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Fish Health Unit
Report of Activities Undertaken in 2021

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EXECUTIVE SUMMARY

This report summarises the activities undertaken by the Fish Health Unit (FHU) of the Marine Institute (MI) in 2021. The services of the FHU, undertaken on behalf of the State, are largely driven by European legislation on aquatic animal health. New EU Animal Health Law came into force from April 21st 2021. Regulation (EU) 2016/429 lays down the rules for the prevention and control of animal diseases which are transmissible to animal or humans and has replaced the regulatory framework provided by Directive 2006/88/EC. The MI is the Competent Authority (CA) responsible for implementation of aquatic animal health regulation in Ireland.

Aquatic animal health regulations apply to aquaculture establishments (AEs) such as finfish farms and shellfish farms and requires them to obtain a Fish Health Approval (FHA) from the CA prior to operation. In addition to issuing FHAs to aquaculture establishments, the CA conducts regular health surveillance of fish and shellfish farms. The CA is also responsible for regulating the movement of aquatic animals within Ireland and during intra-EU and third country movements to and from the state.

The MI hosts the National Reference Laboratories (NRLs) for finfish, mollusc and crustacean health. Testing conducted by the NRLs directly supports the implementation of the aquatic animal health controls in Ireland. NRL staff are also actively engaged in applied research to continually address disease diagnosis, treatment and management issues.

This report provides stakeholders with an insight of the role the MI FHU plays in the application of aquatic animal health regulations. Through the publication of this report, the MI hopes to build a greater understanding of the issues relating to aquatic animal health in Ireland with a view to increasing engagement with all stakeholders.

New Animal Health Law. In 2021 the MI worked with a number of stakeholders to implement the new requirements in Regulation (EU) 2016/429 and associated delegated acts and implementing acts which came into force on 21st April. This involved significant operational changes including approval and registration procedures, surveillance programmes and health certification.

BREXIT. Additional controls for the trade of live animals between Great Britain (GB) and Ireland came into place on the 1st January 2021. These controls placed additional requirements on certification of exports to GB. Imports from GB were required to enter Ireland through designated Border Control Posts (BCPs) and the CA worked closely with BCPs to provide technical advice to support the application of those controls.

COVID-19. The COVID-19 pandemic presented significant ongoing challenges for delivery of Fish Health work programmes in 2021. Despite this, laboratory services, CA operations and surveillance inspections continued following risk assessment of our working processes.

Through a combination of remote working, social distancing and additional safety measures, programmes were completed largely as planned.

Fish Health Approvals. During 2021, the CA maintained FHAs for 386 AEs involved in the production of fish or shellfish. The majority (320) of these AEs were associated with shellfish farming. In addition, the CA maintained one FHA for a disease control aquatic food establishment and issued two FHAs for treatment vessels. In total, 15 new FHAs were issued to AEs during 2021.

Health Surveillance. During 2021, as part of a risk-based surveillance scheme, Department of Agriculture Food and the Marine (DAFM) Veterinary Inspectors (VIs) and FHU staff undertook 215 inspections of FHA holders in Ireland under the direction of the CA. Targeted surveillance was carried out for diseases of national importance. This involved sampling aquatic animals from representative sites and laboratory testing for identified pathogens in the NRLs. Based on this testing, existing disease-free status was maintained for diseases listed as notifiable in Regulation (EU) 2016/429.

Aquatic Animal Movements. To prevent the introduction or spread of diseases, movements of aquatic animals are controlled by the CA. Movements must be approved in advance. Approval is given depending on the health status in the originating and receiving sites which is checked by the CA on a case-by-case basis. The CA approved 1203 movements of molluscan shellfish, principally oysters, in 2021. These approvals included internal (national) movements, intra-EU movements (between EU Member States) and third country imports and exports. To facilitate outwards movements, health certification was provided for 139 individual consignments of molluscs requiring physical inspection on 116 occasions. The CA approved 100 movements of salmon, salmon ova and gametes. To facilitate outward movements, health certification was provided for 46 individual consignments of salmon and salmon ova. In addition, the CA approved 417 applications associated with the inwards movements of ornamental aquatic animals to Ireland.

Disease Notifications and Outbreaks. There were no reported outbreaks of diseases listed as notifiable under Regulation (EU) 2016/429 in 2021. There were three reports of crayfish mortality associated with crayfish plague in 2021. Crayfish plague is listed as a notifiable disease by The World Organisation for Animal Health (OIE) but not in Council Directive 2006/88/EC. The crayfish plague outbreaks occurred in the Rivers Loobagh and Maigue, Co. Limerick and the River Clonaslee, Co. Laois.

In summary, fish health inspection and monitoring activities undertaken in 2021 continued to demonstrate a high level of compliance with statutory requirements in EU Regulation. Furthermore, the continued implementation of statutory controls by state agencies in Ireland with the support of all stakeholders ensured a high health status for aquatic animals in Ireland, was maintained in 2021.

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ABBREVIATIONS USED IN THIS REPORT

AE	Aquaculture Establishment
AGD	Amoebic Gill Disease
AHL	Animal Health Law
BIM	Bord Iascaigh Mhara
BKD	Bacterial Kidney Disease
CA	Competent Authority
CFP	Crayfish Plague
CMS	Cardiomyopathy Syndrome
DAFM	Department of Agriculture, Food and the Marine
EU	European Union
EURL	European Union Reference Laboratory
FHA	Fish Health Approval
FHMP	Fish Health Management Plan
FHU	Fish Health Unit
INAB	Irish National Accreditation Board
ISO	International Organisation for Standardisation
MI	Marine Institute
MS	Member State (EU)
NPWS	National Parks and Wildlife Services
NRL	National Reference Laboratory
NSAI	National Standards Authority of Ireland
OIE	World Organisation for Animal Health
OsHV1-µVar	Oyster herpesvirus 1 microvariant
PD	Pancreas Disease
PMCV	Piscine Myocarditis Virus
PVP	Private Veterinary Practitioner
SI	Statutory Instrument
SVC	Spring Viraemia of Carp
TRACES	Trade Control and Expert System
VI	Veterinary Inspector
BCP	Border Control Post

1 INTRODUCTION

This report describes the activities undertaken by the Marine Institute (MI) Fish Health Unit (FHU) in 2021 to deliver its responsibilities in the area of aquatic animal health under Regulation (EU) 2016/429. The activities of the FHU are delivered through two complementary services, that of the Competent Authority (CA) which regulates aquatic animal movements and health management; and the National Reference Laboratories (NRLs) for fish and shellfish diseases, which conducts standardised testing and applied research to support the mission of the CA. The purpose of this report is to provide all stakeholders with an improved understanding of the operations of the MI in this area of work, and the findings encountered by the FHU in 2021. MI activities associated with the control of sea lice on salmon farms is not included in this report and are reported separately.

2 REGULATORY BACKGROUND AND FHU RESPONSIBILITIES

2.1 Relevant Regulation

The FHU is the CA responsible for the implementation of aquatic animal health legislation in Ireland. The primary legislation in this regard is Regulation (EU) 2016/429 on transmissible animal diseases and amending and repealing certain acts in the area of animal health ("Animal Health Law") which came into force on April 21st 2021. The new Regulation retains successful concepts from Directive 2006/88/EC, which was repealed in 2021, with some additions and improvements. A number of delegated and implementing acts providing additional details on animal health rules supplement Regulation (EU) 2016/429.

Aquaculture operators and establishments who were previously authorised under Directive 2006/88/EC were automatically deemed to be approved under the new regulation. Such operators and establishments are therefore subject to the relevant obligations provided for under the new Animal Health Law.

Regulation (EU) 2016/429 and supporting legislation provides a comprehensive risk-based approach to aquatic animal health management. Amongst other conditions, detailed rules and controls for are given for the following areas:

- Approval and registration of Aquaculture Establishments (AEs);
- Aquatic animal health surveillance;
- Control of movements of aquatic animals;
- Disease notification and control

In 2021, the CA office started the process of implementing new elements of the Animal Health Law through a phased risk-based approach. Details of some of the significant changes in requirements in the new Animal Health Law compared with the previous regulation are provided in (*Appendix 3)*.

2.2 Approval and Registration of Aquaculture Establishments (AEs)

All finfish and shellfish farms, plants processing round (i.e. ungutted) fish and treatment vessels must register with the CA for Fish Health Approval (FHA). In addition, certain shellfish purification centres and ornamental fish wholesalers which may present a risk of disease spread must register for FHA. The CA issues an FHA once it is satisfied that the establishment meets all relevant regulatory fish health requirements. As part of the approval process, each Aquaculture Establishment (AE) must produce a Fish Health Management Plan (FHMP) which is approved by the CA. An FHMP requires the establishment to identify biosecurity measures relevant to their operation and demonstrate how it will comply with regulatory animal health requirements. A register of AEs is available on FHU website. In addition, specialist transporters and put and take fisheries must register with the CA but are not required to hold a FHA. Importers of cold-water ornamental aquatic animals to closed facilities that do not discharge to the environment must also register with the CA without a requirement for a full FHA.

2.3 Disease Notification and Control

A fundamental element of the AHL is the requirements for AEs to monitor the health of their animals and to notify the CA on the presence or suspected presence of a disease listed in *Annex II* of Regulation (EU) 2016/429. In the event of detection of a listed disease, the legislation provides specific details on the obligations of the member state, through the CA, to report the outbreak to the EU commission and other Member States and specific measures to prevent the spread of the disease within Member States and the EU.

In addition, Ireland has identified a number of diseases of national significance which require notification in the event of suspicion or confirmation of its presence at a site.

2.4 Aquatic Animal Health Surveillance

A key principle of fish health controls under the AHL is the requirement for the CA to implement an active health surveillance programme. This programme is based primarily on inspection of AEs supported by targeted surveillance for specific diseases. The frequency of the health surveillance inspections is risk-based and is determined on the likelihood of disease introduction or spread at individual sites. Generally, high-risk sites are inspected annually, medium risk sites every two years and low risk sites every three years. The major factors for determining the risk of introduction and spread of disease is the number of movements of

aquatic animals in and out of the site and the proximity to other sites in the production area. To implement the health surveillance inspection programme, Department of Agriculture, Food and the Marine (DAFM), Veterinary Inspectors (VIs) conduct on-the-ground site inspections and health visits at aquaculture sites under the supervision of the CA. In addition, targeted surveillance is carried out for certain diseases for which Ireland is declared free, either on a countrywide basis or in identified zones. This involves testing susceptible aquatic animals for specific disease pathogens using test methods recognised in EU regulation or in the World Organisation for Animal Health (OIE) Manual of Diagnostic Tests for Aquatic Animals.

In addition to the health surveillance programme implemented by the CA, AEs are required to undertake their own health surveillance, using Private Veterinary Practitioners (PVPs) where appropriate for the aquaculture production system. As well as advising AE operators directly on aquatic animal health issues, PVPs undertaking this surveillance are legally required to report immediately the suspicion of notifiable or unexplained emerging diseases to the CA. This industry-based surveillance, forms a critical part of the overall health surveillance programme in Ireland and elsewhere in Europe.

