ICES WGPDMO REPORT 2010

ICES SCIENCE COMMITTEE

ICES CM 2010/SSGHIE:02

REF. SCICOM, ACOM

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

23–27 February 2010

Uppsala, Sweden

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

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

Recommended format for purposes of citation:

ICES. 2010. Report of the Working Group on Pathology and Diseases of Marine Organisms (WGPDMO), 23-27 February 2010, Uppsala, Sweden. ICES CM 2010/SSGHIE:02. 66 pp. https://doi.org/10.17895/ices.pub.8923

Contents

Executive summary

The ICES Working Group on Pathology and Diseases of Marine Organisms (WGPDMO) met 23–27 February 2010 at the National Veterinary Laboratory in Uppsala, Sweden. The meeting chaired by S. Jones (Canada) was well attended with 15 participants representing 11 ICES Member Countries. In order to consider the nine Terms of Reference, intersessional work was done by WGPDMO members and many 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).
- an update of new information relating to hyperpigmentation in dab including histological features and laboratory efforts to detect an aetiological agent for this condition (ToR c), report Section 6).
- a review of information relating to the population effects of disease in commercial and non-commercial fish and shellfish species (ToR d), report Section 7).
- a review of population dynamics and epidemiological models that may be useful in assessing the impacts of diseases in fish and shellfish populations (ToR e), report Section 8).
- advice provided in response to OSPAR request 2010/3 to summarise the current state of knowledge on parasite interactions from finfish mariculture on the condition of wild fish populations (salmonid and non-salmonid) at regional and local scales (ToR j), report Section 9 and Annex 6).
- an update on the progress achieved in the implementation of the Fish Disease Index (FDI) and related assessment procedures in marine monitoring and assessment programmes. Including a review of the application of the on other fish species for which data are available in the ICES Experimental Database (ToR f), report Section 10).
- identifying 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 a more complete and systematic submission of macroscopic and microscopic liver histology data to the ICES Data Centre was identified (ToR i), report Section 12).

- With the exceptions of ToR b and ToR g, which have been deferred, and ToR d and ToR f, which need further in-depth study, the WGPDMO concluded that the remaining Terms of Reference for 2010 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 2011. The meeting will be held in Lagnaro, Italy from 1–5 March 2011.

1 Opening of the meeting

The ICES Working Group on Pathology and Diseases of Marine Organisms (WGPDMO) was hosted by the National Veterinary Institute (SVA) in Uppsala, Sweden, with S. 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, 23 February 2010, with the Chair welcoming the participants, particularly new members, N. Chukalova (Russia) and H. Seibel (Germany). A list of participants is appended in Annex 1.

Apologies were received from D. Bruno (Scotland), J. Barja (Spain), S. Ford (USA), O. Haenen (The Netherlands), N. House (Canada), S. Maclean (USA), G. Rodjuk (Russia) and N. Ruane (Ireland). A. Hellström provided instructions on in-house facilities and general meeting arrangements. A. Engvall, the Director of the SVA, welcomed the WGPDMO to the facility and wished them a successful and productive meeting.

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. 2009/2/SSGHIE02 (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

The Chair highlighted items of relevance to WGPDMO. S. Jones reminded the WGPDMO that the WGPDMO National Reports of new disease trends are published as ICES advice in the form of an ICES Advisory Document. This emphasises the continued need for high quality and accuracy in the summarisation of the WGPDMO report.

3.1 ICES Annual Science Conference 2009

The 2009 ICES Annual Science Conference (ASC) was held 21-26 September 2009 in Berlin, and was comprised of 20 theme sessions. Theme Session Q ``Interactions between aquaculture and wild stocks: comparative experiences for Atlantic cod and Atlantic salmon`` consisted of 19 papers, two of which focused on sea lice interactions between farmed and wild salmon.

3.2 ICES Annual Science Conference 2010 and Theme Session F

The 2010 ICES Annual Science conference will be held in Nantes, France. Theme Session F "Monitoring biological effects and contaminants in the marine environment: where do we go from here?" is of special interest to the WGPDMO as regards environmental effects monitoring. The session will be convened by J. Thain (UK), C. Couillard (Canada) and D. Vethaak (Netherlands). Members were encouraged to participate in this Theme Session.

4 Other relevant activities for information

The WGPDMO recognises that the World Organization for Animal Health (OIE) collates information on reports of OIE listed diseases, including those of aquatic animals. The OIE Collaborating Centre for Information on Aquatic Animal Diseases (contact person S.W. Feist) collates the occurrence of OIE-listed diseases for adding to the International Database on Aquatic Animal Diseases. It may be possible to create a link from the collabcen website (http://www.collabcen.net) to the ICES WGPDMO report for information specifically on disease trends.

The WGPDMO acknowledges the existence of a new project called DATAQUEST. A new European Food Safety Authority (EFSA) negotiated procedure designed to produce a publishable data sources inventory relevant for identifying emerging diseases of fish. Since the project aims are complementary to that of the WGPDMO for detection of disease trends and emerging disease, the WGPDMO (S. Jones) will contact the coordinator of DATAQUEST to ensure that information contained in WGPDMO reports is identified in the DATAQUEST inventory.

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 2009 submitted by Canada, Denmark, Finland, France, Germany, Ireland, Netherlands, Norway, Poland, Russia, Scotland, Sweden, England and Wales 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*	saithe	*Pollachius virens*
clam, soft	*Mya arenaria*	salmon, Atlanic	*Salmo salar*
clam, stout razor	*Tagelus plebeius*	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*
flounder	*Platichthys flesus*	trout, brown	*Salmo trutta*
haddock	*Melanogrammus aeglefinus*	trout, rainbow	*Oncorhynchus mykiss*
herring, Atlantic	*Clupea harengus harengus*	trout sea	*Salmo trutta*
herring, Baltic	*Clupea harengus membras*	turbot	*Psetta maxima*
mussel, blue	*Mytilus edulis*	whitefish	*Coregonus* sp.

5.2 Wild Fish

5.2.1 Viruses

Lymphocystis – The low prevalence recorded in dab over the past years in the German Bight has continued with the value of 0.2 % in 2009 being the lowest ever recorded in this area. An increasing trend in prevalence since 2006 (from 3.0% to 5.9% in 2009) is apparent in dab off the north-east coast of England (off Tees). An increased prevalence of 9.9% (from 0.6% recorded in 2008) was recorded in flounder from the Gulf of Gdansk. Polish data (subdivisions 25 and 26) indicate the mean prevalence in flounder increased to 1.8%, in comparison to 2007 (1.3%) and 2008 (0.7%). In flounder from Russian EEZ (subdivision 26, Baltic Sea), the prevalence in 2009 was higher (9.9%) than in 2008 (0.6%) and 2007 (1.6%).

Viral Haemorrhagic Septicemia Virus (VHSV) – The virus was identified by qRT-PCR or isolation in cell culture from fish belonging to several species from Lake Superior, USA. There were no reports of significant mortalities. This is a new geographic record and confirms the virus is present in all the Great Lakes.

5.2.2 Bacteria

Acute/Healing Skin Ulcerations – German data show prevalence in flounder ranged from 0.8 % (western Gulf of Finland) to 8.5 % (outside Gulf of Gdansk). Polish data (subdivisions 25 and 26) indicate that in flounder, prevalence increased from 0.2% in 2008 to 1.4%. In the Russian EEZ (subdivision 26), prevalence increased to 2.2%, compared to 0.7% (2008) and 0.2% (2007). Differences in prevalence among country reports may be explained by differences in sample composition resulting from seasonal or gear effects. In dab, prevalence in Liverpool Bay (Irish Sea) declined from 15% in 2008 to 5.4%. Data from dab collected off Flamborough (North Sea) shows ulcer prevalence to have increased to 6.5 % since 1993. The prevalence in herring in the Gulf of Finland (Baltic Sea) ranged from 0.0 % to 1.2 %.

***Francisella* sp.** – Observed in one cod from Mecklenburg Bight in the southwestern Baltic Sea with macroscopic liver lesions and confirmed using immunohistochemistry.

5.2.3 Parasites

Crustacea – Copepoda

Tracheliastes maculatus – Increasing prevalence on bream from the Curonian Lagoon (subdivision 26) from 18.3% (2007) to 26% (2009).

Lepeophtheirus pectoralis – Prevalence in dab was highest in the Irish Sea, showing an increase from 2007 and 2008, and reaching 68% in Morecambe.

Sphyrion lumpi – Decreasing prevalence in deep-water redfish from Barents Sea has been observed since 1991.

Myxozoa

Tetracapsuloides bryosalmonae **–** The organism was reported for the first time in wild salmon in Sweden. Prevalence in two northern populations, determined by using real-time PCR, was 43% (n=30) and 35% (n=31).

Nematoda

Anisakis simplex **(larvae) –** A mathematical model estimating prevalence in southern Baltic herring has indicated an upward trend in year effect since 2007. However in the intensity model, a declining trend in year effect in has been calculated since 2001. In capelin, prevalence increased from 8% (n=100) to 76% (n=100) between 2002 and 2009.

Red Vent Syndrome (RVS) – The condition associated with A. simplex larvae was reported for the first time in adult salmon from 10 randomly selected rivers in Norway. Red vents were also found in adult salmon in Norway without associated *A. simplex* larvae. In Scotland, a mean prevalence of 43% was a significant increase compared with 12% observed in 2008.

Trematoda

Diplostomidae – *Diplostoma* sp. was reported for the first time in herring from the Gulf of Finland by macroscopic examination. Prevalence ranged from 0.0 % to 5.5 % and tended to increase eastward in the Gulf. The prevalence of "black spot" disease (*Posthodiplostomum cuticola* mc) in bream from the Curonian Lagoon (subdivision 26), parasitic cataract (aetiological agents: *Diplostomum spathaceum* mc and *Tylodelphys clavata* mc) decreased from 20.8% and 2.7%, respectively in 2008 to 14.7% and 1.2%, respectively in 2009.

5.2.4 Other Diseases

Eye pathologies – In capelin from the Barents Sea, prevalence decreased from 9.0% (n=1089) in 2008 to 0.2% (n=9168) in 2009. Similar lesions were found in fingerlings of cod and polar cod. While the aetiology was not clear, the eyes were grossly red and there was evidence that the colour was associated with a microsporidian infection.

Hyperpigmentation – A very low prevalence (3.7%) in dab from the German Bight was observed in Aug./Sept. Prior to 2007 prevalences in excess of 50% were recorded at this site. The condition is now most prevalent, approximately 49% in 2008 and 2009, in sites on or around the Dogger Bank. A similarly high prevalence (35.8%) has been noted at another North Sea site off Flamborough. A prevalence of 4.2% was observed at Rye Bay (English Channel), which is the highest recorded from that area.

Liver nodules – Compared with previous years a high prevalence of liver nodules > 2 mm was recorded in flounder from sampling sites in the Baltic Sea off the Lithuanian coast (9.0 %) and outside the Gulf of Gdansk, Poland, (5.5 %) in Aug./Sept. 2009. In dab, the prevalence again decreased in Red Wharf Bay (Irish Sea) from 15.3% in 2008 to 6.4%. A continuing general downward trend in prevalence is apparent in the North Sea with prevalence at Dogger Bank stations reaching a maximum of 4.8%. The highest prevalence in the North Sea was 7% at Amble off the northeast coast of England. In contrast, Irish Sea stations recorded prevalences between 5.5% and 6.4%, which were higher compared with previous years. A prevalence of 25.9% recorded in south Cardigan Bay was much higher than observed in previous years.

Toxic Algae – The prevalence of gill, liver and kidney lesions in bream from the Curonian Lagoon (subdivision 26) probably associated with toxic cyanobacteria blooms, was 26.0% compared to 34.3% in 2008.

5.2.5 Conclusions

1) The prevalence of lymphocystis in dab from the German Bight was the lowest ever recorded in that area.

2) Viral Haemorrhagic Septicemia Virus has been identified for the first time in Lake Superior, USA in several fish species without associated mortalities.

3) *Tetracapsuloides bryosalmonae* was diagnosed for the first time in two populations of salmon in northern Sweden.

4) Eye pathologies observed in Atlantic and polar cod appeared to be associated with a previously undescribed pathogen.

5) *Francisella* sp. was reported for the first time in cod from the southwestern Baltic Sea.

5.2.6 Recommendations

ICES WGPDMO recommends that:

i) ICES Member Countries continue 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. OSPAR Coordinated Environmental Monitoring Programme (CEMP), HELCOM). Data generated according to established ICES and BEQUALM guidelines should be submitted to the ICES Data Centre.

ii) Fish disease monitoring data be used in evaluating the effects of disease on population dynamics, provide essential baseline data to serve as a reference prior to establishment of the culture of marine species, and to better understand pathogen interactions between wild and farmed fish.

iii) WGPDMO develop standards and guidelines for consistent reporting of diseases in the WGPDMO National Reports. WGPDMO Members are encouraged to provide information on diseases in wild fish using the new standards and guidelines.

iv) ICES Member Countries that do not have fish disease monitoring programmes, seriously consider making a commitment to long-term monitoring of fish diseases. The WGPDMO regrets that Scotland has discontinued a 21-yr fish disease monitoring programme and urges the country to reconsider this decision, particularly in light of the pending OSPAR CEMP requirement for countries to perform wild fish disease monitoring.

v) WGPDMO members undertake intersessional studies to understand the aetiology of the novel red eye pathologies observed in gadoids from the Barents Sea.

5.3 Farmed Fish

5.3.1 Viruses

Infectious Pancreatic Necrosis (IPNV) – In Norway, the number of outbreaks in salmonids has increased to 222 from 158 in 2008. In contrast, clinical IPN has declined in Scotland, possibly because of the widespread use of a commercial vaccine.

Infectious Salmon Anaemia Virus (ISAV) – detected for the first time in Prince Edward Island, Canada in Atlantic salmon maintained in freshwater at a land-locked facility. No signs of disease were observed in any of the fish sampled. Sequence data indicated this was a new strain of the North American genotype. In Norway, the number of outbreaks in Atlantic salmon decreased from 17 (2008) to 10 (2009). Six sites were confirmed positive in the Shetland Islands (Scotland).

Pancreas disease (PD) – In Norway, the number of outbreaks in salmonids decreased from 108 (2008) to 73 (2009), which is the first reduction in the number of outbreaks since 2002.

Viral nervous necrosis (VNN) – was diagnosed in 1 cod farm in Norway in 2009, a reduction from 3 farms in 2008.

5.3.2 Bacteria

Aeromonas salmonicida* subsp. s*almonicida – In Finland, the number of outbreaks increased to 6 farms compared with 2 farms in 2008. Rainbow trout, whitefish and sea trout were affected.

