.D.;Fernández Robledo, J.A.; Metzger, M.J. Survival and Detection of Bivalve Transmissible Neoplasia from the Soft-Shell Clam *Mya arenaria* (MarBTN) in Seawater. Pathogens 2022, 11, 283. https://doi.org/10.3390/pathogens11030283

Kerr R, Ward GM, Stentiford GD, Alfjorden A, Mortensen S, Bignell JP, Feist SW, Villalba A, Carballal MJ, Cao A, Arzul I, Ryder D, Bass D (2018). *Marteilia refringens* and *Marteilia pararefringens* sp. nov. are distinct parasites of bivalves and have different European distributions. Parasitology 1–10. https://doi.org/10.1017/ S003118201800063X

Mortensen S, Skår C, Bøgwald M, Ghebretnsae DB, Jelmert, A. (2022). The surveillance and control programme for bonamiosis and marteiliosis in European flat oysters, *Ostrea edulis*, and blue mussels, *Mytilus* sp. in Norway in 2021. Rapport fra havforskningen 2022-7, 12 s. https://www.hi.no/en/hi/nettrapporter/rapport-fra-havforskningen-en-2022-7

Mortensen S, Skår C, Bøgwald M, Ghebretnsae DB, Jelmert, A. (2023). The surveillance and control programme for bonamiosis and marteiliosis in European flat oysters, *Ostrea edulis*, and blue mussels, *Mytilus* sp. in Norway in 2022. Rapport fra havforskningen 2023-25. https://www.hi.no/hi/nettrapporter/rapport-fra-havforskningen-en-2023-25

Nylund A, Plarre H, Hodneland K, Devold M, Aspehaug V, Aarseth M, Koren C, Watanabe K. Haemorrhagic smolt syndrome (HSS) in Norway: pathology and associated virus-like particles. Dis Aquat Organ. 2003 Mar 17;54(1):15-27. doi: 10.3354/dao054015.

Poppe, T. T., Reed, A. K., Hofossæter, M., & Wisløff, H. (2021). Novel myocardial pathology in farmed salmonids. Journal of Fish Diseases, 44, 1657–1660. https://doi.org/10.1111/jfd.13486.

Sandlund, N.; Skår, C.; Karlsbakk, E. First identification of mycobacteriosis in Atlantic mackerel (*Scomber scombrus*). *Journal of Fish Diseases* **2023**, *n/a*, doi:https://doi.org/10.1111/jfd.13765.

Skujina, I; Hooper, C; Bass, D; Feist, S.W.; Bateman, K.S.; Villalba, A.; Marballal, M.J.; Iglesias, D.; Cao, A.; Ward, G.M.; Ryder, D.R.G.; Bignell, J.P.; Kerr, R.; Ross, S.; Hazelgrave, R.; Macarie, N.A.; Prentice, M.; King, N.; Thorpe, J.; Malham, S.K.; McKeown, N.J.; Ironside, J.E. Discovery of the parasite *Marteilia cocosarum* sp. nov. in common cockle (*Cerastoderma edule*) fisheries in Wales, UK and its comparison with *Marteilia cochillia*. Journal of Invertebrate Pathology 2022, 1922, 107786. https://doi.org/10.1016/j.jip.2022.107786

Villalba A., Ramilo A., Abollo E and Fuentes J. (2010) Mass mortality of European flat oyster (Ostrea edulis) spat associated with a viral infection in Galicia (NW Spain). In: Aquaculture Europe 10, October 2010, Porto. European Aquaculture Society, Oostende, p 1380−1381

Zhao, M.; Plough, L.V.; Behringer, D.C.; Bojko, J.; Kough, A.S.; Alper, N.W.; Xu, L.; Schott, E.J. Cross-Hemispheric Genetic Diversity and Spatial Genetic Structure of Callinectes sapidus Reovirus 1 (CsRV1). Viruses 2023, 15, 563. https://doi.org/10.3390/v15020563

Annex 1: List of participants

Name	Institute	Country of institute
Charlotte Axén	National Veterinary Institute	Sweden
Miguel Bao	Institute of Marine Research	Norway
John Bignell	Cefas	UK
Ryan Carnegie	Virginia Institute of Marine Science	US
Deborah Cheslett	Marine Institute	Ireland
Paolo Cipriani	Institute of Marine Research	Norway
Annelies Declercq	Lab of Aquaculture & *Artemia* Ref Center	Belgium
Ana Maria Eriksson-Kallio	Finnish Food Authority	Finland
Nellie Gagné	Fisheries and Oceans Canada	Canada
Åse-Helen Garseth	Norwegian Veterinary Institute	Norway
Lucilla Giulietti	Institute of Marine Research	Norway
Ana Grade	Portuguese Institute for Sea and Atmosphere	Portugal
Olga Haenen	Central Institute for Animal Disease Control	Netherlands
Árni Kristmundsson	Institute for Experimental Pathology at Keldur	Iceland
Arne Levsen	Institute of Marine Research	Norway
Lone Madsen	Technical University of Denmark	Denmark
Stein Mortensen	Institute of Marine Research	Norway
Richard Paley	Cefas	UK
Magdalena Podolska	National Marine Fisheries Research Institute	Poland
Paula Ramos	Portuguese Institute for the Ocean and Atmosphere	Portugal
Neil Ruane	Marine Institute	Ireland
Nina Sandlund	Institute of Marine Research	Norway
Jörn Scharsack	Thünen Institute for Fish Biology	Germany
Silvia Soares	Marine Directorate	UK
Julia Storesund	Institute of Marine Research	Norway
Janet Whaley	NOAA Fisheries	US