2.5 Control of the Movement of Aquatic Animals

Regulation (EU) 2016/429 and associated Delegated Regulations provide detailed rules on the control of the movement of aquatic animals between aquaculture sites, to protect the health status of the receiving site. Any movement of aquaculture animals from one AE to another for farming or restocking purposes requires approval by the CA prior to that movement occurring. Other movements of aquatic animals may also require approval. Online applications to move aquatic animals are facilitated through the MI Fish Health Website.

2.6 Internal (National) Movements

Movements of aquaculture animals within Ireland may only occur between approved aquaculture establishments. An application for approval of such movements must occur at least 72 hours prior to the intended movement. Each application is assessed by the CA considering the following details where relevant:

- The health status of the zones of origin and destination. (The originating area must have at least the same or better health status as the final destination).
- The susceptibility to disease of the species moved and at the receiving site.
- Whether or not there are clinically diseased animals or unresolved mortalities at the origin site.
- Veterinary inspection reports if required.
- Any other factors relevant to aquatic animal health.

Figure 1. Specialised transport wellboat for moving salmon between sites. Such movements require approval by the CA office in the MI and strict biosecurity measures are applied to prevent potential spread of aquatic pathogens.

2.7 Movements between Member States within the EU (INTRA-EU Movements)

Any cross-border movement of live aquaculture animals between Member States (MS) must be notified to the CA in the receiving country via the EU's Trade Control and Expert System (TRACES). TRACES is a web-based veterinary certification tool used by the European Union for controlling movements of all live animals and animal products within and outside of its borders. Approved movements from MS into Ireland are reconciled with the corresponding TRACES certificate from the country of origin by the CA. TRACES certificates are, in-turn, generated by the CA for consignments of live animals originating from Irish AEs and destined for sites in another MS. On many occasions, a TRACES notification is sufficient for the CA to approve an export from Ireland. However, for movements of susceptible or vector species between areas subject to disease surveillance programmes, full health certification and inspection within 72 hours prior to departure may be required. In such cases, inspection and health certification for export is performed on the ground by DAFM VIs at the request of the CA. Specific rules on intra-EU movements are provided for in Commission Delegated Regulation (EU) 2020/990.

2.8 Imports and exports from and to third countries outside the EU

Additional rules exist for the importation of live animals into the EU. All such movements must enter MS through officially recognised Border Control Posts (BCPs) where they must be presented for inspection with appropriate health declarations.

The CA worked with Irish BCPs in 2021 to ensure consignments of aquatic animals imported into Ireland from outside of the EU comply with our health standards. Specific rules apply for entry of live aquatic animals in the EU from third countries are provided for in Commission Delegated Regulation (EU) 2020/692.

Requirements to export to third countries outside of the EU are determined by the importing country. This usually requires animal health certification and additional documentation compared to movements to EU MS. In January 2021, GB implemented reciprocal post-brexit animal health controls for imports of aquatic animals from the EU. The CA facilitates exports to GB and other third countries by issuing health certificates.

2.9 Competent Authority Office Operations

The CA office is responsible for delivery of all tasks associated with the implementation of aquatic animal health controls in Ireland apart from third country import controls at BCPS. To deliver this programme the MI works closely with DAFM VIs who undertake on the ground inspections of AEs on a regionalised basis. A Service Level Agreement is in place between the MI and DAFM veterinary services to ensure inspections are delivered to agreed protocols and standards. The CA office maintains a quality management system which was first certified by the National Standards Authority of Ireland (NSAI) in 2014 and transitioned to the requirements of ISO 9001:2015 which the CA are now certified to. This commitment to quality has enabled the CA Office to ensure that best operational practices are adhered to. Under this certification scheme delivery of the work programme is audited independently by NSAI on an annual basis. In 2021, the CA office successfully passed the annual audit visits by the NSAI, as it has every year, since initial certification in 2014.

2.10 National Reference Laboratories

The NRLs for aquatic animal health in Fish, Molluscs and Crustaceans in Ireland reside in the FHU in the MI. The NRLs form part of a network of reference laboratories in EU Member States under the direction of the relevant EU Reference Laboratory. The roles of the NRLs are set out in Article 101 of Regulation (EU) 2017/625. Most importantly, the NRLs provide the CA with testing services for the notifiable aquatic animal diseases listed in *Annex II* of Regulation

(EU) 2016/429 and other diseases of national importance using internationally recognised and standardised methods. Tests used to detect the major diseases of concern in the legislation and of national importance to Ireland are accredited to ISO 17025 standards. Accreditation is awarded by the Irish National Accreditation Board (INAB). The MI passed its annual ISO 17025 surveillance inspection in 2021.

Figure 2. Delivery of regulatory programmes for aquatic animal health in Ireland is a collaborative approach between the competent authority, NRLs and DAFM veterinary services.

2.11 Significant Aquaculture Sectors in Ireland

Aquaculture is a significant economic activity in Ireland and in 2021 primary aquaculture production was worth €175 million (BIM The Business of Seafood Report 2021). The primary products were salmon (€109 million), oysters (€45 million) and mussel (€17 million) with other fish (€2 million) and shellfish (€2 million) species making up the rest of the production. In addition to aquaculture production, significant industries exist around put and take fisheries (angling) and the trade in ornamental aquatic animals, both of which are also subject to control under Regulation (EU) 2016/429.

Figure 3a & 3b. Pacific oyster and Salmon production are the two largest aquaculture activities in Ireland and much of the work of the FHU is directed to application of legislation and control of aquatic animal health in these two sectors.

3 MOLLUSCAN SHELLFISH ACTIVITIES

3.1 Fish Health Approvals (FHAs)

In 2021, the CA maintained 320 FHAs for shellfish AEs. These were divided between AEs producing Pacific oysters (55%), mussels (25%), multiple species (16%) and other species (4%). During 2021, 13 new approvals were issued and 12 approvals were revoked. In all cases revocation of FHAs were due to cessation of aquaculture activities at the site.

3.2 Shellfish Health Surveillance Programme Inspections

There is a relatively high frequency of animal movements associated with the majority of AEs producing Pacific oysters in Ireland. Consequently, AEs farming Pacific oysters are generally categorised as 'medium risk' sites and are therefore inspected every two years. Conversely, AEs producing mussels and other shellfish species are associated with fewer movements of animals and are therefore categorised as 'low risk' site and are generally inspected every three years. This inspection frequency may increase at individual sites where ongoing

compliance issues are identified. In 2021, 165 shellfish AEs were inspected as part of the annual surveillance programmes (*Table 1*). Minor non-compliances were detected during 52 inspections. These were primarily associated with failure to keep certain records. Medium non-compliances were detected in two inspections and were associated with continued non-compliance surrounding record keeping and notification of mortality. No serious non-compliances were found in 2021.

Table 1. Shellfish Health Surveillance Inspections in 2021 and associated non-compliance findings

Inspection Type	No. Inspected	No. of AEs inspected with non-compliances (% of FHAs inspected)		
		Minor	Medium	Serious
Pacific Oysters	101	35 (35%)	2 (2%)	-
Mussels	35	11 (31%)	-	-
Multiple Species	27	5 (19%)	-	-
Other	2	1 (50%)	-	-
Total	**165**	**52 (32%)**	**2 (1%)**	**-**

Minor non-compliance
Minor shortfalls in record keeping. Minor housekeeping issues.

Medium non-compliance
Ongoing and repeated issues with record keeping or housekeeping issue.

Serious non-compliance
Operator has failed in his duties to an extent that the health status of bay or country may be affected (e.g., failure to inform CA of movements of shell or failure to report mortalities). This designation may also be used where there has been a continued disregard of minor or medium non-compliances identified in previous inspections. A serious non-compliance will normally result in in a compliance notice being issued. Failure to implement the compliance notice within the specified time limit can result in a revocation of the FHA.

3.3 Targeted Surveillance

During 2021, targeted surveillance continued for a number of shellfish diseases listed in Annex II of Regulation (EU) 2016/429 and those covered under national measures specifically applicable for Ireland. Specific monitoring was undertaken to maintain disease free status for two mollusc diseases, namely *Bonamia ostreae* and OsHV-1µVar.

Bonamia ostreae is a listed disease in Regulation (EU) 2016/429 that affects native oysters (*Ostrea edulis*) and is caused by a *haplosporidia* protozoan parasite. The only active native oyster fishery in Ireland recognised to be free from *B. ostreae* is Tralee Bay. This site was tested for the presence *B. ostreae* in 2021 and results of that testing confirm Tralee remains free from *B. ostreae.*

Five areas in Ireland were declared free from OsHV-1µVar at the beginning of 2021. OsHV-1µVar generally infects juvenile Pacific oysters (seed and spat) and has historically caused significant mortalities in this population in Ireland and throughout Europe. Infection with OsHV-1µVar is not a listed disease in Regulation EU 2016/429 but it has been controlled by the application of additional national measures in Ireland. Hence, the FHU monitors Pacific oyster growing areas for its presence or absence to support disease free status. This has allowed Ireland to place restrictions on oyster movements in and out of these disease-free bays. All five areas designated a disease free were tested for the presence of the virus during 2021 (by targeted surveillance testing of 30 animals) and laboratory analysis demonstrated that all areas remained free of OsHV-1µVar.

Despite the fact that all existing OsHV-1µVar disease free bays remained disease free in 2021, following an appeal by the local industry it was decided to remove Galway Bay from the surveillance programme and remove movement restrictions in this bay. This decision was made because, it has become increasingly difficult for operators to source disease free seed and the fact that there is growing evidence that some disease resistance has developed among oysters reducing impacts from the disease. Subsequent to removal of Galway Bay from the surveillance programme and following consultation with industry, it was decided to remove all remaining disease free bays from the programme, because of the operational limitations associated with the continued health controls and the reduced impact associated with the disease.

3.4 Shellfish Movements

3.4.1 Internal (national) Movements

In total, in 2021 the CA approved 326 movements of molluscan shellfish within Ireland. Most of these shellfish movements (305) were associated with the trade in Pacific oysters reflecting both the size and nature of Pacific oyster culture in Ireland.

3.4.2 Intra-EU Movements (between EU Member States)

The number of intra-EU movements of shellfish approved by the CA in 2021 are shown in *(Table 2)* below. Approximately, 399 movements of oysters in to Ireland from other MS were approved comprising of 635 million of seed oysters. The majority of these inward movements originated from France. This highlights the reliance of the Irish oyster industry on supply of seed from France and the importance of the health status of the oyster seed originating from France.

For most 2021 intra-EU mollusc movements into and out of Ireland, a TRACES notification was sufficient to allow movement as the molluscs are moving to an area of equivalent or lower health status to that in the bay of origin. TRACES notifications are monitored and approved by the CA office.

3.4.3 Third Country Import and Exports

The number of third country imports and exports of shellfish approved by the CA in 2021 are also shown in *(Table 2)* below. There were six third country imports of seed oysters and 113 exports approved in 2021. All imports were consignments of Pacific oysters seed from GB. Conversely, all exports were adult Pacific oysters or mussels to GB. To facilitate these exports 139 physical inspections by DAFM VIs was required to sign health certificates.