***Francisella* sp.** – In Ireland, the first occurrence of *Francisella philomiragia* subsp. *noatunensis* was recorded in farmed cod at a pump-ashore facility. Typical pathology but no significant mortalities were observed. The infected fish were the progeny of wild stock caught in the south east of Ireland (Waterford), indicating a likely source of the infection. In Norway, a decreasing trend in the number of outbreaks from 14 (2008) in 2008 to 8 (2009) was because several cod farms have closed mainly due to francisellosis.

Moritella viscosa – In Norway, ulcerations in salmonids associated with the bacterium were observed at 36 locations, a decrease from 51 locations in 2008. The outbreaks occurred mainly in Atlantic salmon (n=34), and also in rainbow trout (n=2).

This represents the second year with a reduction in *M. viscosa* outbreaks and could be due to vaccination and improved management.

Yersinia ruckeri – In Finland, a decreased in the number of outbreaks in rainbow trout in the Archipelago Sea (Baltic Sea, Finland) to 19 from 25 in 2008. Outbreaks (n=15) were also observed in farmed whitefish and were caused by biotype 2. There were 4 outbreaks in farmed rainbow trout and whitefish caused by biotype 1 strains.

5.3.3 Parasites

Microsporidia

Desmozoon lepeophtherii - The etiological agent for the new disease found in farmed Atlantic salmon at the Norwegian west coast in 2008 and 2009 was determined to be *Desmozoon lepeophtherii* (syn. *Paranucleospora theridion*). The parasite has a two-host life cycle (salmon lice and salmon) and includes 2 distinct developmental cycles in salmon, 1 in the internal organs and 1 in epithelial cells.

Myxozoa

Parvicapsula pseudobranchicola – In Norway, the number of outbreaks in salmonids increased from 29 in 2008 to 34.

Henneguya zschokkei – In Finland, up to 50 % of farmed whitefish were infected in the Baltic Sea. Severely infected fish cannot be distributed to the market due to the large number of cysts in the muscle.

Crustacea – Copepoda

***Lepeophtheirus salmonis* –** In Norway, the mean number of salmon lice per farmed salmonids increased threefold in 2009 compared with 2008. Significant losses due to sea lice were reported for salmon farms in Cobscook Bay (USA), despite the use of emamectin benzoate (EMB) in the feed and pre-treatment of smolts. In Canada bio-assays showed virtually complete resistance of salmon louse to EMB on Atlantic salmon. Because of an absence of new treatments, infections are now also being treated with other previously used chemicals (e.g. Excis, deltamethrin, azamethiphos). However there is good evidence that in some regions, salmon lice have developed resistance to most classes of treatments.

5.3.4 Other Diseases

Toxic algae – In Denmark, all Atlantic salmon (12 – 15 tonnes) and 30% of rainbow trout (7.2 tonnes) died in early spring at one sea farm in the Kattegat. The fish had been held in seawater over winter. The cause was identified as *Pseudochattonella farcimen*. Cod and whitefish in net cages in the same area were not affected.

5.3.5 Conclusions

1) In Norway, Pancreas Disease outbreaks in salmon decreased for the first time since 2002.

2) In Norway, IPN outbreaks in salmon increased reaching the highest level since 2002.

3) In Norway, *Flavobacterium psychrophilum* has been isolated from salmonids at several marine farms in 2008 and 2009.

4) In Ireland, *Francisella philomiragia* subsp. *noatunensis* occurred for the first time in cod.

5) In Norway, a new disease found in farmed Atlantic salmon was determined to be caused by the microsporidian *Desmozoon lepeophtherii* (syn. *Paranucleospora theridion*) which also occurs in the salmon louse.

6) In Finland, *Henneguya zschokkei* was a significant problem in whitefish farming in the Baltic Sea. Severely affected fish cannot be distributed to the market due to the large number of cysts in the muscle.

7) In Norway, the mean number of salmon lice per farmed salmonid increased compared with 2008 and losses were reported for salmon farms in Cobscook Bay (USA), despite treatment. There is good evidence that salmon lice have developed resistance to most classes of treatments.

8) In Denmark, mortalities in cultured salmon and rainbow trout maintained over-winter in seawater at one site, were caused by the toxic algae, *Pseudochattonella farcimen*.

5.3.6 Recommendations

ICES WGPDMO recommends that:

i) WGPDMO 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 using the new standards and guidelines.

5.4 Wild and farmed molluscs and crustaceans

5.4.1 Viruses

Herpes viruses in bivalves - In France, abnormal mortality outbreaks have been reported in Pacific oysters, affecting all oyster producing areas. Most of the mortality events were observed during spring and summer and mainly in oysters less than 18 months old. Mortality rates were particularly high (from 30 to 100%). PCR confirmed the presence of OsHV-1 in 57 of 61 analysed batches (93%). The mortalities were attributed to a combination of adverse environmental factors together with the presence of a newly described genotype of OsHV-1 μVar (first reported during the mortalities in France in 2008) and bacteria of the genus *Vibrio* (see Bacteria section below). In 2008 both the "reference" OsHV-1 genotype and the newly described genotype were identified during the mortalities however in the 2009 batches analysed to date (n=33) only the OsHV-1 μVar could be detected.

In Ireland, mortalities ranging from 15% - 100% were also reported in 16 bays. Investigation into the mortalities showed that the OsHV-1 μVar was present in 15 of these bays. A large proportion of the oyster spat deployed in Ireland is imported from France and it is likely that the OsHV-1 μVar was introduced into Ireland with the spat. This represents a significant increase in the number of outbreaks from 2008 when only 3 bays were affected.

High mortalities were also reported in all oyster growing areas in Jersey in the Channel Islands. Two samples were found to be 100% identical to the new variant OsHV-1 μVar .

5.4.2 Bacteria

Vibrio spp. - In France, during the massive mortalities which were reported in Pacific oysters in all oyster producing areas (see Viruses section above), *Vibrio splendidus* was detected in 27 of the 59 analysed batches (45 %) and *Vibrio aestuarianus* was reported in 5 of 59 batches (8%). *Vibrio harveyi* was detected in 2 of 59 batches (3.3%) and *Vibrio tapetis* in 5 of 59 batches (8.5%).

In Ireland, *V. splendidus* and V. aestuarianus were also identified in some of the samples from sites with increased mortalities. However investigation of other areas not affected by mortality showed that whilst OsHV1 μVar was absent in these sites, *V. splendidus* and *V. aestuarianus* could be detected.

5.4.3 Parasites

***Bonamia ostreae* in flat oysters** - In France, following the detection of *Bonamia exitiosa* in 2008, a survey of flat oyster was conducted in several areas (Rance estuary, Morbihan Gulf, Penthièvre, Aix, and Fos) to determine whether *B. ostreae* or *B. exitiosa* were present. Of the 700 individuals analysed by histology, 93 were determined to be positive for *Bonamia* sp. All 79 positive samples examined to date by using PCR-RFLP have been found to contain *B. ostreae*. In Norway, *B. ostreae* was detected for the first time in wild flat oysters sampled in 2008. However there was no evidence of the infection in subsequent samples collected from the same site in 2009.

Marteilia refringens - *Marteilia refringens* type M was found in 5/30 specimens collected from one blue mussel farm in a targeted surveillance programme in Swedish waters.

Paramarteilia - The infection was found in 2/30 spider crabs (*Maja squinado)* from Cardigan Bay, UK, representing a new host record for *Paramarteilia (*cf *canceri*). Parasites were found in several organs and tissues associated with a limited haemocyte response.

Haplosporidium edule - Reported in 7/4500 cockles from the Burry inlet, Wales (UK) by histological observation with molecular confirmation.

Minchinia tapetis - Reported in 1/4500 cockles examined from the Burry inlet, Wales (UK) by histological observation with molecular confirmation. This finding represents a new host and locality record for the parasite.

***Perkinsus* sp.** - Reported in 1/270 cockles from the Dee estuary, north Wales (UK) by histological observation only. This represents a new locality records for *Perkinsus* sp.

Quahog Parasite X (QPX) in the hard clam *Mercenaria mercenaria* - An outbreak occurred in May 2009 in a relatively low-salinity (< 25 ppt) culture site, representing the first occurrence of QPX in Chesapeake Bay (USA). Prevalences of 60% with substantial mortality were reported among cultured clams at one site in the bay. The source of the outbreak is not known, though transplantation of infected clams into a previously QPX-free high-density culture environment is suspected. Salinities during the epizootic were around 20 ppt, and subsequent experimentation indicated that clams with existing infections continued to experience QPX-associated disease and mortality for several weeks at salinities as low as 15 ppt.

5.4.4 Other Diseases

Mortality of *Crassostrea gigas* - Two cases of increased mortality were investigated in Scotland; a 5% loss at one site was attributed to adverse weather conditions. Spawning and stress through movements accounted for a 20% loss at another site.

Mortality of cockles - An unusual mortality of cockles from the Dee estuary in North Wales (UK) in summer 2009 was attributed to a combination of heavy *Parvatrema minutus* infection coupled with a heavy settlement of barnacle larvae on the shells of cockles; affected cockles were unable to completely close their shells leading to death.

Intersex - In a study carried out in 2008 at three sampling sites in the area of the North Sea island of Norderney (Lower Saxony, Germany), ovotestis (development of oocytes within the testes) was found to occur in the sand gaper, representing a new location for the condition in this species. This may indicate the impact of contaminants at these sites.

Algae-like organisms – In Sweden, algae-like organisms were found with associated cellular infiltration in the mantle of wild blue mussels during the survey for marteiliosis near the Norwegian border.

5.4.5 Conclusions

1) A newly described genotype of ostreid herpesvirus 1, called OsHV1 µVar, was detected in *Crassostrea gigas* in France, Ireland and the Channel Islands in association with high mortalities.

2) Marteiliosis (*Marteilia refringens*) has been found in farmed blue mussels in Sweden. This is the first finding of the disease in northern Europe.

3) New host record for *Minchinia tapetis* in cockles from the Burry Inlet (Wales), UK

4) Burry Inlet, Wales (UK) was a new locality record for *Haplosporidium edule* in cockles.

5) Spider crabs *Maja squinado* from Cardigan Bay, Wales (UK) was a new host record for *Paramarteilia* (cf *canceri*).

6) *Bonamia ostreae* was detected for the first time in Norway, in wild European oysters (*Ostrea edulis*).

5.4.6 Recommendations

ICES WGPDMO recommends that:

i) The WGPDMO develop 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.

ii) In case of abnormal mortality events, standardised methods for the collection and diagnosis of samples should be adopted.

6 Provide an update on results of ongoing histopathological studies on organs other than the integument (e.g. eye, thyroid gland, pituitary) in hyperpigmented common dab (*Limanda limanda*) from the North Sea (ToR c)

A draft paper describing the histological features of the condition, efforts to detect an aetiological agent and results from long-term observation of affected dab held under controlled conditions was presented by S. Feist.

6.1 Background Information

During May/June 2007 dab, representing different categories of pigment abnormality, were sampled for laboratory investigations. Samples for bacteriological assessment from skin and kidney revealed the occasional presence of *Vibrio vulnificus*, which was not considered to be significant. No differences in bacterial flora were detected between normal and hyperpigmented dab. Virological testing proved negative in all groups. Histological examination confirmed previous reports that the major differences were primarily in the dermis and due to mild to severe hyperplasia of chromatophores namely melanophores and iridophores. While in the normal pigmented fish melanophores were frequently observed in clusters in the upper dermis, a feature generally lost in hyperpigmented fish with loose melanin granules recorded in the dermis. Melanophores are also more likely to be seen in the epidermis on hyperpigmented fish and iridophores became more conspicuous in the higher pigmented categories. A greater degree of dermal infiltration was observed in fish in which hyperpigmentation was more pronounced suggesting an active immune response, but it was not possible to link hyperpigmentation to any infectious agent. An apparent higher rate of detachment of the epidermis was also recorded in higher pigmented animals but due to the method of capture, mechanical damage cannot be discarded. No differences in the histological description were seen among sampling stations. Examination of other tissues and organs, including liver, spleen, kidney, gonad, gill, brain, heart, intestine and eye did not reveal significant lesions associated with the presence of hyperpigmentation. Affected dab kept in laboratory facilities for 18 months did not show any changes in their original pigment patterns. A manuscript documenting this research is in preparation for peer-reviewed publication (Noguera *et al*. in prep).

Following discussion a number of other factors which may be of relevance to understanding the pathogenesis of the condition were identified. It was noted that there was indication of fatty acid imbalance in cultured fish exhibiting pigment anomalies which suggests that there may be a dietary component involved. Since the condition has variable prevalence depending on geographical region (i.e. most prevalent in the central North Sea compared with the Irish Sea dab populations), the possibility of differential susceptibility according to the genetic distinctiveness between the dab populations could also be important.

6.2 Conclusions

1) From the results presented, there is no evidence of an infectious aetiology associated with hyperpigmentation in dab.
2) Further work is required on genetic characterisation of dab populations and on differences in diet in dab from different regions in the North Sea and Irish Sea.

6.3 Recommendation

ICES WGPDMO recommends that:

1) Further field and laboratory investigations into effects of genetic characteristics and diet in dab are undertaken in order to identify relationships with the prevalence and intensity of hyperpigmentation.

6.4 Reference

Noguera, P. A., Feist, S., Lang, T., Baumgart, F., and Bruno, D. W. 2010. Investigation into hyperpigmentation in the common dab *Limanda limanda* in the northern North Sea. In preparation.

7 Provide a detailed review of information on disease-associated population effects of commercial and non-commercial fish and shellfish species (ToR d)

Selected WGPDMO members have reviewed the information on population effects associated with diseases in commercial and non-commercial fish and shellfish species. The draft paper, entitled "Disease-associated population effects in commercial and non-commercial marine fish and shellfish species" will be prepared for publication in a peer reviewed journal. The draft document was presented by the lead author (T. Lang).

7.1 Background Information

Pathogens are frequently reported from populations of aquatic animals. Variations in the frequency and abundance of pathogens can be shown to depend on spatial or temporal factors including those related to effects such as age or condition. The development of a disease is a function of the combined effects of the pathogen, host and environment. Diseases may be an important and relatively overlooked explanatory factor for host population changes. The draft paper presents an overview of documented cases of population effects associated with diseases in wild marine fishes and crustaceans. Cases involving bivalves and gastropods will also be included as previously planned. The report will provide information on the types of diseases, together with data on causative agents, diagnostic criteria, geographical ranges and effects at the indidual and population level. It was agreed that the paper would focus on documented cases of infectious disease effects and that contaminant-induced non-infectious disorders would not be considered.

