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31 January – 04 February 2012

Lisbon, Portugal

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CIEM Conseil International pour l'Exploration de la Mer

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Executive summary

The ICES Working Group on Pathology and Diseases of Marine Organisms (WGPDMO) met 31 January – 3 February 2012 at the National Institute for Fisheries and the Sea (IPIMAR) in Lisbon, Portugal. The meeting, chaired by Simon Jones (Canada), was well attended with 16 participants representing 14 ICES Member Countries. In order to consider the ten Terms of Reference, intersessional work was done by WGPDMO members and several working documents were provided in advance of the meeting.

The agenda items covered a wide range of topics related to diseases and pathology in wild and farmed finfish and shellfish, with additional attention to environmental concerns.

Highlights of the meeting were:

- a report on new disease trends in wild and farmed fish and shellfish in ICES Member Countries, which is the only annual expert report available on this topic (ToR a, report Section 5)
- a review of the occurrence and mitigation of pathogen transmission from maricultured finfish (ToR b, report Section 6 and Annex 6)
- a review on the management of infections and diseases in commercially valuable bivalves (ToR c, report Section 7 and Annex 7)
- a status update on the manuscript on disease-associated population effects of commercial and non-commercial fish and shellfish species (ToR d, report Section 8)
- a progress report on the Fish Disease Index (FDI) in relation to 1, its implementation in marine monitoring and assessment programmes; 2, the application and further development of assessment criteria; and 3, results of FDI assessments carried out intersessionally addressing diseases of flounder and Baltic cod and data on liver histopathology and macroscopic liver lesions in the common dab (ToR e, report Section 9 and Annex 8)
- an update on the ICES publication "Trends in important diseases affecting the culture of fish and molluscs in the ICES area, 2003 to present" (ToR f, report Section 10)
- a review of parasites in marine finfish and shellfish species posing a hazard to human health (ToR g, report Section 11)
- an update on the status of ICES publications on pathology and diseases of marine organisms (ToR h, report Section 12)
- identify to the ICES Data Centre, the potential value of appropriate products on the ICES website to help publicise the results of available disease data. In addition, the need for age and weight data to accompany the more complete and systematic submission of macroscopic and microscopic liver histology data to the ICES Data Centre was identified (ToR i, report Section 13)
- further evaluation on the potential for collaboration between WGPDMO and other ICES Expert Groups (ToR j, report Section 14)
- a discussion on draft Standards and Guidelines for reporting fish and shellfish diseases in National Reports (report Section 15, Annex 9)

- the WGPDMO concluded that the Terms of Reference for 2012 were addressed in a satisfactory manner and identified a number of issues for further joint work
- since several important issues in the field of pathology and diseases of marine organisms were identified for further consideration, it was agreed that a further meeting of the WGPDMO is required in 2013. The meeting will be held in Legnaro (Padova), Italy, 5–9 March 2013.

1 Opening of the meeting

The ICES Working Group on Pathology and Diseases of Marine Organisms (WGPDMO) was hosted by the Portuguese Ministry of Agriculture and Fisheries at the National Institute for Marine Research (IPIMAR) in Lisbon, Portugal, with Simon Jones (Canada) presiding. The WGPDMO was very appreciative of the host and the excellent venue and accommodations. The meeting was opened at 10:00 hrs on Tuesday, 31 January 2012, with the Chair welcoming the participants, particularly a new member, Eirik Biering (Norway). A list of participants is appended in Annex 1.

Apologies were received from T. Wiklund (Finland), P. Vennerström (Finland), I. Dalsgaard (Denmark) and T. Renault (France). F. Ruano (Portugal) provided instructions on in-house facilities and general meeting arrangements.

The meeting was held as a series of plenary sessions with the option to establish ad-hoc specialist subgroups as appropriate in order to consider some agenda items in detail before reporting conclusions back to the plenum for further consideration and endorsement.

2 Adoption of the agenda

2.1 Terms of reference

The WGPDMO noted the Terms of Reference published as C. Res. 2011/2/SSGHIE03 (Annex 2). The agenda involved intersessional work by the members of the WGPDMO who had been requested to produce written working documents for review at the meeting and inclusion in the WGPDMO report as Annexes, as appropriate. As agreed by the WGPDMO members, all working documents were to be prepared 2 weeks before the meeting and were posted to the ICES SharePoint by the Chair and members. As a result, national reports and several ToR documents were available to the participants prior to the meeting. This ensured that the Terms of Reference could be treated efficiently during the meeting. A list of working documents provided prior to the meeting is presented in Annex 3.

2.2 Adoption of the agenda and timetable

A draft agenda and timetable were presented and adopted with minor changes. The accepted agenda is provided in Annex 4.

2.3 Selection of rapporteurs

Rapporteurs were accepted as indicated in Annex 5.

3 ICES items of relevance to WGPDMO

3.1 ICES Annual Science Conferences

The 2011 ICES Annual Science Conference (ASC) was held 19–23 September 2011 in Gdansk, Poland and was comprised of 19 theme sessions. Theme Session R "Integration of multidisciplinary knowledge in the Baltic Sea to support science-based management" consisted of 25 papers and four posters, one of which, by M. Podolska (WGPDMO) as leading author, had the title " Baltic herring and *Anisakis simplex* larvae: acetylcholinesterase biomarker response and host-parasite interactions in a polluted environment". Another paper of interest "Assessment of genetic risk in fishes inhabiting zones of dumped chemical munitions in the Baltic Sea", was co-authored by Thomas Lang (WGPDMO), as well as a third paper of interest "The usefulness of information on infection of herring with *A. simplex* larvae in management of Baltic herring stock", was co-authored by M. Podolska (WGPDMO).

The ICES ASC in 2012 will be held 17–21 September in Bergen, Norway. Two sessions will have relevance to the WGPDMO: Session G, Implementation of the European Union Marine Strategy Framework Directive (EU MSFD): Implications for science and policy, chaired by W. Nikolaus Probst (Germany), Daniel Oesterwind (Germany) and Matt Gubbins (UK), and a joint ICES/PICES Session Q, Sustainability of aquaculture, chaired by Raymond Bannister (Norway), Chris McKinsey (Canada) and Pauline Kamermans (the Netherlands).

3.2 Implementation of multi-annual management of SCICOM expert groups

WGPDMO discussed the plan by ICES to implement multi-annual management of SCICOM Expert Groups (EGs). In the plan, EGs would be appointed for a fixed 3-year term, coinciding with the term of the Chair. ToRs would be identified for the entire duration of the term, except for specific *ad hoc* requests. Reporting would consist of brief progress reports in years 1 and 2 and a full report at the end of year 3. At the end of the term, EGs would complete a self-assessment of their outcomes and outputs. EGs that require more than one term would request an extension coincident with the self-assessment, providing a rationale for the extension, and suggesting a new set of ToRs. The extension may involve ToRs that have evolved from existing ToRs, or the same ToRs may be recommended in cases where EGs focus on new information that becomes available annually.

The WGPDMO recognized that the proposed plan would provide flexibility to EGs to adopt ToRs that are annual, single-term or multi-term. An example of an annually-defined ToR is the "Annual update of new disease trends in wild and farmed fish, molluscs and crustaceans based on National Reports". Furthermore, the WGPDMO agreed that a 3-year term would provide a greater opportunity to produce substantial and defensible products (e.g., published manuscripts) within a defined and realistic timeframe, thus disseminating the work of the EG not only to ICES but to the wider scientific community. The WGPDMO further recognized the benefits of reviewing, revising and showcasing its work on a regular basis.

4 Other relevant activities for information

WGPDMO acknowledges the work of WGCRAB in reviewing infections with *Hematodinium* spp. in crabs. This work may lead to future collaborations between these EGs.

WGPDMO was informed of the planned revision of the HELCOM Baltic Sea monitoring programme, which is based on the goals and ecological objectives defined in the HELCOM Baltic Sea Action Plan (http://www.helcom.fi/BSAP/en_GB/intro/). With regards to hazardous substances, a set of core and candidate indicators to monitor and assess the state of the Baltic Sea was developed by the HELCOM CORESET project (http://www.helcom.fi/projects/on_going/en_GB/coreset/). Fish diseases (according to ICES guidelines) and the Fish Disease index (FDI) as tool for data analysis and assessment are among the core indicators suggested by the project. The results of the CORESET project are currently under national discussion. If the core indicators suggested are accepted, countries will be encouraged to carry out regular wild fish disease monitoring in the Baltic Sea. A similar status has already been accomplished in the OSPAR area (northeast Atlantic) under the OSPAR Coordinated Environmental

Monitoring Programme (CEMP), where fish disease monitoring is part of the general and the PAH-specific biological effects monitoring (http://www.ospar.org/content/content.asp?menu=00900301400135_000000_000000). It is envisaged that these developments will have implications on the implementation of the EU Marine Strategy Framework Directive (MSFD) (http://ec.europa.eu/environment/water/marine/directive_en.htm) and its national monitoring and assessment requirements regarding the achievement of Good Environmental Status in the European seas with regards to MSFD Descriptor 8 addressing contaminants and their effects.

5 Produce an update of new disease trends in wild and cultured fish, molluscs and crustaceans based on national reports (ToR a)

The update in the following sections is based on national reports for 2011 submitted by Canada, Denmark, Finland, England and Wales, France, Germany, Ireland, Latvia, Norway, Poland, Portugal, Russia, Scotland, Sweden and the USA. It documents significant observations and highlights the major trends in newly emerging diseases and in those identified as being important in previous years.

5.1 Common and scientific names of host fish and shellfish species reported in Section 5

bluefish	*Pomatomus saltatrix*	oyster, eastern	*Crassostrea virginica*
bream	*Abramis brama*	oyster, European flat	*Ostrea edulis*
capelin	*Malotus villosus*	oyster, Kumamoto	*Crassostrea sikamea*
clam, angelwing	*Cyrtopleura costata*	oyster, Pacific	*Crassostrea gigas*
clam, Baltic macoma	*Macoma balthica*	perch, European	*Perca fluviatilis*
clam, dwarf surf	*Mulinia lateralis*	periwinkle	*Littorina littorea*
clam, hard	*Mercenaria mercenaria*	rangia, common	*Rangia cuneata*
clam, Japanese littleneck	*Venerupes philippinarum*	redfish, beaked	*Sebastes mentella*
clam, soft	*Mya arenaria*	saithe	*Pollachius virens*
clam, stout razor	*Tagelus plebeius*	salmon, Atlanic	*Salmo salar*
clam, wedge shell	*Donax trunculus*	salmon, chum	*Oncorhynchus keta*
cockle	*Cardium edule*	salmon, pink	*Oncorhynchus gorbuscha*
cod	*Gadus morhua*	salmon, sockeye	*Oncorhynchus nerka*
crab, European edible	*Cancer pagurus*	sand gaper	*Scrobicularia plana*
crab, spider	*Maja spinado*	striped bass	*Morone saxatilis*
dab, common	*Limanda limanda*	sole, English	*Parophrys vetulus*
eelpout	*Zoarces viviparous*	trout, brown	*Salmo trutta*
flounder	*Platichthys flesus*	trout, rainbow	*Oncorhynchus mykiss*
haddock	*Melanogrammus aeglefinus*	trout sea	*Salmo trutta*
herring, Atlantic	*Clupea harengus harengus*	turbot	*Psetta maxima*
herring, Baltic	*Clupea harengus membras*	whitefish	*Coregonus* sp.
lamprey	*Lampetra fluviatilis*	wrasse, ballan	*Labrus bergylta*
lumpsucker	*Cyclopterus lumpus*	wrasse, corkwing	*Symphodus melops*
mussel, blue	*Mytilus edulis*	wrasse, goldsinny	*Ctenolabrus rupestris*
octopus	*Octopus vulgaris*		

5.2 Wild Fish

5.2.1 Viruses

Infectious Salmon Anaemia Virus (ISAV) - Screening by qRT-PCR in 2011 of adult Atlantic salmon collected from West Greenland in 2010 found one of 331 adult salmon positive for the virus. Sequence analysis indicated the HPR0 genotype and showed it to be nearly identical to ISAV from brood fish from the Penobscot River (Maine, USA) in 2009 and 2010.

Infectious Haematopoietic Necrosis Virus (IHNV) - The virus is enzootic in Canadian sockeye salmon stocks. Screening of 4 sockeye stocks has revealed a highly variable prevalence (0 to 86%) among and within stocks over a 25- year surveillance period.

Infectious Pancreatic Necrosis Virus (IPNV) - Isolated in Ireland from one returning adult Atlantic salmon in the Burrishoole catchment, Co. Mayo. There were no clinical signs of disease. The isolate was Sp serotype, but genetically different from virulent isolates from farmed salmon. In Norway, the virus was detected for the first time in the Vefsn Region, in 6 sea trout.

Viral Haemorrhagic Septicaemia Virus (VHSV) - Historical findings of genotype II were reported from two fish species in Finland: clinically healthy lampreys from the estuaries of the rivers Lestijoki and Kalajoki, in 2003, and also in Baltic herring in coastal waters. Isolates from herring occurred at a prevalence of 6.7 % in samples collected during 2004–2006.

Heart and Skeletal Muscle Inflammation (HSMI) - In Norway, PCR-screening for the piscine reovirus (PRV) in approximately 1000 wild caught Atlantic salmon brood fish from 2007–2009 showed presence of the virus at a mean prevalence of 13.4%. Histopathological examination of hearts from PRV–positive fishes revealed no HSMI related lesions. PRV is widespread in Atlantic salmon returning to Norwegian rivers and the virus can be present in high titres without causing lesions of HSMI. The virus was also found in sea-trout brood fish.

Piscine Myocarditis Virus (PMCV) - The virus associated with Cardiomyopathy Syndrome (CMS) was observed by PCR-screening in two of approximately 800 Norwegian salmon from the same samples screened for PRV. Thus, PMCV is not widespread in Norwegian wild salmon broodfish.

Lymphocystis - German samples from December showed an increase in the prevalence of lymphocystis in Baltic dab from Kiel Bight(9.1%) and from the Mecklenburg Bight (11.6%), compared to 2010.

5.2.2 Bacteria

Skin Ulcerations - The prevalence in dab from most areas in the North Sea has remained low but has increased in the German Bight to 2.0% (summer) and 2.6% (winter) from 1.1% (summer) and 0.4% (winter) in 2010. Ulcerations in Baltic cod from the Arkona Sea (Western Baltic) sampled during August decreased to 10.9% (from 19.1% in 2010) and to 8.7% (from 9.64% in 2010) in December samples. The mean prevalence of skin ulcers in cod from the Polish EEZ of the Baltic increased to 4.4% from 1.7% in 2010.

Vibriosis - In Norway, wrasse species and lumpsucker used as 'cleaner fish' for removal of sea lice exhibited ulcerative lesions associated with a number of *Vibrio* species. *V. splendidus* was most frequently identified along with *V. anguillarum* O1, O2 (biotype I & II) in the wrasse at most locations across the country with *V. wodanis*, previously associated with winter ulcer disease in salmon, being occasionally detected.

5.2.3 Parasites

Crustacea – Copepoda

Lepeophtheirus salmonis - High levels of sea lice were recorded on wild salmonids in Norway. Sea trout were heavily infested with sea lice in the northern part of Ryfylke, Hardanger, parts of Sognefjorden, Trondheimsfjorden and Namsenfjorden. The areas where the infection pressure on salmon smolts rose were: Hardanger, Sognefjorden and Trondheimsfjorden. As an example, the results from post-smolt trawling in Sognefjordenin in week 21, showed 39 % of salmon smolts (n=23) had more than 10 lice, a limit that is considered critical for smolts going to sea, and 83% had more than 0.1 lice/g, a physiological threshold. In week 23, no smolts (n=6) had more than 10 lice, but 17% had more than 0.1 lice/g. In week 23, 47% of sea trout (n=15) from the outer Sognefjorden had more than 0.1 louse/g whereas in week 26, 23% had more than 0.1 louse/g (n=22).

This is an extract of a report in Norwegian available at: http://www.imr.no/nyhetsarkiv/2011/desember/mye_lakselus_i_2011/nb-no

Sphyrion lumpi - The level of infestation on beaked red fish in the Norwegian-Barents Sea (ICES Subareas IIa and IIb), increased to 40% from 28% in 2009.

Myxozoa

Parvicapsula kabatai - The prevalence of 74% in spawning pink salmon in the Quinsam River (Canada) was the highest since reporting began in 2003. The alternating pattern of low and high prevalence in even and odd year pink salmon persists.

Nematoda

Combined infections - The presence of three anisakids, *Anisakis simplex*, *Contracaecum osculatum* or *Pseudoterranova decipiens,* was recorded in the liver of Baltic cod with an average infection prevalence in the Polish EEZ of 11.2%. Results suggest that the prevalence of anisakids (especially *C. osculatum*) in cod increased in comparison to an average of 4% from 1987 to 1993.

Anisakis simplex - GLM-models of *A. simplex* prevalence in Baltic herring revealed an increasing trend in year effect between 2007 and 2010, but this declined in 2011. The prevalence of infection remained negatively correlated with the average mass of individual herring. The prevalence of infection with *A. simplex* in herring increased in the Russian EEZ of the Baltic Sea (P=3.6%, n=1317) in comparison to 2009 (P=0.8%, n=1192) and 2010 (P=1.7%, n=1469).

The abundance index (number of parasites per fish examined) of infection with *A. simplex* in cod from the Barents Sea (ICES Subarea I) was higher in 2011 (38.6) in comparison to the previous years (2008, 14.2; 2009, 18.4; 2010, 3.0). Prevalence in this area is usually high and reached 100% in last two years. In recent years both *A. simplex* larvae in capelin and haddock showed an upward tendency in Barents Sea (ICES Subarea I). In 2011, the average intensity for haddock was 48.7 parasites. The abundance in capelin declined to 0.3 in 2011 from 0.7 in 2010 and 1.6 in 2009.

Pseudoterranova decipiens - The prevalence in Barents Sea cod (ICES Subarea I) underwent large interannual variations. The highest prevalence (40%) was noted in

2004, but prevalence was not recorded in 2006 and 2007. The prevalence in 2009 and 2010 reached 19.2% and 24%, respectively and then decreased to 8% in 2011.

Trematoda

***Cryptocotyle* sp. metacercariae** - Infection in flounder in March (Russian EEZ of the Baltic) was lower (P=0.8%, I=1–80, A=0.2) than in 2010 (P=1.6%, I=1–52, A=0.3) and in the same period of 2009 (P=1.1%, I= 1–26, A=0.1).

Diplostomum spathaceum and ***Tylodelphys clavata*** metacercariae - In bream from Curonian Lagoon (Russian EEZ of the Baltic), the prevalence of parasitic cataract increased from 0.5% in 2010 (n=384) to 3.8% in 2011 (n=226).

Cestoda

***Diphyllobothrium dendriticum* plerocercoid** - Found for first time in abdominal cavity of 5.3% of smelt (n=150) sampled in Curonian Lagoon (Russian EEZ of the Baltic).

Acanthocephala

***Corynosoma* sp. larvae** - Infections in smelt from the Curonian Lagoon (Rusian EEZ of the Baltic) increased (P=88.0%, I=1–84, A=7.2) in comparison with 2010 (P=74.1%, I=1–17, A=3.0, n=27).

5.2.4 Other Diseases

Epidermal Hyperplasia/Papilloma - The prevalence in dab from the inner German Bight (North Sea) has increased to 1.4% (summer) and 5.8 % (winter) compared to 2010: 0.0 (summer) to 2.0 % (winter).

Fungi - Large granulomas were found in the kidney and liver of one returning Baltic salmon. The fish tested negative for viral and BKD-infections. Histological examination showed fungal infection and further analysis isolated *Ochroconis humicola* on PG-1 and marine agar plates. If confirmed, this will be the first finding of the disease in Sweden. The prevalence of *Loma* sp. in cod sampled in December 2011 at a dumpsite of World War II chemical munitions east of Bornholm, Baltic Sea was 88.6% (n = 140). In other areas of the Baltic Sea the prevalence of *Loma* sp. varied between 0.0 % and 35.7 %.