It should be noted that a movement approval can often cover more than one consignment. However, each consignment must be visually inspected and certified before dispatch.

Table 2. National and International Movements of Shellfish Approved by the Competent Authority of the Marine Institute in 2021

Species	Internal	Inward Movements		Outward Movements	
	National Movements (tonnes/millions)	Intra-EU (tonnes/millions)	Third Country (tonnes/millions)	Intra-EU (tonnes/millions)	Third Country (tonnes/millions)
Pacific Oyster	284 (1,883 T)	47 (1,137T)	-	281 (2360.5T)	92 (118,313T)
Pacific Oyster Seed	21 (21.8 M)	351 (635.5M)	6 (1.5 M)	4 (2.05M)	-
Flat Oyster	5 (13.5 T)	-	-	42 (94.3T)	5 (4.56T)
Mussel	16 (344.2 T)	1 (684T)	-	32 (799.8T)	16 (399.6 T)
Mussel Seed	-	-	-	-	-
Total	326	399	6	359	113

3.5 Shellfish Disease Notifications

3.5.1 Mortality Reporting

Oyster producers are required to keep details of all increased mortalities. Where mortalities at a given point in the production cycle are significantly above those

expected under prevailing conditions, mortalities are notified to the CA. For Pacific oyster related mortalities, reporting trigger levels have been introduced:

- Seed and spat – report at mortalities of 30% or above
- Half-grown and adults – report at mortalities of 10% or above

In 2021, reports of increased mortalities associated with Pacific oysters were reported from 24 AEs operating in 14 different bays. The majority of mortality reports were associated with Pacific oysters greater than 10g with just three reports associated with seed or spat oysters. Laboratory investigations by the NRL indicate that *Vibrio aestuarianus* continued to be the predominant cause of mortality in Pacific oysters in 2021.

For the second consecutive year there were no reports of oyster mortalities associated with OsHV-1µVar in 2021. This supports growing evidence that some oysters produced in French hatcheries in recent years may have an increased resistance to the virus.

There is also practical evidence from industry that improved management procedures adopted by industry have reduced the impact of OsHV-1µVar in Irish oyster production. It is now clear that infection with *V. aestuarianus* is a significantly greater challenge to the industry, compared to OsHV-1Var infections.

Table 3. Mortality Reports for Pacific Oysters received by the Competent Authority in the Marine Institute in 2021

No. Bays Reporting Mortality	No. of Mortality Reports	No. of Samples Received	Primary Pathogen Detected	
			OsHV-1µVar	*V. aestuarianus*
14	27	17	0	14

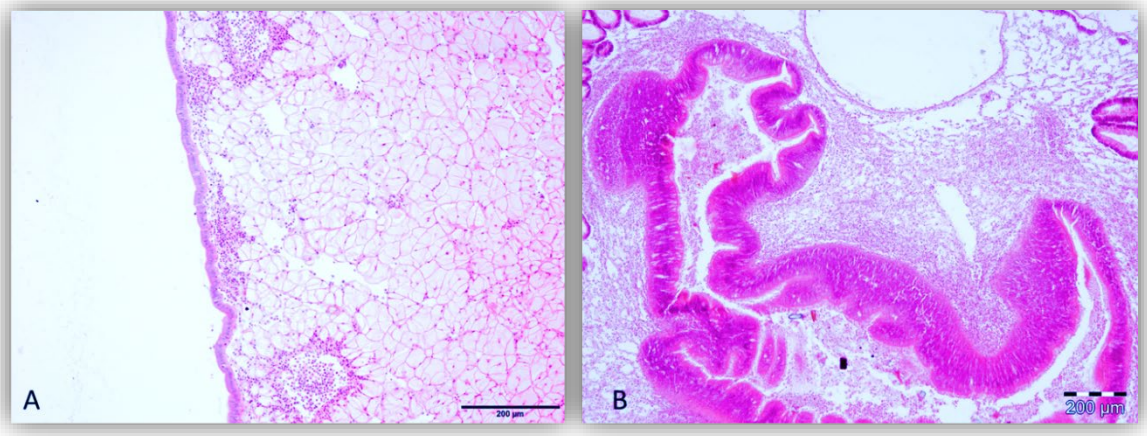

Figure 4. Histopathology associated with the two major pathogens causing disease in Pacific oysters. Haematoxylin and eosin stains of (A) Sinus and mantle pathology associated with *Vibrio aestuarianus* infection and (B). Haemocytic infiltration of the connective tissue associated with the presence of oyster herpes virus.

4 SALMON FARMING ACTIVITIES

Atlantic salmon production is the largest aquaculture activity in Ireland by value. In 2021, it is estimated that salmon production was worth €109 million at the point of first sale. Salmon are usually farmed in two stages. First, the salmon are hatched from eggs and raised in land-based freshwater tanks. When they are 12 to 18 months old the juvenile salmon, called smolts, are transferred to floating sea cages or net pens anchored in sheltered bays along the coast. For fish health purposes the term smolt is considered to relate to salmon that have undergone the physiological changes required to adapt to the marine setting through the process of smoltification and are ready to transfer to sea. Once in sea cages the salmon are then held for another 12 to 24 months, when they are harvested for processing. This production cycle influences where health surveillance is targeted in the salmon aquaculture sector.

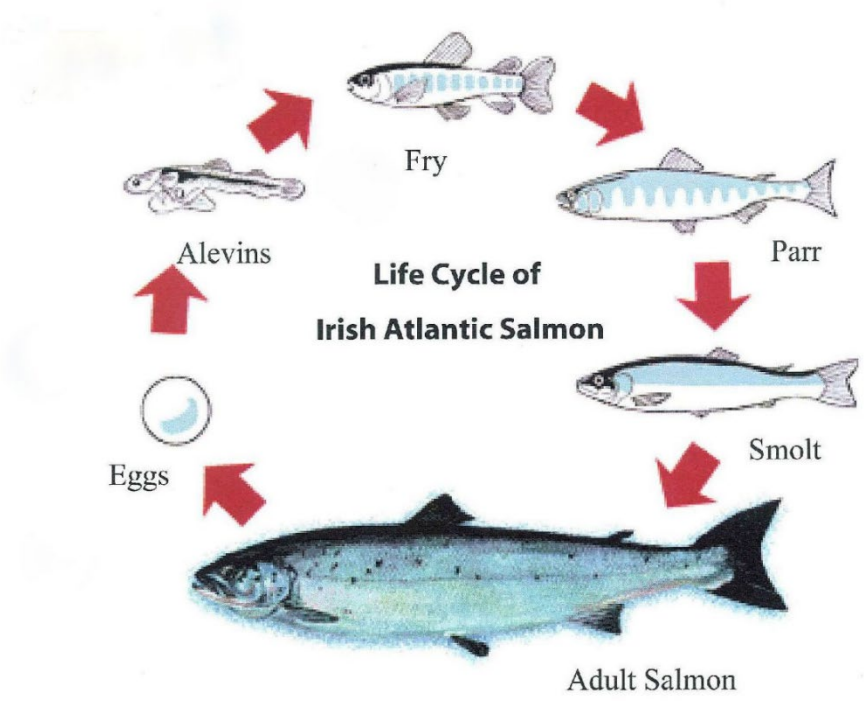

Figure 5. Life cycle of Atlantic salmon. Salmon have a juvenile freshwater stage and an adult seawater stage. This life cycle determines how salmon aquaculture production is performed and therefore how the Competent Authority organises health surveillance activities for this aquaculture sector in Ireland.

4.1 Fish Health Approvals for Salmon Sites

During 2021, a total of 57 production sites held a FHA related to salmon production in Ireland. Of these sites, 42 were operational and included 14 freshwater/hatchery sites and 28 marine farm sites. An additional nine sites held FHA in relation to salmon production for restocking purposes.

4.2 Salmon Health Surveillance

4.2.1 Inspections

All marine production sites and the majority of land-based freshwater sites including hatchery sites are designated as high-risk facilities for the purposes of the health surveillance programme. These high-risk sites are therefore inspected annually. In 2021, all operational marine sites (28) and 14 freshwater sites were inspected as part of the annual health surveillance programme *(Table 4.)*. An additional six sites producing Atlantic salmon for restocking were also inspected and were found to be compliant with fish health regulations and the requirements of their approval.

Minor non-compliances were recorded during two salmon farm inspections undertaken in 2021. These non-compliances related to:

- Net cleanliness
- Inappropriate notification to MI of non-commercial movement of fish

Table 4. Shellfish Health Surveillance Inspections in 2021 and associated non-compliance findings

Inspection Type	No. Inspected	No. of AEs inspected with non-compliances (% of FHAs inspected)		
		Minor	Medium	Serious
Marine Sites	28	1 (2.5%)	-	-
Fresh Water Sites	14	1 (2.5%)	-	-
Total	42	2 (5%)	-	-

Minor non-compliance
Minor shortfalls in record keeping. Minor housekeeping issues.

Medium non-compliance
Ongoing and repeated issues with record keeping or housekeeping issue.

Serious non-compliance
Operator has failed in his duties to an extent that the health status of bay or country may be affected (e.g., failure to inform CA of movements of shell or failure to report mortalities). This designation may also be used where there has been a continued disregard of minor or medium non-compliances identified in previous inspections. A serious non-compliance will normally result in in a compliance notice being issued. Failure to implement the compliance notice within the specified time limit can result in a revocation of the FHA.

4.2.2 Targeted Surveillance

Ireland is declared free of all diseases listed as notifiable in Regulation (EU) 2016/429 for which salmonid species are susceptible. In addition, under national measures described in Commission Implementing Decision (EU) 2021/260, Ireland is declared free from bacterial kidney disease (BKD) and gyrodactylosis caused by *Gyrodactylus salaris* (GS). In 2021, Ireland continued to implement a targeted surveillance programme to demonstrate disease freedom for a number of pathogens potentially affecting salmon. During this targeted surveillance, 25 samples consisting of a total of 698 Atlantic salmon were tested. None of the pathogens targeted during this surveillance were detected. In addition to the targeted pathogen surveillance, these samples were subject to general bacteriological and histological screening and no significant health findings were identified. Therefore, during 2021 the targeted surveillance programme did not detect any evidence of the presence of EU listed diseases or diseases controlled under national measures in salmon.

Figure 6. Fish health inspection of an approved salmon site.

4.3 Salmon Movements

4.3.1 Internal (National) Movements

In 2021, the CA office approved 77 movements of salmon and salmon ova and gametes within Ireland. These movements included approval to move up to 11.2 million salmon ova and gametes, up to 7.4 million fish from freshwater sites including fish transferring to marine sites, and up to 1.8 million salmon between marine sites for on growing or use as broodstock *(Table 5.).*

4.3.2 Intra-EU Movements (between Member States)

The number of intra-EU movements of salmon approved by the CA in 2021 are shown in *(Table 5)* below. There were four intra-EU inward movements of salmon ova (1.1 million) and nine intra-EU outwards movements of salmon smolts (1.1million) authorised by the CA.

4.3.3 Third Country Imports & Exports

Ten third country exports of salmon ova (19.3 million) were approved by the CA.