During the WGPDMO discussion T. Renault informed the group about available information on bivalve and gastropods diseases, mainly viral, causing significant effects at the population level. Selected bivalve and gastropod infectious diseases will be included in the document. It was further decided to include a section on the effects of M74 Syndrome in Baltic salmon. A. Alfjorden and T. Renault will be included as co- authors.

Several additional points for inclusion in the paper were identified and discussed:

- The importance of 'low level' chronic infections and disease occurrence in juvenile fish will be emphasised as potentially significant factors affecting recruitment to adult populations.

- Recognition of the combined effects in cases of mixed infections (a normal occurrence in wild fish) in addition to effects related to environmental variables.
- Discussion on the principles of disease ecology currently applied to wild terrestrial animals and their applicability for marine fish models.
- Consideration of a section dealing with the socio-economic impact of disease in the marine environment.

7.2 Recommendation

ICES WGPDMO recommends that:

1) WGPDMO members work intersessionally to complete the draft manuscript on disease effects in populations.

8 Provide a review of population dynamics and epidemiological models that are, or can be, used for assessing the impacts of diseases on fish and shellfish populations (ToR e)

T. Lang provided a review of papers specifically dealing with this topic. Examples were given for models that have been developed and applied in order to identify causes or to quantify population effects of diseases in wild finfish and shellfish. The compilation selected key papers and is partly based on information already contained in the 2009 WGPDMO report. In addition, some examples derived from analysis of disease occurrence in 'closed systems' (in experiments and aquaculture facilities) were included. The examples given below provide an indication of the breadth of published studies, which include fish and shellfish and a range of pathogens.

8.1 Paper 1: Deriso *et al.* (2008)

A framework is provided for evaluating the cause of declines in the stock of Pacific herring (*Clupea pallasi*) in Prince William Sound, Alaska, USA, by integrating covariates into a fisheries stock assessment model. This allowed the evaluation of the effects of fisheries vs. natural and other human impacts. The results revealed that multiple factors influence populations and that analysis of factors in isolation can be misleading.

8.2 Paper 2: Gauthier *et al.* (2008)

Epidemiological models were developed to estimate disease-associated mortality in striped bass (*Morone saxatilis*) from Chesapeake Bay (USA) from cross-sectional prevalence data that have been generalized to represent disease processes more realistically. Recent stock assessments in Chesapeake Bay indicate that non-fishing mortality in striped bass has increased since 1999, concomitant with a very high (> 50%) prevalence of visceral and dermal disease caused by *Mycobacterium* spp.

8.3 Paper 3: McCallum *et al.* (2005)

A deterministic model of microparasitic infection in a fishery with a reserve (= protected area) was used to investigate equilibrium yield and parasite prevalence inside and outside the reserve as a function of three control variables: the proportion of habitat inside the reserve, fishing mortality and the rate of interchange between the stock and the reserve. While the model is generic, it was parameterized with values that may be appropriate to the interaction between abalone and *Rickettsia* sp. The findings indicated that the presence of a pathogen did not necessarily decrease yield when a reserve is present, particularly if the rate of movement of adult hosts between stock and reserve is low.

8.4 Paper 4: Mellergaard and Spangaard (1997)

A simple model was applied to estimate the annual mortality caused by the internal parasite *Ichthyophonus hoferi* in Atlantic herring (*Clupea harengus*) in the years 1991 to 1993 in the waters around Denmark based on prevalence data, estimates of life expectancy (derived from infection experiments) and on the assumption that the infection is lethal for all infected fish. Annual mortality in the different areas was estimated at 12.8 to 36% in 1991, decreasing to a few percent in 1993. According to ICES stock assessment data, the spawning stock biomass of North Sea herring was reduced by 50% during the period 1990 to 1995 and the authors speculate that this reduction may have been due to a combination of increased fishing intensity and the general effect of the *I. hoferi* epizootic.

8.5 Paper 5: Murray (2008)

Existing and potential modelling approaches in the control and prevention of disease emergencies affecting wild and farmed aquatic animals are reviewed. Modelling has been or can be applied in relation to preventing disease outbreaks from occurring, efficient surveillance to allow appropriate management intervention, controlling the spread of disease (subdivided into Susceptible-Infected-Removed [SIR] models, coupled hydrodynamic-particle transport models and network models) and evaluating the consequences of outbreaks. The author concludes that import risk analysis and SIR modelling have been applied fairly extensively and that risk-based surveillance is likely to be a driver for increased modelling effort in the near future.

8.6 Paper 6: Patterson (1996)

A model of disease dynamics was developed to assess the impact of the outbreak of *I. hoferi* in North Sea herring. Rates of infection by the disease and mortality rates of infected fish were estimated from field observations of prevalence, relative abundance, and commercial catches. At the height of the outbreak infection rates and mortality rates were about 0.4 $year^{-1}$ and 1.5 $year^{-1}$, respectively. Parameterization of infection rate as a year-class and age effect was more complex and did not provide a better fit than a year and age parameterization. The impact of *I. hoferi* on the North Sea herring stock was estimated to be significant but not catastrophic. Had the outbreak not occurred (but with catches being the same), the stock size would have been some 21% higher in 1994. Had the outbreak not occurred (but with fishing mortality being the same), the stock would have been 11% higher in 1994 and the catches from 1991 to 1994 would have been 9.6% higher.

8.7 Paper 7: Powell *et al.* (2008)

A 54-y survey time series for the Delaware Bay, New Jersey (USA) was evaluated to identify the characteristics of regime shifts in the populations of eastern oyster (*Crassostrea virginica*) and the influence of MSX and Dermo diseases on population stability. Natural mortality was low in most years prior to the appearance of MSX in 1957. From 1957 through 1966, natural mortality generally remained above 10% annually and twice exceeded 20%. Natural mortality remained well below 15% during the 1970s and into the early 1980s when oyster abundance was continuously high. The largest mortality event in the time series, an MSX epizootic that resulted in the death of 47% of the stock, occurred in 1985. Mortality rose again with the outbreak of Dermo in 1990 and has remained above 15% for most years since that time and frequently has exceeded 20%.

8.8 Paper 8: Reno (1998)

Reno (1998) reviewed the principles of epizootiology relating to the dissemination, dynamics, distribution, and control of infectious diseases in populations, with an orientation toward those that may come into play in fish populations. Among the factors that have been shown to be important are the ''contagiousness'' of the pathogen (transmission coefficient, b), duration of infection, host population density, development of immunity, and efficacy of therapeutants. These factors have been used in models assessing the dynamics of diseases in wild and captive fish populations.

8.9 Conclusions

1) Disease modelling in wild fish and shellfish populations is an effective tool for the assessment of impacts at the population level.
2) The best approach to understanding the role of disease would be to use existing stock assessment models which are able to incorporate additional factors, including disease, pathogen burdens and pathology.
3) There is a clear requirement for continued disease monitoring to provide the necessary data for developing effective models.
4) This ToR has direct relevance to the ongoing WGPDMO work developing a paper on 'Disease associated population effects in commercial and non-commercial marine fish and shellfish species' currently in preparation (see ToR d this report).

8.10 Recommendation

ICES WGPDMO recommends that:

1) Member countries establish programmes facilitating the collection of disease data concurrently with traditional stock assessment data to permit the evaluation of the population effects of disease in fish and shellfish.

8.11 References

Deriso, R. B., Maunder, M. N., and Pearson, W. H. 2008. Incorporating covariates into fisheries stock assessment models with application to Pacific herring. Ecological Applications, 18(5): 1270–1286.

Gauthier, D. T., Latour, R. J., Heisey, D. M., Bonzek, C. F., Gartland, J., Burge, E. J., and Vogelbein, W. K. 2008 Mycobacteriosis-associated mortality in wild striped bass (*Morone saxatilis*) from Chesapeake Bay, USA. Ecological Applications, 18(7): 1718–1727.

McCallum, H., Gerber, L., and Jani, A. 2005. Does infectious disease influence the efficacy of marine protected areas? A theoretical framework. Journal of Applied Ecology, 42: 688–698.

Mellergaard, S., and Spanggaard, B. 1997. An *Ichthyophonus hoferi* epizootic in herring in the North Sea, the Skagerrak, the Kattegat and the Baltic Sea. Dis Aquat Org., 28: 191–199.

Murray, A. G. 2008. Existing and potential use of models in the control and prevention of disease emergencies affecting aquatic animals. Rev. sci. tech. Off. int. Epiz., 27(1): 211–228.

Patterson, K. R. 1996. Modelling the impact of disease-induced mortality in an exploited population: the outbreak of the fungal parasite *Ichthyophonus hoferi* in the North Sea herring (*Clupea harengus*). Can J Fish Aquat Sci., 53: 2870–2887.

Powell, E. N., Ashton-Alcox, K. A., Kraeuter, J. N., Ford, S. E., and Bushek, D. 2008. Long-term trends in oyster population dynamics in Delaware Bay: regime shifts and response to disease. Journal of Shellfish Research, 27(4): 729–755.

Reno, P. W. 1998. Factors involved in the dissemination of disease in fish populations. Journal of Aquatic Animal Health, 10: 160–171.

9 To provide advice on OSPAR request 2010/3: 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 (ToR j)

S. Jones provided background information on the OSPAR request on effects of mariculture on populations of wild fish directed to the WGPDMO and to three other relevant ICES EGs under the new ICES SCICOM Steering Group on Human Interactions on Ecosystems (SGHIE): WG on Environmental Interactions of Mariculture (WGEIM), WG on North Atlantic Salmon (WGNAS) and WG on Application of Genetics in Fisheries and Mariculture (WGAGFM). The WGPDMO was requested to provide information on the current state of knowledge on effects on the condition of wild fish populations from parasite interactions between farmed and wild fish. He briefly summarised the contents of an OSPAR report assessing the impact of mariculture (OSPAR 2010) that raised a number of unresolved questions, leading to the requested advice from ICES.

A document entitled 'The effects of interactions of parasites from mariculture on the condition of wild fish populations: implications of future growth in mariculture' with S. Jones, T. A. Mo and D. Bruno as co-authors had been prepared intersessionally (Annex 6) and was presented to the WGPDMO by S. Jones. The report largely focuses on salmon lice on Atlantic and Pacific salmon because most information available on parasite interactions between farmed and wild fish has been generated in relation to the salmon lice issue. Besides background information on parasites in mariculture and on sea lice in particular, issues highlighted in the report are the management of salmon lice in salmon farms, the evidence of mariculture-derived salmon lice infections in wild salmonids and the evidence of impacts to wild salmonids on the individual and population levels. The report further provides a framework for qualitative risk assessments and a number of conclusions and recommendations. In the discussion of the report, a number of issues were raised by WGPDMO:

9.1 Population effects

Despite the efforts to understand the complex interactions between sea lice and wild and farmed fish there is so far comparatively little information available on effects on populations of wild salmonids, e.g., on the relative contribution of the parasite interactions to the decline in the stock of Atlantic salmon.

9.2 Complex disease interactions

In order to better understand the complex disease interactions between salmon lice and its host species, studies on the role of salmon lice as vectors for other diseases (including sea lice pathogens and hyperparasites) and on the effects of salmon lice on the vulnerability of infected fish to other diseases should be encouraged and supported.

9.3 Resistance to chemotherapeutants

There is evidence of increasing resistance of sea lice to chemotherapeutants used in aquaculture. At the same time, potential environmental effects of the chemical compounds in use have caused serious concern. The WGPDMO, therefore, emphasised the need to develop effective and environmentally safe therapeutants and vaccines, to implement mariculture management strategies reducing sea lice infections and to develop technical measures, including barriers between farm cages and the environment, that minimise the risk of disease transmission and toxic environmental effects.

9.4 Risk assessment

The examples of risk assessment matrices provided in the report are considered as a useful tool for assessing the risk associated with parasite interactions between farmed and wild fish, e.g., in relation to the salmon louse problem. However, they need to be adapted to the questions asked and the local conditions in the area to be assessed. A prerequisite for conducting a reliable risk assessment is the availability of appropriate data.

9.5 Research and Monitoring

The report on parasite interactions largely focuses on salmon lice in salmon, mainly because of the availability of data from studies driven by the economical significance of sea lice infections in salmon mariculture and the perceived impacts to wild salmon. However, the WGPDMO emphasised that information required to assess the impact of sea lice on other susceptible wild host species such as sea trout (*Salmo trutta*) and Arctic char (*Salvelinus alpinus*) is largely lacking. Furthermore, in light of the globally expanding mariculture, there is a risk that similar problems may increasingly occur in other farmed fish (salmonids and non-salmonids) and shellfish species and for other diseases and parasites. Therefore, more research and monitoring programmes addressing interactions between farmed and wild species are urgently needed and should be supported in ICES member countries.

9.6 Conclusions

Salmon mariculture in the northern hemisphere is associated with salmon lice infections. Infections among the cultured stock can become severe and lead to serious skin lesions when left untreated. Management practices routinely involve surveillance and treatment when necessary to control infections. There is evidence that salmon louse infections are elevated within populations of wild salmon that occur in the proximity of salmon mariculture. There is also evidence from some regions that these management actions are reflected in reduced salmon louse infections on the wild salmon. However, with the information available, it is not possible to conclude with confidence that these elevated salmon louse infections have or have not had a measurable effect on the abundance of wild salmon populations.

1) There is considerable information concerning management of salmon lice in mariculture. However, further expansion of salmon mariculture in coastal habitats shared by wild salmon in some regions will further increase the prevalence and intensity of salmon louse infections on the wild

salmonids. This risk is largely related to the absence of local salmon production thresholds, resistance of salmon lice to existing medications in many regions leading to treatment failures, and the absence in many regions of long-term systematic monitoring programmes for salmon lice on juvenile salmonids.

2) Most evidence of parasite interactions between farmed and wild fish was obtained from studies on salmon lice in salmon. However, in light of the globally expanding mariculture industry, it can be expected that similar problems may occur in other farmed fish and shellfish species and with other diseases and parasites. However, comprehensive risk assessments cannot be made at present due to lack of information. Further research and monitoring studies are urgently needed.

9.7 Recommendations

ICES WGPDMO recommends that:

i) In order to reduce the risk of sea lice interactions between farmed and wild fish, ICES member countries establish salmon mariculture production thresholds, based on capacity to produce salmon louse larvae, in coastal ecosystems presently or potentially occupied by salmon mariculture.

ii) ICES member countries encourage and support the development of hydrodynamic and particle tracking modelling studies of coastal ecosystems presently or potentially occupied by salmon mariculture and other types of mariculture.

iii) ICES member countries support the development of measures to reduce the risk associated with salmon lice interaction between farmed and wild fish by developing novel efficient and environmentally-safe therapeutants, vaccines and technical measures such as barriers between farms and the environment.

iv) ICES member countries should establish and maintain systematic monitoring programmes of salmon lice on salmonids in coastal areas with, or likely to have, salmon mariculture.

v) In light of the expanding mariculture industry, ICES member countries should enhance research and monitoring activities addressing interactions between other fish and shellfish species and other diseases and parasites, including potential population effects.