Toxic Algae - In Russian EEZ of the Baltic (Curonian Lagoon), the prevalence of bream gill, liver and kidney lesions probably associated with toxic cyanobacteria blooms decreased (P=27.0%, n=226) in comparison with 2010 (P=42.0%, n= 384).

Chronic skin ulcer - During spring and summer an increased number of cod, turbot and mackerel with external ulcer-like lesions in the skin have been observed from the Baltic Sea in the Hanöbukten area (Sweden) and near Bornholm (Denmark). The lesions are chronic, some with granulomas. Immunohistochemistry has ruled out infection with *Francisella* sp. Although histology indicates the presence of fungi, a primary aetiology has not been determined.

Hyperpigmentation - In dab from the inner German Bight (North Sea), prevalence increased to 13.5% (December 2011) from 5.1% (December 2010). Dab sampled off Flamborough (North Sea) exhibited an increase from 35.8 in 2009 to 70 % in 2011. Similarly, dab sampled off Humber (North Sea) showed an increase of 28 % to 44 %. In contrast, smaller increases were observed at 10 other sites in the North Sea, eastern English Channel and Irish Sea. Hyperpigmentation was noted only sporadically in dab from the Baltic Sea. New findings indicate that hyperpigmentation is associated with differences in fatty acid profiles in various tissues compared with normally pigmented fish.

Skeletal deformities - In Baltic cod from the Polish EEZ (ICES Subdivisions 25 and 26), the mean prevalence of skeletal deformation decreased to 0.25% in comparison to two previous years 2009 (0.55%) and 2010 (0.41%).

Liver neoplasms and associated lesions - Non-specific degenerative, regenerative and inflammatory lesions were observed in liver of 100% of eelpout (n = 781) collected in various coastal and offshore areas of the Baltic Sea. Lesions were regarded as early toxicopathic; non-neoplastic changes were present at an average prevalence of 56 %. Pre-neoplastic lesions (foci of cellular alteration) were rare (prevalence 0.06%) and benign and malignant liver neoplasms were absent.

5.2.5 Conclusions

1) The WGPDMO noted with concern that some ICES member countries have not provided sufficient resources to support wild fish monitoring programmes, resulting in an insufficient spatial and temporal coverage of fish populations. It was emphasised that this lack of data will affect marine ecosystem health assessments in national and international programmes (e.g. under the EU Marine Strategy Framework Directive, OSPAR Coordinated Environmental Monitoring Programme (CEMP), and revised HELCOM monitoring programme).

2) The piscine reovirus (PRV) associated with Heart and Skeletal Muscle Inflammation (HSMI) in farmed fish is widespread in the wild Atlantic salmon returning to Norwegian rivers. High levels of the virus, estimated from qPCR assays, can be present in the wild salmon without histopathological lesions of HSMI.

3) Infestations with parasitic copepods remain prevalent in many wild fish species (i.e., salmonids, flounder, redfish) in various areas.

4) Heavy infections with anisakid nematodes (*Anisakis simplex*, *Contracaecum osculatum* and *Pseudoterranova decipiens*) persist in Baltic cod from Subdivisions 25 and 26, and in herring from Subdivisions 24 to 26.

5.2.6 Recommendations

ICES WGPDMO recommends that:

i) ICES Member Countries continue to fund or, in cases where no fish disease monitoring programmes has been implemented, make a commitment to fund fish disease monitoring programmes to sustain fish health surveillance of wild stocks. Information obtained is of vital importance to integrated assessments of the health of marine ecosystems (e.g. in relation to the EU Marine Strategy Framework Directive, OSPAR Coordinated Environmental Monitoring Programme (CEMP), and revised HELCOM monitoring programme). Data generated according to established ICES and BEQUALM guidelines should be submitted to the ICES Data Centre.

ii) Commercially exploited marine fish (including anadromous salmonids) should be monitored by member countries for the presence of parasites representing a risk for human health.

5.3 Farmed fish

5.3.1 Viruses

Infectious Salmon Anaemia Virus (ISAV) - Between 2003 and 2011, a total of 7002 tests were conducted on apparently healthy or freshly dead Atlantic salmon sampled from commercial aquaculture in British Columbia (BC), Canada using a validated RT-PCR assay for ISAV. All test results were negative. To date, the OIE criteria (refer to latest Manual) for confirming the detection of ISAV have not been met and clinical ISA has never been observed in cultured finfish in BC. The number of outbreaks in Norway was 1, a decrease from 7 in 2010.

Infectious Pancreatic Necrosis Virus (IPNV) - The number of cases in Atlantic salmon and rainbow trout in Norway was 154, a decrease from 198 in 2010. Clinical IPN occurred in four marine salmon sites in Ireland, two of these outbreaks resulted in losses of 10–15 %. In Finland, IPNV was isolated at 5 different rainbow trout farms, down from 9 in 2010.

Viral Haemorrhagic Septicaemia Virus (VHSV) - There were no cases of VHSV in salmonids in Norway in 2011. VHS virus was isolated on three occasions from rainbow trout at two farms in the Åland restriction area in Finland. The numbers of cases in this area has fluctuated since the first case in 2000. The Uusikaupunki-Rauma restriction compartment on the west coast of Finland was declared virus-free in 2011.

Heart and Skeletal Muscle Inflammation (HSMI) - HSMI is associated with a novel piscine reovirus (PRV). The number of cases in Norway was 162, an increase from 131 in 2010.

Piscine Myocarditis Virus (PMCV) - The causative agent of cardiomyopathy syndrome of farmed and wild Atlantic salmon is a double-stranded RNA virus belonging to the family Totiviridae. The number of cases in Norway was 74 in 2011, an increase from 53 in 2010.

Salmonid Alphavirus (SAV) - The severity of pancreas disease (PD) in salmon continues to decline in Ireland, with six cases in 2011 with an average mortality of 5%. In Norway, 18 cases were detected in rainbow trout, the highest ever registered in this species. In Norway, four cases occurred outside the endemic zone. Subtype SAV2 was detected for the first time in Norway, and these cases in salmon were associated with clinical disease.

Viral Nervous Necrosis Virus (VNNV) - In Maine (USA) farmed cod experienced 5% mortality in three weeks, with mortality rates among cages ranging from 0% to 16%. Multiple year classes of cod from different hatcheries were affected, and the most heavily affected cage contained 150–200 g fish. Three of seven cages were affected and fish in those tested positive for VNNV by RT-PCR of brain and eye tissue. Strict biosecurity was implemented. Overall mortality declined slightly, coincident with a decrease in water temperature.

European Perch Rhabdovirus Virus - Detected in sea trout experiencing low mortalities during the autumn at one coastal farm in the archipelago of Stockholm, Sweden. This is the first report from this species in this area in over 10 years.

5.3.2 Bacteria

Pseudomonas anguilliseptica - The bacterium was isolated from lumpfish with tail fin rot in Norway. In Finland, the bacterium has become one of the main disease problems: it is isolated every year from rainbow trout and whitefish (five disease outbreaks in 2011, three in 2010, five in 2009, two in 2008).

Vibrio - *Vibrio logei*-like species and *V. splendidus* were isolated from Ballan wrasse, with fin-rot in Norway. Two cases of *V. anguillarum* diagnosed in farmed Ballan wrasse. *Vibrio ordalii* was isolated from two related cases in lumpfish showing clinical signs.

***Tenacibaculum* sp.** - Isolated from eroded fins of Ballan wrasse fins in Norway.

Atypical *Aeromonas salmonicida* - Isolated from Ballan wrasse in Norway.

***Yersinia ruckeri* -** In Finland, only 4 biotype 2 outbreaks were recorded in 2010 and 6 in 2011, comparing to 16 in 2009 and 20 in 2008. This reduction is attributed to a new vaccine including *Y. ruckeri* biotypes 1 and 2.

5.3.3 Parasites

Crustacea

Lepeophtheirus salmonis - Sea lice numbers in Cobscook Bay, Maine were substantially lower than in 2010, but may be due to fewer fish in the Bay. Salmon farms southwest of Cobscook Bay, where previously only *Caligus* spp. were seen, required treatment for *L. salmonis*, suggesting a southward extension in the range of *L. salmonis*. In the southwest New Brunswick area of the Bay of Fundy, Canada in 2010/11, azamethiphos and hydrogen peroxide were used as treatments under Emergency Registration permits. The use of deltamethrin was discontinued after October 2010. In Norway, there were fewer sea lice in 2011 than in 2010 (http://www.lusedata.no). Spring-delousing had a marked effect: in May, the average number of adult females in farms was below 0.025 per fish across the country. Although this average value increased in autumn, it remained below the treatment action level in all regions. In Ireland, annual sea lice surveillance data are found at www.marine.ie/home/publications. In Norway, the use of cleaner wrasses goldsinny wrasse, corkwing wrasse and Ballan wrasse have become more important in managing salmon lice on farmed salmon. Recent tests suggest a similar role for lumpsucker.

Paramoebida

Amoebic Gill Disease - Emerged as a significant problem in Ireland with nine clinical cases reported. Five of these cases resulted in mortalities of > 20% and the disease has persisted in some cases through the winter. On the west coast of Scotland, five clinical cases were reported from farmed Atlantic salmon, the first occurrence since 2007. PCR testing of material from one site confirmed the presence of *Neoparamoeba perurans.* Reported losses varied from 2% to 47%.

Dinoflagellate

Amyloodinium ocellatum - In Portugal, severe outbreaks are the main concern for sea bream and sea bass especially in the semi-intensive production in earthen ponds. Mortality, ranging from 40% to 60% in several farms, occurred during summer in, namely at Algarve, Sado and Aveiro. Mortality was most severe in units with higher stocking densities.

Blue-green algae

In Scotland, one hatchery attributed losses to an algal bloom. Affected species included brown trout adults and yearlings (100% mortality), and salmon fry and brown trout fry (75% mortality).

5.3.4 Conclusions

1) Sea lice treatments have achieved varying degrees of success with further evidence of resistance. WGPDMO are not aware of new pharmaceuticals that could be replacement treatments.
2) Data from Ireland indicate that the impact of salmonid pancreas disease is declining.
3) In Norway, heart and skeletal muscle inflammation and cardiomyopathy syndrome show increasing trends.

5.3.5 Recommendations

ICES WGPDMO recommends that:

i) WGPDMO continues to develop standards and guidelines for consistent reporting of diseases in the WGPDMO National Reports. WGPDMO members are encouraged to provide information on diseases in farmed fish by using a standard format.

5.4 Wild and farmed molluscs and crustaceans

5.4.1 Viruses

Herpes Virus in Bivalves - In France, high mortalities associated with OsHV-1 μVar among juvenile (<1-year old) Pacific oysters continued in 2011. In Ireland, OsHV-1 μvar continues to spread, with reports from 23 bays, compared with 16 in 2009. Losses of up to 80% in 2011 compared with up to 100% in 2009 and 2010, possibly as a result of cooler summer water temperatures.

Reo-like virus in Blue Crabs - A reo-like virus (RLV) was observed in a majority of sampled dead and dying crabs from soft shell shedding facilities from Delaware to Florida, USA and mortalities may reach 25%. The virus is easily passed by injection and experimental data suggested transmission by cohabitation and cannibalism.

Gill Epithelial Cell Nuclear Virus in Soft Clams: Occurred in samples collected from the upper Chesapeake Bay in 2010 at prevalences up to 89%. Clams were not tested for virus in 2011.

5.4.2 Bacteria

Roseovarius Oyster Disease (ROD) of *Crassostrea virginica* - No reported outbreaks in the USA since 2009.

5.4.3 Fungi

Shell (=foot) disease in oysters - *Ostracoblabe implexa*-like infections were found in flat oysters for the first time in Sweden, at localities from Gothenburg north to the border with Norway. The prevalence ranged up to 50%. The disease is known to occur in 5% to 10% of Portuguese oysters in Portugal.

Microsporidia in shore crabs - A novel microsporidium with extreme morphological plasticity has been detected in 5% of shore crabs from the English Channel. The parasite alternates between a *Nadelspora*-like lineage (consistent with a parasite previously described from Dungeness crabs in the USA), and an Ameson-like lineage (consistent with a previous description in shore crabs from Europe). The alternation in life cycle variants corresponds to different sites of infection in the heart myofibres and sarcolemmal spaces of skeletal muscle (*Nadelspora*-like lineage), and the skeletal myofibres per se (*Ameson*-like lineage). Both types are identical via sequencing of the partial SSU rRNA gene. This finding represents one of the most extreme forms of morphological plasticity observed in the Phylum Microsporidia.

5.4.4 Parasites

Marteilia refringens - was identified for the first time in blue mussels from the Tamar estuary in SW England. Seven of 150 mussels were identified as positive by histological examination and four were confirmed as *M. refringens* by PCR and sequence analysis. Phylogenetic analysis placed the sequences for the 4 positive samples in the same lineage as the *M. refringens* 'M' type. Further confirmation, provided by EURL, showed both Type "M" and Type "O" in these mussels.

***Perkinsus atlanticus* in *Ruditapes spp.* -** *P. atlanticus* / *P. olseni* continues to be found at a high prevalence in the native European clam in Portugal and Spain, but its prevalence in the introduced clam, *R. philippinarum* has recently increased to 20% with associated mortality.

P. marinus* in *Crassostrea virginica - levels were typical in the mid-Atlantic (Chesapeake and Delaware Bays), USA, until August, when extreme freshwater runoff due to Hurricane Irene followed by Tropical Storm Lee, depressed salinities and infection levels, especially in the upper regions of the estuaries. In the upper Chesapeake Bay, the mean annual prevalence among oyster samples from 43 fixed survey sites set a record low of 38%, compared to the record high of 94% in 2002. In upper Delaware Bay, mean prevalence on three major oyster reefs dropped to 10% from 78% in 2010.

***P. chesapeaki* in the soft clam and the stout razor clam** - along with other clam species sampled in 2010 from upper Chesapeake Bay, occurred at prevalences up to 100%. Clams were not tested in 2011.

Mikrocytos sp. - In 2010 and 2011, mortalities were reported among wedge-shell clams from a wild stock in Brittany, France (Bays of Audierne and Douranenez). A *Mikrocytos*-like parasite was observed in samples examined by histology and morphological and molecular characterisation is ongoing.

Bonamia exitiosa - occurred in flat oysters from the Fal Estuary, England, in a sample obtained in December 2010. One of 30 oysters was identified by histology as *Bonamia* positive; this infection was confirmed by PCR and sequencing as *B. exitiosa*. This was the first report of *B. exitiosa* in the United Kingdom. It was not associated with mortality.

B. ostreae was reported for the first time in a sample of flat oysters from the Menai Strait in North Wales in September 2011. Eleven of 30 oysters (37%) were infected at grade 1. All positives were confirmed as *B. ostreae* by molecular analysis.

***Haplosporidium nelsoni* in eastern oyster** - a general decrease in prevalence and intensity in wild oysters at some locations in lower Chesapeake Bay, has been attributed to increasing resistance to *H. nelsoni* parasitism (Carnegie & Burreson. 2011. Declining impact of an introduced pathogen: *Haplosporidium nelsoni* in the oyster *Crassostrea virginica* in Chesapeake Bay. Mar. Ecol. Prog. Ser., 432, 1–15). Evidence for the development of resistance comes from long-term data sets showing a declining trend in both prevalence and intensity, and comparison with naive sentinel oysters that continue to sustain high prevalence and mortality. Fall surveys in the upper Chesapeake (Maryland) found only one of 43 sites positive for *H. nelsoni*, due to the freshwater storm runoff rather than resistance.

The 2010 epizootic in the Damariscotta River, Maine, USA was not repeated in 2011. Growers reported no unusual mortality during the late summer and fall, when *H. nelsoni* mortalities occurred in 2010. Wild oysters sampled in December 2010 and again in April 2011 at six sites (N= 720 total) in the river showed prevalences of about 20% by histology. Histologically detected prevalence remained about 20% during the summer, although the prevalence of PCR-positive signals was close to 100% in the same oysters, indicating the continued presence of *H. nelsoni* in the river.

***Haplosporidium costale* in eastern oysters** - Oyster mortalities of up to 80% occurred at three Rhode Island farms in the spring and early summer of 2011. Mortalities were reported in both 1 and 2 year-old oysters from different hatcheries supplying seed to these farms. Oysters at all three farms were positive by histology and/or PCR methods, with prevalences ranging from 0 to 43%. Although winter mortality is atypical for *H. costale* and the parasite may not have been involved in the early deaths, it undoubtedly contributed to some of the later mortalities. Although *H. costale* has been reported sporadically in Rhode Island and adjacent waters, this is the first report of significant mortalities associated with the parasite in this state.

5.4.5 Other diseases

Over 1100 dead octopus washed up on beaches in Portugal, most likely due to freshwater inflow. Similar occurrences have been reported in the past.

5.4.6 Conclusions

1) Ostreid herpesvirus 1 µvar continues to cause significant mortalities in juvenile Pacific oyster culture. The virus is now reported in Pacific oysters from 23 bays in Ireland.
2) *Marteilia refringens* was described for the first time in blue mussels in the Tamar Estuary, UK.
3) A novel microsporidium with extreme morphological plasticity has been detected in shore crabs from the English Channel, UK.
4) *Bonamia exitiosa* was reported for the first time in a flat oyster from the Fal Estuary, UK and *B. ostrea* has now been found in flat oysters from the Menai Strait, UK.
5) Evidence suggests that eastern oysters have developed resistance to *Haplosporidum nelsoni* in lower Chesapeake Bay, USA.
6) Significant mortalities in eastern oysters due to *H. costale* were reported for the first time in Rhode Island, US.
7) A *Mikrocytos* sp. has been detected in wedge-shell clams from the Bays of Audierne and Douranenez, Brittany, France.

5.4.7 Recommendations

ICES WGPDMO recommends that:

i) The WGPDMO develops standards and guidelines for consistent reporting of diseases in the WGPDMO National Reports. WGPDMO Members are encouraged to provide information on diseases in wild and farmed shellfish using the new standards and guidelines.

6 Provide a review on the occurrence and mitigation of pathogen transmission from maricultured finfish (ToR b)

D. Bruno presented a working document prepared intersessionally by S. Jones, D. Bruno and L. Madsen, providing a theoretical basis for understanding and mitigating pathogen transmission from maricultured to wild finfish (see Annex 6).

6.1 Summary of paper

This report is the third in a series of documents on disease interactions between wild and farmed finfish prepared by the WGPDMO. The first was prepared in 2009 based on the OSPAR request for advice 2010/3 "To summarise the current state of knowledge on parasite interactions from finfish mariculture on the condition of wild fish populations (both salmonid and non-salmonid) both at a local and regional scale" and addressed the effects of interactions of parasites from mariculture on the condition of wild fish populations and implications of future growth in mariculture, emphasising salmon lice *Lepeophtheirus salmonis* in salmonid mariculture (ICES 2010). The second, prepared in 2011, focused on disease interactions between farmed and wild marine finfish species with emphasis on potential threats, pathogen descriptions and diseases in farmed and wild marine finfish species, excluding salmon (ICES 2011).

The current document is structured in the following way, and the aspects addressed are summarized below:

Background: The growing awareness among fisheries managers and policy makers of fish disease is highlighted; specifically, an awareness of the possibility that pathogens are transmitted between maricultured and wild aquatic organisms. It is pointed out that maricultured stocks are routinely observed and screened, leading to a greater knowledge of infection and disease than is the case for wild populations. This inequity may give rise to a perception that maricultured fish are more likely to harbour disease-causing pathogens whereas wild stocks are 'pristine', which is not necessarily the case.