Table 5. Salmon Movements Approved by the Competent Authority Office of the Marine Institute in 2021

Life Cycle Stage	National Movements (millions)	Inward Movements (millions)		Outward Movements (millions)	
		Intra-EU	Third Country	Intra-EU	Third Country
Ova	8 (4.2)	4 (1.1)	-	-	10 (19.3M)
Gamete	1 (7)	-	-	-	
Pre-smolts	20 (2)	-	-	5 (0.9)	
Smolts	33 (5.4)	-	-	4 (0.2)	
On-Growing (Marine Sites)	15 (1.8)	-	-	-	
TOTAL	77 (20.3)	4 (1.1)	-	9 (1.1)	10 (19.3)

In addition, the CA approved 177 applications for importations of dead whole ungutted salmon into Ireland during 2021, for further food processing.

Health certification was provided for 46 individual consignments of salmon and salmon ova to facilitate outward movements from Irish AEs.

It should be noted that a movement approval can often cover more than one consignment. However, each consignment must be visually inspected and certified before dispatch.

4.4 Disease Notifications

4.4.1 Mortality Events

Regulation (EU) 2016/429 requires AEs to immediately inform the CA of the suspicion and/or confirmation of any disease listed in the legislation. In 2021, there were no reports of diseases listed in Regulation (EU) 2016/429 from Irish salmon aquaculture sites.

There is no regulatory requirement for operators to report non-listed diseases to the CA but during 2021, the MI recorded six salmon mortality events associated with infectious disease *(Table 6)*. This information was obtained through a mixture of industry reporting and data gathering at surveillance inspections.

Pancreas Disease (PD), cardiomyopathy syndrome (CMS) and Amoebic gill disease (AGD) were the infectious diseases causing mortality on salmon farms in 2021. Three mortalities events involving infectious disease were also associated with contributory factors, namely freshwater treatments and a phytoplankton bloom.

In addition, the MI was informed of a large scale mortality event affecting two adjacent farms in a single Bay. The cause of this event was a phytoplankton bloom and caused significant mortality across both the farms.

Table 6. Mortality Events on Salmon Marine Sites in 2021

Event No.	Duration (weeks)	Month(s)	Average Weekly % Mortality (Range)	Reported Primary Cause(s)[1]			
				PD	CMS	AGD	Other[2]
1	4	Aug – Oct	6.56 (2.57-15.54)			*	
2[3]	1	April	1.04		*		
3[3]	1	May	2.09		*		
4	Not Specified	May	6		*		*
5	Not Specified	June	6		*		*
6	1	October	1.42	*			*

1 *primary causes as diagnosed by private veterinary practitioner*
2 *other contributory non-infectious causes e.g. most commonly phytoplankton blooms, jellyfish, predators, treatments or physical damage*
3 *from the same farm*

4.5 The Use of Cleaner Fish on Salmon Farms

Sea lice infestation of salmon is a recognised fish health issue during salmon production. Cleaner fish are used increasingly throughout the salmon farming sector worldwide as a biological control for sea lice infestations. The use of cleaner fish reduces the use of physical and chemical treatments to control sea lice. The two species of fish commonly utilised in the role are lumpfish and several species of wrasse. Cleaner fish may be cultured specifically for the purpose or caught from the wild. Generally, in Ireland, lumpfish originate from cultured sources while wrasse are caught from the wild. However, significant technical efforts are being made by the salmon industry to culture wrasse for use as cleaner fish and it is expected that farmed wrasse will become a viable option for use in Ireland in 2022.

To prevent any potential spread of fish pathogens to salmon sites by the introduction of cleaner fish the CA continues to work with industry to develop protocols to reduce the risk. A risk analysis has been completed and control procedures have been developed. The risk analysis and management plans are available in the Farmed Salmonid Handbook. As part of these protocols, extensive health screening is undertaken on a bay-by-bay basis prior to fishing for wrasse. Prior to movement of cleaner fish onto a salmon farm a veterinary report is required to demonstrate that the fish are clinically healthy. In 2021, the CA approved 41 national movements of wrasse (involving up to a maximum 439,800 fish), and 26 national movements of lumpfish (approx. 571,000 fish) onto salmon sites for use as cleaner fish. In addition, four movements into Ireland were approved for lumpfish ova (approx. 3 million) from Norway and ten exports of lumpfish (approx. 207,000 fish) to GB.

Table 7. Cleaner fish Movements on to Salmon Farms Approved by the Competent Authority Office of the Marine Institute in 2021 for Sea Lice Control purposes

Species	National Movements (thousands)	Inwards Movements (thousands)		Outwards Movements (thousands)	
		Intra-EU	Third Country	Intra-EU	Third Country
Wrasse	41 (439.8)	-	-	-	-
Lumpfish	26 (571.0)	-	-	-	10 (207.1)
Lumpfish (Ova)	-	4 (3,000)	-	-	-
TOTAL	67 (1,010)	4 (3,000)	-	-	10 (207.1)

To facilitate movements of cleaner fish the NRL undertook fish health screening of 473 wrasse from six bays. Fish were screened for viral and bacterial pathogens as well as by histological examination for general health purposes. No significant health findings were associated with this screening and all movements of cleaner fish applied for were approved by the CA.

Figure 7. Lumpfish are used as cleaner fish on marine salmon farms to control sea lice infestations. Cleaner fish are increasingly being used throughout the salmon farming sector worldwide as a biological control for sea lice infestations. The two species of cleanerfish commonly utilised in the role are lumpfish and several species of wrasse.

5 OTHER FINFISH AQUACULTURE PRODUCTION SITES

In 2021, there were eight AEs producing trout, one AE producing perch and one AE producing both trout and perch which had fish health approvals to operate issued by the CA.

5.1 Finfish (other than Salmon) Health Surveillance

In 2021, eight health surveillance inspections were carried on trout and perch farms in Ireland. No non-compliances were identified during these inspections.

5.2 Finfish (other than Salmon) Movements

National movements, intra-EU movements and third country movements for trout and perch approved by the CA office in 2021 are shown in (*Table 8*). Health certification was provided for six consignments of fish prior to outward movement from Irish AEs.

Table 8. Non-salmon fish movements approved by the Competent Authority office of the Marine Institute in 2021.

Species	National Movements (thousands)	Inward Movements (thousands)		Outward Movements (thousands)	
		EU	Third-Country	EU	Third-Country
Carp	1 (41)	-	-	-	-
Perch	4 (310,000)	-	-	-	-
Trout	17 (892,510)	4 (982)	1 (350)	6 (4.7)	-
Trout (Ova)	1 (200,000)	5 (1,850,000)	1 (450,000)	-	-
TOTAL	23 (1,402,551)	9 (1,850,982)	2 (450,350)	6 (4.7)	-

In addition to the movements of live fish shown in (*Table 8)*, 193 TRACES certificates were received and approved by the CA for un-gutted trout consignments received from Northern Ireland for further food processing.

6 PUT & TAKE FISHERIES

Put and take fisheries are defined in Regulation (EU) 2016/429 as "ponds and other installations where the population of aquatic animals is maintained only for recreational fishing purposes, by restocking with aquaculture animals which are confined and unable to escape." In 2021, there were 65 put and take fisheries registered with the CA in Ireland. No new registrations were issued for a put and take fishery during this period. During 2021, the CA approved 216 movements of fish on to stocked fisheries, in Ireland. Stocked fisheries include put and take fisheries.

Given the enclosed nature of put and take fisheries and the low level of fish movements to and from them, these operations present a low risk for the introduction and spread of disease. During 2021, the CAO used the derogation provided in Article 176 of Regulation (EU) 2016/429 to remove the requirement for full approval of put and take fisheries. Despite this put and take fisheries are still required to register with the CA. As registered establishments health surveillance inspections of Put and Takes fisheries are not required, although fish movements are still required to be notified to the CA and operators are required to keep specific records.

6.1 Disease Notifications

No outbreaks of disease in angling venues was reported to the CA in 2021.

7 ORNAMENTAL AQUATIC ANIMALS

Figure 8. (Pterophyllum sp.) All persons bringing ornamental aquatic animals into Ireland either for commercial or personal use must first register with the CA before receiving fish.

Specific regulations are in place to control the risk of potential introduction or spread of disease associated with the trade of ornamental aquatic of disease. The level of control varies between tropical and cold-water animals with particular attention paid to cold-water ornamental animals given that they are capable of surviving in the Irish environment. All operators bringing ornamental aquatic animals into the State must register with the CA before receiving fish. During 2021, 361 intra-EU inward movements and 56 third country imports of ornamental aquatic animal consignments were approved by the CA. A significant number of these consignments originated from GB and contained multiple species of ornamental animals destined for several locations in Ireland. This included private individuals, as well as wholesale and retail establishments. Additional animal health controls commenced in January 2021 for such consignments from GB as a result of BREXIT including newly introduced requirements to check all such consignments at BCPs.

Table 9. Ornamental movements approved by the Competent Authority office of the Marine Institute in 2021**.**

Movement Type	Inward Movements	
	Intra-EU	Third Country
Commercial	265	45
Non-Commercial	96	11
TOTAL	361	56

7.1 Disease Notifications

In 2021, there were no reports of diseases listed in *Annex II* of Regulation (EU) 2016/429 or diseases for which Ireland has additional national measures associated with ornamental aquatic animals.

8 NRL ACTIVITIES

The NRLs provide laboratory testing services to support the implementation of aquatic animal health controls in Ireland. This involves supporting the health surveillance activities undertaken by the CA and PVP activities undertaken on behalf of AEs. The NRLs in the MI operate within a quality management system and the majority of tests utilised are ISO 17025 accredited by the Irish National Accreditation Body (INAB). Testing is conducted using methods required by regulation or recommended in the OIE manual of diagnostic tests for aquatic animals. This ensures the results obtained during testing are reliable and robust as well as being fit for purpose.

8.1 Finfish NRL

In total, the NRL analysed 2,137 fish from 79 samples for a variety of purposes in 2021 *(Table 10)*. Analysis consisted of histopathological, virological, bacteriological and molecular examinations undertaken as required by the relevant work programme.

For 2021, 89.6% of fish analysed in the NRL were associated with salmon farming (Cleaner Fish 24.3% and Atlantic Salmon 65.3%) *(Figure 9)*. This is reflective of the extent of salmon farming activities, in comparison to other finfish aquaculture activities in Ireland and the extensive efforts placed on maintaining fish health within the salmon farming sector.