9.8 References

OSPAR Commission. 2009. Assessment of impacts of mariculture. OSPAR Biodiversity Series: 63 p.

10 Provide an update on the progress achieved in the implementation of the Fish Disease Index (FDI) and the related assessment procedures in marine monitoring and assessment programmes, and review results of the application of the FDI approach on other fish species for which data are available in the ICES Environmental Database (ToR f)

A working document prepared by T. Lang and W. Wosniok for the 2009 ICES/OSPAR Workshop on Assessment Criteria for Biological Effects Measurements (WKIMC), Aberdeen, UK, 14-16 October 2009, was presented by T. Lang (ICES 2009a). It summarises the components of the Fish Disease Index (FDI) approach, describes progress made regarding its implementation in the OSPAR Coordinated Environmental Monitoring Programme (CEMP) and suggests some modifications in its assessment component in order to meet OSPAR requirements regarding the establishment of assessment criteria.

10.1 The fish disease index (FDI) approach

Since 2006, the WGPDMO has been developing a strategy to analyse and assess fish disease data by applying the Fish Disease Index approach (ICES 2008, 2009b). The FDI approach was developed with the primary aim to analyse and assess long-term changes in spatial and temporal patterns in the overall disease status of the common dab (*Limanda limanda*), the main target species for fish disease monitoring in the OSPAR area. The FDI is constructed in a way that it can easily be adapted to disease data from other fish species (e.g., flounder, cod).

The FDI summarises data on the prevalence of a variety of common diseases affecting the fish (3 categories: externally visible diseases, macroscopic liver neoplasms, liver histopathology), as well as their severity grades and effects on the host, into a robust numerical value calculated for individual fish and, as mean values, for representative samples from a population. It further accounts for effects of size, sex and sampling season on the disease prevalence. Changes in mean FDI values over time indicate changes in the disease status within a population of fish in certain geographical monitoring areas.

Changes in mean FDI values are assessed by geographical monitoring area in two ways: (a) a statistical comparison of the mean FDI level recorded in an observation period to the mean level recorded in a consecutive assessment period (ideally, both periods would consist of 10 observations within 5 years each) and (b) a statistical trend test in the assessment period. Both assessments generate information on changes in the disease status of the fish population in the specific areas assessed (e.g., ICES statistical rectangles) that can be visualised on maps using a traffic light system.

A major characteristic of the FDI approach is that the assessments criteria are based on data recorded in the area under study and that, hence, the assessment does not require fixed ambiguous universal background levels (BAC) or environmental assessment criteria (EAC) comparable to those often used in the assessment of contaminant levels. The definition of such universally applicable BAC or EAC for fish disease data is considered as problematic since there is considerable natural variation in disease prevalence on a regional and temporal scale (in particular for the externally visible diseases monitored). As described above, the FDI assessment is based on the existence of long-term prevalence data (ideally 10 years) from regular fish disease monitoring that have to be generated according to standard guidelines. However, it can be adapted to shorter time intervals. For the assessment of data from one-off surveys or from newly established disease monitoring programmes, other assessment strategies have to be applied.

10.2 ICES fish disease data

ICES maintain a fish disease database which is part of the ICES Data Centre-Environment Data. Member Countries running regular fish disease monitoring programmes according to ICES and BEQUALM (Biological Effects Quality Assurance in Monitoring Programmes) standard guidelines submit their data on a regular basis. At present, there are data on more than 600,000 dab from areas in the North Sea and adjacent areas, partly covering a period of almost 30 years. In addition, data on diseases of flounder and cod have been submitted.

Based on OSPAR requests, the WGPDMO, in 2008 and 2009, carried out FDI assessments of the disease data for the common dab maintained in the ICES fish disease database which is part of the ICES Data Centre-Environment Data (ICES 2008, 2009a). Main conclusions from these assessments were that (a) the FDI approach can successfully be applied and generates information on significant changes in the disease status of dab populations and (b) there are sufficient ICES data on externally visible diseases but only limited data on macroscopic liver neoplasms and no data at all on liver histopathology.

At its 2010 meeting, the WGPDMO reviewed the current status of the fish disease data submission to ICES and noted that some new submissions have been made since the 2009 meeting for externally visible diseases and macroscopic liver lesions. However, data on liver histopathology are still lacking. It was indicated though that submission of such data will occur soon (see Section 11 on ICES Data Centre). There was consensus that new data assessment using the FDI approach will be carried out once a substantial amount of new data has been submitted. The application of the FDI for other fish species (flounder and cod) relevant for OSPAR and HELCOM monitoring, will further be developed.

10.3 OSPAR and fish disease monitoring and assessment

The monitoring and assessment of fish diseases in flatfish (common dab, *L. limanda*, and flounder, *P. flesus*) according to ICES and BEQUALM guidelines are part of the general and the PAH-specific biological effects components of the OSPAR pre-CEMP (CEMP: Coordinated Environmental Monitoring Programme). At present, fish diseases surveys are still carried out by OSPAR contracting parties on a voluntary basis because assessment criteria developed have not yet been finally adopted by OSPAR (a prerequisite for assigning a mandatory status to wild fish disease monitoring within the CEMP).

In 2009, Germany proposed that the FDI was formally adopted as an assessment tool as well as to change the status of the monitoring of externally visible fish diseases, macroscopic liver neoplasms and liver histopathology from a voluntary to a mandatory component of the CEMP. At its 2009 meeting, OSPAR ASMO decided not to adopt the FDI index for the time-being, as some contracting parties expressed reservations with regard to the adoption of the fish disease criteria as a formal assessment tool at the current time. But contracting parties were encouraged to undertake monitoring of liver neoplasms and liver histopathology and submit data to the ICES fish disease database in line with the pre-CEMP requirements. It was further decided to organise a joint ICES/OSPAR workshop which was held in 2009 with the task to further develop assessment criteria for biological effects of contaminants, including fish disease aspects (see below).

10.4 Modifications of the FDI approach

During the ICES/OSPAR Workshop on Assessment Criteria for Biological Effects Measurements (WKIMC), 14–16 October 2009, Aberdeen, Scotland, some modifications to the assessment component of the FDI approach were proposed (ICES 2009a).

The original FDI approach differs from the OSPAR assessment strategy for other indicators (for example biomarkers and contaminants) in that it does not apply universally applicable assessment criteria (BAC, EAC; see above) and therefore does not fully meet the OSPAR requirements. However, some suggestions were made at the workshop to develop such assessment criteria for fish disease data as an addition to the original FDI approach:

- The fish disease data assessment can be carried out in a two-tiered approach. For contaminant specific biological effects, the assessment focuses on macroscopic liver neoplasms and contaminant-specific liver histopathology, using information on externally visible diseases and non-specific liver histopathology as additional information (see Table 9.1). For general biological effects, the assessment focuses on externally visible diseases, non-specific liver histopathology, macroscopic liver neoplasms and contaminant-specific liver histopathology. For this purpose, the original disease category liver histopathology is split into two new categories, namely non-specific liver histopathology and contaminant-specific liver histopathology.
- The two-tiered assessment approach is carried out on the basis of the original FDI approach. For liver neoplasms and contaminant-specific liver histopathology, the additional use of defined assessment criteria (AC) for 'elevated responses/above background' and for 'significant responses/unacceptable effects' are proposed (see Table 9.1).
- The AC proposed for macroscopic liver neoplasms is defined based on the methodological sampling guidelines and as being equivalent to a prevalence of 2 % (one fish out of a sample of 50 fish examined is affected by a macroscopic liver tumour). The AC for the FDI is set to a value of 2. Until further information is available, no distinction is made regarding the AC for 'elevated responses/above background' and for 'significant responses/unacceptable effects' (see Table 9.1).
- The AC proposed for contaminant-specific liver histopathology is defined accordingly in case of the occurrence of liver tumours, but is calculated slightly differently for the occurrence of non-neoplastic lesions. The AC for the FDI is set to a value of 2. Until further information is available, no distinction is made regarding the AC for 'elevated responses/above background' and for 'significant responses/unacceptable effects' (see Table 9.1).
- For both AC, mathematical transformations of the FDI values are required that still need to be developed.
- Ways to develop AC for externally visible disease still have to be explored. Due to the strong natural variation of disease prevalences (see above), it is felt that the development of BAC for externally visible diseases is not feasible.

- The AC for 'background' (equivalent to a BAC) in relation to macroscopic liver neoplasms and for contaminant-specific liver histopathology is set to FDI values of < 2 (see Table 9.1).

These modifications do not only offer the advantage that they are more consistent with the OSPAR assessment strategy for contaminants and biomarkers, but also that they allow the assessment of results from one-off surveys and from newly established fish disease monitoring programmes.

10.5 Table 9.1: Criteria proposed for the assessment of contaminant-specific effects on fish health (criteria for the elevated response/above background and the significant/unacceptable effects levels are identical since no distinctions can be made, the colour "red" should be used for their graphical representations in maps or similar illustrations; see explanations in the text) (from: ICES (2009) Report of the ICES/OSPAR Workshop on Assessment Criteria for Biological Effects Measurements (WKIMC))

Disease category	Background	Elevated response/ above background	Significant response/ unacceptable effects
Externally visible diseases (to be used as additional information for the assessment)	Not applicable	Statistically significant increase in mean FDI level in the assessment period compared to a prior observation period or Statistically significant upward trend in mean FDI level in the assessment period	Statistically significant increase in mean FDI level in the assessment period compared to a prior observation period or Statistically significant upward trend in mean FDI level in the assessment period
Liver histopathology: non-specific (to be used as additional information for the assessment)	Not applicable	Statistically significant increase in mean FDI level in the assessment period compared to a prior observation period or Statistically significant upward trend in mean FDI level in the assessment period	Statistically significant increase in mean FDI level in the assessment period compared to a prior observation period or Statistically significant upward trend in mean FDI level in the assessment period
Liver histopathology: contaminant-specific	Mean FDI < 2	Mean FDI ≥ 2 A value of FDI = 2 is, e. g., reached if the prevalence of liver tumours is 2 % (e. g., one specimen out of a sample of 50 specimens is affected by a liver tumour). Levels of FDI ≥ 2 can be reached if more fish are affected or if combinations of other toxicopathic lesions occur.	Mean FDI ≥ 2 A value of FDI = 2 is, e. g., reached if the prevalence of liver tumours is 2 % (e. g., one specimen out of a sample of 50 specimens is affected by a liver tumour). Levels of FDI ≥ 2 can be reached if more fish are affected or if combinations of other toxicopathic lesions occur.

Macroscopic liver neoplasms	Mean FDI < 2	Mean FDI ≥ 2 A value of FDI = 2 is reached if the prevalence of liver tumours (benign or malignant) is 2 % (e. g., one specimen out of a sample of 50 specimens is affected by a liver tumour). If more fish are affected, the value is FDI > 2.	Mean FDI ≥ 2 A value of FDI = 2 is reached if the prevalence of liver tumours (benign or malignant) is 2 % (e. g., one specimen out of a sample of 50 specimens is affected by a liver tumour). If more fish are affected, the value is FDI > 2.

10.6 Conclusions

1) The WGPDMO regretted that the OSPAR Committee did not adopt the FDI approach formally as official OSPAR strategy, the result being that fish disease monitoring is still not mandatory in OSPAR countries.

2) The WGPDMO appreciated the work done over the past years to develop the Fish Disease Index approach and the related assessment procedure as well as the efforts to establish assessment criteria meeting OSPAR requirements. It strongly emphasised that the modified assessment procedure has to be seen as a combination of the original FDI approach with the OSPAR assessment criteria approach.

3) Further work is needed to define and discriminate elevated response/above background from significant response/unacceptable effects as well as to develop and establish the modified assessment criteria. WGPDMO should therefore revisit the issue at its 2011 meeting.

4) As there is only little new data available in the ICES fish disease database (dab, flounder, cod), no new assessment applying the FDI approach were made. However, such assessment should be made as soon as new data become available and results should be reviewed at the 2011 WGPDMO meeting.

5) The ICES fish disease database should be updated with new data submitted by ICES Member Countries on a regular basis. In addition, data on confirmed cases of macroscopic liver neoplasms and liver histopathology available in national databases should be incorporated into the ICES database. It is essential that laboratories submitting disease data to ICES apply ICES standard methodologies and take part in existing quality assurance programmes (BEQUALM: Biological Effects Quality Assurance in Monitoring Programmes).

10.7 Recommendations

ICES WGPDMO recommends that:

i) OSPAR notes the progress made in the modification of the Fish Disease Index assessment approach and adopts the Fish Disease Index and the related assessment procedures as formal assessment strategy/criteria for the OSPAR Coordinated Environmental Monitoring Programme (CEMP);

ii) The ICES fish disease database is updated with new data submitted by ICES Member Countries on a regular basis and in a timely fashion. Efforts should be made in particular to submit data on confirmed cases of macroscopic liver neoplasms and liver histopathology that are available in national databases but are so far largely lacking in the ICES database. It is essential that laboratories submitting disease data to ICES apply ICES standard methodologies and take part in existing quality assurance programmes (BEQUALM: Biological Effects Quality Assurance in Monitoring Programmes);

iii) The WGPDMO further develop the assessment criteria and revisit the issue at its 2011 meeting. If substantial new data submissions have been made, a new assessment should be carried out intersessionally, also for species other than the common dab.

10.8 References

ICES. 2008. Report of the Working Group on Pathology and Diseases of Marine Organisms (WGPDMO), 4–8 March 2008, Galway, Ireland. ICES CM 2008/MCC:01. 128 pp.

ICES. 2009. Report of the Working Group on Pathology and Diseases of Marine Organisms (WGPDMO), 24–28 February 2009, Riga, Latvia. ICES CM 2009/MCC:01. 119 pp.

ICES. 2010. Report of the ICES/OSPAR Workshop on Assessment Criteria for Biological Effects Measurements (WKIMC), 14–16 October 2009, Aberdeen, Scotland, UK. ICES CM 2009/ACOM:50. 239 pp.

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

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

S. Feist, Series Editor, gave an update on progress during the last year regarding the leaflets which provide a diagnostic summary for diseases and parasites of fish and shellfish in the North Atlantic Ocean and adjacent seas. Fifty-six lea flets are currently available on the ICES website: http://www.ices.dk/products/idleaflets.asp. In addition to the four new leaflets previously proposed, discussions during this meeting led to the proposal for a new leaflet on hyperpigmentation in dab. The proposed new leaflets are listed below.