Definition of disease: It is pointed out that a diseased individual is one in which clinical signs are observable, repeatable and attributable to an aetiological agent, including parasites, viruses and/or bacteria. Up-to-date and highly sensitive diagnostic techniques are able to detect small numbers of pathogens, leading to the detection of a high prevalence of infection which may not be reflected in the prevalence of the associated disease.

Factors affecting the ability to determine risks associated with pathogen transmission in the wild: This section provides information on knowledge required to understand disease transmission within and between fish populations and on a number of factors that should be considered in studies of disease in wild fish populations.

Criteria for establishing causal relationships: The difficulties in establishing causal relationships between infection and mortality or changes in population abundance are highlighted, and criteria facilitating the demonstration of transmission are provided.

Biology of the pathogen: This section details important aspects of the pathogen characteristics and factors that have an impact on pathogenicity and virulence.

Modes of pathogen transmission: The major transmission routes are described: horizontal between infected and non-infected hosts, vertical through passing of the pathogen via milt or eggs to the offspring, and spread by other hosts or vectors (other parasites, fish, piscivorous animals or inanimate objects such as clothing, vessels or equipment).

Environmental factors affecting pathogen transmission: The onset and development of a disease reflects a complex interaction between host, pathogen and the environment, and environmental factors may act on the pathogen as well as on the host. However, only limited data are available on such environmental stressors.

Anthropogenic factors in pathogen transmission: Although control, therapy and management measures have successfully reduced the spread of pathogens and the risk of transmission of infections, there is still concern that inadequacies in these management practises, and fishery-related changes in population structure, may enhance transmission.

Summary: It is emphasised that finfish mariculture is a globally growing industry and there is an increasing demand for studies on pathogen transmission in aquatic ecosystems. Appropriate data are largely lacking, and strong baseline and ecological impact studies on wild populations are required to support existing efforts to reduce transmission risks and to aid in the establishment of new regulations and policies.

6.2 Conclusions

1) In the discussion, it was pointed out that the document on the occurrence and mitigation of pathogen transmission from maricultured finfish is a valuable and relevant contribution, reflecting WGPDMO's activities in this field. The document should be disseminated to a wider audience, preferably in combination with the two previous documents (ICES 2010, 2011).

2) Publication in the ICES Cooperative Research Report Series was suggested. Since the documents on disease interactions and transmission, prepared in 2011 and in 2012, represent a continuation of the work carried out by WGPDMO in 2010 to meet OSPAR request 2010/3, it was suggested that OSPAR should be informed about the preparation of these documents for publication.

3) It was further suggested that contact with ICES WGEIM should be established to exchange information on this subject and to collaborate as appropriate.

6.3 Recommendations

ICES WGPDMO recommends that:

i) WGPDMO members involved in preparing the document on the occurrence and mitigation of pathogen transmission from maricultured finfish consider integrating the document together with the two previous documents on diseases interactions between wild and farmed finfish prepared by WGPDMO in 2010 and 2011, for possible publication in the ICES Cooperative Research Report Series.

ii) OSPAR takes notice of the documents on disease interaction and transmission prepared by WGPDMO in 2011 and 2012 because they represent a continuation of work by WGPDMO on OSPAR request 2010/3.

6.4 References

ICES. 2010. Report of the Working Group on Pathology and Diseases of Marine Organisms (WGPDMO) ICES CM 2010/SSGHIE:02.

ICES. 2011. Report of the Working Group on Pathology and Diseases of Marine Organisms (WGPDMO) ICES CM 2011/SSGHIE:04.

7 Provide a review on the management of infections and diseases in commercially valuable bivalves (ToR c)

A. Alfjorden summarized a document prepared intersessionally by T. Renault, which highlighted the importance of shellfish farming in world aquaculture and the fact that one of the factor that limit production is infectious disease (see Annex 7).

7.1 Background information

Significant advances have already been made in the understanding and controlling diseases in molluscs, but important gaps remain in the following areas:

- (i) diagnosing infectious diseases;
- (ii) controlling mollusc movements and transfers;
- (iii) understanding interactions between host, pathogen and environment;
- (iv) improving disease resistance using the genetic variability through selective breeding;
- (v) development, testing and adoption of new pathogen inactivation methods.

The report summarized the limitations in controlling or managing disease in molluscan aquaculture, including the ongoing risk of exposure to potentially pathogenic organisms while filter-feeding in open waters; absence of vaccination as a management tool, behavioural anomalies that might provide early signs of disease are more difficult to observe; frequent movement of seed among countries fosters the movement of disease agents; and the restricted use of drugs.

The WGPDMO appreciated the report's recommendations for standardized methods of sample collection, processing and diagnostic methods, but felt that techniques other than molecular ones (e.g., histological) should have been mentioned. The report underscored the need to investigate parasite life cycles and survival mechanisms outside the host, and to better understand of disease-resistance mechanisms in aquacultured species. The final section discussed pathogen inactivation methods; however, the WGPDMO requested clarification on the designation of Ultra Violet light as a "new" method.

7.2 Conclusions

1) The WGPDMO considers that the recently funded European Comission BIVALIFE project has begun investigating the issues raised in this ToR and anticipates receiving updates on project results as they become available.

7.3 Recommendations

The WGPDMO recommends that:

i) Results of the BIVALIFE project are used to update this report at a future meeting of the WGPDMO.

8 Provide a status update on the manuscript on disease-associated population effects of commercial and non-commercial fish and shellfish species (ToR d)

Thomas Lang presented an update of a manuscript in development entitled 'Disease-associated population effects in commercial marine fish and shellfish species' prepared by WGPDMO members (T. Lang, A. Alfjorden, S. Feist, S. Ford, S. Jones, S. MacLean, L. Madsen, V. Öresland, T. Renault) and a member of WGCRAB (G. Stentiford).

8.1 Background information

It was noted that there are many reports suggesting population effects of disease, but in only limited cases are quantitative data available to demonstrate such. There is a lack of integrated multidisciplinary studies to adequately assess the impact of disease on populations and, therefore, the role of disease in population dynamics is often underestimated. This manuscript addresses diseases with documented or suspected population effects in gastropods, bivalves, crustaceans and fish and provides information on diagnostic criteria, causative agent, host range, geographical range, and individual and population effects. The aim of the manuscript is to raise awareness in the stock assessment community that diseases may play an important role in population dynamics and should be given greater consideration. The WGPDMO agreed that T. Lang, S. Feist and S. Jones will serve as coordinating editors to bring the manuscript to publication.

The current version of this manuscript had been condensed since its discussion at the 2011 WGPDMO meeting. The sections that were modified or omitted were discussed by the WGPDMO members. The section on diseases of Crustacea, prepared by G. Stentiford, was removed as it has been published elsewhere. It was agreed that the vast majority of cases in the manuscript are of commercial species and that reference to non-commercial species should be removed from the title. A table identifying clear cut, as well as speculative, cases in which disease affects populations will be prepared by the coordinating editors and presented to the authors for review and revision. Information presented in the manuscript will be consistent with related documents currently in preparation by WGPDMO (e.g., papers on Disease Trends and Disease Transmission). The manuscript also will be presented to stock assessment experts in order to obtain feedback on the format and value of information. The WGPDMO agreed that the manuscript be published in the ICES Cooperative Research Report Series.

8.2 Conclusions

1) The manuscript provides a summary of diseases of marine organisms based on prevalence, intensity, mortality and other parameters which may confer impacts at the population level.
2) Quantitative data on population effects of diseases are only available for a limited number of cases. This paper reports on cases with quantitative evidence and suspected links to effects on populations.
3) Disease effects in populations of marine fish and shellfish are considered to be of particular significance to stock assessment and may be underestimated in current population assessments.
4) The ICES Cooperative Research Report Series is the target outlet for publication, as the series is valued by the stock assessment community.

8.3 Recommendations

ICES WGPDMO recommends that:

i) The manuscript ``Disease-associated population effects in commercial marine fish and shellfish species`` is finalised and submitted to the ICES Cooperative Research Report Series for publication.

9 Provide a progress report on the Fish Disease Index (FDI) in relation to 1, its implementation in marine monitoring and assessment programmes; 2, the development of assessment criteria; and 3, results of FDI assessments carried out intersessionally addressing diseases of flounder and Baltic cod and data on liver histopathology and macroscopic liver lesions in the common dab (ToR e)

T. Lang and W. Wosniok presented a report (Annex 8) detailing progress made on the Fish Disease Index (FDI), a tool developed in WGPDMO to analyse and assess data on diseases in wild fish (ICES 2009, Lang & Wosniok 2008).

9.1 Background information

The Fish Disease Index (FDI) was originally constructed to address diseases in dab (*Limanda limanda*) but after some modification, can also be used for disease data obtained from other fish species.

9.2 Implementation in marine monitoring and assessment programs

WGPDMO was informed that fish disease studies are still a voluntary component of the general and PAH-specific biological effects monitoring programme under the OSPAR Coordinated Environmental Monitoring Programme (CEMP). The FDI approach has repeatedly been recommended by ICES/OSPAR as an analysis and assessment tool for wild fish disease data. HELCOM is currently revising its environmental Baltic Sea monitoring programme according to the requirements and ecological objectives defined in the HELCOM Baltic Sea Action Plan (BSAP). In 2011, the HELCOM CORESET project recommended a number of Core and Candidate Indicators to be measured in future monitoring, including those for hazardous substances and their effects. The implementation of Core Indicators, including fish diseases and the FDI, is currently under discussion at the national level. Once these indicators are adopted, Baltic Sea countries will be encouraged to include them in their national monitoring programmes. One of the 11 Descriptors of the EU Marine Strategy Framework Directive (MSFD) for good ecological status (GES) of the marine environment in Europe (to be achieved in 2020) is Descriptor 8 addressing contaminants and their effects (D8). EU member countries will be obliged to set up an adequate marine monitoring programme, aiming at an assessment of the ecological status of their national waters with respect to D8, which will (likely) comprise chemical contaminant as well as biological effects monitoring in an integrated fashion. The designs of the national monitoring programmes have not yet been finalised, but it is envisaged that fish disease monitoring and the FDI approach will be a component.

9.3 Development of assessment criteria

WGPDMO was informed of the FDI assessment strategy developed for externally visible diseases in dab that follows the OSPAR concept for the assessment of biological effects of contaminants and comprises the application of Background Assessment Criteria (BAC) and Environmental Assessment Criteria (EAC). Both are derived from empirical German long-term data on dab diseases in the North Sea and the western Baltic Sea. BACs are defined as the lowest 10^{th} percentile of the FDI distribution, and EACs are the FDIs that are associated with a loss of 10% in condition factor (CF) of the population. Results of the assessment of externally visible diseases of dab from the North Sea and the western Baltic Sea using these BACs and EACs were presented to WGPDMO in two ways, (a) as graphs showing temporal changes in the ratio (%) of fish with FDIs lower than the BAC (green), FDIs between BAC and EAC (amber) and FDIs higher than the EAC (red) and (b) as graphs showing temporal changes in mean FDIs of the sample and the BAC and EAC boundaries (Annex 8). The results indicate that mean FDIs consistently exceeded the EAC in some of the areas monitored (e.g. outer Firth of Forth, Ekofisk, Dan Field), in particular in the past years, indicating a significant loss in condition due to diseases within the population.

9.4 Intersessional assessments of FDI criteria

Diseases of flounder and Baltic cod and data on liver histopathology and macroscopic liver lesions in the common dab were assessed intersessionally by using the FDI. WGPDMO was informed that diseases of flounder and cod to be used to calculate FDIs have been identified based on available empirical data and that construction of the FDIs, BACs and EACs are underway. Results were presented from a preliminary assessment of macroscopic liver neoplasm and liver histopathology data sets in dab. The fish had been collected from the North Sea, Baltic Sea and Icelandic waters during a one time survey within the ICON project (Annex 8).

9.5 Discussion

In the discussion it was pointed out that the construction of the FDI permits the inclusion of other diseases or pathological changes monitored (e.g. data on gonadal histopathology). Furthermore, age data can be incorporated as one of the parameters used for the standardisation process, as well as length, sex and sampling season. This was considered important since the impact of age on disease prevalence has repeatedly been demonstrated. It was noted that the BAC and EAC for externally visible diseases of dab were calculated by region (North Sea, Baltic Sea, Icelandic waters) in order to take into account regional characteristics regarding, e.g. disease patterns and disease susceptibility. This approach can also be applied for datasets so far not analysed, such as those from the Irish Sea or English Channel area.

9.6 Conclusions

1) The FDI approach (data analysis and assessment) for externally visible diseases of dab (*Limanda limanda*) is considered ready for application in national fish disease monitoring programmes as well as in integrated monitoring and assessment programmes related to contaminants and their biological effects.
2) The FDI approach will be applied using the full set of ICES fish disease data.
3) Further work is needed to establish the FDI approach for diseases of flounder (*Platichthys flesus*) and cod (*Gadus morhua*); results are expected to be available before the 2013 WGPDMO meeting.
4) Further work is also needed to establish the FDI approach for macroscopic liver lesions and liver histopathology in dab and flounder. The strategy, methodology and testing will be conducted in collaboration with Cefas, UK.

5) The FDI methodology will be published, preferably in the ICES TIMES series. The results of the application of the methodology, using data sets available in national databases, will be published in a peer-reviewed scientific journal.

9.7 Recommendations

ICES WGPDMO recommends that:

i) The FDI approach for externally visible diseases of dab (*Limanda limanda*) is applied on the full set of disease data submitted by Member Countries and maintained in the ICES fish disease database.

ii) The FDI approaches for diseases of flounder (*Platichthys flesus*) and cod (*Gadus morhua*) are finalised and validated and results are reported to WGPDMO at its 2013 meeting.

iii) The FDI approaches for macroscopic liver neoplasms and liver histopathology of flatfish are finalised and are validated using appropriate datasets; results are reported to WGPDMO at its 2013 meeting.

iv) The methodology used for the FDI approach is published in the ICES TIMES series.

9.8 References

ICES. 2009. Report of the Working Group on Pathology and Diseases of Marine Organisms (WGPDMO). ICES CM 2009/MCC:01.

Lang, T., Wosniok, W. 2008. The Fish Disease Index: a method to assess wild fish disease data in the context of marine environmental monitoring. ICES CM 2008/D:01, 13 pp.

10 Provide an update of the ICES publication “Trends in important diseases affecting the culture of fish and molluscs in the ICES area 2003 to present” (ToR f)

N. Ruane provided a summary of progress to date on the report (by N. Ruane, T. Renault, S, Jones) where information on the diseases affecting cultured fish have been updated using data from previous WGPDMO reports and published literature.

10.1 Background information

An important component of the work of the ICES WGPDMO is to provide annual reviews of national reports on the disease status of wild and farmed fish and molluscs in the ICES area. The first report which collated this information from 1998 to 2002 was published in 2004. At the 2011 WGPDMO meeting it was proposed that information for the period since 2003 be incorporated to provide an update on the status of the major diseases affecting fish and shellfish described in the original report and to include an overview of emerging diseases.

For each disease, sections describing the agent involved, clinical signs, geographical distribution and temporal trends and control or preventative measures are provided. The emerging diseases ‘heart and skeletal muscle inflammation (HSMI)’, ‘cardiomyopathy syndrome (CMS)’, ‘gill disease’ which has a multifactorial aetiology and ‘francisellosis’ have been added.

It was agreed that the current format provides the information clearly and it was proposed that a Table listing diseases by the fish species mentioned in the report, should be included in the document. Further work is required intersessionally to complete the shellfish sections and to consider inclusion of additional disease conditions affecting fish and shellfish. The information will be formatted as an ICES Cooperative Research Report and the completed draft will be made available for review at the 2013 WGPDMO meeting. It was suggested that in order to increase awareness of this publication, a note be placed on the European Association of Fish Pathologists (EAFP) website and in an edition of the Bulletin of the EAFP which is distributed to all members.

10.2 Conclusions

1) The collation of information on the trends of important diseases affecting the culture of fish and molluscs since 2003 provides a valuable summary for research scientists and fisheries managers.
2) This report will be a valuable source of information on diseases that are not currently notifiable under Council Directive 2006/88/EC or listed by the World Organisation for Animal Health (OIE).

10.3 Recommendations

ICES WGPDMO recommends that:

i) Work continues intersessionally to complete the report ("Trends in important diseases affecting the culture of fish and molluscs in the ICES area 2003 to present") for review at the 2013 meeting of the WGPDMO and subsequent publication as an ICES Cooperative Research Report.

11 Provide a review on parasites in marine finfish and shellfish species posing a hazard to human health (ToR g)

A. Alfjorden presented a summary of progress made with respect to a review (by A. Alfjorden, M. Podolska, L. Madsen, T. Karaseva) on parasites in marine finfish and shellfish species posing a hazard to human health.

11.1 Background information

A range of parasites and other infectious agents reported by the WGPDMO in the annual update of disease trends have the potential to be harmful to human health if ingested in under processed food. These zoonotic agents include larval stages of the nematodes *Anisakis simplex* and *Pseudoterranova decipiens*. The risk to human health may occur through gastrointestinal infection with the possibility of subsequent peritonitis and the involvement of other sites in the body. Infections may also lead to allergic reactions to pathogen-related substances, such as urticaria followed by abdominal pain. The WGPDMO considered this an appropriate task because of the upward trend in the exposure to potentially infectious agents occurring in finfish and shellfish resulting from the consumption of raw seafood. The review will identify those agents recognized as potentially harmful and provide a literature review of risks and mitigation strategies.

11.2 Conclusions

1) There is an upward trend in reports of anisakidosis resulting from an increase in the consumption of raw fish.
2) The consumption of bivalves contaminated with water-borne pathogens (e.g. *Cryptosporidium* and *Giardia* spp.) may pose a risk of human illness.

11.3 Recommendations

ICES WGPDMO recommends that:

i) Data described in the report entitled "Parasites in marine finfish and shellfish species posing a hazard to human health" should be prepared for publication.

ii) A new term of reference that reviews bacterial and viral infections of fish or shellfish causing zoonoses in humans should be prepared.

12 Provide an update on the status of ICES publications on pathology and diseases of marine organisms (ToR h)

S. Feist, Series Editor, provided an update on progress during the last year

12.1 ICES identification leaflets for diseases and parasites of fish and shellfish

ICES leaflets provide a diagnostic summary for diseases and parasites of fish and shellfish in the North Atlantic Ocean and adjacent seas. Fifty-seven leaflets are currently available on the ICES website: http://www.ices.dk/products/idleaflets.asp. Proposed new leaflets are listed below and include two on emerging diseases in Atlantic salmon that were proposed during the meeting: heart and skeletal muscle inflammation (HSMI) and cardiomyopathy syndrome (CMS).

No.	Title	Lead Author
No. 58	Gonadal neoplasia in bivalves	T. Renault
No. 59	Brown ring disease in clams	C. Paillard
No. 60	QPX	S. Ford
No. 61	Liver neoplasia in flatfish	S. Feist
No. 62	Hyperpigmentation in dab	T. Lang
No. 63	Heart & skeletal muscle inflammation (HSMI)	E. Biering
No. 64	Cardiomyopathy syndrome (CMS)	D. Bruno

Revised and updated leaflets on *Perkinsus marinus*, Marteiliosis and SSO in oysters (Nos. 30, 19 and 39) have replaced the original versions and a further two on nematode infections (Nos. 7 and 8) are almost ready for replacing existing versions. Two further leaflets on neoplasia in mussels and oysters require additional editorial work. It has not been possible to contact the original author of leaflet No. 3 on *Ichthyophonus* who has been retired for several years. S. Jones and S. Feist will prepare an updated leaflet intersessionally. In order to broaden awareness of the identification leaflets it is intended to provide a link to these on the website of the European Association of Fish Pathologists (EAFP).

12.2 Other publications

12.2.1 Manuscript on the Fish Disease Index for ICES TIMES

The manuscript describing the methodologies involved in the use of the Fish Disease Index (FDI) as a tool for the analysis and assessment of wild fish disease data (co-authors W. Wosniok and T. Lang) is in progress and will be submitted to ICES during spring 2012 for publication in the ICES TIMES Series.