Table 10. Finfish samples tested by the National Reference Laboratory in 2021

Testing Programme	Species	No. of Samples	No. of Fish
National Serveillance[1]	Atlantic Salmon	21	619
	Trout (Rainbow or Brown)	3	90
	Lumpfish	1	30
Mortality Investigations	Carp	1	1
	Atlantic Salmon	1	10
Health Checks	Atlantic Salmon	2	69
	Coarse Fish	3	70
	Trout	3	54
Screening for Cleaner Fish Movements	Wrasse	8	473
Private Testing[2]	Atlantic Salmon (inc. Brood Fish)	24	537
	Lumpfish	3	18
	Miscellaneous	1	6
Research Projects	Atlantic Salmon	8	160
Total		**79**	**2137**

1 For diseases listed as notifiable in Regulation (EU) 2016/429 and of concern under national measures
2 Testing requested by private companies and private veterinary practitioners

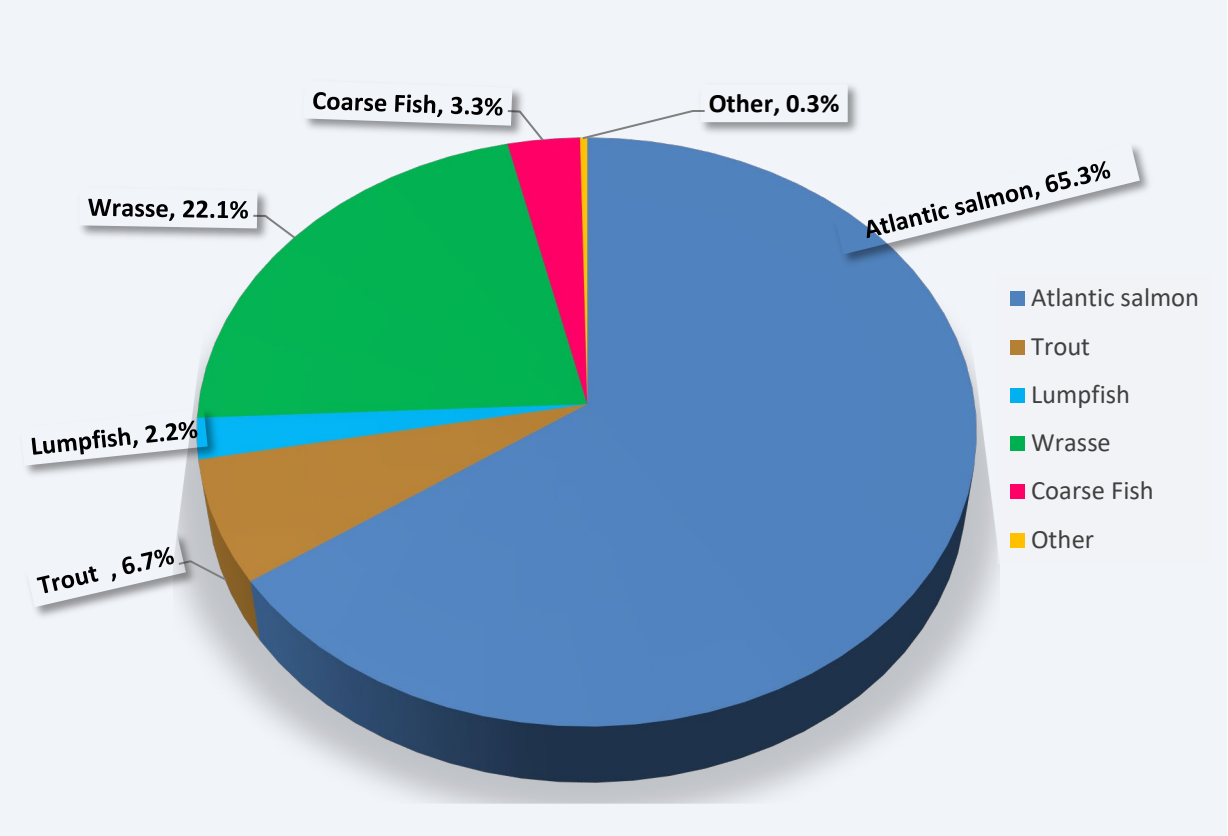

Figure 9. Percentage of 2,137 samples tested in the finfish NRL by species in 2021. 89.6% of samples analysed in the NRL was associated with salmon aquaculture (Atlantic salmon 65.3% and cleaner fish 24.3%).

8.2 Significant Findings from Finfish NRL Testing

No agents responsible for diseases listed as notifiable in Commission Regulation (EU) 2016/429 or controlled under national measures in Ireland were detected during testing conducted by the NRL in 2021. Analysis carried out by the NRL in 2021, identified the presence of piscine orthoreovirus (PRV) and piscine myocarditis virus (PMCV) by molecular analysis, for one incident of reported mortalities for salmon in marine farms. PMCV is the aetiological agent responsible for cardiomyopathy syndrome (CMS). The presence of CMS at site was confirmed by PVP. PRV has been associated with heart and skeletal muscle inflammation (HMSI) in Atlantic salmon but is also commonly detected in the absence of disease. The particular mortality event in question was thought to have been multifactorial, with both pathogen and phytoplankton blooms playing a role.

8.3 Molluscan Shellfish NRL

In 2021, the NRL tested a total of 54 samples consisting of 827 Pacific oysters (*C. gigas*), 840 native oysters (*O. edulis*) and 15 king scallops (*P. maximus*) under a range of testing programmes *(Table 11)*. Testing consisted of histological, cytological and bacteriological examination in combination with molecular analysis as determined by the aims of the programme.

Table 11. Molluscan shellfish samples tested by the National Reference Laboratory in 2021

Programme	Species	No. of Samples	No. of Animals
National Serveillance[1]	Pacific Oysters	6	390
	Native Oysters	1	150
Mortality Investigations	Pacific Oysters	17	437
	Native Oysters	5	150
	King Scallops	1	15
Research	Native Oysters	24	540
Total		54	1,682

[1] For diseases listed as notifiable in EU 2016/429 and under national measures (namely Bonamia ostreae, oyster herpesvirus-1 uVar & emerging diseases).

In general, reported mortality in Pacific oysters was similar in 2021 compared with 2020 with 13 and 14 bays reporting mortalities in 2020 and 2021 respectively. The majority of mortality reports concerned stock larger than 10g and as in 2020 OsHV-1µVar was not detected in any of the samples tested. As in previous years, the predominant aetiological agent detected in mortality samples was *Vibrio aestuarianus* which continues to be the most significant pathogen in Pacific oyster production sites in Ireland. Fourteen of the 17 samples tested contained *Vibrio aestuarianus*. Bacteria belonging to the *Vibrio splendidus* clade was also detected in combination with *V. aestuarianus* in samples associated with two mortality events.

8.4 NRL Research and Projects

In 2021, the FHU worked closely with the Fisheries Advisory Ecosystems Services Section of the MI in support of a project aimed at the restoration of native oyster populations in a number of bays across Ireland. The project is funded from European Maritime Fisheries Fund. The protistan parasite *Bonamia ostreae* which was first detected in Ireland in 1987 and subsequently spread to the majority of native oyster fisheries in the country. The parasite is endemic in all of the bays where restoration projects are underway. These bays are Swilly, Galway, kilkieran and Clew Bay. *Bonamia ostreae* can significantly impact native oyster populations and understanding the potential impact of this disease on attempts to restore native oyster populations in Irish bay is important. Regular screening of native oysters has not been conducted for several years in bays that were determined to be infected with *Bonamia ostreae.* As a result, recent data on *Bonamia ostreae* prevalence and distribution in the restoration bays is limited. FHU work in this project aims to increase our knowledge of the disease in identified bays and provide up to date data on prevalence and distribution of *Bonamia ostreae.* This information is being used to inform decision making in the current project.

To date 540 native oysters for the four bays have been screened for the presence of *Bonamia ostreae* and the results are currently being correlated with fisheries survey data gathered from the restoration project bays.

The NRL is working closely with GMIT to support delivery of a Cullen fellowship grant to investigate micro parasite presence and prevalence in velvet crabs in Galway Bay and to identify potential further reservoirs or host species. This project is also investigating the structure of velvet crab pathobiomes in response to *Paramarteilia* species infection using next generation sequencing technology.

Despite impacts of COVID restriction on the programme two full years of velvet crab sampling in Galway Bay was completed in December 2021. Histological and genetic examination of these samples is ongoing. To date 60 *Paramarteilia*-positive samples have been confirmed.

Dissemination of project findings in 2021 included presentations at a MI, Marine Research Programme Postgraduate Workshop virtual event 2021 and conferences for the British Society of Parasitology, the Scandinavian-Baltic Society of Parasitology and the Irish Society of Parasitology. To assist with the project timeline and work plan following major disruptions as a result of the ongoing COVID-19 pandemic the project has been extended and is due to be completed by Summer 2023.

This project will increase current knowledge of parasite-host relationships in crustaceans and identify the probability of disease occurrence in crustacean populations. Ultimately, it is hoped that information from the project will potentially contribute to the effective management of velvet crab fisheries in Ireland.

The NRL undertook work to support a Horizon 2020 funded project - Controlling microbiome circulations for better food systems (CIRCLES). CIRCLES aims to explore food system-specific microbiomes from farm to fork, and the potential exploitation of these systems to enhance food production and overall sustainability. The project focuses on six food systems relevant to the EU market – tomatoes, spinach, poultry, pigs, Atlantic salmon and seabream aquaculture. Work undertaken by the MI pertains to targeted sampling at specific production and life stages of both farmed and wild Atlantic salmon to assess the interactions, in terms of microbiome exchanges, between fish production and microbiomes in natural environment. The project commenced in 2018 and the role of the MI in this project will be completed by the end of 2022. The MI have currently completed 70% of sampling for farmed salmon (WP5) and 100% of sampling events for wild salmon (WP6) for which it is responsible. Sample processing is completed for WP6 and three samples remain to be taken and processed for WP5. All DNA extracts have been provided to project partner, DTU, to complete sequence analysis.

9 ADDITIONAL ACTIVITIES UNDERTAKEN BY THE FHU IN 2021

9.1 Transboundary Surveillance Programme in Lough Foyle

As a result of the long-standing negotiation of the international border in Lough Foyle, licences have not been issued for aquaculture activity in the Lough. This means that AEs operating in Lough Foyle cannot be authorised by the CA in Ireland. Despite this situation, in recent years, production of Pacific oysters in the Lough has grown to very significant levels. In 2021, a two-year shellfish health surveillance programme was completed in the Lough in conjunction with DAERA and the Loughs Agency. The aim of the programme was to evaluate the health status of oysters in Lough Foyle. Results from the programme indicate that *V. aestuarianus* is present in the Lough and was likely associated with oyster mortality events observed in recent years. No other significant pathogens were detected during the two-year programme. In addition, to completing the surveillance programme, the CA continued to maintain measures aimed at preventing the movement of oysters from the Lough for on growing or relaying in Ireland and only oysters going for human consumption are permitted to be moved from the Lough.

9.2 National Monitoring Programme for Crayfish Plague

Aphanomyces astaci (*A. astaci*) is a water mould that causes lethal crayfish plague (CFP) in the White-clawed crayfish (WCC) *Austropotamobius pallipes* which is the only crayfish species that is native to Ireland. CFP is believed to have originally entered Europe with the introduction of a non-native North American species of crayfish, which are resistant to this disease. CFP is listed as a notifiable disease by the OIE but not in the Animal Health Law Regulation (EC) 2016/429. The WCC is endangered and protected under the EU Habitats Directive. In recent years, outbreaks of CFP have occurred in Ireland and the disease appears to be spreading. To prevent the further spread of this deadly disease in Ireland water users should adhere to the check clean dry protocols.