No.	Title	Lead author
No. 57	Gonadal neoplasia in bivalves	T. Renault
No. 59	Brown ring disease in clams	C. Paillard
No. 60	Juvenile oyster disease	S. Ford
No. 61	Liver neoplasia in flatfish	S. Feist
No. 62	Hyperpigmentation in dab	T. Lang

11.2 Other publications

A manuscript entitled: "Disease-associated population effects in commercial and non-commercial marine fish and shellfish species" (by Lang *et al.*), exists in draft version and will be submitted for publication upon completion.

A manuscript entitled "Histopathology of mussels (*Mytilus* spp.) for health assessment in biological effects monitoring" (by Bignell *et al.*), is in preparation and will be submitted to the ICES Techniques in Marine Environmental Science Series (TIMES).

A manuscript describing the Fish Disease Index (FDI) and its assessment procedures is in preparation and will be submitted to the ICES TIMES series (by W. Wosniok and T. Lang).

11.3 Recommendations

ICES WGPDMO recommends that:

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

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

The WGPDMO reviewed information provided by the ICES Data Centre on recent disease data submissions and on some related issues. The summary as follows was provided by T. Lang.

12.1 Recent data submissions and related issues

It was noted that some new disease data submissions were made since the 2009 WGPDMO meeting. However these were incomplete (not all countries submitted new data) and were restricted to externally visible diseases and macroscopic liver neoplasms (liver nodules > 2 mm). So far, no data on liver histopathology of flatfish have been submitted and, therefore, the data could not be analysed and assessed using the Fish Disease Index (FDI) approach (see Agenda Item 10). The WGPDMO strongly emphasised that all data available should be submitted in a timely fashion and that Member Countries should more strongly commit themselves to do so. It was once more pointed out that the ICES disease database represents a unique tool to assess long-term changes in the health status of wild marine fish species with great potential for ecosystem health assessments under OSPAR, HELCOM and in the context of the EU Marine Strategy Framework Directive. This, however, requires the availability of current and complete datasets. It was pointed out that part of the reasons for OSPAR ASMO - at its 2009 meeting - not to formally adopt the Fish Disease Index (FDI) approach as assessment criteria for the OSPAR Co-ordinated Environmental Monitoring Programme (CEMP) was that data on liver histopathology and macroscopic liver neoplasms were lacking in the ICES database and that, therefore, a full assessment of the disease status as requested by OSPAR could not be made (see Section 10).

The ICES Data Centre has repeatedly offered to publicise disease assessment results carried out by WGPDMO in an appropriate manner on its website and make it, thus, widely available. Such products should be of interest to WGPDMO because they would reflect WGPDMO's activities in relation to wild fish disease monitoring. Together with the ICES Data Centre, the WGPDMO should develop such products. However, this also requires the availability of current disease data in the ICES database.

A practical question raised by WGPDMO concerned the submission of additional data for fish that have already been included in previous submissions. For instance: Is it possible to supplement disease data already existing in the ICES database with new information, e.g., biomarker data from the same fish without having to resubmit the entire data-set?

ICES requested input from WGPDMO on the new ICES quality assurance database that will allow storage of intercalibration participation results derived from QUASIMEME and other intercalibration organisations such as BEQUALM. In addition, it will store reference material standard values. These QA data will then be linked to the monitoring data in DOME to allow automated proficiency checks of analytical laboratories during assessments. As regards proficiency assessment, the WGPDMO request the possibility to pass/fail a laboratory based on the results of the BEQUALM intercalibration exercises with the ability to change following remedial action. A pass/fail system is only needed for disease categories (externally visible diseases, macroscopic liver neoplasms and liver histopathology) and not for single diseases. Cut-off points have been defined through BEQUALM and by WGPDMO (see section 16.2 of the 2009 WGPDMO report). Fish disease intercalibration reports and examples of participation results from relevant intercalibrations requested by ICES for Data Centre consideration will be submitted by the responsible BEQUALM lead laboratory Cefas.

12.2 Conclusions

1) The WGPDMO appreciated the long-term efforts of the ICES Data Centre with regard to the establishment of the ICES fish disease database and associated quality assurance procedures. It further appreciated the repeated offer of the ICES Data Centre to help publicising results of disease data assessments through appropriate products on the ICES website. Contacts between WGPDMO and the ICES Data Centre will be made in order to accomplish this.

2) It was once more noted with concern that the disease data available in national institutes conducting regular wild fish disease monitoring surveys have not yet completely been submitted to ICES. This is mainly true for data on macroscopic liver neoplasms and even more so for liver histopathology, for which data are so far completely lacking. However, it was indicated by WGPDMO members that submissions will soon occur.

12.3 Recommendations

ICES WGPDMO recommended that

i) ICES Member countries submit their wild fish disease data generated according to ICES standard guidelines available in their national databases to the ICES Data Centre in order to facilitate a more comprehensive analysis and assessment of spatial patterns and trends in the health status of wild fish by applying the Fish Disease Index (FDI) approach.

ii) WGPDMO (T. Lang, W. Wosniok, and S. Feist) makes contact with the ICES Data Centre in order to develop appropriate web-based products, providing results of fish disease data assessments to a wider audience in an easy-to-communicate way.

iii) ICES clarify the questions regarding the addition of new data for disease datasets already existing in the ICES database.

13 Report to SSGHIE on plans to promote cooperation between EGs covering similar scientific issues (ToR k)

13.1 Conclusions

To facilitate cooperation among ICES Expert Groups it was proposed that the WGPDMO Chair would make contact with the Chair of WGCRAB and other relevant

Expert Groups (e.g. WGEIM, WGAGFM, WGNAS, WGMME) to ensure they were aware of WGPDMO expertise on fish and shellfish disease issues.

14 Other business

14.1 Working group procedures

The WGPDMO continued to work in a paperless environment as first adopted for the 2007 meeting. The presentation of the reports, subsequent discussion and modifications were carried out electronically. The chair reminded members who have agreed to assist in the preparation of working documents of their responsibilities to complete these tasks in advance of the Working Group meeting.

14.2 Additional Presentations

Prof. A. Kiessling of the Norwegian University of Life Sciences in Oslo and the Swedish University of Agriculture in Umeå, gave a presentation to the WGPDMO entitled ``Why do fish grow?``. The presentation reviewed research results on the physiology of salmonid skeletal muscle during growth, activity and spawning and stimulated some discussion.

14.3 Publication of working documents

The WGPDMO discussed the merits of adopting fewer, but more important terms of reference, which would provide a greater opportunity and incentive to commit more time to intersessional work. A benefit of this more focused effort would include the possibility of publishing these documents in peer-reviewed literature.

15 Progress on tasks

Progress of 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 14.1 provides more information on items completed and those which require further action. Several intersessional tasks to be fulfilled prior to the 2009 WGPDMO meeting were identified.

Table 14.1 Progress on tasks of WGPDMO's Terms of Reference for 2009.

	TERM OF REFERENCE	STATUS
a	Produce a report on new disease trends in wild and cultured fish, molluscs and crustaceans, based on national reports	On-going task; will be revisited in 2011 as part of ToR a.
b	Produce standards and guidelines for reporting fish and shellfish diseases to the WGPDMO;	This task was deferred.
c	Provide an update on results of ongoing histopathological studies on organs other than the integument (e.g. eye, thyroid gland, pituitary) in hyperpigmented common dab (Limanda limanda) from the North Sea	Task completed. Furthered updates will be provided in country reports.
d	Provide a detailed review of information 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 review of population dynamics and epidemiological models that are, or can be, used for assessing the impacts of diseases on fish and shellfish populations	Task complete. Results of the review will be incorporated into the intersessional work in support of population effects.
f	Provide an update on the progress achieved in the implementation of the Fish Disease Index (FDI) and the related assessment procedure in marine monitoring and assessment programmes, and review results of the application of the FDI approach on other fish species for which data are available in the ICES Environmental Database	Ongoing task. Assessment criteria for FDI will be further developed and the task will be revisited in 2011 as part of ToR d.
g	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;	This task was deferred.
h	Provide an update on the status of ICES publications on pathology and diseases of marine organisms	On-going task; will be revisited in 2011 as part of ToR f
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 2011 as part of ToR g
j	To provide advice on OSPAR request 2010/3: 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	Task complete. Future activities will focus on marine species in ToR b
k	This strategic initiative is currently being planned and suggestions from EGs on their engagement in the SICMSP are sought.	Task withdrawn by ICES.
l	Report to SSGHIE on plans to promote cooperation between EGs covering similar scientific issues	Task complete.

16 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 2011 to consider the results of intersessional work, and to discuss new disease trends and new and outstanding items. The next meeting is planned for Lagnaro, Italy, during 1–5 March 2011. In addition, WGPDMO members are encouraged to consider theme sessions for future ICES Annual Science Conferences.

17 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 2011 WGPDMO meeting are appended in Annex 8.

18 Approval of draft WGPDMO report

A rough draft of the 2010 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.

19 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 2010 WGPDMO meeting was closed at 12:30 hrs on 27 February 2010.

Annex 1: List of participants

NAME	ADDRESS	PHONE/FAX	EMAIL
Anders Alfjorden	National Veterinary Institute, Sweden Department of Animal Health and Antimicrobiotics Division of Fish S-75189 Uppsala Sweden	+46 186 74000 (Institute) +46 186 74044 (Institute) +46 18 674 191 +46 70 3747 665	anders.alfjorden@sva.se
Deborah Cheslett	Marine Institute Rinville Oranmore County Galway Ireland	+353 91 387249 +353 91 387201	deborah.cheslett@marine.ie
Natalia N. Chukalova	Laboratory of Parasitology and Fish Diseases, Atlantic Research Institute of Marine Fisheries and Oceanography, 5, Dm. Donskoy Str., 236022 Kaliningrad, Russia	+7 4012 925 369 +7 4012 219 995	chukalova@atlant.baltnet.ru; chukalova@gmail.com
Stephen W. Feist	Cefas Weymouth Laboratory Barrack Road The Nothe Weymouth Dorset DT4 8UB UK	+44 1305 206600 +44 1305 206601	stephen.feist@cefas.co.uk
Anders Hellström	National Veterinary Institute, Sweden Department of Animal Health and Antimicrobiotics Division of Fish S-75189 Uppsala Sweden	+46 1867 4000 +46 1830 9162	anders.hellstrom@sva.se
Simon R.M. Jones (Chair)	Department of Fisheries and Oceans Pacific Biological Station 3190 Hammond Bay Road Nanaimo, British Columbia V9T 6N7 Canada	+1 250 729 8351 +1 250 756 7053	simon.jones@dfo-mpo.gc.ca
Tatjana Karaseva	Knipovich Polar Research Institute of Marine Fisheries and Oceanography 6, Knipovich str., 183038 Murmansk, Russia	+7 8152 47 33 62 +7 8152 47 33 31	karaseva@pinro.ru
Thomas Lang	Johann Heinrich von Thűnen Institute, Federal Research Institute for Rural Areas, Forestry and Fisheries, Institute of Fisheries Ecology, Deichstrasse 12 D-27472 Cuxhaven Germany	+49 4721 38034 +49 4721 53583	thomas.lang@vti.bund.de

Lone Madsen	Technical University of Denmark National Veterinary Institute Division of Veterinary Diagnostics and Research Stigbøjlen 4 DK-1870 Frederiksberg C Denmark	+45 3533 2763	lm@aqua.dtu.dk
Tor Atle Mo	National Veterinary Institute PO Box 8156 DEP N-0033 Oslo Norway	+47 2321 6110	tor-atle.mo@vetinst.no
Vidar Öresland	Institute of Marine Research Box 4 S-453 21 Lysekil Sweden	+46 523 18734 +46 523 13977	vidar.oresland@fiskeriverket.se
Magdalena Podolska	Sea Fisheries Institute Gdynia ul. Kollataja 1 Pl-81-332 Gdynia Poland	+48 587356225 +48 587356110	bilbo@mir.gdynia.pl
Tristan Renault	IFREMER Laboratoire de Génétique et Pathologie, La Tremblade, 17390 France	+33 5 46762649 +33 5 46762611	trenault@ifremer.fr
Henrike Seibel	Research and Technology Centre (FTZ) Hafentoern 1 25761 Buesum Germany	+49 4834 604 128 +49 4834 604 128	seibel@ftz-west.uni-kiel.de
Tom Wiklund	Åbo Akademie University, Laboratory of Aquatic Pathobiology, Artillerigaten 6, 20520, Åbo, Finland	+358 2 215 4301	twicklund@abo.fi

Annex 2: 2009 Terms of Reference

The **Working Group on Pathology and Diseases of Marine Organisms** [WGPDMO] (S. Jones, Chair) met 23-27 February 2010 at the National Veterinary Institute, Uppsala, Sweden, to:

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

b) produce standards and guidelines for reporting fish and shellfish diseases to the WGPDMO;

c) provide an update on results of ongoing histopathological studies on organs other than the integument (e.g. eye, thyroid gland, pituitary) in hyperpigmented common dab (*Limanda limanda*) from the North Sea;

d) provide a detailed review of information on disease-associated population effects of commercial and non-commercial fish and shellfish species;

e) provide a review of population dynamics and epidemiological models that are, or can be, used for assessing the impacts of diseases on fish and shellfish populations;

f) provide an update on the progress achieved in the implementation of the Fish Disease Index (FDI) and the related assessment procedure in marine monitoring and assessment programmes, and review results of the application of the FDI approach on other fish species for which data are available in the ICES Environmental Database;

g) 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;

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) Effects of mariculture on populations of wild fish (OSPAR request 2010/3);

k) Report to SSGHIE on plans to promote cooperation between EGs covering similar scientific issues;

WGPDMO will report by 20 April 2010 (via SSGHIE) for the attention of SCICOM and ACOM.