12.2.2 Manuscript on Trends in Diseases Affecting the Culture of Fish and Molluscs in the ICES Area: 2003 – Present

Work will continue intersessionally to complete the report including information on diseases affecting fish and molluscs for review at the 2013 meeting of the WGPDMO and subsequent publication as an ICES Cooperative Research Report.

12.2.3 Manuscript on Disease-Associated Population Effects in Commercial Marine Fish and Shellfish Species

Work will continue intersessionally to complete the manuscript "Disease associated population effects in commercial marine fish and shellfish species" prior to publication as an ICES Cooperative Research Report.

12.3 Conclusions

1) Several revised and new leaflets are now available at the ICES web-site. The publication of updated and new ICES Identification leaflets for diseases and parasites of fish and shellfish should be continued.

12.4 Recommendations

ICES WGPDMO recommends that:

i) WGPDMO members continue to consider additional titles for the leaflet series and other relevant publications in peer-reviewed literature.

ii) WGPDMO members complete the two manuscripts for publication as ICES Cooperative Research Reports.

13 Provide expert knowledge and advice on fish disease and related data to the ICES Data Centre on a continuous basis (ToR i)

Members of the WGPDMO had been contacted by the ICES data centre on various occasions during 2011 in order to clarify details concerning the submission of data to the ICES data base. The problems addressed mostly dealt with the adequate coding of data that was being submitted. Problems had been solved by direct response to the Data Centre. It can be expected that problems of this kind will come up also in the future in connection with items that are entered into the data base for the first time.

13.1 Conclusions

1) There is an ongoing need to encourage member countries to submit existent fish disease data and fish weight to the ICES Data Centre. These data are required for the development of Environmental Assessment Criteria for fish diseases (see Section 9).

13.2 Recommendations

ICES WGPDMO Recommends that:

i) ICES Member countries submit wild fish disease data generated according to ICES standard guidelines, including data on macroscopic liver neoplasms and contaminant-specific liver histopathology to the ICES Data Centre in order to allow a consistent assessment of spatial patterns and trends in the health status of wild fish.

ii) ICES Member countries submit data on fish weight and age, were available, together with fish disease data.

iii) The ICES Data Centre includes fish weight and fish age in the screening procedure for data submissions.

14 Evaluate potential for collaboration with other EGs in relation to the ICES Science Plan and report on how such cooperation has been achieved in practical terms (e.g. joint meetings, back-to-back meetings, communication between EG chairs, having representatives from own EG attend other EG meetings) (ToR j)

The expertise of G. Stentiford (WGCRAB) continued to be recognised within the context of WGPDMO ToR d as a co-author of the draft manuscript. Dr. Stentiford's inclusion as a co-author was discontinued however, following the publication of his contribution under separate cover. The WGPDMO welcomes similar collaborations in ongoing and future Terms of Reference.

The chair of WGPDMO collaborated with chairs of WGEIM, WGMASC and WGAGFM in the development of a theme session entitled "Sustainability of Aquaculture" for ASC Bergen 2012.

15 Other business

15.1 Working group procedures

The effective and efficient work of the WGPDMO towards completion of its Terms of Reference was facilitated through extensive use of the SharePoint tool. The chair reminded members who have agreed to assist in the preparation of working documents intersessionally of their responsibilities to complete these tasks in advance of the WG meeting.

15.2 Standards and guidelines

The Chair reviewed a draft discussion document (Annex 9) entitled "Standards and Guidelines for the Reporting of Pathogens and Diseases in National Reports", the objective of which was to introduce some level of uniformity into the data provided to the WGPDMO. Members discussed the document and while agreeing on the importance of increased uniformity, there was recognition of the challenges associated with requiring formal statistical analyses of National Data. The WGPDMO agreed to continue to develop the Standards and Guidelines intersessionally.

15.3 Nomination of WGPDMO chair

As the term for the current WGPDMO chair is ending, nominations were solicited from the Working Group for a new chair-person to assume duties beginning January 2013. N. Ruane (Ireland) was nominated by S. Ford (USA) and accepted the nomination.

16 Progress on tasks

Progress of tasks in the Terms of Reference was reviewed and it was concluded that all items had been dealt with in a satisfactory manner. Table 15.1 provides more information on items completed and those which require f urther action. Several intersessional tasks to be fulfilled prior to the 2013 WGPDMO meeting were identified.

Table 16.1. Progress on tasks of WGPDMO's Terms of Reference for 2012.

	TERM OF REFERENCE	STATUS
a	Produce a report on new disease trends in wild and cultured fish, molluscs and crustaceans, based on national reports	Multi-year task; revisit in 2013 as part of ToRa.
b	Provide a review on the occurrence and mitigation of pathogen transmission from maricultured finfish	Ongoing task; intersessional work will integrate this work with related earlier WG reports for publication
c	Provide a review on the management of infections and diseases in commercially valuable bivalves	Ongoing task.
d	Provide a status update on the manuscript on disease-associated population effects of commercial and non-commercial fish and shellfish species	Ongoing task; intersessional work will continue on this manuscript.
e	Provide a progress report on the Fish Disease Index (FDI) in relation to 1, its implementation in marine monitoring and assessment programmes; 2, the development of assessment criteria; and 3, results of FDI assessments carried out intersessionally addressing diseases of flounder and Baltic cod and data on liver histopathology and macroscopic liver lesions in the common dab	Ongoing task; intersessional will continue on this manuscript.
f	Provide an update of the ICES publication "Trends in important diseases affecting the culture of fish and molluscs in the ICES area 2003 to present"	On-going task; will be revisited in 2013 as part of ToR d
g	Provide a review on parasites in marine finfish and shellfish species posing a hazard to human health	On-going task; will be revisited in 2013 as part of ToR b
h	Provide an update on the status of ICES publications on pathology and diseases of marine organisms	On-going task; will be revisited in 2013 as part of ToR h
i	Provide expert knowledge and advice on fish disease and related data to the ICES Data Centre on a continuous basis	On-going task; will be revisited in 2013 as part of ToR i
j	Evaluate potential for collaboration with other EGs in relation to the ICES Science Plan and report on how such cooperation has been achieved in practical terms (e.g. joint meetings, back-to-back meetings, communication between EG chairs, having representatives from own EG attend other EG meetings)	Ongoing task.

17 Future activities of WGPDMO

There are several important issues in the field of pathology and diseases of marine organisms that require further consideration. It was agreed that a further meeting of WGPDMO is required in 2013 to consider the results of intersessional work, and to discuss new disease trends and outstanding items. The next meeting is planned for Legnaro (Padova), Italy, during 5–9 March 2013. In addition, WGPDMO members are encouraged to consider theme sessions for future ICES Annual Science Conferences.

18 Approval of recommendations

The recommendations to the ICES Council contained in this report were discussed by the WGPDMO and approved. The recommendations and justifications for new Terms of Reference for the 2013 WGPDMO meeting are appended in Annexes 10 and 11, respectively.

19 Approval of draft WGPDMO report

A rough draft of the 2012 WGPDMO report was approved before the end of the meeting and outstanding issues were identified and delegated to WGPDMO members. Information specifically sought by or provided to other ICES bodies will be extracted from the Terms of Reference conclusions and annexes and sent separately to the Chairs of the relevant ICES Working Groups.

20 Closure of the meeting

The Chair thanked the local host for providing excellent meeting facilities and arrangements and thanked the WGPDMO participants for their hard work and input during, and in preparation for, the meeting. The 2012 WGPDMO meeting was closed at 18:00 hrs on 3 February 2012.

Annex 1: List of participants

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Annex 2: WGPDMO 2011 Terms of Reference

The **Working Group on Pathogens and Diseases of Marine Organisms [**WGPDMO] S. Jones, chair) met at the National Institute for Fisheries and the Sea (IPIMAR), Lisbon, Portugal, 31 January–4 February 2012 to:

a) Produce a report on new disease trends in wild and cultured fish, molluscs, and crustaceans based on national reports;

b) Provide a review on disease interactions between farmed and wild marine finfish species with emphasis on potential threats;

c) Provide a review on the management of infections and diseases in commercially valuable bivalves;

d) Provide a status update on the manuscript on disease-associated population effects of commercial and non-commercial fish and shellfish species;

e) Provide a progress report on the Fish Disease Index (FDI) in relation to 1, its implementation in marine monitoring and assessment programmes; 2, the application and further development of assessment criteria; and 3, results of FDI assessments carried out intersessionally addressing diseases of flounder and Baltic cod and data on liver histopathology and macroscopic liver lesions in the common dab;

f) Provide an update of the ICES publication 'Trends in important diseases affecting the culture of fish and molluscs in the ICES area 2003 to present;

g) Provide a review on parasites in marine finfish and shellfish species posing a hazard to human health;

h) Provide an update on the status of ICES publications on pathology and diseases of marine organisms;

i) Provide expert knowledge and advice on fish disease and related data to the ICES Data Centre on a continuous basis;

j) Evaluate potential for collaboration with other EGs and other ICES initiatives in relation to the ICES Science Plan and report on how such cooperation has been achieved in practical terms (e.g. joint meetings, back-to-back meetings, communication between EG chairs, having representatives from own EG attend other EG meetings).

WGPDMO will report by 1 April 2012 (via SSGHIE) for the attention of SCICOM and ACOM.

Supporting Information

Priority:	The current activities of this Group will lead ICES into issues related to the ecosystem affects of fisheries, especially with regard to the application of the Precautionary Approach. Consequently, these activities are considered to have a very high priority.
Scientific justification and relation to action plan:	Action Plan No: 1. **Term of Reference a)** New disease conditions and trends in diseases of wild and cultured marine organisms continue to appear and an assessment of these should be maintained (all WGPDMO members); **Term of Reference b)** Production of farmed salmonids in open seacages has resulted in disease interactions between farmed and wild salmonids in many regions around the world. In 2010 WGPDMO responded to an OSPAR request on "Effects on

mariculture on populations of wild fish" with a focus on the documented effects caused by salmon lice on wild salmonids. As developing mariculture for other fish species is increasing and will use the same open net-pen technology, similar problems will likely occur. ICES WGPDMO will further develop a review on pathogen interactions between farmed and wild marine finfish species with emphasis on potential threats. A specific objective of this review will be to elaborate strategies for identifying and mitigating pathogen transmission from farmed finfish species (S. Jones, D. Bruno, L. Madsen).

Term of Reference c)

Preventing and controlling disease has become a priority for the sustainability of mollusc aquaculture. Great effort has already been made, but needs to be pursued as gaps exist for:

- the diagnosis of infectious diseases and the identification of pathogens;
- the relationship between the presence of Pacific oyster and mussel pathogens and observed mortality;
- the understanding of interactions between host, pathogen and environment;
- the effects and the efficiency of inactivation methods on Pacific.

For instance, very little is known about the occurrence and reservoirs of pathogens in the aquatic environment, in terms of the mechanisms promoting interactions of the infectious agent at the cellular and molecular levels with biotic and abiotic substrates, ecological factors affecting their survival, influence of changing climate, and the role these all play in bivalve diseases.

Moreover, existing knowledge suggests that there are differences in the impact of pathogens in different sites and with different operators. Specific knowledge gaps relates to why these differences exist and how to reduce the impact of the mortalities. The use of different sites and the monitoring of environmental parameters will aid in identifying ways in which shellfish farmers can improve disease management (A. Alfjorden, T. Renault, L. Madsen).

Term of Reference d)

There is increasing information from studies in wild freshwater and marine fish species that diseases affect growth, reproduction and survival of different life stages of fish and shellfish and thus, may have an impact on recruitment and stock structure. However, only in few cases have diseases been explicitly considered in population dynamics models. Since the potential risk to fish and shellfish populations due to diseases is of considerable ecological and economical concern, and since the Term of Reference for 2010 could not be addressed in a sufficient way, the WGPDMO recognizes a need to revisit the issue at its 2011 meeting. Furthermore, population dynamics and epidemiological models will be reviewed in light of their applicability for studies in wild fish and shellfish. It is anticipated that the results of the review will be relevant to a range of ICES Expert Groups, including the stock assessment groups. (A. Alfjorden, S.W. Feist, S. Ford, S. Jones, T. Lang, , S. MacLean, L. Madsen, V. Öresland, T. Renault, W. Wosniok).

Term of Reference e)

The Fish Disease Index (FDI) approach has been developed for the analysis and assessment of data obtained by ICES Member Countries running regular fish disease surveys as part of their national environmental monitoring programmes. The approach has been considered by OSPAR as assessment method required for the implementation of fish disease monitoring as a mandatory component of the OSPAR Coordinated Environmental Monitoring Programme (CEMP) at the 2009 OSPAR ASMO meeting. However, the approach has not yet been formally adopted and, therefore, fish disease monitoring in OSPAR countries is still carried out on a voluntary basis. In the meantime, additional assessment criteria have been developed that supplement the assessment component of the FDI approach and meet the OSPAR assessment strategy for biological effects monitoring. New data submissions to the ICES fish disease database are envisaged (long-term data on liver histopathology and

	macroscopic liver neoplasms as well as current data on externally visible diseases) and new data analyses and assessments applying the FDI approach should be carried out. Furthermore, there is need to review the results of an application of the FDI approach on other fish species than dab, a task that could not be fulfilled at the 2010 WGPDMO meeting due to the insufficient data available so far in the ICES Data Centre - Environment Data (T. Lang, W. Wosniok, S. Feist,). **Term of Reference f)** The document 'Trends in important diseases affecting the culture of fish and molluscs in the ICES area 1998–2002' provided valuable information to researchers and fisheries managers on trends of diseases in aquaculture. That document requires updating with new information on those diseases of most importance for aquaculture during 2003 to the present. (N. Ruane, T. Renault, S. Jones). **Term of Reference g)** Several parasites and other infectious agents frequently reported by the WGPDMO in the annual update of disease trends, have the potential to be harmful to human health if ingested in underprocessed seafood. These include, but are not limited to, larval stages of the nematodes *Anisakis simplex and Pseudoterranova decipiens,* The risk to human health may occur in two ways: gastrointestinal infections with the possibility of subsequent peritonitis or the involvement of other sites in the body. Infections may also lead to allergic reactions to pathogen-related substances (e.g. secretory products) present in seafood. The WGPDMO considers this a timely task because of the recent upward trend in the occurrence of potentially hazardous infectious agents observed in finfish and shellfish in ICES member countries. This task will identify those agents recognized as potentially harmful and provide a literature review of risks and mitigation strategies (A. Alfjorden, M. Podolska, L. Madsen, T. Karaseva). **Term of Reference h)** A number of ICES publications, either web-based or in ICES publication series, are being prepared or updated at present, the progress of which has to be reviewed by WGPDMO. It will be necessary to consider ways by which these can be linked to each other. New publications have to be considered. (S.W. Feist, L. Madsen, D. Bruno). **Term of Reference i)** This is in compliance with a request from the ICES Data Centre. (W. Wosniok, T. Lang).
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 20–25 members and guests.
Secretariat facilities:	None.
Financial:	No financial implications.
Linkages to advisory committees:	There are no obvious direct linkages with the advisory committees.
Linkages to other committees or groups:	There is a very close working relationship with all the groups of the Fisheries Technology Committee. It is also very relevant to the Working Group on Ecosystem Effects of Fisheries.
Linkages to other organizations:	The work of this group is closely aligned with similar work in FAO and in the Census of Marine Life Programme.

Annex 3: Working documents distributed prior to the meeting

	2010 WGPDMO Terms of Reference	Working document (file)	Posted on SharePoint
a)	Produce an update on new disease trends in wild and cultured fish, molluscs and crustaceans, based on national reports;	WGPDMO2010_Norway_NatlReport WGPDMO2010_Latvia_NatlReport WGPDMO2010_France_NatlReport WGPDMO2010_Portugal_NatlReport WGPDMO2010_Scotland_NatlReport WGPDMO2010_Sweden_NatlReport WGPDMO2010_Poland_NatlReport WGPDMO2010_USA_NatlReport WGPDMO2010_Germany_NatlReport WGPDMO2010_Ireland_NatlReport WGPDMO2010_Russia_NatlReport WGPDMO2010_Canada_NatlReport WGPDMO2010_Finland_NatlReport Guidelines for National Reporting WGPDMO2010_Denmark_NatlReport WGPDMO2010_UK_NatlReport	1/31/12 1/31/12 1/31/12 1/31/12 1/31/12 1/29/12 1/28/12 1/27/12 1/27/12 1/25/12 1/25/12 1/24/12 1/24/12 1/24/12 1/23/12 1/19/12
b)	Provide a review on disease interactions between farmed and wild marine finfish species with emphasis on potential threats	ToRb Disease interactions transmission strategies	1/23/12
c)	Provide a review on the management of infections and diseases in commercially valuable bivalves	WGPDMO 2012 ToRc	1/31/12
d)	Provide a status update on the manuscript on disease-associated population effects of commercial and non-commercial fish and shellfish species	WGPDMO 2012 ToR d Pop Effects Draft	1/31/12
e)	Provide a progress report on the Fish Disease Index (FDI) in relation to 1, its implementation in marine monitoring and assessment programmes; 2, the application and further development of assessment criteria; and 3, results of FDI assessments carried out intersessionally addressing diseases of flounder and Baltic cod and data on liver histopathology and macroscopic liver lesions in the common dab	FDI Principles V1	2/01/12
f)	Provide an update of the ICES publication 'Trends in important diseases affecting the culture of fish and molluscs in the ICES area 2003 to present	ToRf New Trends in Important Diseases	1/24/12
g)	Provide a review on parasites in marine finfish and shellfish species posing a hazard to human health	ToRgAnisakid risks_Karaseva_draft.docx ToRg Anisakid Risk and Mitigation Podolska draft	1/26/12 1/24/12
h)	Provide an update on the status of ICES publications on pathology and diseases of marine organisms		
i)	Provide expert knowledge and advice on fish disease and related data to the ICES Data Centre on a continuous basis		
j)	Evaluate potential for collaboration with other EGs and other ICES initiatives in relation to the ICES Science Plan and report on how such cooperation has been achieved in practical terms		

Annex 4: Agenda

1) Opening of the meeting

2) Terms of Reference, adoption of Agenda and Timetable, selection of Rapporteurs

3) ICES items of relevance to WGPDMO

3.1) ICES Annual Science Conferences: 2011 Gdansk; 2012 Bergen

3.2) Multi-Annual Management of SCICOM Expert Groups: Implementation

4) Other relevant WGPDMO information

5) Produce a report on new disease trends in wild and cultured fish, molluscs and crustaceans, based on national reports (ToR a)

6) Provide a review on the occurrence and mitigation of pathogen transmission from maricultured finfish (ToR b)

7) Provide a review on the management of infections and diseases in commercially valuable bivalves (ToR c)

8) Provide a status update on the manuscript on disease-associated population effects of commercial and non-commercial fish and shellfish species (ToR d)

9) Provide a progress report on the Fish Disease Index (FDI) in relation to 1, its implementation in marine monitoring and assessment programmes; 2, the development of assessment criteria; and 3, results of FDI assessments carried out intersessionally addressing diseases of flounder and Baltic cod and data on liver histopathology and macroscopic liver lesions in the common dab (ToR e)

10) Provide an update of the ICES publication "Trends in important diseases affecting the culture of fish and molluscs in the ICES area 2003 to present" (ToR f)

11) Provide a review on parasites in marine finfish and shellfish species posing a hazard to human health (ToR g)

12) Provide an update on the status of ICES publications on pathology and diseases of marine organisms (ToR h)

13) Provide expert knowledge and advice on fish disease and related data to the ICES Data Centre on a continuous basis (ToR i)

14) Evaluate potential for collaboration with other EGs in relation to the ICES Science Plan and report on how such cooperation has been achieved in practical terms (e.g. joint meetings, back-to-back meetings, communication between EG chairs, having representatives from own EG attend other EG meetings) (ToR j)