The first National Crayfish Plague Surveillance Programme (NCPSP) concluded in June 2020. The MI, in conjunction with NPWS, established a second follow on surveillance programme (NCPSP 2020-2022). This surveillance programme aimed to further understand and monitor outbreaks of CFP in Ireland, identify potential disease vectors and assess the impact of CFP on native WCC populations.
The NCPSP 2020-2021 continues to use environmental DNA (eDNA) filtered from river water as a primary screening methodology for CFP and eDNA samples are also used to screen for the presence of WCC, and eight additional non-indigenous crayfish species, which may be carriers of CFP. A time series study to assess persistence and prevalence of CFP in the environment at specific CFP-positive sites was included in the new surveillance programme. In addition, field ecology surveys were planned for selected catchments to confirm the presence of WCC, with field ecology surveys matched to eDNA sampling locations and time points to allow for comparison of the different methodologies.

Twenty-seven catchments were surveyed, sites in each catchment were selected according to catchment size, the presence of Special Areas of Conservations and CFP status. In 2021, the MI completed laboratory analysis of samples collected during the first year of the surveillance programme. Altogether 116 sites from 15 catchments were sampled and a total of 420 water samples were collected and then processed using modified eDNA extraction protocols. The analysis of samples collected during the 2021 fieldwork, 105 sites in 12 catchments comprising 327 water samples, will be processed and tested in early 2022.

During 2021, the NRL also detected *A. astaci* in three WCC mortality samples submitted for investigation. Two of these mortality samples were from the Shannon Estuary South catchment close to the River Maigue which had previously been confirmed CFP-positive by both mortality and eDNA analysis. The third WCC mortality event reported by Letizia Cocchiglia (RPS

Professional Services Firm) from the River Clodiagh at Clonaslee, Co. Laois was the first confirmed detection of *A. astaci* in the Shannon 25A catchment. It is worth noting this mortality sample is very close to the Barrow catchment border and within 20km of one of the sites confirmed CFP-positive by eDNA analysis in November 2020 from this catchment *(Figure 11).*

Figure. 10a & 10b The endangered native white clawed crayfish and environmental sampling for the presence of Aphanomyces astaci DNA. A. astaci is the causative agent of crayfish plague.

In summary, data suggests the continuing spread of CFP both within and between catchments. Twenty individual sites in seven different catchments tested positive for the presence of *A. astaci*. Fourteen of these sites were confirmed CFP positive for the first time. Two of the seven catchments, Sligo and Moy, tested positive for the presence of CFP for the first time in this year. A summary of all CFP-positive catchments across Ireland, confirmed through eDNA or mortality data, is presented in *(Figure 11)*. In all catchments, WCC DNA was detected at one site at least. For most catchments the presence of WCC DNA was detected at multiple sites with the exception of the Barrow and the Suir. No non-indigenous crayfish species have been detected in any CFP-positive eDNA samples tested to date.

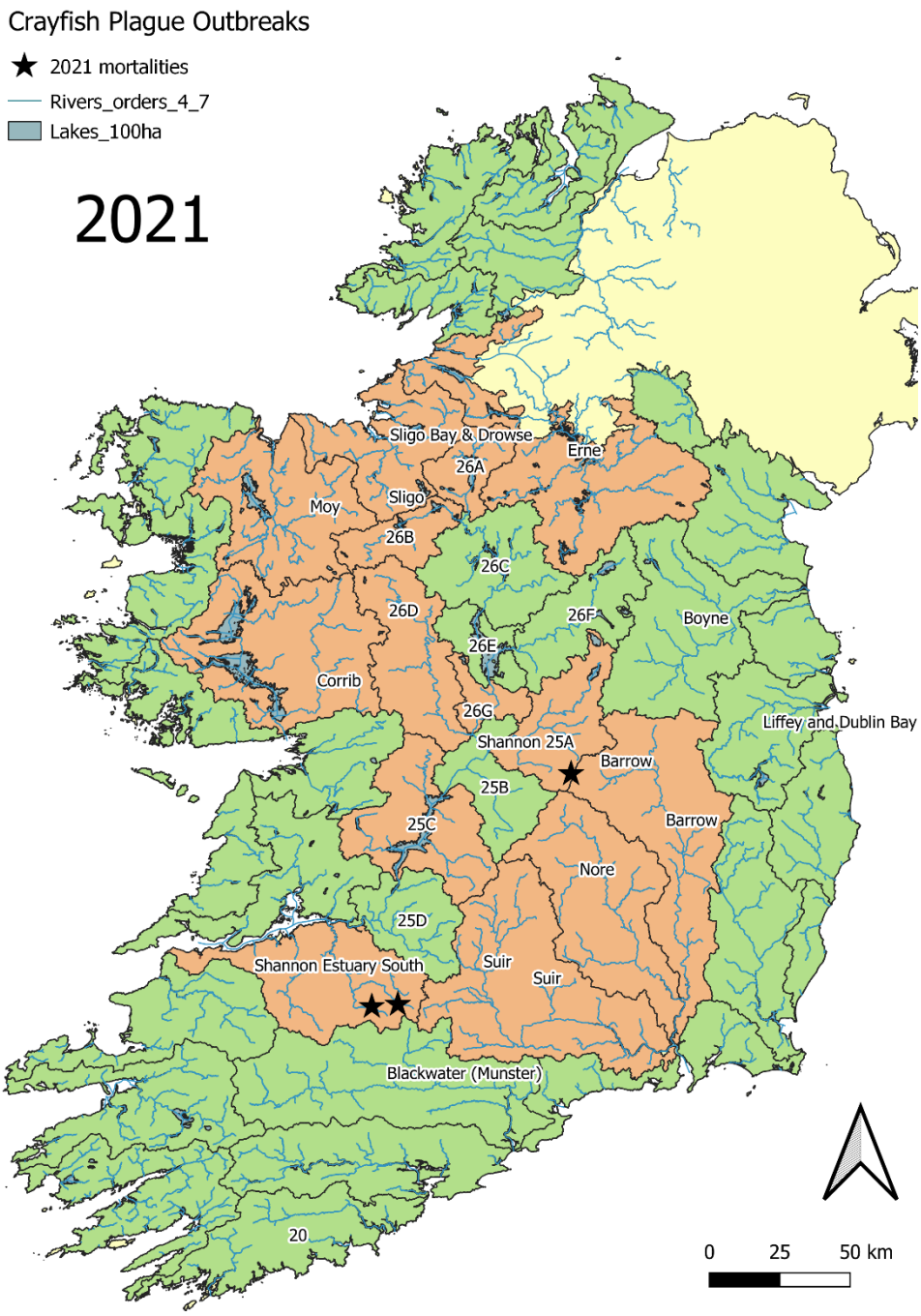

Figure 11. Identified crayfish plague positive catchments in Ireland (peach) determined using both eDNA and mortality data. Crayfish plague-related White-clawed crayfish mortalities are indicated by a black star.

APPENDIX 1 - ADDITIONAL SOURCES OF INFORMATION

Information Sources

1. Marine Institute Fish Health website provides a range of information of aquatic animal health in Ireland. This includes;
   - Information Leaflets on important diseases of aquatic animals
   - Requirements for Fish Health Authorisations
   - Registers of Authorised Aquaculture Businesses (APBs), Put and Take Fisheries, Approved Aquaculture Transporters and Authorised Processing Establishments in Ireland. (Registers of APBs)
   - Reporting Aquatic Animal Mortalities
   - Details for Importers of ornamental aquatic animals

2. The Farmed Salmonid Handbook provides a comprehensive manual on fish health for Ireland's salmon and trout farming industry. It contains detailed and practical information on all aspects of fish stock care ranging from veterinary issues, environmental protection, feed & nutrition, treatments and current legislation. The *Handbook* was compiled by experts from both private and governmental organisations. The handbook was launched in 2011. An updated version of the handbook was made available in July 2017.

3. European Union Reference Laboratory for fish and Crustacean Diseases is situated within the unit for Fish and Shellfish Diseases at DTU Aqua – National Institute of Aquatic Resources at the Technical University of Denmark. The functions and duties of the EURL are concerned with harmonizing diagnostic procedures for notifiable fish and crustacean diseases in Europe. The Unit for Fish and Shellfish Diseases at DTU Aqua has since 1994 been designated as the EURL for fish diseases. From July 2018, the functions and duties were expanded to also include crustacean diseases.

4. European Union Reference Laboratory for Mollusc Diseases is situated in IFREMER in France and is responsible for coordinating methods employed by EU Member States for diagnosing diseases of bivalve molluscs.

5. World Organisation for Animal Health (OIE) Aquatic Animal Health Code. he Aquatic Animal Health Code provides standards for the improvement of aquatic animal health worldwide. It also includes standards for the welfare of farmed fish and use of antimicrobial agents in aquatic animals. The sanitary measures of the Aquatic Code should be used by the Competent Authorities of importing and exporting countries for early detection, reporting and control of pathogenic agents in aquatic animals.

6. World Organisation for Animal Health (OIE) Manual of Diagnostic Tests for Aquatic Animals The manual provides a standardised approach to the diagnosis of the diseases listed in the Aquatic Code, to facilitate health certification for trade in aquatic animal products.

APPENDIX 2 - FHU PUBLICATIONS 2021

1. **Dore, B., Power, A., Kenny, E., Bradley, F., O' Kane, P., Cheslett, D., White, S., & Swords, F.** (2021). Fish Health Unit Report of Activities Undertaken in 2020. Marine Environment and Health Series, No. 43. Marine Institute, Ireland. http://hdl.handle.net/10793/1717

2. Mc Dermott, T., D'Arcy, J., Kelly, S., Downes, J. K., **Griffin, B.,** Kerr, R. F., O'Keeffe, D., O'Ceallachain, M., Lenighan, L., Scholz, F., & Ruane, N. M. (2021). Novel use of nanofiltered hyposaline water to control sea lice (Lepeophtheirus salmonis and Caligus elongatus) and amoebic gill disease, on a commercial Atlantic salmon (Salmo salar) farm. Aquaculture Reports, 20, 100703. https://doi.org/10.1016/j.aqrep.2021.100703

3. Arzul, I., Furones, D., **Cheslett, D.**, Gennari, L., Delangle, E., Enez, F., Lupo, C., Mortensen, S., Pernet, F. & Peeler, E. (2021) Manual for bivalve disease management and biosecurity. H2020 VIVALDI Project. 44p
https://www.vivaldi-project.eu/fr/content/download/158545/file/VIVALDI-Manual%20EN.pdf

4. McDermott, T., Downes, J., D'Arcy, J., Kelly, S., **White, S.,** Brennan, A., Sammon, M., Scholz, F., Robinson, G. & Ruane, N. (2021). Using a blow-up tarpaulin for reverse osmosis freshwater treatment of AGD and sea lice in Atlantic salmon [Poster presentation]. Aquaculture Europe 2021, 4-7 October 2021, Madeira, Portugal.