Supporting Information

Priority	High: The development of the Fish Disease Index has also increased the interest of HELCOM of developing the index into an assessment tool.
Scientific justification and relation to action plan	**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)** Under the new ICES structure, the WGPDMO will report to the SciCom which has many members unfamiliar with wild and farmed fish/shellfish disease issues and methodologies. The WGPDMO will review and, as necessary, develop standards and guidelines for improving the consistency with which data are presented and interpreted. (S. Jones, S. MacLean, V. Őresland, A. Alfjorden, L. Madsen) **Term of Reference c)** Hyperpigmentation has continued to increase in the common dab (Limanda limanda) populations in the North Sea. Since this topic was not fully addressed during the 2009 meeting, there remains a need for further information on pathology associated with hyperpigmentation other than the integument (e.g. eye, thyroid gland, pituitary, liver, spleen, gonad) in order to assess potential causes or effects of the condition. (S.W. Feist, D. Bruno, T. Lang) **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 2009 could not be addressed in a sufficient way, the WGPDMO recognizes a need to revisit the issue at its 2010 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. (T. Lang, S.W. Feist, S. Jones, S. Ford, W. Wosniok, V. Öresland, S. MacLean, L. Madsen) **Term of Reference e)** 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 2009 could not be addressed in a sufficient way, the WGPDMO recognizes a need to revisit the issue at its 2010 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. (W. Wosniok, T. Lang, S.W. Feist, M. Podolska) **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. 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). Progress achieved at the 2009 WGPDMO meeting will be reviewed by an ICES Review Group. Based on the outcome of the Review

	Group and the subsequent advice provided by the ICES Advisory Committee, the OSPAR Environmental Assessment and Monitoring Committee (ASMO) will consider the formal adoption of the FDI approach at its meeting in April 2009. The WGPDMO wishes to be informed of the results of the deliberations and the progress made regarding the adoption of the FDI approach. 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 2009 WGPDMO meeting due to the insufficient data available so far in the ICES Environmental Database. (W. Wosniok, T. Lang, M. Podolska) **Term of Reference g)** 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. (S. Jones, S. MacLean, S. Ford) **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) **Term of Reference j)** This is an OSPAR request 2010/3. Background: The scale of cultivation of both fish and shellfish species in coastal waters of the OSPAR area continues to increase. In some countries, the value of aquaculture products exceeds that from wild capture fisheries. Aquaculture is currently concentrated in coastal waters. taking advantage of the sheltered conditions available there, and also in response to other practical economic and engineering factors, such as accessibility for operators and to downstream processing facilities, and the difficulty and cost of maintaining structures in open water offshore areas. Some of the environmental interactions of coastal aquaculture operate on very local scales. These include enrichment of the seabed by waste feed and faeces, or the potential toxic effects of used chemicals such as medicines and antifoulants. These generally can be regulated through local licensing and consenting systems. However, other forms of environmental interactions have the potential to have influence over rather larger areas. A number of these concern wild fish populations. Examples include the pressure on wild stocks to provide raw materials (fish protein and lipid) for pelleted diets for farmed fish, interbreeding of escaped farmed fish with wild stocks reducing their fitness, and the more direct stress arising from the possible transfer of parasites of farmed to wild stocks (notably sea lice from farmed salmon to wild salmon and sea trout) and consequent impacts on wild populations. (S. Jones, T-A. Mo, D. Bruno). **Term of Reference k)** Collaboration across EGs is encouraged and may be facilitated by e.g. inviting EG chairs and/or key members to attend meetings of your EG, and to use teleconferencing and videoconferencing as means to engage participants remotely. (S. Jones)
Resource requirements	None required other than those provided by the host institute.
Participants	The Group is normally attended by 20–25 representatives of ICES Member Countries and guests with expertise in pathology and diseases of marine organisms.

Secretariat facilities	Required to a limited extent for data and publication issues.
Financial	No financial implications.
Linkages to advisory committees	ACOM
Linkages to other committees or groups	WGBEC, WGNAS, WGMAFC, WGMASC, WGEIM
Linkages to other organizations	BEQUALM, OIE, EU, OSPAR, HELCOM

Annex 3: Working documents distributed prior to the meeting

	2007 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 reporyts;	WGPDMO2010_Poland_NatlReport	1/26/10
		WGPDMO2010_Norway_NatlReport	2/4/10
		WGPDMO2010_UK_NatlReport	2/4/10
		WGPDMO2010_France_NatlReport	2/5/10
		WGPDMO2010_Ireland_NatlReport	2/5/10
		WGPDMO2010_USA_NatlReport	2/9/10
		WGPDMO2010B_Finland_NatlReport	2/10/10
		WGPDMO2010_Sweden_NatlReport	2/11/10
		WGPDMO2010_Scotland_NatlReport	2/12/10
		WGPDMO2010_Denmark_NatlReport	2/16/10
		WGPDMO2010_Canada_NatlReport	2/17/10
		WGPDMO2010_Russia_NatlReport	2/17/10
		WGPDMO2010_Netherlands_NatReport	2/17/10
		WGPDMO2010_Germany_NatlReport	2/18/10
b)	Produce standards and guidelines for reporting fish and shellfish diseases to the WGPDMO		
c)	Provide an update on results of ongoing histopathological studies on organs other than the integument (e.g. eye, thyroid gland, pituitary) in hyperpigmented common dab (Limanda limanda) from the North Sea		
d)	Provide a detailed review of information on disease-associated population effects of commercial and non-commercial fish and shellfish species	WGPDMO 2010 ToR d Population Effects V3	2/19/10
e)	Provide a review of population dynamics and epidemiological models that are, or can be, used for assessing the impacts of diseases on fish and shellfish populations		
f)	Provide an update on the progress achieved in the implementation of the Fish Disease Index (FDI) and the related assessment procedure in marine monitoring and assessment programmes, and review results of the application of the FDI approach on other fish species for which data are available in the ICES Environmental Database	WGPDMO 2010 ToR f Fish Disease Index	2/18/10
g)	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		
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	ICES data summary Gross Disease	2/4/10
		Update from ICES Data Centre	2/18/10

	2007 WGPDMO Terms of Reference	Working document (file)	Posted on SharePoint
j)	To provide advice on the current state of knowledge on the interaction of finfish mariculture on the condition and wild fish populations (both salmonid and non-salmonid) both at a local and regional scale, including from parasites, escaped fish and the use of fish feed in mariculture. Advice is requested on how the interactions will change as a result of an expansion of mariculture activities.	WGPDMO 2010 ToR j Parasite Effects	2/19/10
k)	Report to SSGHIE on your plans to promote cooperation between EGs covering similar scientific issues		
	Announcement of ASC 2010 Session F: Monitoring biological effects and contaminants in the marine environment		2/16/10

Annex 4: Agenda

1) Opening of the meeting

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

3) ICES Annual Science Conferences 2009 and 2010

3.1) 2009 ASC Theme Session Q

3.2) 2010 ACS Theme Session F: Monitoring biological effects and contaminants in the marine environment

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 an update on results of ongoing histopathological studies on organs other than the integument (e.g. eye, thyroid gland, pituitary) in hyperpigmented common dab (*Limanda limanda*) from the North Sea (ToR c)

7) Provide a detailed review of information on disease-associated population effects of commercial and non-commercial fish and shellfish species (ToR d)

8) Provide a review of population dynamics and epidemiological models that are, or can be, used for assessing the impacts of diseases on fish and shellfish populations (ToR e)

9) To provide advice on OSPAR request 2010/3: 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 (ToR j)

10) Provide an update on the progress achieved in the implementation of the Fish Disease Index (FDI) and the related assessment procedure in marine monitoring and assessment programmes, and review results of the application of the FDI approach on other fish species for which data are available in the ICES Environmental Database (ToR f)

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

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

13) Report to SSGHIE on plans to promote cooperation between EGs covering similar scientific issues (ToR l)

14) Any other business

15) Analysis of progress with tasks

16) Future activities of WGPDMO

17) Approval of Recommendations

18) Approval of draft WGPDMO Report

19) Closing of the meeting

Annex 5: Rapporteurs

Agenda Item(s)	2009 WGPDMO Terms of Reference	Rapporteurs
1-4	Introductory session	S.Jones
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, T. Karaseva T. Wiklund, A. Alfjorden, N. Chukolova D. Cheslett, L. Madsen, T. Renault
6	Provide an update on results of ongoing histopathological studies on organs other than the integument (e.g. eye, thyroid gland, pituitary) in hyperpigmented common dab (Limanda limanda) from the North Sea (ToR c)	S. Feist, D. Cheslett, T. Karaseva
7	Provide a detailed review of information on disease-associated population effects of commercial and non-commercial fish and shellfish species (ToR d)	T-A Mo, T. Renault
8	Provide a review of population dynamics and epidemiological models that are, or can be, used for assessing the impacts of diseases on fish and shellfish populations (ToR e)	S. Feist, V. Öresland
9	To provide advice on the current state of knowledge on the interaction of finfish mariculture on the condition of wild fish populations (both salmonid and non-salmonid) both at a local and regional scale, including from parasites, escaped fish and the use of fish feed in mariculture. Advice is requested on how the interactions will change as a result of an expansion of mariculture activities (ToR j)	T. Lang, V. Öresland
10	Provide an update on the progress achieved in the implementation of the Fish Disease Index (FDI) and the related assessment procedure in marine monitoring and assessment programmes, and review results of the application of the FDI approach on other fish species for which data are available in the ICES Environmental Database (ToR f)	L. Madsen, T. Lang
11	Provide an update on the status of ICES publications on pathology and diseases of marine organisms (ToR h)	M. Podolska, H. Seibel, T. Renault
12	Provide expert knowledge and advice on fish disease and related data to the ICES Data Centre on a continuous basis (ToR i)	T.A. Mo, T. Wiklund, N. Chukolova
13	Report to SSGHIE on your plans to promote cooperation between EGs covering similar scientific issues (ToR l)	S. Jones
14	Other business	S. Jones
15–19	Analysis of progress with tasks, future activities of WGPDMO, approval of recommendations, approval of draft report, closing of the meeting	S. Jones

Annex 6: Provide a review of the effects of interactions of parasites from mariculture on the condition of wild fish populations: implications of future growth in mariculture (ToR j)

Prepared by S. Jones, T.A. Mo and D. Bruno

Background

Since its 2009 meeting the WGPDMO along with three other ICES Expert Groups: WGEIM (Environmental Interactions of Mariculture), WGNAS (North Atlantic Salmon) and WGAGFM (Application of Genetics in Fisheries and Mariculture), all aligned in the new ICES structure under the SCICOM Steering group SGHIE (Human Interactions on Ecosystems) were tasked with a new term of reference: "Effects of mariculture on populations of wild fish". This request had been forwarded from OSPAR as request 2010/3. More detail on the request is found in Annex 2 of this report. The present working paper was developed to guide discussion during the meeting of the WGPDMO regarding parasite interactions between wild and cultured finfish.

Parasites in mariculture

Open netpen (sea cage) mariculture is associated with the emergence of parasitic infections in finfish (Kent, 2000; Kent and Poppe, 2002; Seng and Colorni, 2002; Sitjà-Bobadilla, 2004; Nowak, 2007). This emergence is related to factors associated with the netpen environment including the increased availability of susceptible hosts, often maintained at high densities. The free-flow of water through the netpen also provides access to intermediate hosts, potential contact with wild reservoir hosts and release of fish effluent (e.g. faeces, mucous) facilitating the maintenance of parasite life-cycles. In addition, biofouling of netpens may provide a substrate for the settlement of certain parasite stages or intermediate hosts (Sitjà-Bobadilla, 2004). It is also evident that relative to wild fish, netpen-reared fish are more accessible for the observation and surveillance of clinical signs and other evidence of disease. In addition to parasites, the relatively high density of fish typically held in netpens facilitates the transmission of viral and bacterial pathogens.

While it is acknowledged that parasite infections of cultured fish in open marine netpens initially derive from wild fish, there are very few data on infections in the wild reservoirs (Kent *et al*., 1998; Nowak, 2007). Several reasons exist for this paucity of information (Lester, 1984), but a significant factor is the difficulty of maintaining adequate funding to marine disease surveillance programmes. While the stock assessment of valuable species is a common practice among countries that support commercial fisheries, health data, including those associated with parasite infections, are rarely included. A consequence of this knowledge gap is the limit to which conclusions can be drawn regarding impacts to wild populations from parasites affecting cultured fish.

Sea lice

A notable exception to this knowledge gap is the occurrence of parasitic sea lice on salmon cultured in open netpens in the north-eastern and north-western Atlantic Ocean and on the coasts of North and South America bordering the Pacific Ocean. Sea lice are parasitic copepods belonging to the family Caligidae. The life cycle is direct and includes 3 stages that disperse in the plankton. Following settlement on the host, the parasite develops to maturity and begins to reproduce. The salmon louse, *Lepeophtheirus salmonis* is most commonly associated with maricultured salmon in the northern hemisphere whereas in Chile, the related parasite *Caligus rogercresseyi* is frequently observed on maricultured salmon. Regardless of species, the direct life cycle leads to high levels of infections among cultured stock which leads directly to disease or to a higher frequency of secondary infections (Costello, 2006). Costello (2009) noted that sea lice are the most significant parasitic pathogen in salmon farming in Europe and the Americas, with an estimated annual cost to the world industry of €300 million. Numerous controlled laboratory studies have confirmed that sufficiently intense salmon louse infections will cause morbidity and mortality in salmon (Wagner *et al*., 2008), however Todd *et al*. (2006) reported that wild Atlantic salmon in poor condition were not more likely to have high lice burdens. The abundance and frequent occurrence of this parasite, its widespread geographic distribution and ability to contribute to a progressive decline in fish health suggests that salmon lice derived from mariculture may be harmful to wild salmonids when infections exceed natural levels (OSPAR, 2009). The evidence for a relationship between the management of salmon lice in salmon mariculture and measurable impacts of salmon lice to the health of wild salmon populations was recently reviewed (Jones 2009). Other recent reviews of pathogen interactions between wild and mariculture populations include Raynard *et al*. (2007) and Revie *et al*. (2009). In addition, the ecology, host-parasite interactions, genetics, reproductive biology and economic impacts of salmon lice have been reviewed (Tully and Nolan, 2002; Boxaspen, 2006; Todd, 2007; Costello, 2009). The purpose of this paper is to review evidence associated with the measurable impacts of salmon lice salmon on wild salmon populations and the extent to which these are associated with mariculture. The basis of a qualitative risk analysis approach in assessing current and expanding mariculture activities is described.

Management of salmon lice on salmon farms

Outbreaks of salmon lice have been observed globally and appear to be an inevitable outcome of salmon mariculture (Johnson *et al*., 2004; Costello, 2006). Management of the infections has therefore been integrated into salmon husbandry in most jurisdictions. Within mariculture sites salmon lice are managed through systematic surveillance combined with the use of chemical treatments, applied either topically or in-feed (Rae, 2002). In addition, alternative non-chemical methods that seek to break the cycle of parasite transmission by alternately fallowing then stocking sites with a single year-class of salmon are also applied. A limited number of chemical compounds are available for use against salmon lice (Grave *et al*., 2004; Jones, 2009), and in some jurisdictions only some of these are licensed. Since 2001, emamectin benzoate, known commercially as Slice, has been used almost exclusively world-wide in the treatment of salmon lice. Reduced efficacy of emamectin benzoate was recently reported in Scotland (Lees *et al*., 2008) and Chile (Bravo *et al*., 2008) and there have been numerous anecdotal and governmental reports of its reduced efficacy from Norway, Ireland, eastern Canada and Scotland (Jones, 2009; Norwegian Food Safety Authority http://www.mattilsynet.no/). Historically, the tendency for widespread use of single classes of compounds had already led to resistance in salmon lice against other classes of compounds (Sevatdal *et al*., 2005). In the absence of new compounds with novel modes of action against salmon lice, ongoing opportunities for chemotherapeutic intervention will be limited. Consequently, practices for salmon lice control must adapt to include strategic rotations of existing compounds and the use of non-chemical methods, including integrated pest management (Brooks, 2009). Other approaches to salmon lice management such as selective salmon breeding for resistance or vaccination remain either experimental or impractical for wide-scale commercial applications. Salmon lice are controlled by cleaner wrasse at up to 40% of Norwegian production sites and the parasite is managed at some of these sites without additional chemical treatments (see Sayer *et al*., 1996).