15) Any other business

16) Analysis of progress with tasks

17) Future activities of WGPDMO

18) Approval of Recommendations

19) Approval of draft WGPDMO Report

20) Closing of the meeting

Annex 5: Rapporteurs

Agenda Item(s)	2011 WGPDMO Terms of Reference	Rapporteurs
1-4	Introductory session	L. Madsen
5	Produce a report on new disease trends in wild and cultured fish, molluscs and crustaceans, based on national reports (ToR a) • wild fish • farmed fish • wild and farmed shellfish	M. Podolska, S. Feist, A. Alfjorden D. Bruno, S. Maclean, E. Biering S. Ford, N. Ruane, L. Madsen
6	Provide a review on the occurrence and mitigation of pathogen transmission from maricultured finfish (ToR b)	T. Lang, F. Ruano, T. Karaseva
7	Provide a review on the management of infections and diseases in commercially valuable bivalves (ToR c)	N. Ruane, S. Ford, T. Karaseva
8	Provide a status update on the manuscript on disease-associated population effects of commercial and non-commercial fish and shellfish species (ToR d)	S. Maclean, D. Bruno, R. Medne
9	Provide a progress report on the Fish Disease Index (FDI) in relation to 1, its implementation in marine monitoring and assessment programmes; 2, the development of assessment criteria; and 3, results of FDI assessments carried out intersessionally addressing diseases of flounder and Baltic cod and data on liver histopathology and macroscopic liver lesions in the common dab (ToR e)	T. Lang, E. Biering, W. Wosniok
10	Provide an update of the ICES publication “Trends in important diseases affecting the culture of fish and molluscs in the ICES area 2003 to present” (ToR f)	S. Feist, M. Podolska, R. Medne
11	Provide a review on parasites in marine finfish and shellfish species posing a hazard to human health (ToR g)	F. Ruano, D. Bruno
12	Provide an update on the status of ICES publications on pathology and diseases of marine organisms (ToR h)	A. Alfjorden, R. Medne
13	Provide expert knowledge and advice on fish disease and related data to the ICES Data Centre on a continuous basis (ToR i)	W. Wosniok, T. Lang
14	Evaluate potential for collaboration with other EGs in relation to the ICES Science Plan and report on how such cooperation has been achieved in practical terms (e.g. joint meetings, back-to-back meetings, communication between EG chairs, having representatives from own EG attend other EG meetings) (ToR j)	L. Madsen
15–20	Analysis of progress with tasks, future activities of WGPDMO, approval of recommendations, approval of draft report, closing of the meeting	S. Jones

Annex 6: Disease interactions between farmed and wild marine finfish species: recognition and mitigation of pathogen transmission from maricultured finfish (ToR b)

Prepared by: S.R.M. Jones, D.W. Bruno and L. Madsen

Background

Since 2010 the Working Group on Pathology and Diseases of Marine Organisms (WGPDMO) has prepared two working papers with a focus on pathogen interactions between maricultured and wild fish. The first, "The effects of interactions of parasites from mariculture on the condition of wild fish populations: implications of future growth in mariculture" emphasised salmon lice *Lepeophtheirus salmonis* in salmonid mariculture. The second paper entitled "Disease interactions between farmed and wild marine finfish species with emphasis on potential threats" described pathogens and diseases in farmed and wild marine finfish species, excluding salmon.

There is growing awareness among fisheries managers and policy makers of fish disease; specifically, an awareness of the possibility that pathogens are transmitted between maricultured and wild aquatic organisms. Maricultured stocks are routinely observed and screened leading to a greater knowledge of infection and disease than is the case for wild populations. This inequity may give rise to a perception that maricultured fish are more likely to harbour disease-causing pathogens whereas wild stocks are 'pristine'. While it is true that conditions of mariculture result in higher densities and abundance of susceptible fish which can alter host-pathogen relationships, cultured fish are closely monitored, fed a highly nutritious diet, vaccinated against many diseases caused by bacteria and viruses and are treated for parasites. Strict quarantine procedures have also been established to address the introduction of fish species (non-native species culture and/or captive breeding programmes) and their pathogens to mariculture in new locations. The objective of the present paper is to provide a theoretical basis for understanding and mitigating pathogen transmission from maricultured finfish.

Definition of disease

A diseased individual is one in which clinical signs are observable, repeatable and attributable to an aetiological agent including parasites, viruses and/or bacteria. Fish displaying clinical signs are considered to be in significant deviation from a natural status or equilibrium (Olivier and MacKinnon1998). Additionally, sub-clinical disease or the carrier state is a condition in which pathogens are detected in the host without clinical signs. Highly sensitive diagnostic techniques such as polymerase chain reaction (PCR) are able to detect small numbers of pathogens or their genetic material, resulting in an increase in the perceived prevalence of the pathogen but not necessarily an increase in the incidence of disease. The level of infection necessary to cause clinical disease must be empirically derived for each pathogen and its host(s), which can be difficult to determine in wild populations.

Factors affecting the ability to determine risks associated with pathogen transmission in the wild

Understanding pathogen transmission within and between fish populations requires some knowledge of fish ecology (Riley *et al.* 2008). Factors that should be considered in comprehensive studies of disease in wild fish populations include:

1. Challenging environmental conditions often hamper sampling and experimentation efforts;
2. Historical data are rarely available to provide baseline or normal values for the population (Harvell *et al.* 1999);
3. Most historical data only include mortality rates rather than information on the mechanism(s) of mortality (Hedrick 1998; Noakes *et al.* 2000);
4. Wild fish that die as a result of infection are removed from the ecosystem and not available for sampling or study (Bergh 2007);
5. The complexity of disease interactions with its host and the surrounding environment affects the clear interpretation of experimental results. Most evidence is obtained from controlled laboratory studies of single-variables involving the pathogen and its host where multi-factorial studies are needed (Håstein and Lindstad 1991). This experimental bias can lead to the misinterpretation of data in the context of the host and its dynamic environment (Hedrick1998);
6. Multiple and/or silent infections can lead to the exacerbation of clinical signs attributed to one pathogen;
7. Highly sensitive diagnostic tools can inflate prevalence values, but contribute little towards understanding the impact of a pathogen on its host;
8. Bi-directional transfer of pathogens between wild and farmed fish is difficult to quantify (LaPatra 2003);
9. General absence of baseline disease data from sites, prior to their use by aquaculture;
10. An appropriate and standardised measure of susceptibility to pathogens often lacking within wild populations.

Criteria for establishing causal relationships

Statistically significant correlations provide a measure of the strength of associations, however confirming a causal relationship between infection and mortality or changes in population abundance is often more difficult to establish (McVicar 1997). A systematic approach to establishing causality included the description of a series of criteria (Hill 1965): strength, consistency, specificity, temporality, biological gradient, plausibility, coherence, experimental evidence and analogy. Although, confidence in epidemiological causality now depends more on observation and measurement than on criteria (Rothman and Greenland 2005), variations of Hill's criteria may still be useful. For example, deducing transmission from observations of pathogens and clinical signs of disease in marine fish may be assisted by the following criteria (Olivier and MacKinnon 1998; Olivier 2002):

1) Source fish must contain pathogen;

2) Pathogen must remain present in a diseased fish;

3) Surrounding water must contain susceptible (recipient) fish;

4) Pathogen must survive in the environment;

5) Pathogen must be present at a biologically significant concentration to initiate an infection in susceptible fish;

6) Pathogen must spread to other fish;

7) A susceptible host must be exposed to the pathogen by a route that allows infection.

Biology of the pathogen

The infectivity of a pathogen relates to its ability to enter, spread and reproduce within a host with or without the onset of disease (Thomas and Elkinton 2004). Pathogenicity and virulence relates to the capacity of a pathogen to cause disease in an individual or population (Steinhaus and Martignoni 1970; Lacey and Brooks 1997; Thomas and Elkinton 2004; Shapiro-Ilan *et al.* 2005), and are understood to have environmental determinants.

The ability of the pathogen to survive in the environment has a direct impact on its ability to colonize and infect a host. Conditions found at aquaculture sites differ from those in the wild potentially leading to differential selective pressures on pathogens (McVicar 1997). In culture conditions, environmental selection pressures characteristic of different geographic areas can lead to genetic differences among pathogen populations (Nowak 2007). Replication rates affect the substitution rate within the virus genome, indicating a relationship with genetic diversity of some viruses (Nylund *et al.* 2007). Lower replications rates will result in lower substitution rates possibly limiting the virus' ability to adapt to its changing environment (Nylund *et al.* 2007). The pathogenicity of an organism can also impact its survival and subsequent host infection rate. Highly pathogenic diseases may cause hosts to die before the transmission has occurred whereas low pathogenic organisms may be retained longer within host populations, prolonging the period of transmission (McVicar 1997). In addition, differences in antibiotic resistance among bacterial strains following use in mariculture of oxolinic acid or oxytetracycline, potentially lead to alterations of structure within bacterial populations (Björklund *et al.* 1991; Spanggaard *et al.* 1993; Ervik *et al.* 1994; McVicar 1997).

Modes of pathogen transmission

Transmission strategies employed by aquatic pathogens include horizontal, vertical and vector-borne. Horizontal transmission refers to the direct movement through the water column of a pathogen from an infected to a naïve individual and the open design of most cages allows the transmission of pathogens from the environment, or from wild to farmed fish (Johansen *et al.* 2011). The rate of horizontal transmission is dependent on the frequency of contact between individuals, the susceptibility of the host (general health and immune ability) and the transmission coefficient (ability of the pathogen to invade, replicate and disperse) (Reno 1998). The reproductive rate (R_o) of the pathogen is expressed as the number of successful infections per unit time. A large value for R_o implies a greater ability for the pathogen to infect, reproduce and spread to susceptible hosts within or between populations. Large R_o pathogens can lead to the exhaustion of susceptible hosts and the cessation of further replication and spread. Smaller R_o pathogens have a more limited ability to cause an epizootic, as they are normally slower to replicate and transmit. As expected, intermediate R_o pathogens can persist in a population for a greater period of time. An evolutionary advantage of low and intermediate R_o pathogens is the maintenance of a high proportion of susceptible individuals in the population (Reno 1998). It is noteworthy that R_o values have rarely been applied to disease infections in wild fish due to the difficulties in tracking and sampling the fish. Moreover, long-term infections are often more difficult to investigate, as natural variations among populations with respect to environmental factors, immigration, emigration, births, deaths, other infections and mortalities due to predation must be considered.

Vertical transmission involves the passing of a pathogen with milt or eggs, resulting in infection among offspring. From an evolutionary perspective, vertical transmission increases the availability of susceptible hosts and establishing an infection in a population. Vertical transmission will theoretically increase the transmission co-efficient and decrease the threshold density of hosts required for infection and is normally associated with longer infectious periods (Reno 1998).

Diseases can also be spread by a third host or vector. Vectors can include other parasites, fish, piscivorous animals or inanimate objects such as clothing, vessels or equipment.

Environmental factors affecting pathogen transmission

Pathogens are a natural component of an environment and provide strong selective pressure on hosts that assists in maintaining healthy populations. The onset and development of disease reflects a complex interaction between host, pathogen and the environment (Snieszko 1974). It is recognised that these factors may act synergistically on a pathogen and on the host, both at the individual and population level. Limited data exist regarding studies of multiple environmental stressors and their impacts on disease susceptibility. Environmental stressors related to host susceptibility for which data exist include temperature, organic chemical and metal pollutants, dissolved oxygen and other gases, suspended solids, salinity and pH (see Grant and Jones 2010).

Anthropogenic factors in pathogen transmission

The adoption of chemotherapeutant and some vaccination programmes has assisted in reducing the spread of many pathogens. In addition, biosecurity practices on farms, such as fallowing sites to break disease cycle, disease testing of fish prior to transfer, single year class stocking, coordinating treatments and harvesting within embayments have mitigated the artificial transmission of infections (Bron *et al.* 1993; Ewart and Ford 1993; Costello *et al.* 2001; Brooks 2009). There is evidence however, that transport of inadequately disinfected eggs for the purpose of expanding or restocking mariculture has contributed to the global spread of Infectious Salmon Anaemia Virus (ISAV) (Kibenge *et al.* 2009; Vike *et al.* 2009) and that vessels used to move fish aid in transmission of the virus over shorter distances (Murray *et al.* 2002). Overfishing can lead to the removal of both healthy and diseased individuals from a population. Theoretically, selection as a result of a fishery results in changes in the population structure (e.g. age, longevity, body size, condition, recruitment and genetic factors), affecting the proportion of susceptible fish (Harvell *et al.* 1999; Pauly *et al.* 2002; Berkeley *et al.* 2004).

Summary

Finfish mariculture is a rapidly growing driver of coastal economies: the annual global production of maricultured salmon is greater than two million tonnes, almost double the catch of Pacific salmon in 2007 (Noakes and Beamish 2011). Coincident with this growth, systematic research on pathogen transmission in aquatic ecosystems is lacking in many ICES member countries. Therefore, the apparent absence of pathogen-transfer events between cultured and wild fish populations (DipNet 2006 2007, Grant and Jones 2010) may be related to a scarcity of multi-variable, large-scale, long-term comprehensive data-sets focusing on aquatic animal health. Such data-sets will be required to interpret the complex interactions inherent to pathogen transmission and the development of disease in wild populations. Recent studies (Jones 2009; Marty *et al.* 2010) concluded from locally relevant datasets that there was good evidence for maricultured salmon to contribute salmon lice to infections on wild salmon populations. The same datasets were unable however, to determine the magnitude with which the parasites contributed to changing abundances of wild salmon populations. The application of mathematical models to such datasets may provide insight into the transmission of aquatic pathogens between farmed and wild fish. Simple models have been used to predict the density independent transmission of *Gyrodactylus salaris* among wild spawning salmon (Anttila *et al.* 2008). Open recruitment models aid in predicting transmission of salmon lice *L. salmonis* (Amundrud and Murray 2009; Murray 2009). The application of mathematical models in disease management and risk assessment procedures (Peeler *et al.* 2009) is expected to provide strategic options to managers.

Ongoing expansion of finfish mariculture in ICES member countries will place increased pressure on the policies and regulations governing disease surveillance and monitoring. Pathogen spread from farmed marine finfish to wild marine finfish is not well documented. Strong baseline and ecological impact studies will be required to support existing efforts and, with the adoption of emerging aquaculture programmes, to aid in the establishment of new regulations and policies.

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Annex 7: Provide a review on the management of infections and diseases in commercially valuable bivalves (ToR c)

Prepared by T. Renault

Introduction

Aquaculture is a dynamic activity where the growth rate of the sector has been around 4% during the last decade (FAO 2006). The major stakes that aquaculture has to face are embedded in the concept of sustainable development. In practice, this addresses the creation of processes and methods directed towards a better use of natural resources, and a better protection of consumer health while preserving the competitiveness of the European aquaculture in a global and open economy.

Global mollusc production is continuously increasing, and has become one of the largest aquaculture activities in the world. Molluscs are the second most important group by quantity and by value (FAO, 2009) and the world production in 2006 was estimated at 14.1 million tonnes, representing 27% of the total world aquaculture production valued at US$ 11.4 billion. Mollusc aquaculture is characterised by a focus on a limited number of species including oysters and mussels being raised at an industrial level. The marine bivalve industry has grown to be very important for many regions contributing substantially to social and economic activity in the coastal zones. By volume, oysters (Ostreidae) are the second most important aquacultured taxonomic group to cyprinids at 4.6 million tonnes (FAO, 2006). The Pacific cupped oyster, *Crassostrea gigas*, itself had the greatest contribution with a world-wide production volume of 4.4 million tonnes.

Shellfish farming, relying directly upon natural environments and feeding resources, is facing various risks and limiting factors which include primarily, as well as in every farmed species, infectious diseases. This is also of the most relevance for the hatchery production of seeds, which developed rapidly during the recent years.

Disease outbreaks can be related to an increase of population density that may favours disease transmission, an increase of animal transfers including trade of live animals for restocking purposes, the weakening of aquaculture species due to environmental stress including global change impacts, and the diversity in host genetic and immune competence.

The control of farmed shellfish health is one of the key elements to maintain the competitiveness and to increase the sustainability of the industry as a whole. Preventing and controlling diseases has become a priority for the sustainability of mollusc aquaculture. Great effort has already been made, but needs to be pursued for preventing and controlling infectious diseases based on different approaches:

- i) diagnosing infectious diseases;
- ii) controlling mollusc movements and transfers;
- iii) understanding interactions between host, pathogen and environment;
- iv) improving disease resistance using the genetic variability through selective breeding;
- v) developing, testing and adopting new pathogen inactivation methods.

Limitation of current management techniques for bivalve mollusc diseases is a major issue. Bivalves (oysters and mussels) such as all other molluscs are unique in terms of health management. The reasons for this are:

i) Molluscs including wild and cultivated ones, live in the open water. As they are sessile filter feeders filtering large volumes of water, they are exposed to a range of pathogens. They are also directly subjected to the fluctuations of their environment. Cultured and wild molluscs tend to share the same ecological habitats and there is no real distinction between farming and harvest from natural populations regarding risk of disease emergence and spread.

ii) Oysters and mussels, like other invertebrates, lack an adaptive immune system and an immunological memory, and they rely totally on their innate immune system to overcome diseases. It relies on cells (i.e. phagocytes) and blood-borne molecules Hence, vaccination cannot be used to protect them against pathogens and indirect diagnosis tests including serology are not available. The direct detection of infectious agents remains the only possible approach.

iii) The behaviour of diseased individuals is usually extremely difficult to observe with the presence of the shell itself. Moreover, shellfish production is an economical activity occurring usually in open-water (with the exception of hatchery/nursery-reared animals). Classical production techniques do not offer the conspicuous advantage of daily monitoring and early warnings, such as changes in feeding behaviour and signs of weakening. Thus, shellfish farmers frequently perform “after-the-fact” monitoring which means it is difficult to collect moribund or recently deceased specimens for pathogen detection and diagnosis.

iv) As a consequence of the traditional farming techniques used for shellfish production, there are many transfers of different mollusc species between production areas. Animal transfers have positive impact on the development of mollusc aquaculture sector. They have, however, also been identified as a major threat to biodiversity and as vectors for pathogens.

v) The use of currently available drugs in aquaculture is highly regulated and restricted to avoid risks to public safety. Many countries are thus developing and implementing regulations on the use of antimicrobials, veterinary drugs and chemicals in aquaculture. Moreover, oysters and mussels are usually reared in the open sea which strongly limits the use of drugs because of the quantity to be used and their potential impact on the environment. In addition, animals are continuously at risk of exposure to pathogens present in their environment including those disseminated by native fauna. Physical disinfection methods such as Ultra Violet (UV) or chemotherapy including the use of probiotics may, however, be successfully applied in mollusc hatcheries and nurseries because of the confined nature of the facilities.

As a consequence, the current techniques and approaches developed for other farmed animal species (e.g. cattle, fish) cannot be directly derived for applications to bivalves. This implies that few ways to reduce the detrimental effects of pathogens are available.

Key drivers to improve disease diagnosis

Effective health management measures are based on diagnosis procedures such as: (i) a systematic approach to disease monitoring including the early detection of early infected animals, (ii) the use of sensitive and rapid diagnosis techniques, (iii) the collection of diagnosis data, and (iv) the establishment of diagnostic laboratories using standardised procedures with samples collected according to defined rules. Mollusc health surveillance/control programmes require both adequate legislation and standardised procedures for pathogen diagnosis. Valid laboratory results are essential for diagnosis, surveillance and trade.