APPENDIX 3 - EU Regulations and Statutory Instruments Relevant for Aquatic Animal Health in Ireland in 2021

The European Parliament and the Council adopted the Regulation (EU) 2016/429 on transmissible animal diseases ("Animal Health Law") has been applicable since April 21st 2021.

Overall, the new Regulation aims is comprehensive and aims to achieve the following:

- Reduces a huge number of legal acts into a single law and brings together for the first time rules for both terrestrial and aquatic animals in one legislation
- Creates detailed and clearer rules that enable authorities and operators to focus on key priorities: preventing and eradicating disease
- Clarifies responsibilities for farmers, vets and others dealing with animals
- The rules allow greater use of new technologies for animal health activities - surveillance of pathogens, electronic identification and registration of animals
- Better early detection & control of animal diseases, including emerging diseases linked to climate change, will help to reduce the occurrence and effects of animal epidemics
- Offers more flexibility to adjust rules to local circumstances, and to emerging issues such as climate and social change

A number of delegated and implementing acts have been adopted by the Commission to make the new rules applicable.

Prior to and since April 21st 2021 the CA has been taking actions to fully implement the requirements of the new Animal Health Law in Ireland. A list of the relevant and delegated and implementing acts listed below.

Regulation (EU) 2016/429	Regulation (EU) 2016/429 of the European Parliament and of the Council of 9 March 2016 on transmissible animal diseases and amending and repealing certain acts in the area of animal health ('Animal Health Law'). **Summary of Significant Changes:** • Article 9 sets out a new framework for categorisation of listed diseases replacing previous exotic and non-exotic classification. • Article 10 provides a detailed list of operator responsibilities for animal health and biosecurity. • Article 176(2) provides exemption from approval option for certain described establishment types that are considered lower risk. e.g. put and take fisheries. • Article 179 provides for the approval of disease control aquatic food establishments by the CA. • Article 186 details on record keeping obligations of AEs and is revised to include animal health certificates, in paper or electronic form, required to accompany movements of aquaculture animals arriving at the establishment. • Article 218 details operator obligations to issue self-declaration document for movements of aquaculture animals to another MS.
Commission Implementing Regulation (EU) 2018/1882	Commission Implementing Regulation (EU) 2018/1882 of 3 December 2018 on the application of certain disease prevention and control rules to categories of listed diseases and establishing a list of species and groups of species posing a considerable risk for the spread of those listed diseases. **Summary of Significant Changes:** • New disease categorisation in place and lists of susceptible and vector species See appendix 4 below.
Commission Delegated Regulation (EU) 2020/692	Commission Delegated Regulation (EU) 2020/692 of 30 January 2020 supplementing Regulation (EU) 2016/429 of the European Parliament and of the Council as regards rules for entry into the Union, and the movement and handling after entry of consignments of certain animals, germinal products and products of animal origin.
Commission Delegated Regulation (EU) 2020/990	Commission Delegated Regulation (EU) 2020/990 of 28 April 2020 supplementing Regulation (EU) 2016/429 of the European Parliament and of the Council, as regards animal health and certification requirements for movements within the Union of aquatic animals and products of animal origin from aquatic animals. **Summary of Significant Changes:** • Article 14 details information to be contained in self-declaration documents for different species and categories of aquaculture animals where an animal health certificates is not required.
Commission Delegated Regulation (EU) 2019/2124	Commission Delegated Regulation (EU) 2019/2124 of 10 October 2019 supplementing Regulation (EU) 2017/625 of the European Parliament and of the Council as regards rules for official controls of consignments of animals and goods in transit, transhipment and onward transportation through the Union, and amending Commission Regulations (EC) No 798/2008, (EC) No 1251/2008, (EC) No 119/2009, (EU) No 206/2010, (EU) No 605/2010, (EU) No 142/2011, (EU) No 28/2012, Commission Implementing Regulation (EU) 2016/759 and Commission Decision 2007/777/EC.

Commission Delegated Regulation (EU) 2020/691	Commission Delegated Regulation (EU) 2020/691 of 30 January 2020 supplementing Regulation (EU) 2016/429 of the European Parliament and of Council as regards rules for aquaculture establishments and transporters of aquatic animals. **Summary of Significant Changes:** • Article 3 provides derogations from requirement on operators to apply for approval of AEs. • Under article 4(e) vessels or other mobile premises where aquaculture animals are kept temporarily to be treated or undergo another husbandry-related procedure to be approved by the CA. • Wholesalers of ornamental aquatic animals will also be approved under Article 4(c). • Article 22 details on additional record keeping obligations of operators to include self-declaration documents issued in accordance with Article 18 of Regulation (EU) 2016/429, covering both received and issued forms as relevant.
Commission Delegated Regulation (EU) 2020/692	Commission Delegated Regulation (EU) 2020/692 of 30 January 2020 supplementing Regulation (EU) 2016/429 of the European Parliament and of the Council as regards rules for entry into the Union, and the movement and handling after entry of consignments of certain animals, germinal products and products of animal origin.
Commission Delegated Regulation (EU) 2020/687	Commission Delegated Regulation (EU) 2020/687 of 17 December 2019 supplementing Regulation (EU) 2016/429 of the European Parliament and the Council, as regards rules for the prevention and control of certain listed diseases. **Summary of Significant Changes:** • Part III provides specific details of control measures for operators and the CA in the event of suspicion of or confirmation of category A diseases in AEs and the wild. • Sampling methods, fallowing periods and surveillance schemes fallowing infection are provided in Annexes XII-XV.
Commission Delegated Regulation (EU) 2020/689	Commission Delegated Regulation (EU) 2020/689 of 17 December 2019 supplementing Regulation (EU) 2016/429 of the European Parliament and of the Council as regards rules for surveillance, eradication programmes, and disease-free status for certain listed and emerging diseases. **Summary of Significant Changes:** • Annex VI provides specific requirements as regards to disease of aquatic animals and risk based surveillance with frequency of risk-based animal health visits being revised in Chapter 3.
Commission Implementing Regulation (EU) 2020/690	Commission Implementing Regulation (EU) 2020/690 of 17 December 2019 laying down rules for the application of Regulation (EU) 2016/429 of the European Parliament and of the Council as regards the listed diseases subject to Union surveillance programmes, the geographical scope of such programmes and the listed diseases for which the disease-free status of compartments may be established.

Commission Implementing Decision (EU) 2021/260	Commission Implementing Decision (EU) 2021/260 of 11 February 2021 approving national measures designed to limit the impact of certain diseases of aquatic animals in accordance with Article 226(3) of Regulation (EU) 2016/429 of the European Parliament and of the Council and repealing Commission Decision 2010/221/EU. **Summary of Significant Changes:** • Disease free status under national measures and annual reporting requirements are detailed.
Commission Implementing Regulation (EU) 2021/620	Commission Implementing Regulation (EU) 2021/620 of 15 April 2021 laying down rules for the application of Regulation (EU) 2016/429 of the European Parliament and of the Council as regards the approval of the disease-free and non-vaccination status of certain Member States or zones or compartments thereof as regards certain listed diseases and the approval of eradication programmes for those listed diseases.
Commission Implementing Regulation (EU) 2021/404	Commission Implementing Regulation (EU) 2021/404 of 24 March 2021 laying down the lists of third countries, territories or zones thereof from which the entry into the Union of animals, germinal products and products of animal origin is permitted in accordance with Regulation (EU) 2016/429 of the European Parliament and the Council.
Commission Delegated Regulation (EU) 2019/2124	Commission Delegated Regulation (EU) 2019/2124 of 10 October 2019 supplementing Regulation (EU) 2017/625 of the European Parliament and of the Council as regards rules for official controls of consignments of animals and goods in transit, transhipment and onward transportation through the Union.
Commission Implementing Regulation (EU) 2020/2236	Commission Implementing Regulation (EU) 2020/2236 of 16 December 2020 laying down rules for the application of Regulations (EU) 2016/429 and (EU) 2017/625 of the European Parliament and of the Council as regards model animal health certificates for the entry into the Union and movements within the Union of consignments of aquatic animals and of certain products of animal origin from aquatic animals, official certification regarding such certificates and repealing Regulation (EC) No 1251/2008 (Text with EEA relevance). **Summary of significant Changes:** • Introduction seven specific animal health certificates for live aquatic animal movements (Intra-EU trade) and one certificate for entry of third country imports into the EU.

APPENDIX 4 - Notifiable Diseases Listed in Annex II of the EU Animal Health Regulation 2016/429

Notifiable diseases are those listed in *Annex II* of Regulation (EU) 2016/429.

Notifiable diseases are classified into five categories (A to E) in Implementing Regulation (EU) 2018/1882, with each category having its own set of criteria for listing and requirements for surveillance and control.

Categories of listed diseases as defined by Implementing Regulation (EU) 2018/1882

Category A **disease:** a listed disease that does not normally occur in the Union and for which immediate eradication measures must be taken as soon as it is detected.
Category B **disease:** a listed disease that which must be controlled in all Member States with the goal of eradicating it throughout the Union (no diseases of aquatic animals are currently designated category B).
Category C **disease:** a listed disease which is of some relevance to some Member States and for which measures are needed to prevent it from spreading to parts of the Union that are officially disease-free or that have eradication programmes for the listed disease concerned.
Category D **disease:** a listed disease for which measures are needed to prevent it from spreading on account of its entry into the Union or movements between Member States.
Category E **disease:** a listed disease for which there is a need for surveillance within the Union.

Category A diseases do not normally occur in the European Community and have the potential for significant economic consequences in aquaculture or have potential to cause detrimental environmental effects to wild species if they occur in the European community.

Category A listed as notifiable in Regulation (EU) 2016/429

Fish	Molluscs	Crustacean
Epizootic haematopoietic necrosis (EHN)	Microcytosis mackini	Taura syndrome
	Perkinsus marinus	Yellowhead disease

Category C+D+E diseases listed as notifiable in Regulation (EU) 2016/429

Fish	Molluscs	Crustacean
Infectious salmon anaemia (ISA)	Bonamia ostreae	White spot disease
Viral haemorrhagic Septicaemia (VHS)	Marteilia refringens	
Infectious haematopoeitic necrosis (IHN)	Bonamia exitosa	

Diseases Listed Under National Measures for Ireland - In addition to the diseases listed above, Ireland is free of the following diseases for which we have applied national measures under Article 226(3) of Regulation (EU) 2016/429 and enacted through Implementing Regulation (EU) 2021/260.

Diseases for which Ireland has implemented national measures

Fish
Gyrodactylus salaris
Spring viraemia of carp (SVC)
Bacterial kidney disease
Koi herpes virus (KHV)*

* KHV is listed as a category E disease in Implementing Regulation (EU) 2018/1882 but Ireland has taken additional national measures and is declared free of KHV in Implementing Regulation (EU) 2021/260. This means trade into Ireland is restricted to fish from disease free areas.