Evidence for mariculture-derived salmon lice infections in wild salmonids

A higher occurrence of salmon lice on wild salmon collected from coastal areas with salmon mariculture is commonly cited as evidence that mariculture is a source of the infections. Thus salmon louse infections within wild sea trout (*Salmo trutta*) populations along Ireland's west coast suggested a spatial pattern of correlation with embayments containing louse-infected farmed salmon (Tully and Whelan, 1993; Tully *et al*., 1999). Similarly, surveys of sea trout and Arctic char (*Salvelinus alpinus*) showed higher prevalence and abundance of *L. salmonis* in areas of salmon farming compared with those captured in areas with little or no salmon farming activity (Bjørn *et al*., 2001; Bjørn and Finstad, 2002). Salmon lice were first reported on juvenile pink (*Oncorhynchus gorbuscha*) and chum salmon (*O. keta*) in 2003 in a region of coastal BC occupied by salmon mariculture and infections were found to be higher on fish caught near the mariculture operations (Morton and Williams, 2003; Morton *et al*., 2004). The latter observation was supported in a series of advection-diffusion-decay models, based on observations of infections on the wild juvenile salmon (Krkošek *et al*., 2005, 2006, 2007a). Other efforts to sample the same salmon populations found that spatial heterogeneity in salmon lice abundance was statistically related to fish size and time of collection (Jones *et al*. 2004, 2006, 2007). However, in neither the Canadian nor the Norwegian studies were salmon louse data from mariculture included in the analyses. Furthermore, salmon louse infection datasets from the wild populations longer than three or four years are rarely available, limiting an ability to verify any correlations.

Frazer (2009) postulated that a decline in lice numbers on wild fish could be reduced by short growing cycles for farm fish, medicating farm fish and keeping farm stocking levels low. Several studies conducted within Loch Torridon in Scotland provided the first convincing evidence of a quantitative relationship between louse productivity in mariculture and the density of infective salmon lice larvae in the water column (see Penston *et al*., 2009, and references therein). Furthermore, a series of hydrodynamic models provided the quantitative framework for understanding spatial and temporal aspects of this relationship (see Amundrud and Murray, 2009, and references therein). Taken together, there is compelling evidence that the risk of infection among wild salmon populations can be elevated in areas that support salmon mariculture. There is also evidence suggesting salmon louse management activities within mariculture reduce the prevalence and intensity of infection on the wild fish (Penston *et al*., 2009). Spatial and temporal aspects of this zone of elevated risk of infection will therefore be strongly dependent on local hydrological processes and on the management practices employed in mariculture. Recent efforts to model spatial variation in diseases recognises the connectivity or clustering that can occur among mariculture sites within coastal regions (Green, 2010). Pathogen connectivity among mariculture sites may reflect movements of water and wild fish (Uglem *et al*., 2009). The extent to which the elevated infections pose a risk to the health of wild salmon populations is uncertain and discussed below.

Evidence for Impacts to Wild Salmon

Individual Salmon: Controlled laboratory studies have shown that several parasite- and host-related factors contribute to the extent to which salmon lice infections are harmful to individual salmon. Thus, skin damage increases with the numbers of parasites and the stage of their development: preadult and adult stages are typically more harmful than immature stages. Similarly, susceptibility to the adverse effects of the infection decreases with host age or size and there are significant differences among host species. The impact of *L. salmonis* infection ranges from perturbations in ion-regulation, cortisol-mediated stress, reduced swimming performance up to death (Wagner *et al*., 2006). There is considerable evidence that natural resistance to salmon lice is greater in Pacific salmon compared with Atlantic salmon. This may also be related to the distinct genetic characteristics of the Pacific Ocean strain of *L. salmonis* (Yazawa *et al*., 2008). Pink salmon develop natural resistance to *L. salmonis* within weeks of entering the ocean (Jones *et al*., 2008).

Salmon Populations: A generally poor understanding of the factors influencing the survival of wild salmon in the ocean combined with an absence of long-term salmon louse data series presents a challenge to understanding the impacts of salmon lice. Furthermore, the inability to track individual salmon lice limits the extent with which causal relationships can be established between mariculture and wild populations. Despite this uncertainty, numerous jurisdictions have established strategies to minimize the dispersal of salmon lice from mariculture. Ireland, Norway and British Columbia (BC, western Canada) require treatment, harvest or other actions are undertaken when infections among cultured stock exceed proscribed thresholds. In addition, the results of monitoring and surveillance programmes are being made publically available, providing information that is useful in determining the effectiveness of the treatment programmes. In Ireland, salmon louse data have been collected from salmon mariculture and have been made public since 1994 (O'Donohoe *et al*., 2008). In Norway a National Action Plan against Salmon Lice on Salmonids (NA) was adopted in 1997 with a goal of minimizing the harmful effects of lice on farmed and wild salmonids. Salmon lice data derived from mariculture, aggregated by geographic zone, are publically available (http://www.lusedata.no/default.aspx) (Heuch *et al*., 2005). The Norwegian National Salmon Fjords Programme, in which salmon farming is limited to certain fjords or portions of fjords, appears to have mixed success possibly due to the small sizes of the protected areas (Bjørn *et al*., 2008). Many salmon farms in the Hardangerfjord have adopted a treatment threshold that is more stringent than the national requirement to compensate for higher infection pressures that may be because of the relatively high density of mariculture (K. Boxaspen, personal communication).

In Scotland, the Tripartite Working Group concept provides a framework for cooperation among government, wild salmon stakeholders and salmon mariculturists in the form of area management agreements (McVicar, 2004).

In BC, salmon mariculture began in the early 1980s and the systematic collection and reporting of sea lice data from farmed salmon has been undertaken since 2003 (Saksida *et al*., 2007). Salmon lice data from BC salmon farms, aggregated by zone are publically available (http://www.al.gov.bc.ca/ahc/fish_health/sealice_monitoring_results.htm). Krkošek *et al*. (2007) estimated that in the Broughton Archipelago of BC, mariculture-derived salmon lice will contribute to local extinction of pink salmon populations within four generations. However, infection levels on juvenile pink salmon in that region have been declining since 2004 and in 2008, were as low as those occurring in regions of the coast of BC without salmon mariculture (Jones and Hargreaves, 2009). Whether these observations indicate the success of management actions in salmon mariculture or reflect the action of unknown environmental processes is not clear. In all regions observations continue to indicate that in the absence of effective salmon louse management, there is the possibility of increased salmon louse infection levels on wild salmonids migrating in waters occupied by salmon mariculture. The observations also support a need to maintain marine monitoring efforts since the ability to objectively assess infections levels in wild populations is impaired in regions where coordinated and ongoing monitoring programmes for infections in wild salmon are lacking.

Risk Assessment and Future Research

Crawford (2003) recognised two factors in assessing environmental risk associated with aquaculture activities: the probable consequences of these activities and the likelihood of these consequences occurring. This report describes the assessment of risk to wild salmon associated with salmon louse infections by using the approach of Crawford (2003). The context for this assessment and the potential for risk associated with salmon louse infections on wild salmon were established earlier in this report and in Jones (2009). A qualitative risk assessment combines the severity of the consequences of infection, expressed as the fraction of the population at risk of direct mortality (Table 1), with a qualitative measure of the likelihood of these consequences occurring (Table 2). While the benefits of adopting a standard approach to assessing the risk of impact from mariculture-derived salmon louse in wild populations are evident, there is some uncertainty in estimating likelihoods of effects. According to available information, impact will reflect a complex interaction of host and environmental factors, the latter including both anthropogenic and natural. Thus, unique risk assessment matrices will likely be required among coastal zones whose spatial extent will be defined by local characteristics. Table 3 provides a non-exhaustive list of actors affecting likelihood of adverse salmon louse infection consequences. By combining the consequence and the likelihood parameters it is possible to generate a qualitative risk analysis matrix (Table 4).

There is considerable information already available to inform on the risk of salmon louse infections associated with further expansion of salmon mariculture. However, two key gaps are evident. No criteria or definitions are available for threshold mariculture densities, possibly measured as fish / km^2 that are based on the potential to produce viable salmon lice larvae. It is possible that ongoing hydrodynamic modelling of coastal ecosystems will provide the basis for establishing these density thresholds. Related to this point is the evident increase in the frequency with which available salmon louse treatments are failing to control infections. A continuation of this trend will affect the mariculture densities that are permitted in given water bodies. Secondly, there is little evidence for ongoing, systematic salmon louse monitoring of juvenile salmonids in most jurisdictions. The quantification of infective larvae through the use of sentinel salmon may provide a complementary means of assessing infections on wild salmon.

Conclusions

Salmon mariculture in the northern hemisphere is associated with salmon lice infections. Infections among the cultured stock can become severe and lead to serious skin lesions when left untreated. Management practices routinely involve surveillance and treatment when necessary to control infections. There is evidence that salmon louse infections are elevated within populations of wild salmon that occur in the proximity of salmon mariculture. There is also evidence from some regions that these management actions are reflected in reduced salmon louse infections on the wild salmon. With the information available, it is not possible to conclude with confidence that these elevated salmon louse infections have or have not had a measurable effect on the abundance of wild salmon population.

There is considerable information concerning management of salmon lice in mariculture. However further expansion of salmon mariculture in coastal habitats shared by wild salmon in some regions will further increase the prevalence and intensity of salmon louse infections on the wild salmonids. This risk is related to the absence of salmon production thresholds for individual water bodies, resistance of salmon lice to existing medications in many regions leading to treatment failures, and the absence in many regions of long-term systematic monitoring programmes for salmon lice on juvenile salmonids.

Recommendations

- Member countries should establish salmon mariculture production thresholds, based on capacity to produce salmon louse larvae, in coastal areas with or likely to have salmon mariculture;
- Member countries should encourage and support the development of hydrodymanic and particle tracking modelling studies of coastal ecosystems presently or potentially occupied by salmon mariculture;
- Member countries should support the development and licensing of novel classes of salmon louse treatments;
- Member countries should establish and maintain systematic monitoring programmes of salmon lice on juvenile salmon in coastal areas with or likely to have salmon mariculture.

References

Amundrud, T. L., and Murray, A. G . 2009. Modelling sea lice dispersion under variable environmental forcing in a Scottish sea loch. Journal of Fish Diseases, 32: 27–44.

Bjørn, P. A., Finstad, B., and Kristoffersen, R. 2001. Salmon lice infection of wild sea trout and Arctic char in marine and freshwaters: the effects of salmon farms. Aquaculture Research, 32: 947–962.

Bjørn, P. A., Finstad, B., Nilsen, R., Asplin, L., Uglem, I., Skaala, Ø., Boxaspen, K. K., and Øverland, T. 2008. Nasjonal overvåkning av lakselusinfeksjon på ville bestander av laks, sjøørret og sjørøye i forbindelse med nasjonale laksevassdrag og laksefjorder (Norwegian national surveillance of salmon lice epidemics on wild Atlantic salmon, sea trout and Arctic char in connection with Norwegian national salmon rivers and fjords). NINA Rapport, 377: 1–33.

Bjørn, P. A., and Finstad, B. 2002. Salmon lice, *Lepeophtheirus salmonis* (Kroyer), infestation in sympatric populations of Arctic charr, *Salvelinus alpinus* (L.), and sea trout, *Salmo trutta* (L.), in areas near and distant from salmon farms. ICES Journal of Marine Science, 59: 131–139.

Boxaspen, K. 2006. A review of the biology and genetics of sea lice. ICES Journal of Marine Science, 63: 1304–16.

Bravo, S., Sevatdal, S., and Horsberg, T. E. 2008. Sensitivity assessment of *Caligus rogercresseyi* to emamectin benzoate in Chile. Aquaculture 282:7-12.

Brooks, K. M. 2009. Considerations in developing an integrated pest management programme for control of sea lice on farmed salmon in Pacific Canada. Journal of Fish Diseases, 32: 59–73.

Costello, M. J. 2006. Ecology of sea lice parasitic on farmed and wild fish. Trends in Parasitology, 22: 475-483.

Crawford, C. 2003. Qualitative risk assessment of the effects of shellfish farming on the environment in Tasmania, Australia. Ocean and Coastal Management, 46: 47–58.

Costello, M. J. 2009. The global economic cost of sea lice to the salmonid farming industry. J. Fish Dis., 32: 115–118.

Frazer, L. N. 2009. Sea-cage aquaculture, sea lice, and declines of wild fish. Conservation Biology, 23: 599–607.

Grave, K., Horsberg, T. E., Lunestad, B. T., and Litleskare, I. 2004. Consumption of drugs for sea lice infestations in Norwegian fish farms: methods for assessment of treatment patterns and treatment rate. Diseases of Aquatic Organisms, 60: 123–131.

Green, D. M. 2010. A strategic model for epidemic control in aquaculture. Preventative Veterinary Medicine (in press).

Heuch, P. A., Bjørn, P. A., Finstad, B., Holst, J. C., Asplin, L., and Nilsen, F. 2005. A review of the Norwegian 'national action plan against salmon lice on salmonids': the effect on wild salmonids. Aquaculture, 246: 79–92.

Johnson, S. C., Treasurer, J. W., Bravo, S., Nagasawa, K., and Kabata. Z. 2004. A review of the impact of parasitic copepods on marine aquaculture. Zoological Studies 43: 229–243.

Jones, S. R. M. 2009. Controlling salmon lice on farmed salmon and implications for wild salmon. CAB Reviews: Perspectives in Agriculture, Veterinary Sciences, Nutrition and Natural Resources 4 (048) doi: 10.1079/PAVSNNR20094048.

Jones, S. R. M., and Nemec, A. 2004. Pink salmon action plan: sea lice on juvenile salmon and some non-salmonid species in the Broughton Archipelago in 2003. Canadian Science Advisory Secretariat Research Document 2004/105. Fisheries and Oceans Canada. 87 p.

Jones, S. R. M., Wosniok, W., and Hargreaves, N.B. 2006. The salmon louse *Lepeophtheirus salmonis* on salmonid and non-salmonid fishes in British Columbia. Proceedings of the 11th Symposium of the International Society for Veterinary Epidemiology and Economics. Cairns, Australia, 7 pp.