Molecular techniques for diagnosing bivalve infectious agents have been developed during the last decade. Real time Polymerase Chain Reaction (PCR) techniques are already used for routine detection of pathogens infecting marine molluscs. Although they are now moving from a developmental phase in specialized laboratories for research purposes to routine application, molecular tools need formal validation. These diagnostic tools are not standardized and differences exist in the quality of reagents quality and preparation, in controls, as well as in the interpretation of results. Obviously, the use of a "standardized" diagnostic tool for routine analysis should allow the implementation of a calibrated and controlled process in laboratories. It is recognised that for such purpose, studies conducted in parallel with the same isolates in several laboratories would be necessary.

Understanding complex interactions between animal, pathogen and environment

Reducing the impact of pathogens is likely to rely on knowledge of their biology, their life cycle and the mechanisms that allow them to survive outside the host. Marine bivalves including oysters and mussels are typically reared in estuarine environments frequently subjected to fluctuations of environmental factors such as temperature, salinity and pollution. Outside the host, the environment of pathogens is thus composed of many different types of factors. The pressure of different stressors, including variations of salinity and temperature, may lead to potentially irreversible alterations of pathogens and host metabolism.

Published data suggests that most diseases affecting cultured molluscs are also affecting wild populations. Since mollusc culture is commonly practised in close contact with wild stocks, the introduction of an infectious agent into open-water can impact sympatric wild resources. Also, transplanted wild shellfish can be asymptomatic carriers of pathogens that may infect cultured populations. However, the hard evidences of transfer of pathogens between wild and farm populations are missing due mainly to lack of relevant data on life cycles and important ecological aspect of the life of pathogens. In addition, a lack of knowledge on the host range for mollusc pathogens seriously impedes the reliability of the results derived from risk analysis studies.

Understanding immunity of aquacultured mollusc bivalve species

According to Snieszko (1974), the development of an infectious disease results from an imbalance between the host and the pathogen due to different factors including internal factors of both protagonists (virulence of the pathogen, susceptibility of the host). During the last decade, various molecular techniques including mRNA differential display, Suppressive Subtractive Hybridization (SSH) and Expressed Sequence Tag (EST) libraries have been applied in bivalves in order to identify immune genes and to assess the level of gene expression. About 50 000 ESTs from bivalves are now available in various databases. Such data provides the basis for understanding the role of the innate immune system against various pathogens and may be useful in defining selection markers for improved resistance to infections.

Developing and adopting new pathogen inactivation methods

Creating a controlled growth environment during the inland growth cycle of the shellfish by reducing the presence of pathogens through the use of a disinfection barrier is one of the main objectives for sustainable aquaculture.

The disinfection barrier is a state of the art disinfection technology based on Ultra-Violet light. Ultra Violet (UV) light has been shown to be effective in damaging DNA or RNA. It has the ability to inactivate all microorganisms without creating collateral damage in the environment. The inactivation level is defined by the amount of germicidal UV light that each microbe absorbs during the exposure time in the UV system. The necessary dose level is "microbe dependent" - meaning that each microbe has its characteristic inactivation dose. The Ultra Violet light as an inactivation method overcomes the drawbacks of currently available drugs which are highly regulated and have a narrow pathogen impact range.

Annex 8: Provide a progress report on the Fish Disease Index (FDI) in relation to 1, its implementation in marine monitoring and assessment programmes; 2, the development of assessment criteria; and 3, results of FDI assessments carried out intersessionally addressing diseases of flounder and Baltic cod and data on liver histopathology and macroscopic liver lesions in the common dab (ToR e)

Prepared by W. Wosniok and T. Lang

Implementation of the Fish Disease Index (FDI) approach in marine monitoring and assessment programmes

OSPAR Coordinated Environmental Monitoring Programme (CEMP): There is no major change since 2010. Fish disease monitoring is part of the OSPAR pre-CEMP and the FDI approach has been recommended by ICES as analysis and assessment tool to be incorporated into integrated monitoring and assessment programmes on hazardous substances and their biological effects.

HELCOM Baltic Sea Action Plan (BSAP): HELCOM is revising its environmental Baltic Sea monitoring programme according to the requirement and ecological objectives defined in the HELCOM Baltic Sea Action Plan (BSAP). The HELCOM CORESET project, in 2011, recommended a number of Core and Candidate Indicators to be measured in future monitoring, including those for hazardous substances and their effects. Fish Diseases and the FDI are among the Core Indicators, together with lysosomal stability, reproductive success in fish and amphipods, PAH metabolites in fish, TBT-induced imposex in gastropods, and the micronuclei assay for geno- and cytotoxic effects. At present, this set of indicators is under discussion at the national level.

EU Marine Strategy Framework Directive (MSFD): One of the 11 MSFD Descriptors for good ecological status (GES) of the marine environment in Europe (to be achieved in 2020) is Descriptor 8: Contaminants and their effects. EU member countries will be obliged to set up an adequate marine monitoring programme, aiming at an assessment of the ecological status of their national waters with respect to D8, which will (likely) comprise chemical as well as biological effects monitoring in an integrated fashion. Final decisions on the design of such national monitoring programmes have not yet been made, but it is envisaged that fish disease monitoring and the FDI approach will be a component, at least in some countries.

Application and further development of assessment criteria

New and region-specific assessment criteria (BAC: background assessment criteria; EAC: environmental assessment criteria) for externally visible diseases of dab in the regions North Sea, Baltic Sea and Icelandic waters have been developed based on empirical data from the German long-term fish disease monitoring programme.

BAC: Mean FDIs were calculated by sampling area and sampling campaign in the period 1986-2010. Based on these data, the lowest 10 % percentile of the mean FDI values was calculated and used to define the BAC. FDI values <BAC represent natural background conditions, values ≥BAC give reason for concern (“alarm bell”), but are still considered acceptable. This was done separately for the North Sea, Baltic Sea and for Icelandic waters, since the areas are known to be characterised by differences in the ‘natural’ levels of disease prevalence.

EAC: Following the OSPAR concept, EACs for biological responses are used to indicate unacceptable effects of hazardous substances. Values >EAC indicate that unacceptable biological effects occur or are likely to occur. Since externally visible fish disease are regarded as general stress indicators, with contaminants being only one out of a number of stressors, EACs were defined following a different concept. Here, the values >EAC represent unacceptable effects of diseases on fish populations affected and are calculated based on the existing relationship between mean FDIs in the population and mean condition factors in the population (CF = weight*100/length^3). The EAC for the FDI is reached when a reduction of the CF by 10 % is present (see Figure 1).

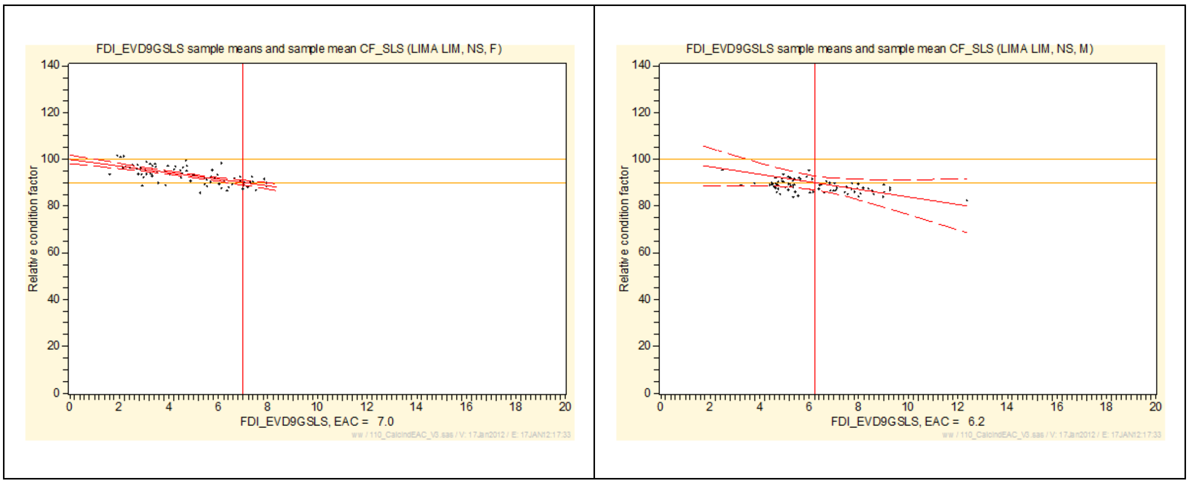

Figure 1. Relationship between mean FDI for externally visible diseases (9 diseases; see Table 1) and mean condition factor (CF) of female (left figure) and male (right figure) dab (*L. limanda*) in the period 1986–2010 in the North Sea. The vertical red line indicates the FDI value when the CF is decreased by 10 %.

Results of FDI assessments carried out intersessionally addressing diseases of flounder and Baltic cod and data on liver histopathology and macroscopic liver lesions in the common dab

***Externally visible diseases/parasites*:** Based on the development of modified assessment criteria (BAC/EAC) (see under (2)), an assessment of German long-term data on 9 externally visible diseases of dab (see Table 1) from areas in the North Sea and in the western Baltic Sea (see Figure 2) was performed. The results are shown in Figure 3 and Figure 4. The ratio of fish whose FDI was < BAC (reflecting natural conditions), ≥BAC and ≤EAC (reflecting levels above background, causing some concern) or > EAC (reflecting an unacceptable effect of the diseases on the condition factor, causing major concern) are shown for each of the samplings in the areas over the time span 1986–2010 (Figure 3). While fish from the two Baltic Sea area B01 (Kiel Bight) and B12 (Mecklenburg Bight) were characterised by a low portion of fish with FDI > EAC, some of the North Sea areas, in particular N06 (outer Firth of Forth), N04 (Dogger Bank), P01 (Dan oil/gas field) and P02 (Ekofisk) showed an elevated proportion of fish with FDI >EAC. In areas N06 and P01 there is evidence that the proportion of fish with FDI >EAC has increased over time. In the other areas, no clear trend was observed.

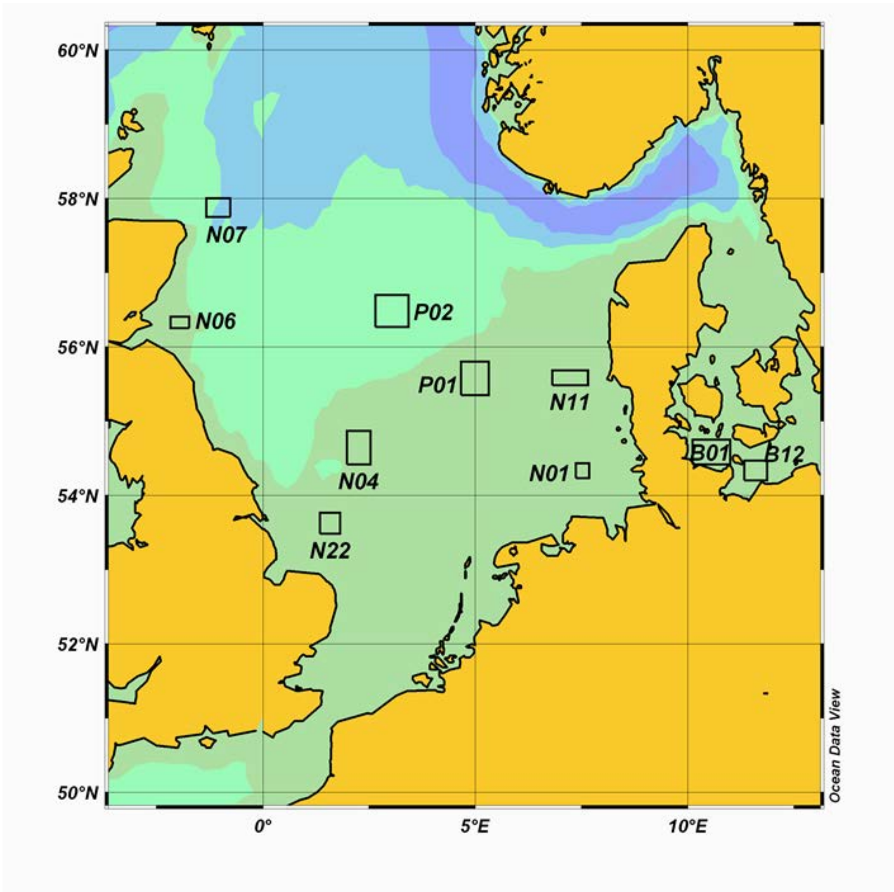

Figure 2. Location of German fish disease monitoring areas for dab (*Limanda limanda*) in the North Sea (N01: German Bight, N04: Dogger Bank, N06: outer Firth of Forth, N07: North Scotland, N11: Horns Reef, N22 off Humber, P01: Dan oil/gas field, P02: Ekofisk oil field) and the western Baltic Sea (B01: Kiel Bight, B12: Mecklenburg Bight).

The results of an assessment based on changes in the mean FDI over time in the same areas as in Figure 3 are presented in Figure 4. The figures provide information on fluctuations in the mean FDI values and the BAC and EAC used for the assessment (for information on the calculation of BAC/EAC, see (2)). In most areas, the mean FDI were above background (≥BAC), indicating that the FDI were higher compared to the areas and samplings with the lowest FDI recorded (10 % percentile) and, thus, that the health status was not 'optimal'. Looking at the most current data, there is indication that the health status has worsened and that this has led to a significant decrease in mean conditions factors and, thus, to mean FDI values exceeding the EAC.

For monitoring and assessment of externally visible diseases in flounder (*P. flesus*) (Table 2) and cod (*G. morhua*; Table 3), a set of diseases/parasites was identified which has been monitored, e.g., in the Baltic Sea on a long-term basis (by Germany, Poland and Russia) and for which data are available either in national databases or in the ICES Database.

***Macroscopic liver neoplasms*:** Monitoring in place is currently based on gross examination of flatfish (dab, flounder) livers (n = 50; dab ≥25 cm, flounder 30–34 cm) for the presence of macroscopic liver nodules > 2 mm in diameter (according to ICES and BEQUALM guidelines). Some studies have also addressed other fish species such as eelpout (*Zoarces viviparus*), cod (*Gadus morhua*) and herring (*Clupea harengus*).

Liver nodules >2 mm found are fixed and histologically examined in order to confirm the finding of neoplasm. Both benign and malignant liver neoplasms (including hepatic, biliary and other neoplasms) are placed into this category; pre-neoplastic lesions (foci of cellular alteration) are not included. Regarding the aetiology, exposure to and effects of carcinogenic anthropogenic contaminants are considered as causes.

Since liver neoplasms are regarded as contaminant-induced biological effects, there occurrence is considered in the assessment categorically as an unacceptable effects. Thus, all fish affected fall in the category >EAC. Fish without liver neoplasms fall in the category <BAC and, thus, represent unaffected baclground level. The category ≥BAC and ≤EAC is not assigned.

An example of an assessment is given in Figure 5 (left graph). This is based on data on the prevalence of macroscopic liver neoplasms in dab (≥20 cm; n = 530) from the North Sea and adjacent areas (western Baltic Sea, Icelandic waters) from a one-off survey carried out in 2008 as part of the ICON project. The results reveal that macroscopic liver neoplasms were rare and only affected a limited number of dab in the German Bight, Ekofisk and Firth of Forth. It has to be taken into account, however, that the sample size was low and that, so far, no severity grades, weighting factors or adjustment factors for the effects of size, sex and season were incorporated in the calculations and the assessment. These are still under development.

Data on macroscopic liver neoplasms derived from studies on other fish species (flounder, eelpout, cod) have so far not been assessed. However, such data are available and will be used in the near future.

***Liver histopathology*:** According to the ICES/BEQUALM guidelines, 30–50 dab (≥20 cm) or flounder (≥25 cm) are examined for a range of standardized histopathological liver lesions (see Table 2 and 4), grouped in 5 categories: non-specific lesions, early toxicopathic non-neoplastic lesions, pre-neoplastic lesions (foci of cellular alteration), benign neoplasms, and malignant neoplasms.

For the assessment of the results, it is suggested to use 3 categories (as for externally visible diseases), reflecting values <BAC (natural background), ≥BAC and ≤EAC (above background; causing some concern) and > EAC (unacceptable effect). Fish without lesions or with only non-specific lesions are assigned to the <BAC fraction (green), those with early toxicopathic non-neoplastic and/or with pre-neoplastic lesions to the ≥BAC and ≤EAC fraction (yellow) and those with benign and/or malignant liver neoplasms to the >EAC fraction (red).

Figure 5 (right graph) shows an example of an assessment done with a limited set of data on liver histopathology in dab from the North Sea and adjacent areas (Icelandic waters) (n = 185) obtained in the ICON project. The results reveal some regional differences, with the Icelandic fish being to healthiest ones. It has to be taken into account, however, that the sample size was low and that, so far, no severity grades, weighting factors or adjustment factors for the effects of size, sex and season were incorporated in the calculations and the assessment. These are still under development. Data on liver histopathology derived from studies on other fish species (flounder, eelpout, cod) have so far not been assessed. However, such data are available and will be used in the near future.

Table 1. Diseases of dab (*Limanda limanda*), their severity grades and weighting factors used for calculating the Fish Disease Index (FDI) (tbd: to be defined).

Disease category	Disease/parasite	Aetiology	Severity grade	Weighting factor
Externally visible diseases	Lymphocystis	Viral	1,2,3	1.84
	Epidermal hyperplasia/papilloma	Viral	1,2,3	1.75
	Acute/healing skin ulcerations	Bacterial	1,2,3	2.41
	Acute/healing fin rot/erosion	Bacterial	-	6.06
	X-cell gill disease	Parasitic (amoeba-like)	-	7.58
	Hyperpigmentation	Unknown	1,2,3	1.97
	Stephanostomum baccatum	Digenean trematode (mc)	1,2,3	1.00
	Acanthochondria cornuta	Parasitic copepod	1,2,3	1.24
	Lepeophtheirus pectoralis	Parasitic copepod	1,2,3	1.20
Macroscopic liver neoplasms	Histologically confirmed benign or malignant liver neoplasms	Carcinogenic contaminants	tbd	tbd
Non-specific liver histopathology	Degenerative, regenerative or inflammatory liver lesions	Multifactorial, stress	tbd	tbd
Contaminant-specific liver histopathology	Early toxicopathic non-neoplastic liver lesions	Contaminants	tbd	tbd
	Pre-neoplastic lesions (foci of cellular alteration)	Carcinogenic contaminants	tbd	tbd
	Benign neoplasms	Carcinogenic contaminants	tbd	tbd
	Malignant neoplasms	Carcinogenic contaminants	tbd	tbd

Table 2. Diseases of flounder (*Platichthys flesus*), their severity grades and weighting factors used for calculating the Fish Disease Index (FDI) (tbd: to be defined).

Disease category	Disease/parasite	Aetiology	Severity grade	Weighting factor
Externally visible diseases	Lymphocystis	Viral	1,2,3	1.84
	Acute/healing skin ulcerations	Bacterial	1,2,3	2.41
	Acute/healing fin rot/erosion	Bacterial	-	6.06
	Skeletal deformities	Multifactorial	1,2,3	2.0
	Lepeophtheirus pectoralis	Parasitic copepod	1,2,3	1.2
	Cryptocotyle sp.	Digenean trematode (mc)	1,2,3	1.0
Macroscopic liver neoplasms	Histologically confirmed benign or malignant liver neoplasms	Carcinogenic contaminants	tbd	tbd
Non-specific liver histopathology	Degenerative, regenerative or inflammatory liver lesions	Multifactorial, stress	tbd	tbd
Contaminant-specific liver histopathology	Early toxicopathic non-neoplastic liver lesions	Contaminants	tbd	tbd

	Pre-neoplastic lesions (foci of cellular alteration)	Carcinogenic contaminants	tbd	tbd
	Benign neoplasms	Carcinogenic contaminants	tbd	tbd
	Malignant neoplasms	Carcinogenic contaminants	tbd	tbd

Table 3. Diseases of cod (*Gadus morhua*), their severity grades and weighting factors used for calculating the Fish Disease Index (FDI) (tbd: to be defined).