APPENDIX 5 - List of All Marine Environment Health Series

No. 1. Assessment of Water Quality Data from Kilkieran Bay, Co. Galway
Evin McGovern, A. Rowe, B. McHugh, J. Costello, M. Bloxham, Conor Duffy, Eugene Nixon (2001). http://hdl.handle.net/10793/219

No. 2. Trace metal and chlorinated hydrocarbon concentrations in shellfish from Irish waters, 1997-1999. Evin McGovern, A. Rowe, B. McHugh, J. Costello, M. Bloxham, Conor Duffy, Eugene Nixon (2001). http://hdl.handle.net/10793/220

No. 3. The fate of oxytetracycline in the marine environment of a salmon cage farm. R. Coyne*, P. Smith, Christopher Moriarity (2001).* http://hdl.handle.net/10793/221

No. 4. Winter nutrient monitoring of the Western Irish Sea - 1990 to 2000
Evin McGovern, Eileen Monaghan, M. Bloxham, A. Rowe, Conor Duffy, A. Quinn, Brendan McHugh, T. McMahon, M. Smyth, M. Naughton, M. McManus, Eugene Nixon (2002). http://hdl.handle.net/10793/222

No. 5. Monitoring of zebra mussels in the Shannon-Boyle navigation, other navigable regions and principal Irish lakes, 2000 & 2001 Dan Minchin, F. Lucy, M. Sullivan (2002). http://hdl.handle.net/10793/223

No. 6. Monitoring of tributyl tin contamination in six marine inlets using biological indicators. Dan Minchin (2003). http://hdl.handle.net/10793/224

No. 7. Trace metal and chlorinated hydrocarbon concentrations in shellfish from Irish waters, 2000 Denise Glynn, Linda Tyrrell, Brendan McHugh, A. Rowe, Jim Costello, Evin McGovern (2003). http://hdl.handle.net/10793/225

No. 8. Trace metal and chlorinated hydrocarbon concentrations in various fish species, landed at selected Irish ports 1997-2000. Linda Tyrrell, Denise Glynn, A. Rowe, Brendan McHugh, Jim Costello, Conor Duffy, A. Quinn, M. Naughton, M. Bloxham, Eugene Nixon, Evin McGovern (2003). http://hdl.handle.net/10793/226

No. 9. Environmental quality and carrying capacity for aquaculture in Mulroy Bay Co. Donegal. T. Telfor, K. Robinson (2003). http://hdl.handle.net/10793/228

No.10. Trace metal and chlorinated hydrocarbon concentrations in shellfish from Irish waters, 2001. Denise Glynn, Linda Tyrrell, Brendan McHugh, A. Rowe, Eileen Monaghan, Jim Costello, Evin McGovern (2003*).* http://hdl.handle.net/10793/231

No. 11. The Irish coral task force and Atlantic coarl ecosystem study report on two deep-water coral conservation stakeholder workshops held in Galway in 2000 and 2002 A. Grehan, R. Long, B. Deegan, M. O'Cinneide (2003). http://hdl.handle.net/10793/234

No. 12. The occurrence and risk assessment of the pesticide toxaphene in fish from Irish waters. (2003). Brendan McHugh, Denise Glynn, Eugene Nixon, Evin McGovern (2003*).* http://hdl.handle.net/10793/235

No. 13. Trace Metal and Chlorinated Hydrocarbon Concentrations in Various Fish Species Landed at Selected Irish Ports, (2001). Linda Tyrrell, Denise Glynn, Brendan McHugh, A. Rowe, Eileen Monaghan, Jim Costello, Evin McGovern (2003). http://hdl.handle.net/10793/237

No. 14. An epidemiological investigation of the re-emergence of pancreas. Disease in Irish farmed Atlantic Salmon (Salmo Salar L.) in 2002 M. F. McLoughlin, E. Peeler, K. L. Foyle, H. D. Rodger, D. O'Ceallachain, F. Geoghegan (2003). http://hdl.handle.net/10793/239

No. 15. Salmon Mortalities at Inver Bay and Mc Swynes Bay Finfish Farms, County Donegal, Ireland during 2003. Margot Cronin, Caroline Cusack, Fiona Geoghegan, Dave Jackson, Evin McGovern, T. McMahon, Francis O'Beirn, M. O'Cinneide & Joe Silke (2004). http://hdl.handle.net/10793/241

No. 16. Trace Metal and Chlorinated Hydrocarbon Concentrations in Shellfish from Irish waters, (2002). Denise Glynn, Linda Tyrrell, Brendan McHugh, Eileen Monaghan, Jim Costello, Evin McGovern (2004*).* http://hdl.handle.net/10793/255

No. 17. Review of the potential mechanization of kelp harvesting in Ireland Astrid Werner Stefan Kraan (2004). http://hdl.handle.net/10793/261

No. 18. Trace metal and chlorinated hydrocarbon concentrations in Various Fish species landed at selected Irish Port, 2002 Linda Tyrrell, Mary Twomey, Denise Glynn, Brendan McHugh, Eileen Joyce, Jim Costello, Evin McGovern (2004).http://hdl.handle.net/10793/260

No. 19. Proceedings of the 5th Irish Shellfish Safety Scientific Workshop (2005) http://hdl.handle.net/10793/259

No. 20. Trace metal and chlorinated hydrocarbon concentrations in Various Fish Species landed at selected port 2003. Linda Tyrrell, Brendan McHugh, Denise Glynn, Mary Twomey, Eileen Joyce, Jim Costello, Evin McGovern (2005). http://hdl.handle.net/10793/229

No. 21. *Karenia mikimotoi:* An exceptional Dinoflagellate bloom in western Irish waters, Summer 2005. J. Silke, F. O' Beirn and M. Cronin (2005). http://hdl.handle.net/10793/240

No. 22. Research on Pancreas Disease in Irish Farmed Salmon 2004/2005 - Current & Future Initiatives. Neil Ruane, H. Rodger, D. Graham, L. Foyle, A. Norris, J. Ratcliff, K. Murphy, S. Mitchell, C. Staples, H. Jewhurst, D. Todd, Fiona Geoghegan, M. O'Cinneide (2005). http://hdl.handle.net/10793/247

No. 23. Proceedings of the 6th Irish Shellfish Safety Workshop, Galway, 1st December 2005 (2006). http://hdl.handle.net/10793/249

No. 24. Guidelines for the assessment of dredge material for disposal in Irish waters. Margot Cronin, Evin McGovern, Terry McMahon, Rick Boelens, Marine Environment Consultant - Portroe, Nenagh, Co. Tipperary & Corresponding author (2006). http://hdl.handle.net/10793/251

No. 25. Trace Metal Concentrations in Shellfish from Irish Waters, 2003. B. Boyle, Linda Tyrrell, Brendan McHugh, Eileen Joyce, Jim Costello, Denise Glynn, Evin McGovern (2006). http://hdl.handle.net/10793/252

No. 26. Investigation into levels of dioxins, furans, polycholorinated biphenyls and brominated flame retardants in fishery produce in Ireland. ChristinaTlustos, Brendan McHugh, Iona Pratt, Linda Tyrrell, Evin McGovern (2006). http://hdl.handle.net/10793/254

No. 27. Proceedings of the 7th Irish Shellfish Safety Workshop (2007). http://hdl.handle.net/10793/262

No. 28. Isolation and purification of AZAs from naturally contaminated materials, and evaluation of their toxicological effects. Phillip Hess, Pearse McCarron, Nils Rehmann, Jane Kilcoyne, Terry McMahon, Gavin Ryan, Michael P. Ryan, Michael J. Twiner, Gregory J. Doucette, Masayuki Satake, Emiko Ito, Takeshi Yasumoto (2007). http://hdl.handle.net/10793/268

No. 29. Bonamia Ostrea in the native oyster Ostrea edulis: A Review. Sarah Culloty and Marie Mulcahy (2007). http://hdl.handle.net/10793/269

No. 30. Infectious pancreatic Necrosis Virus and its Impact on the Irish Salmon Aquaculture and Wild Fish Sectors. Neil Ruane, Fiona Geoghegan, M. O'Cinneide (2007). http://hdl.handle.net/10793/270

No. 31. Management recommendations for the sustainable exploitation of mussel seed in the Irish Sea. J. A. Maguire, T. Knights, G. Burnell, T. Crowe, Francis O'Beirn, D. McGrath, M. Ferns, N. McDonough, N. McQuaid, B. O'Connor, R. Doyle, C. Newell, R. Seed, A. Smaal, T. O'Carroll, L. Watson, J. Dennis, M. O'Cinneide (2007). http://hdl.handle.net/10793/271

No. 32. Issues and recommendations for the development and regulation of marine aggregate extraction in the Irish sea Cathal O'Mahony, Gerry Sutton, Terry McMahon, Micheal O'Cinneide, Eugene Nixon (2008). http://hdl.handle.net/10793/272

No. 33. Proceedings of the 8th Irish Shellfish Safety Workshop (2008) http://hdl.handle.net/10793/273

No. 34. Pancreas disease in farmed salmon – health management and investigations at Irish farm sites. 2005 – 2008. http://hdl.handle.net/10793/267

No. 35. Pilot water quality monitoring station in Dublin Bay north bank monitoring station (NBMS) MATSIS Project Part 1 Garvan O'Donnell, Eileen Joyce, Shane O'Boyle, Evin McGovern (2008). http://hdl.handle.net/10793/274

No. 36. Irish Sea Marine Aggregate Initiative (IMAGIN), Technical Synthesis Report Gerry Sutton. (2009). http://hdl.handle.net/10793/277

No. 37. Proceedings of the 9th Irish Shellfish Safety Workshop (2009) http://hdl.handle.net/10793/28

No. 38. An Assessment of Dangerous Substances in Water Framework Directive Transitional and Coastal Waters: 2007 – 2009. McGovern, E., Cronin, M., Joyce, E., and McHugh, B. (2011). http://hdl.handle.net/10793/635

No. 39. Chemical Residue in Irish Farmed Finfish, 2011. Glynn, D., McGovern, E., Slattery, T., Ó Conchubhair, D., Toomey, M., Kelly, C., Reid, A. and Moffat, R. (2013). http://hdl.handle.net/10793/876

No. 40. Chemical Residues in Irish Farmed Finfish, 2012-2014.Glynn, D., Kelly, C., Moffat, R., Reid, A., Toomey, M., O'Hea, L., Elliott, M., Hickey, C., Geary, M., Ruane, N., and McGovern, E. (2015). http://hdl.handle.net/10793/1093

No. 41 Proceedings of the 11th Shellfish Safety Workshop, 2020. Clarke, D. & Gilmartin, M. (eds.). Marine Environment and Health Series No. 41. Marine Institute, Ireland http://hdl.handle.net/10793/1663

No. 42. Fish Health Unit Report of Activities Undertaken in 2018 and 2019, (2020). Dore, B., Power, A., Kenny, E., Bradley, F., Cheslett, D., White, S., McCarthy, U., Ruane, N. M. Marine Environment and Health Series, No. 42. Marine Institute, Ireland. http://hdl.handle.net/10793/1597

No. 43. Fish Health Unit Report of Activities Undertaken in 2020., (2021). Dore, B., Power, A., Kenny, E., Bradley, F., O' Kane, P., Cheslett, D., White, S., and Swords, F. Marine Environment and Health Series, No. 43. Marine Institute, Ireland. https://oar.marine.ie/handle/10793/1717

APPENDIX 6 - Photography Credits

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