Annex 2: Resolutions

WGPDMO - Working Group on Pathology and Diseases of Marine Organisms

2021/FT/ASG02 A **Working Group on Pathology and Diseases of Marine Organisms** (WGPDMO), chaired by Richard Paley (United Kingdom) will work on ToR and generate deliverables as listed in the Table below.

	MEETING DATES	VENUE	REPORTING DETAILS	COMMENTS
Year 2022	TBD			Change of chairs: Ryan Carnegie (US) will step down and be replaced by Richard Paley (United Kingdom)
Year 2023	7-10 March	ICES, HQ	Interim report by 1 May to ASG	
Year 2024	TBD	TBD	Final report by 1 May to ASG	

ToR descriptors

ToR	Description	Background	Science Plan Codes	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-e.	Code 1.7, 5.2, 5.6	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.	Code 1.7, 5.6	3 years	Publications in ICES Identification Leaflets for Diseases in Fish and Shellfish
c	Continue to refine application of the Fish Disease Index (FDI).	Results of assessment of the FDI will be reviewed as it continues to be applied to new fish systems, and data harmonization and quality assurance will be addressed as refined guidelines are produced for FDI application.	Code 1.7, 2.5	3 years	Summary in annual reports
d	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 requests from the ICES Data Centre.	Code 6.4	3 years	Reporting as requested

e	Develop a synthesis integrating pathogen life history and ecology and the approaches to, and effectiveness of, management of different pathogens	Understanding the effectiveness of different approaches to disease management in aquaculture and fisheries is critical for disease control. Yet the pathogens of key resource species vary greatly in their biology and their ecological roles, with some management strategies likely to be more effective than others given the biological and functional diversity of host-pathogen relationships. This ToR will use a global synthesis of these relationships as well as approaches to management to identify strategies most likely to be effective for different types of disease systems.	Code 1.4, 1.7, 5.6	Year 1	Peer-reviewed journal article

Summary of the Work Plan

YEAR 1	COMPLETE ANNUAL WORK ON TORS A-C, AND IF NECESSARY TOR D. COMPLETE TOR E. CONSIDER PROPOSAL OF NEW TORS AS NECESSARY. COMPLETE INTERIM REPORT.
Year 2	Complete annual work on ToRs a-c, and if necessary ToR d. Consider proposal of new ToRs as necessary. Complete interim report.
Year 3	Complete annual work on ToRs a-c, and if necessary ToR d. Consider proposal of new ToRs as necessary. Complete final report for the cycle.

Supporting information

Priority	The current activities of this Group provide essential perspective on diseases of economic and ecological significance in the ICES, including intersections with fisheries and aquaculture industries. Identifying strategies for aquatic animal health management through a better understanding of diseases is a fundamental interest. 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 15-20 members and guests.
Secretariat facilities	None.
Financial	No financial implications.
Linkages to ACOM and groups under ACOM	There are no obvious direct linkages.
Linkages to other committees or groups	There is a close working relationship with all the groups in the ASG.
Linkages to other organizations	

Annex 3: List of abbreviations and acronyms

bream, Gilthead	*Sparus aurata*
carpet shell, Grooved	*Ruditapes decussatus*
carpet shell, Pullet	*Venerupis corrugata*
char, Arctic	*Salvelinus alpinus*
clam, soft shell	*Mya arenaria*
cockle, Common	*Cerastoderma edule*
cod, Arctic	*Boreogadus saida*
cod, Atlantic	*Gadus morhua*
cook, Rock	*Centrolabrus exoletus*
crab, Blue	*Callinectes sapidus*
crab, edible	*Cancer pagurus*
dab, common	*Limanda limanda*
garfish	*Belone belone*
herring, Atlantic	*Clupea harengus*
lobster, European	*Homarus gammarus*
lumpfish	*Cyclopterus lumpus*
mackerel, Atlantic	*Scomber scombrus*
mussel, Blue	*Mytilus edulis*
oyster, Eastern	*Crassostrea virginica*
oyster, European flat	*Ostrea edulis*
oyster, Pacific	*Magallana gigas*
saithe, Arctic	*Pollachius viruens*
salmon, Atlantic	*Salmo salar*
sea bass, European	*Dicentrarchus labrax*
sole, common	*Solea solea*
sole, Senagalese	*Solea senegalensis*
trout, Rainbow	*Oncorhynchus mykiss*
trout, Sea	*Salmo trutta*
whiting, Blue	*Micromesistius poutassou*
wrasse, Corkwing	*Symphodus melops*
wrasse, Cuckoo	*Labrus mixtus*
wrasse, Goldsinny	*Ctenolabrus rupestris*