Disease category	Disease/parasite	Aetiology	Severity grade	Weighting factor
Externally visible diseases Macroscopic liver neoplasms	Acute/healing skin ulcerations	Bacterial	1,2,3	2.41
	Epidermal hyperplasia/papilloma	Viral	1,2,3	1.75
	Acute/healing fin rot/erosion	Bacterial	-	6.06
	Skeletal deformities	Multifactorial	1,2,3	2.0
	Pseudobranchial swelling	Parasitic (amoeba-like)	-	7.58
	Lernaeocera branchialis	Parasitic copepod	1,2,3	2.0
	Cryptocotyle sp.	Digenean trematode (mc)	1,2,3	1.0
Macroscopic liver neoplasms	Histologically confirmed benign or malignant liver neoplasms	Carcinogenic contaminants	tbd	tbd
Non-specific liver histopathology	Degenerative, regenerative or inflammatory liver lesions	Multifactorial, stress	tbd	tbd
Contaminant-specific liver histopathology	Early toxicopathic non-neoplastic liver lesions	Contaminants	tbd	tbd
	Pre-neoplastic lesions (foci of cellular alteration)	Carcinogenic contaminants	tbd	tbd
	Benign neoplasms	Carcinogenic contaminants	tbd	tbd
	Malignant neoplasms	Carcinogenic contaminants	tbd	tbd

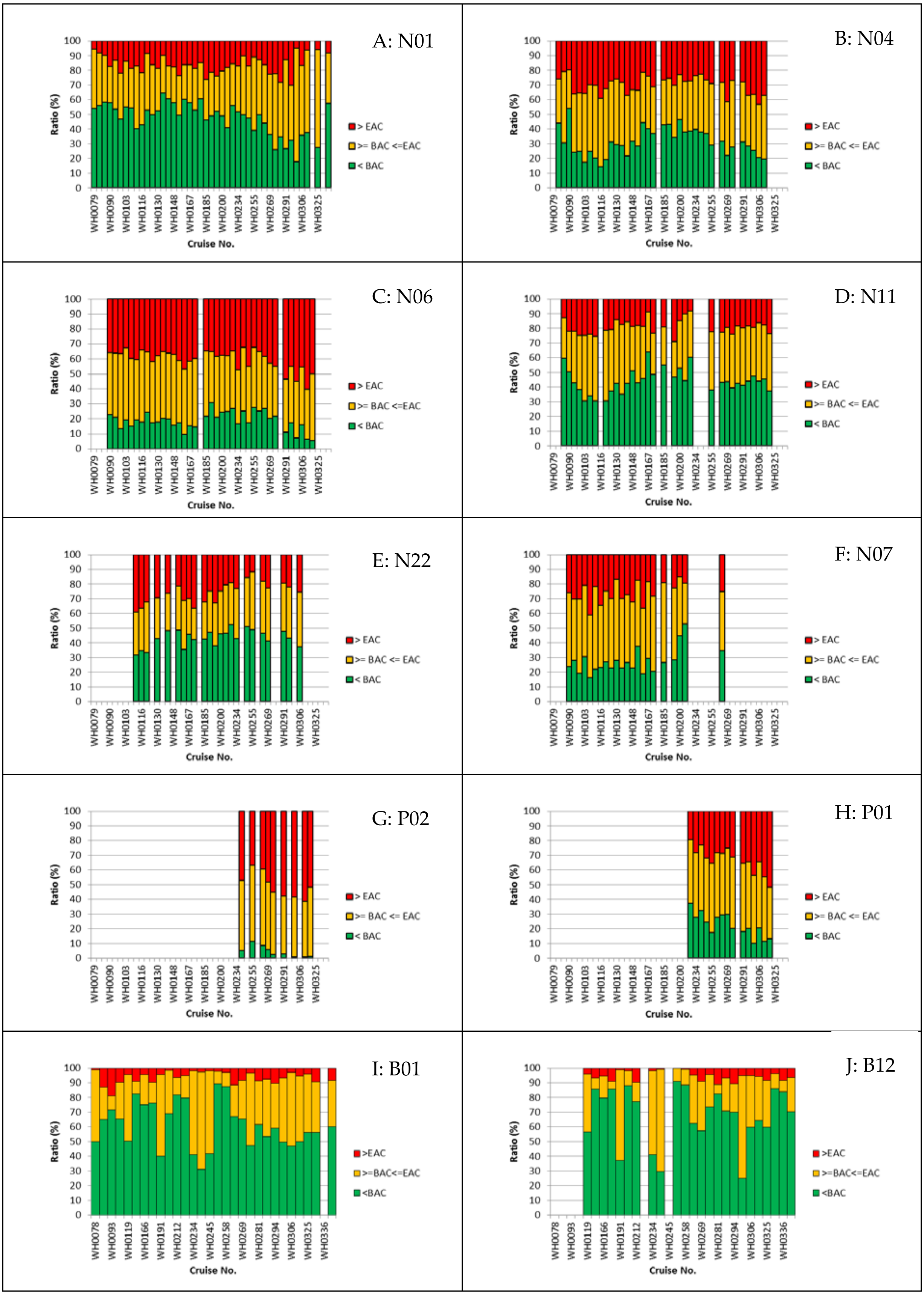

Figure 3. Temporal variation in the ratio of dab (*L. limanda*) with FDIs for externally visible diseases (9 diseases) > BAC, ≥ BAC and ≤ EAC and > EAC in the period 1986–2010 in the North Sea (A-H) and Baltic Sea (I-J) (for location of areas, see Figure 1; BAC: Background assessment criteria, EAC: Environmental assessment criteria).

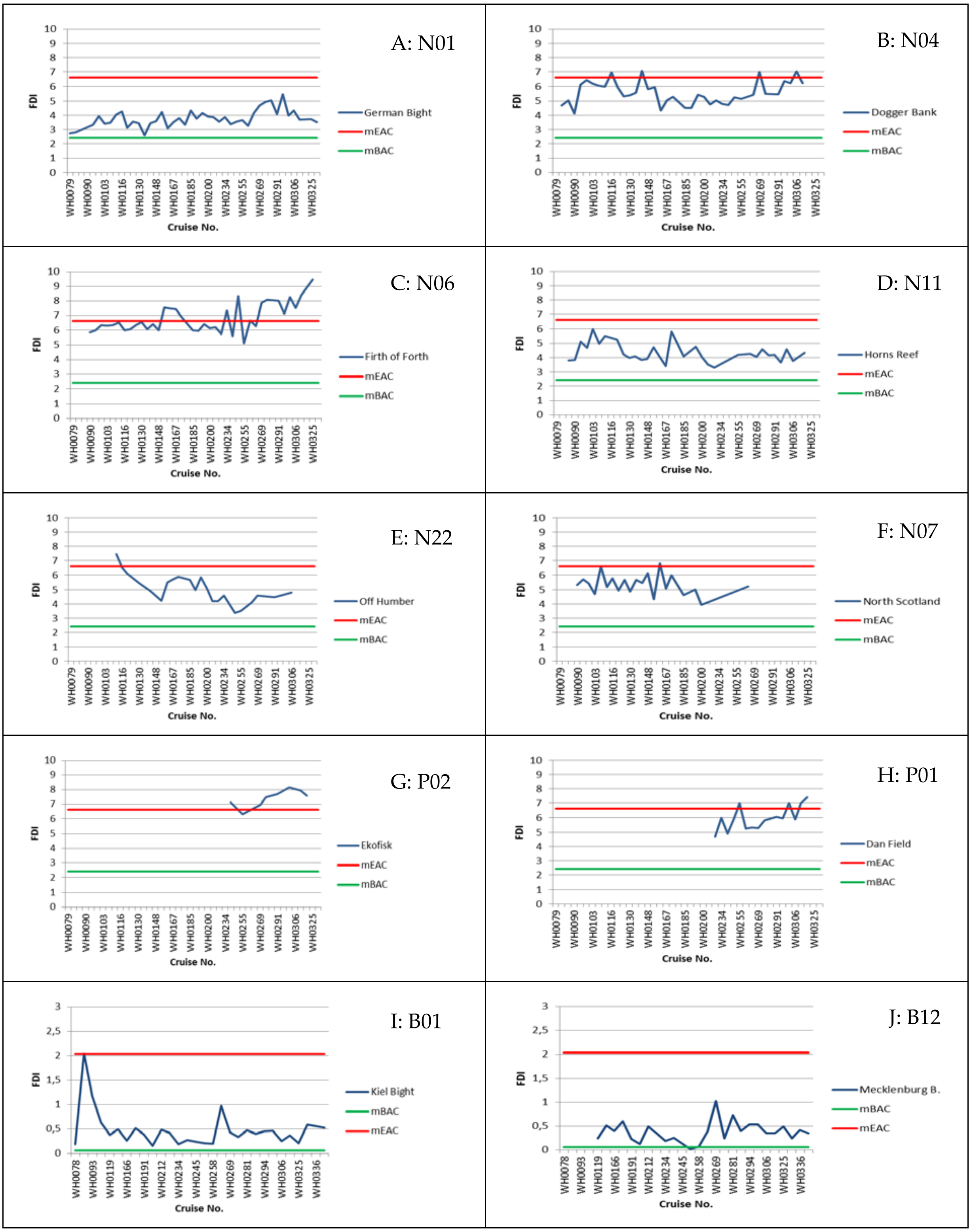

Figure 4. Temporal variation in mean FDI values for externally visible diseases (9 diseases) of dab (*L. limanda*) in the period 1986–2010 in the North Sea (A-H) and Baltic Sea (I-J) (for location of areas, see Figure 1), and data assessment (mBAC/mEAC: background/environmental assessment criteria for populations; values above mEAC indicate a decrease in the population condition factor (CF) by 10 %).

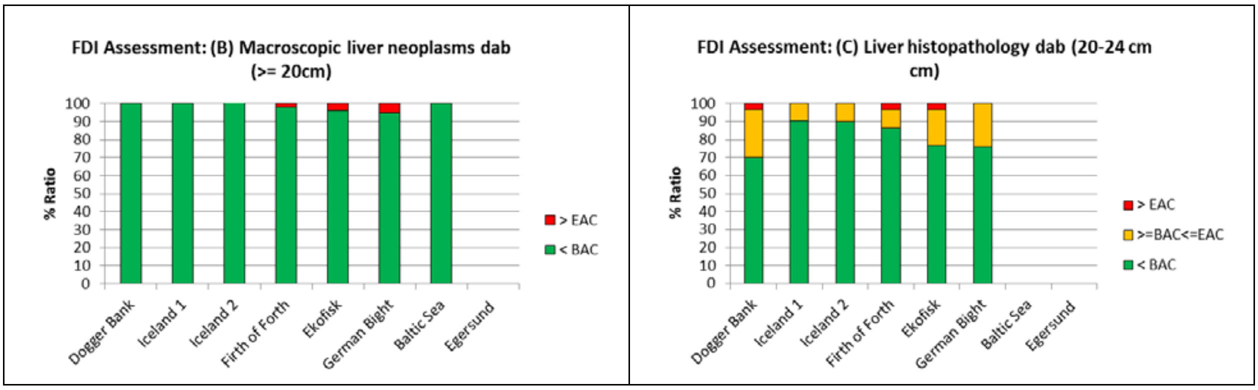

Figure 5. Assessment of data on macroscopic liver neoplasms (left figure) and liver histopathology (right figure) in dab from the North Sea (Dogger Bank, Firth of Forth, Ekofisk, German Bight), Icelandic waters (Iceland 1, 2) and the Baltic Sea, using BAC (= above background) and EAC (= unacceptable biological effects) as assessment criteria (source of data: ICON project).

Appendix: Calculating the Fish Disease Index and assessment criteria

The (individual) FDI summarizes the disease status of individual specimen by a single number. This number is derived from the information about the diseases that were found for that individual. The set of diseases considered is specific for the fish species; Tables 1–3 above gives the disease sets for dab (*Limanda limanda*), cod (*Gadus morhua*) and flounder (*Platichthys flesus*). Some diseases are recorded only as being absent or present ($x = 0$ or $x = 1$), others are recorded as grades (absent / mild / moderate / severe, coded by $g = 0 / 1 / 2 / 3$). The set D_U contains the indices of the ungraded diseases, the set D_G contains the indices of the graded diseases. To identify an observation, the indices s, i, d are used to indicate the sample, the individual within a sample, and the disease to which x or g refers. So, g_{sid} is the grade of disease d observed at individual i in sample s, x_{sid} is the corresponding absence- / presence information. For each disease d, a weight w_d has been defined by expert judgement to express the severity of the disease. The weight is a number between 1 (low severity) and 9 (high severity). For graded diseases, the weight refers to the most severe grade (3). With this notation, the raw individual FDI for individual i in sample s is defined by

$$rFDI_{si} = \frac{100}{\sum_d w_d}\left(\sum_{d \in D_U} x_{sid} \cdot w_d + \sum_{d \in D_G} g_{sid} \cdot \frac{w_d}{3}\right)$$

[F1]

This FDI is termed the raw FDI to distinguish it from the standardized FDI defined below. The first factor in [F1] is a scaling factor that makes FDI values lie between 0 and 100. In the example of dab, $D_U = \{3,9\} = \{Fi, Xc\}$ and $D_G = \{1,2,4,5,6,7,8\} = \{Ac, Ep, Hp, Le, Ly, St, Ul\}$. From the raw individual FDI, the raw mean FDI for sample s is obtained by

$$mrFDI_s = \frac{1}{n_i}\sum_{i=1}^{n_s} rFDI_{si}$$

[F2]

and the standard deviation, as a measure of spread, by

$$srFDI_s = \sqrt{\frac{1}{n_i - 1}\sum_{i=1}^{n_s}\left(rFDI_{si} - mrFDI_s\right)^2}$$

[F3]

The raw mean FDI from a sample, $mrFDI_s$, as well as the spread of the individual values about this mean, $srFDI_s$, may depend on the composition of samples with regard to length (or age), and the proportion of sexes. Also the season within a year may have an effect on the raw individual FDI, its mean and its spread. These sampling effects should not disturb the assessment of the FDI (classification with respect to BAC and EAC, comparison of geographical regions, detection of temporal change). Therefore, as a preparation of the FDI assessment, possible effects of different length distributions or sex proportions in the samples as well as the effect of the sampling season are removed by calculating a standardized FDI. This calculation uses a scale factor and a shift term. To calculate these, the data set is split into sex groups. Individuals with unknown sex form their own group. For each of the sex groups, means of *rFDI* values are calculated for all combinations of length and sampling season. It may be necessary to form length groups and groups of sampling dates in order to ensure that the means to be used in the standardisation step base on sufficiently many data records. As an example, for standardizing FDIs for dab (data from BFCG, Germany) lengths in cm classes from 10cm to 30cm (males) and from 10cm to 34cm (females) were used, and months were grouped into 2-month classes. This grouping generated data cells (= combinations of length class and month class) with either no data or at least 100 observations. For each data cell, its mean raw FDI and the corresponding standard deviation are computed by

$$mrFDI_{cell} = \frac{1}{n_{cell}}\sum_{(lsi,tsi)\in cell} rFDI_{si}$$

[F4]

$$srFDI_{cell} = \sqrt{\frac{1}{n_{cell} - 1}\sum_{(lsi,tsi)\in cell}\left(rFDI_{si} - mrFDI_{cell}\right)^2}$$

[F5]

The summation in [F4] and [F5] includes those observations with length l_{si} and season of sampling t_{si} falling into the length * season cell under consideration. For the standardisation step, a reference cell is required. This can be chosen arbitrarily, but should contain a reasonable number of observations. For the dab data example, the length of 20cm and sampling months September / October were chosen as reference conditions. Mean and standard deviation of raw FDIs from the reference class are denoted by $mrFDI_{ref}$ and $srFDI_{ref}$.

With these quantities available, scale factor and shift term per cell are obtained from

$$factor_{cell} = \frac{srFDI_{ref}}{srFDI_{cell}}$$

[F6]

$$shift_{cell} = -\frac{mrFDI_{cell} \cdot srFDI_{ref}}{srFDI_{cell}} + mrFDI_{ref}$$

[F7]

Using these terms, the standardised individual FDI for an observation is calculated as

$$sFDI_{si} = rFDI_{si} \cdot factor_{cell} + shift_{cell}$$

[F8]

where "cell" indicates the length*season cell into which observation (s,i) falls. Means per sex group are calculated in analogy to [F2], leading to sex-specific means $msFD_s(sex\ group)$. The standardized FDI for the whole sample is then obtained as a weighted sum of the sex group means, where the proportions of fish per sex group serve as weighting factors. Note that up to 3 sex groups may be involved (female, male, undetermined).

$$msFDI_s = \sum_{sex\ group} msFDI_s(sex\ group) \cdot p_{sex\ group}$$

[F9]

To assess the disease status in a sample, the mean standardised FDI, $msFD_s$, is used. For the assessment, a Background Assessment Criterion (BAC) and an Environmental Assessment Criterion (EAC) is used.

The Background Assessment Criterion (BAC) is defined as the 10th percentile of all $msFDI_s$ as illustrated by Figure 6.

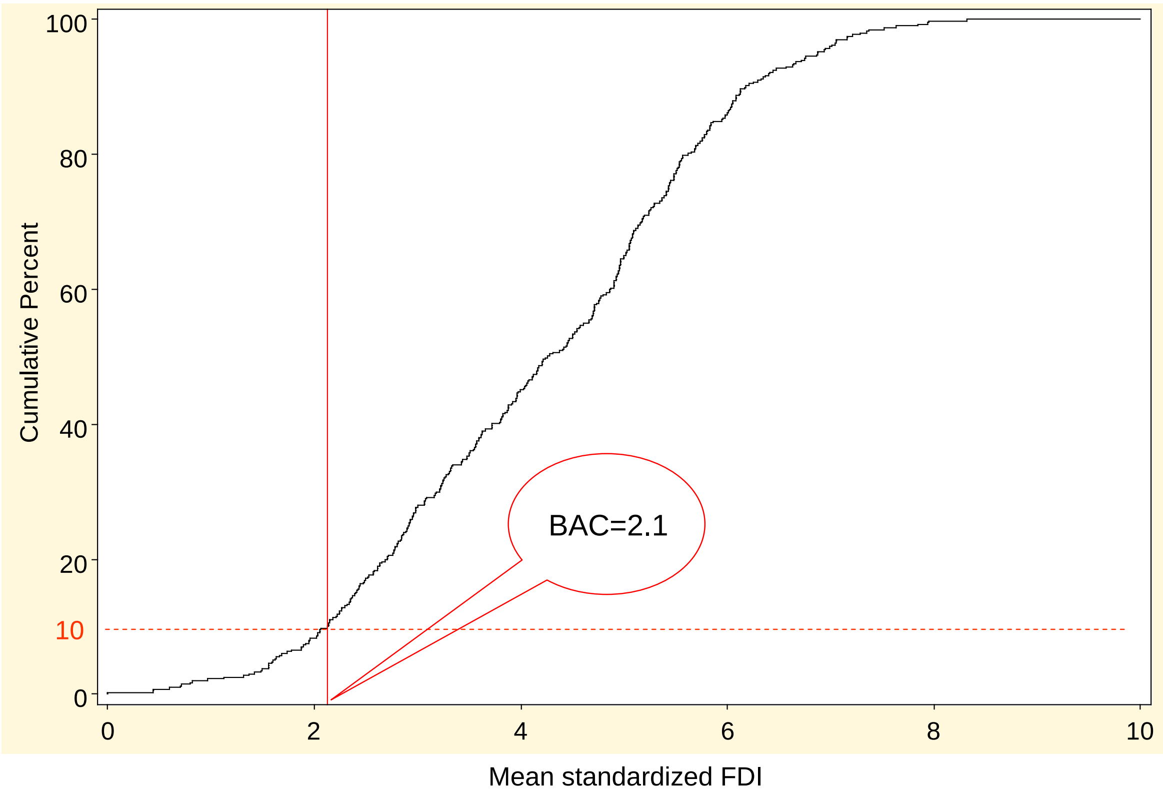

Figure 6. Derivation of the BAC as 10th percentile of means of standardized FDIs. Data: BFCG, 1986–2010, North Sea, dab (*Limanda limanda*), females only.

The derivation of an Environmental Assessment Criterion (EAC) requires data about an effect that is associated with disease status. For the dab example, the condition factor, defined by

$$CF = 100 \cdot \text{weight} / \text{length}^3 \qquad [F10]$$

has this property as shown in Figure 7. The EAC is defined as the *msFDI* that is associated with a loss of 10% in CF, compared to the CF occurring at *msFDI* = 0.

Having defined BAC and EAC, the assessment of FDI values is as follows:

- a disease status $msFD_s \leq$ BAC is considered as representing natural background conditions,
- a disease status BAC < $msFD_s \leq$ EAC is reason for concern, but is still acceptable,
- a disease status EAC < $msFD_s$ indicates that unacceptable biological effects occured or are likely to occur.

The temporal development of the standardised mean FDI can be displayed as in Figure 4. Additional information is provided by reporting the proportion of individuals falling in the three categories. This can be done graphically by stacked bar plots as in Figure 3 above. The information about these proportions is also useful in the framework of integrated monitoring. Most integrated assessment schemes involve quality categories as above and construct an integrated assessment criterion by summing up contributions to these categories.

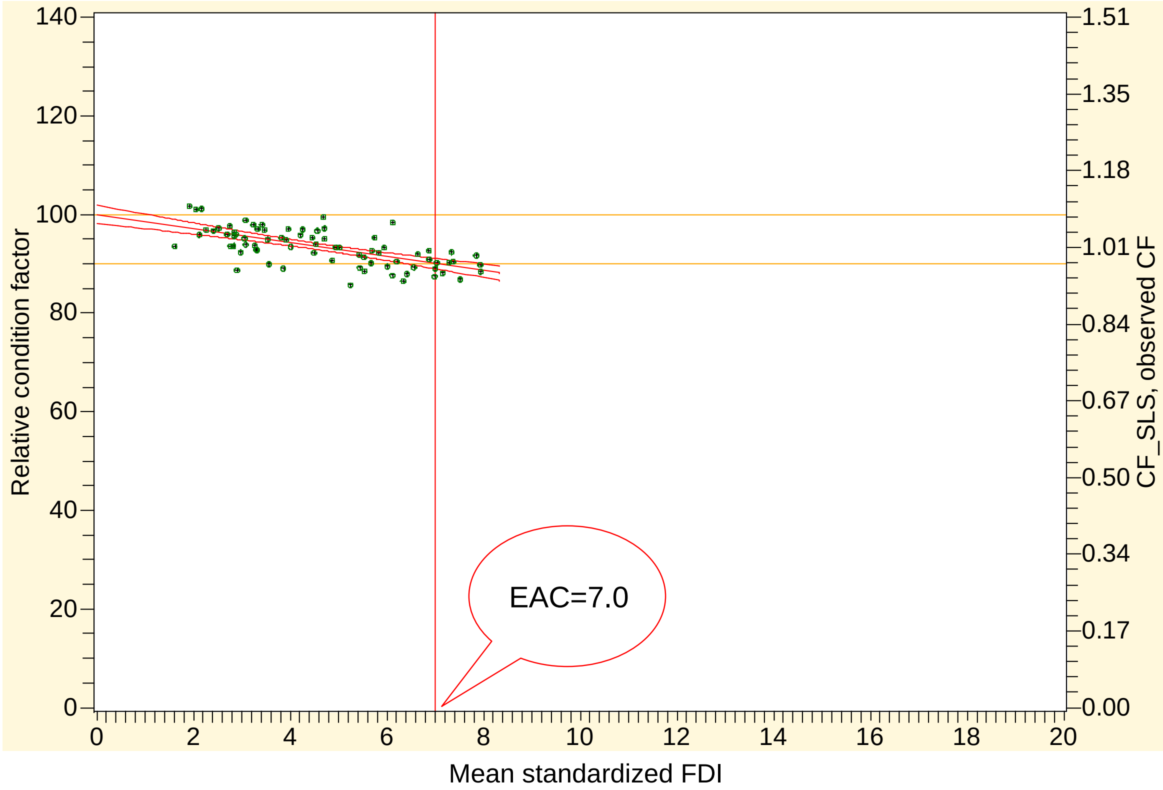

Figure 7. Derivation of the EAC as the standardized FDI associated with a 10% loss in condition factor. Data: BFCG, 1986–2010, North Sea, dab (*Limanda limanda*), females only.

Having defined BAC and EAC, the assessment of FDI values is as follows:

- a disease status $msFD_s \leq$ BAC is considered as representing natural background conditions,
- a disease status BAC < $msFD_s \leq$ EAC is reason for concern, but is still acceptable,
- a disease status EAC < $msFD_s$ indicates that unacceptable biological effects occurred or are likely to occur.

The temporal development of the standardised mean FDI can be displayed as in Figure 4. Additional information is provided by reporting the proportion of individuals falling in the three categories. This can be done graphically by stacked bar plots as in Figure 3 above. The information about these proportions is also useful in the framework of integrated monitoring. Most integrated assessment schemes involve quality categories as above and construct an integrated assessment criterion by summing up contributions to these categories.

Appendix: Notation

Symbols in formulas	Description
d	Index for disease. Numerical codes depend on species. For dab: 1 Ac - *Acanthochondria cornuta* 2 Ep – Epidermal hyperplasia/papilloma 3 Fi – Acute/healing fin rot/erosion 4 Hp - Hyperpigmentation 5 Le – *Lepeophtheirus pectoralis* 6 Ly - Lymphocystis 7 St – *Stephanostomum baccatum* 8 Ul – Acute/healing skin ulceration 9 Xc – X-cell gill disease Number, short form of the disease name and long form of the disease name may be used interchangeably.
D	Number of diseases used in the definition of the FDI.
i	Index for specimen (individual) within a sample
l_{si}	length of individual i in sample s
n_s	Number of specimen in sample s
g_{sid}	Grade of disease observed in sample s at individual i, $g_{sid} = \begin{cases} 0 & \text{disease } d \text{ absent} \\ 1 & \text{disease } d \text{ present, mild} \\ 2 & \text{disease } d \text{ present, moderate} \\ 3 & \text{disease } d \text{ present, severe} \end{cases}$,
FDI_i	FDI of individual i
G_d	number of grades of disease d
$p_{sex\ group}$	proportion of fish per sex group, calculated from the whole data set
s	Index for sample (typically the hauls from a defined geographical area taken during a cruise)
S	Number of samples in the data set
t_{si}	season of sampling individual i in sample s, typically the month of the year
w_d	Weight of disease d, expressing the severity of a disease relative to the other diseases, $w_d = 1$: lowest severity, $w_d = 9$: highest severity. For graded diseases, w refers to the highest grade.
x_{sid}	Indicator variable for the presence of disease d at individual i in sample s, $x_{sid} = \begin{cases} 0 & \text{disease } d \text{ absent} \\ 1 & \text{disease } d \text{ present} \end{cases}$

Annex 9: Standards and guidelines for reporting pathogens and diseases in National Reports

Prepared by S. Jones

Background

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

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

Draft Standards and Guidelines

1. Terms and Definitions: National data should be reported by using published and accepted terms and definitions as used in epizootiology (e.g. Bush *et al.* 1997; http://www.cdc.gov/training/products/ss1000/ss1000-ol.pdf, http://www.cs.columbia.edu/digigov/LEXING/CDCEPI/gloss.html).
2. Sample sizes must be reported for each case.
3. The age and/or size class of the host must be reported.
4. Sample locations must be unambiguous (e.g. lat-long coordinates) or a recognised reference point (e.g. Dogger Bank).
5. The error associated with mean values must be reported through the use of standard deviations, standard errors or 95% confidence limits.
6. Multi-year data (e.g. samples size, prevalence, 95% confidence limits) if available, must be reported either in table or graphic form.
7. Statistical tests must be employed to confirm the significance of changes in trend.

Annex 10: Recommendations

Report Section	Recommendation	For follow up by:
5	1. ICES Member Countries continue to fund or, in cases where no fish dis-ease monitoring programmes has been implemented, make a commit-ment to fund fish disease monitoring programmes to sustain fish health surveillance of wild stocks. Information obtained is of vital importance to integrated assessments of the health of marine ecosystems (e.g. in rela-tion to the EU Marine Strategy Framework Directive, OSPAR Coordi-nated Environmental Monitoring Programme (CEMP), and revised HELCOM monitoring programme). Data generated according to estab-lished ICES and BEQUALM guidelines should be submitted to the ICES Data Centre.	ICES Member Countries
5	2. Commercially exploited marine fish (including anadromous salmonids) should be monitored by member countries for the presence of parasites representing a risk for human health.	OSPAR, ICES Member Countries
5	3. WGPDMO develops standards and guidelines for consistent reporting of diseases in the WGPDMO National Reports. WGPDMO members are encouraged to provide information on diseases in farmed fish and in wild and farmed shellfish by using a standard format.	WGPDMO
6	4. WGPDMO members involved in preparing the document on the occurrence and mitigation of pathogen transmission from maricultured finfish consider integrating the document together with the two previous documents on diseases interactions between wild and farmed finfish prepared by WGPDMO in 2010 and 2011, for possible publication in the ICES Cooperative Research Report Series.	WGPDMO
6	5. OSPAR takes notice of the documents on disease interaction and transmission prepared by WGPDMO in 2011 and 2012 because they represent a continuation of work by WGPDMO on OSPAR request 2010/3.	OSPAR, ICES Member Countries
7	6. Results of the BIVALIFE project are used to update this report at a future meeting of the WGPDMO.	WGPDMO
8	7. The manuscript ``Disease-associated population effects in commercial marine fish and shellfish species`` is finalised and submitted to the ICES Cooperative Research Report Series for publication.	WGPDMO
9	8. The FDI approach for externally visible diseases of dab (*Limanda limanda*) is applied on the full set of disease data submitted by Member Countries and maintained in the ICES fish disease database.	ICES, ICES Member Countries
9	9. The FDI approaches for diseases of flounder (*Platichthys flesus*) and cod (*Gadus morhua*) are finalised and validated and results are reported to WGPDMO at its 2013 meeting.	WGPDMO
9	10. The FDI approaches for macroscopic liver neoplasms and liver histopathology of flatfish are finalised and are validated using appropriate datasets; results are reported to WGPDMO at its 2013 meeting.	WGPDMO
9	11. The methodology used for the FDI approach is published in the ICES TIMES series.	WGPDMO
10	12. Work continues intersessionally to complete the report ("Trends in important diseases affecting the culture of fish and molluscs in the ICES area 2003 to present") for review at the 2013 meeting of the WGPDMO and subsequent publication as an ICES Cooperative Research Report.	WGPDMO
11	13. Data described in the report entitled "Parasites in marine finfish and shellfish species posing a hazard to human health" should be prepared for publication.	WGPDMO
11	14. A new term of reference that reviews bacterial and viral infections of fish or shellfish causing zoonoses in humans should be prepared.	WGPDMO
12	15. WGPDMO members continue to consider additional titles for the leaflet se-	ICES Member Countries

	ries and other relevant publications in peer-reviewed literature.	
12	16. WGPDMO members complete the two manuscripts for publication as ICES Cooperative Research Reports.	WGPDMO
13	17. ICES Member countries submit wild fish disease data generated according to ICES standard guidelines, including data on macroscopic liver neoplasms and contaminant-specific liver histopathology to the ICES Data Centre in order to allow a consistent assessment of spatial patterns and trends in the health status of wild fish.	ICES Member Countries
13	18. ICES Member countries submit data on fish weight and age, were available, together with fish disease data.	ICES Member Countries
13	19. The ICES Data Centre includes fish weight and fish age in the screening procedure for data submissions.	ICES

Annex 11: WGPDMO draft terms of reference for the 2013 meeting

The **Working Group on Pathogens and Diseases of Marine Organisms** (WGPDMO), chaired by Neil Ruane*, Ireland, will meet in Legnaro (Padova), Italy, 5–9 March 2013 to:

a) Produce a report on new disease trends in wild and cultured fish, molluscs, and crustaceans based on national reports;

b) Provide a review on parasites and other infectious agents in marine finfish and shellfish species posing a hazard to human health;

c) Produce a summary of disease interactions between farmed and wild finfish;

d) Provide an update on the ICES publication 'Trends in important diseases affecting the culture of fish and molluscs in the ICES area 2003 – present'.

e) Update the maps of fish and shellfish diseases in ICES member countries on the ICES website

f) Provide a progress report on the Fish Disease Index (FDI) in relation to results of FDI assessments carried out intersessionally addressing diseases of flounder and Baltic cod and data on liver histopathology and macroscopic liver lesions in the common dab

g) Provide a status update on the manuscript on disease-associated population effects of commercial fish and shellfish species

h) Provide an update on the status of ICES publications on pathology and diseases of marine organisms;

i) Provide expert knowledge and advice on fish disease and related data to the ICES Data Centre on a continuous basis.

WGPDMO will report by 25 April 2013 (via SSGHIE) for the attention of ACOM and SCICOM.

Supporting Information

Priority:	The current activities of this Group will lead ICES into issues related to the ecosystem affects of fisheries, especially with regard to the application of the Precautionary Approach. Consequently, these activities are considered to have a very high priority.

Scientific justification and relation to action plan:	Action Plan No: 1. Term of Reference a) New disease conditions and trends in diseases of wild and cultured marine organisms continue to appear and an assessment of these should be maintained (all WGPDMO members); Term of Reference b) A range of parasites and other infectious agents reported by the WGPDMO in the annual update of disease trends have the potential to be harmful to human health if ingested in under processed food. There is an upward trend in the consumption of raw fish and other seafood products which may increase this risk. Human disease may occur through gastrointestinal infection with the possibility of subsequent peritonitis and the involvement of other sites in the body. Agents such as bacteria and virus can also be transmitted via other routes and cause diseases in humans. These infectious agents will be recognized in a literature review of risk, prevention and mitigation strategies, also including an update of the parasitic diseases that were reviewed at the 2012 WGPDMO (A. Alfjorden, M. Podolska, L. Madsen, T. Karaseva) Term of Reference c) WGPDMO has produced reports on disease interactions between farmed and wild finfish on disease in 2010, 2011 and 2012. The first summarized the state of knowledge regarding parasite interactions from finfish mariculture on the condition of wild fish populations; the second focused on disease interactions between farmed and wild marine finfish species with emphasis on potential threats, describing pathogens and diseases in farmed and wild marine finfish species, excluding salmon; and the third reviewed the occurrence and mitigation of pathogen transmission from maricultured finfish where a specific objective was to elaborate strategies for identifying and mitigating pathogen transmission from farmed finfish species. These reports represent a valuable and relevant contribution reflecting WGPDMO's activity in this field and worthy for dissemination to a wider audience. The reports will be reviewed intersessionally and a decision made regarding their suitability for publication either as a single or multiple publications. These papers will be drafted for publication in the ICES Cooperative Research Report Series. Contact with ICES WGEIM will be established to exchange information on this subject and to collaborate if appropriate. OSPAR will be informed regarding the preparation of these documents (S. Jones, D. Bruno, L. Madsen). Term of Reference d) The document 'Trends in important diseases affecting the culture of fish and molluscs in the ICES area 1998–2002' provided valuable information to researchers and fisheries managers on trends of diseases in aquaculture. That document requires updating with new information on those diseases of most importance for aquaculture, including new and emerging diseases, during 2003 to the present. A draft document is available and this will be completed in 2013 with a view to publication as an ICES Cooperative Research Report (N. Ruane, S. Ford, T. Renault, S. Jones, L. Madsen); Term of Reference e) The WGPDMO considers the information on the geographical distribution of fish and shellfish diseases provided on the ICES website (http://www.ices.dk/marineworld/fishdiseases/fishandshellfish.asp) as a valuable contribution to the scientific community reflecting WGPDMO's activities and expertise in this field. The maps give scientists, managers, laypersons and politicians having interest in or needing information on this field the possibility of obtaining a rapid overview on selected diseases. However, much of the information presented at present is outdated and needs to be updated. The WGPDMO will develop a plan on the type of information considered to be useful for presentation on the ICES website and on ways facilitating a regular update. Contacts with the ICES Secretariat will be established to explore relevant requirements and steps to be taken (T. Lang, W. Wosniok, S. Ford, S. Jones, E. Biering).

Term of Reference f)

The Fish Disease Index (FDI) approach has been developed for the analysis and assessment of data obtained by ICES Member Countries running regular fish disease surveys as part of their national environmental monitoring programmes. There is need to review the results of an application of the FDI approach on other fish species than dab (e.g., flounder and cod), a task that could not be fulfilled at the 2012 WGPDMO meeting due to the insufficient data available so far in the ICES Data Centre - Environment Data. Furthermore, the FDI strategy and the assessment criteria proposed for macroscopic liver neoplasms and liver histopathology need to be validated based on national data sets available. Work on the finalisation and the application of the FDI as an assessment tool for environmental monitoring under OSPAR/HELCOM/EU MSFD is considered as a longer-term activity of WGPDMO over the next three years (T. Lang, W. Wosniok, S. Feist).

Term of Reference g)

There is increasing information from studies in wild freshwater and marine fish species that diseases affect growth, reproduction and survival of different life stages of fish and shellfish and thus, may have an impact on recruitment and stock structure. However, only in few cases have diseases been explicitly considered in population dynamics models. Since the potential risk to fish and shellfish populations due to diseases is of considerable ecological and economical concern, and since the Term of Reference for 2010 could not be addressed in a sufficient way, the WGPDMO recognizes a need to revisit the issue at its 2011 meeting. Furthermore, population dynamics and epidemiological models will be reviewed in light of their applicability for studies in wild fish and shellfish. It is anticipated that the results of the review will be relevant to a range of ICES Expert Groups, including the stock assessment groups. (A. Alfjorden, S.W. Feist, S. Ford, S. Jones, T. Lang, , S. MacLean, L. Madsen, V. Öresland, T. Renault, W. Wosniok).

Term of Reference h)

A number of ICES publications, either web-based or in ICES publication series, are being prepared or updated at present, the progress of which has to be reviewed by WGPDMO. It will be necessary to consider ways by which these can be linked to each other. New publications have to be considered. (S.W. Feist, L. Madsen, D. Bruno).

Term of Reference i)

This is in compliance with a request from the ICES Data Centre. (W. Wosniok, T. Lang).

Justification of venue (in a non-ICES Member Country)	WGPDMO was invited by Dr. A. Manfrin to hold its 2013 meeting at the OIE Reference Laboratory for fish diseases, Istituto Zooprofilattico Sperimentale delle Venezie, Dipartimento di Ittiopatologia, in Legnaro PD, Italy. WGPDMO appreciated the invitation and there was consensus to recommend to ICES that the invitation is accepted. It was emphasised that the meeting will be a good opportunity to enhance the collaboration with institutions outside the ICES region involved in studies on diseases and pathology aspects in marine organisms relevant for the work of WGPDMO. Both the WGPDMO and the Italian colleagues will benefit from their expertise and knowledge, specifically in relation to WGPDMO ToR a) on new disease trends in wild and farmed fish and shellfish. The meeting will further foster the contacts with the OIE. The cost implications for the meeting will be the same as in ICES Member Countries and, thus, the choice of the venue will not limit the attendance of WGPDMO members.
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 20–25 members and guests.
Secretariat facilities:	None.
Financial:	No financial implications.
Linkages to advisory committees:	There are no obvious direct linkages with the advisory committees.
Linkages to other committees or groups:	There is a very close working relationship with all the groups of the Fisheries Technology Committee. It is also very relevant to the Working Group on Ecosystem Effects of Fisheries.
Linkages to other organizations:	The work of this group is closely aligned with similar work in FAO and in the Census of Marine Life Programme.