Jones, S. R. M., and Hargreaves, N. B. 2007. The abundance and distribution of *Lepeophtheirus salmonis* (Copepoda: Caligidae) on pink *Oncorhynchus gorbuscha* and chum *O. keta* salmon in coastal British Columbia. Journal of Parasitology, 93: 1324–1331.

Jones, S. R. M., and Hargreaves, N. B. 2009. Infection threshold to estimate *Lepeophtheirus salmonis* associated mortality among juvenile pink salmon. Diseases of Aquatic Organisms, 84: 131–137.

Krkošek, M., Lewis, M. A., and Volpe, J. P. 2005. Transmission dynamics of parasitic sea lice from farm to wild salmon. Proceedings of the Royal Society B, 272: 689–696.

Krkošek, M., Lewis, M. A., Morton, A., Frazer, L. N., and Volpe, J. P. 2006. Epizootics of wild fish induced by farm fish. Proceedings of the National Academy of Sciences of the USA, 103: 15506-15510.

Krkošek, M., Gottesfeld, A., Proctor, B., Rolston, D., Carr-Harris, C., and Lewis, M.A. 2007a. Effects of host migration, diversity and aquaculture on sea lice threats to Pacific salmon populations. Proceeding of the Royal Society B, 274: 3141–3149.

Krkošek, M., Ford, J. S., Morton, A., Lele, S., Myers, R. A., and Lewis, M. A. 2007. Declining wild salmon populations in relation to parasites from farm salmon. Science, 318: 1772–1775.

Kent, M. L., Traxler, G. S., Kieser, D., Richard, J., Dawe, S. C., Shaw, R. W., Prosperi-Porta, G., Ketcheson, J., and Evelyn, T. P. T. 1998. Survey of salmonid pathogens in Ocean caught fishes in British Columbia, Canada. Journal of Aquatic Animal Health, 10: 211–219.

Kent, M. L. 2000. Marine netpen farming leads to infections with some unusual parasites. International Journal for Parasitology, 30: 321–326.

Kent, M. L., and Poppe, T. T. 2002. Infectious diseases of coldwater fish in marine and brackish water. In: Woo, P.T.K., Bruno, D.W. and Lim, L.H.S. (editors). Diseases and Disorders of Finfish in Cage Culture. CAB International, Wallingford, pp. 61–105.

Lees, F., Baillie, M., Gettinby, G., and Revie, C. W. 2008. The efficacy of emamectin benzoate against infestations of *Lepeophtheirus salmonis* on farmed Atlantic salmon (*Salmo salar* L) in Scotland, 2002–2006. PLOS ONE, 3(2): e1549. doi:10.1371/journal.pone.0001549.

Lester, R. J. G. 1984. A review of methods for estimating mortality due to parasites in wild fish populations. Helgoländer Meeresuntersuchungen, 37: 53–64.

McVicar, A. H. 2004. Management actions in relation to the controversy about salmon lice infections in fish farms as a hazard to wild salmon populations. Aquaculture Research 35: 751–758.

Morton, A., Routledge, R., Peet, C., and Ladwig, A. 2004. Sea lice (*Lepeophtheirus salmonis*) infection rates on juvenile pink (*Oncorhynchus gorbuscha*) and chum (*Oncorhynchus keta*) salmon in the nearshore marine environment of British Columbia, Canada. Canadian Journal of Fisheries and Aquatic Sciences, 61: 147–157.

Morton, A. B., and Williams, R. 2003. First report of a sea louse, Lepeophtheirus salmonis, infestation on juvenile pink salmon, *Oncorhynchus gorbuscha*, in nearshore habitat. Canadian Field-Naturalist, 117: 634–641.

Nowak, B. F. 2007. Parasitic diseases in marine cage culture – an example of experimental evolution of parasites? International Journal for Parasitology, 37: 581–588.

O’Donohoe, P., Kane, F., Kelly, S., Nixon, P., Power, A., and Naughton, O., *et al*. 2008. National Survey of Sea Lice (*Lepeophtheirus salmonis* Krøyer and *Caligus elongatus* Nordmann) on Fish Farms in Ireland-2007. Marine Institute, Ireland. Irish Fisheries Bulletin, 31: 35 p.

OSPAR Commission. 2009. Assessment of impacts of mariculture. OSPAR Biodiversity Series: 63 p.

Penston, M. J., and Davies, I. M. 2009. An assessment of salmon farms and wild salmonids as sources of *Lepeophtheirus salmonis* (Krøyer) copepodids in the water column in Loch Torridon, Scotland. Journal of Fish Diseases, 32: 75–88.

Raynard, R., Wahli, T., Vatsos, I., and Mortensen, S. 2007. Review of disease interactions and pathogen exchange between farmed and wild finfish and shellfish in Europe. Report of the Disease Interaction and Pathogen Exchange Network (DIPNET). Aberdeen. 459 p.

Rae, G. H. 2002. Sea louse control in Scotland, past and present. Pest Management Science, 58: 515–520.

Revie, C., Dill, L., Finstad, B., and C.D. Todd. 2009. “Salmon Aquaculture Dialogue Working Group Report on Sea Lice” commissioned by the Salmon Aquaculture Dialogue available at http://wwf.worldwildlife.org/site/PageNavigator/SalmonSOIForm.

Sayer, M. D. J., Treasurer, J. W., and Costello, M. J. 1996. *Wrasse: Biology and use in aquaculture.* Ames: Fishing News Books, Blackwell Science Ltd.

Seng, L. T., and Colorni, A. 2002. Infectious diseases of warmwater fish in marine and brackish waters. In: Woo, P.T.K., Bruno, D.W. and Lim, L.H.S. (editors). Diseases and Disorders of Finfish in Cage Culture. CAB International, Wallingford, pp. 193–230.

Saksida, S., Constantine, J., Karreman, G.A., and Donald, A. 2007. Evaluation of sea lice abundance levels on farmed Atlantic salmon (*Salmo salar* L.) located in the Broughton Archipelago of British Columbia from 2003 to 2005. Aquaculture Research, 38: 219–31.

Sevatdal, S., Copley, L., Wallace, C., Jackson, D., and Horsberg, T. E. 2005. Monitoring the sensitivity of sea lice (*Lepeophtheirus salmonis*) to pyrethroids in Norway, Ireland and Scotland using bioassays and probit modelling. Aquaculture, 244: 19–27.

Sitjà-Bobadilla, A. 2004. Parasites in Mediterranean aquacultured fish: current impact and future research directions. IX European Multicolloquium of Parasitology, Valencia, Spain. Pp 301-308.

Todd, C. D., Whyte, B. D. M., MacLean, J. C. and Walker, A. M. 2006. Ectoparasitic sea lice (*Lepeophtheirus salmonis* and *Caligus elongatus*) infestations of wild, adult, and one sea-winter Atlantic salmon *Salmo salar* returning to Scotland. Marine Ecology Progress Series, 328: 183–193.

Todd, C. D. 2007. The copepod parasite (*Lepeophtheirus salmonis* (Krøyer), *Caligus elongatus* Nordamann) interactions between wild and farmed Atlantic salmon (*Salmo salar* L.) and wild sea trout (*Salmo trutta* L.): a mini review. Journal of Plankton Research, 29: i61–i71.

Tully, O., Gargan, P., Poole, W. R., and Whelan, K. F. 1999. Spatial and temporal variation in the infestation of sea trout (*Salmo trutta* L.) by the caligid copepod *Lepeophtheirus salmonis* (Kroyer) in relation to sources of infection in Ireland. Parasitology, 119: 41–51.

Tully, O., and Whelan, K. F. 1993. Production of nauplii of *Lepeophtheirus salmonis* (Krøyer) (Copepoda: Caligidae) from farmed and wild salmon and its relation to the infestation of wild sea trout (*Salmo trutta* L.) off the west coast of Ireland in 1991. Fisheries Research 17: 187–200.

Tully, O., and Nolan, D. T. 2002. A review of the population biology and host-parasite interactions of the sea louse *Lepeophtheirus salmonis* (Copepoda: Caligidae). Parasitology, 124: S165–S182.

Uglem, I, Dempster, T., Bjørn P. A., Sanchez-Jerez, P., and Økland, F. 2009. High connectivity of salmon farms revealed by aggregation, residence and repeated movements of wild fish among farms. Marine Ecology Progress Series, 384: 251–260.

Wagner, G. N., Fast, M. D., and Johnson, S. C. 2008. Physiology and immunology of *Lepeophtheirus salmonis* infections of salmonids. Trends in Parasitology, 24: 176–183.

Yazawa, R., Yasuike, M., Leong, J., Cooper, G.A., Beetz-Sargent, M., Robb, A., Holt, R., Moore, R., Davidson, W. S., Jones, S. R. M., and Koop, B. F. 2008. EST and mitochondrial DNA sequences support a distinct Pacific form of salmon louse, *Lepeophtheirus salmonis*. Marine Biotechnology, 10: 741–749.

Table 1. Qualitative measures of salmon louse infections on juvenile wild salmon as consequences of salmon mariculture (percentages are estimates and used for illustration purposes).

Level	Descriptor	Detailed description
1	Insignificant	Salmon lice effects not readily detectable
2	Minor	Minor effects (e.g. less than 5% of the population exceed harmful threshold)
3	Moderate	Medium effects (e.g. infections exceeding harmful thresholds occur on 6% to 10% of the population)
4	Major	Large or widespread effects (e.g. infections exceeding harmful thresholds occur on more than 10% of population)

Table 2. Qualitative measures of the likelihood for a given salmon louse consequence to occur.

Level	Descriptor	Description
A	Almost certain	Is expected to occur in most circumstances
B	Likely	Will probably occur in most circumstances
C	Possible	Might occur at some time
D	Unlikely	Could occur at some time
E	Rare	May only occur in exceptional circumstances

Table 3. Factors affecting likelihood of adverse salmon louse infection consequences

Category	Detail	Status
Mariculture	Proximity to wild salmonid nursery streams	Data available
	Mariculture density (e.g. fish/km2): threshold for parasite production, by waterbody	Data not available
	Coordinated salmon louse management, by water body	Data available
	Efficacy of available medicines and/or treatment options	Date becoming available
Hydrography	Physico-chemical characteristics of coastal water bodies (e.g. temp, salinity, etc.)	Data available
	Hydrodynamic and particle tracking models for coastal waterways	Data becoming available
Wild salmonids	Susceptibility of local species	Data available
	Factors further affecting susceptibility	Data becoming available
	Systematic monitoring (5+ years)	Data not available (in most regions)

Table 4. Qualitative risk analysis matrix.

Likelihood	Consequence			
	Insignificant	Minor	Moderate	Major
A (almost certain)	H	H	E	E
B (likely)	M	H	H	E
C (moderate)	L	M	H	E
D (unlikely)	L	L	M	H
E (rare)	L	L	M	H

E: extreme risk, H: high risk, M: moderate risk, L: low risk

Annex 7: Recommendations

Report Section	Recommendation	For follow up by:
5	1. ICES Member Countries continue 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. OSPAR Coordinated Environmental Monitoring Programme (CEMP), HELCOM). Data generated according to established ICES and BEQUALM guidelines should be submitted to the ICES Data Centre.	ICES Member Countries
5	2. Fish disease monitoring data be used in evaluating the effects of disease on population dynamics, provide essential baseline data to serve as a reference prior to establishment of the culture of marine species, and to better understand pathogen interactions between wild and farmed fish.	OSPAR, ICES Member Countries
5	3. WGPDMO develop 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 fish and shellfish using the new standards and guidelines.	WGPDMO
5	4. ICES Member Countries that do not have fish disease monitoring programmes, seriously consider making a commitment to long term monitoring of fish diseases. The WGPDMO regrets that Scotland has discontinued a 21-yr fish disease monitoring programme and urges the country to reconsider this decision, particularly in light of the pending OSPAR CEMP requirement for countries to perform wild fish disease monitoring.	ICES Member Countries, in particular Scotland
5	5. WGPDMO members undertake intersessional studies to understand the aetiology of the novel red eye pathologies observed in gadoids from the Barents Sea.	WGPDMO
6	6. Further field and laboratory investigations into effects of genetic characteristics and diet in dab are undertaken in order to identify relationships with the prevalence and intensity of hyperpigmentation.	WGPDMO
7	7. WGPDMO members work intersessionally to complete the draft manuscript on disease effects in populations.	WGPDMO
8	8. Member countries establish programmes facilitating the collection of disease data concurrently with traditional stock assessment data to permit the evaluation of the population effects of disease in fish and shellfish.	ICES Member Countries
9	9. In order to reduce the risk of sea lice interactions between farmed and wild fish, ICES member countries establish salmon mariculture production thresholds, based on capacity to produce salmon louse larvae, in appropriate water bodies.	OSPAR, ICES Member Countries
9	10. ICES member countries encourage and support the development of hy-drodynamic and particle tracking modelling studies of coastal ecosystems presently or potentially occupied by salmon mariculture and other types of mariculture.	OSPAR, ICES Member Countries
9	11. ICES member countries support the development of measures to reduce the risk associated with salmon lice interaction between farmed and wild fish by developing novel efficient and environmentally-safe therapeutants, vaccines and technical measures such as barriers between farms and the environment.	OSPAR, ICES Member Countries

9	12. ICES member countries should establish and maintain systematic moni-toring programmes of salmon lice on salmonids in coastal areas with, or likely to have, salmon mariculture.	OSPAR, ICES Member Countries
9	13. In light of the expanding mariculture industry, ICES member countries should enhance research and monitoring activities addressing interactions between other fish and shellfish species and other diseases and parasites, including potential population effects.	OSPAR, ICES Member Countries
10	14. OSPAR notes the progress made in the modification of the Fish Disease Index assessment approach and adopts the Fish Disease Index and the related assessment procedures as formal assessment strategy/criteria for the OSPAR Coordinated Environmental Monitoring Programme (CEMP).	OSPAR
10	15. The ICES fish disease database is updated with new data submitted by ICES Member Countries on a regular basis and in a timely fashion. Efforts should be made in particular to submit data on confirmed cases of macroscopic liver neoplasms and liver histopathology that are available in national databases but are so far largely lacking in the ICES database. It is essential that laboratories submitting disease data to ICES apply ICES standard methodologies and take part in existing quality assurance programmes (BEQUALM: Biological Effects Quality Assurance in Monitoring Programmes);	ICES Member Countries
10	16. The WGPDMO further develop the assessment criteria and revisit the issue at its 2011 meeting. If substantial new data submissions have been made, a new assessment should be carried out intersessionally, also for species other than the common dab.	WGPDMO
11	17. WGPDMO members continue to consider additonal titles for the leaflet series and other relevant publications in peer-reviewed literature.	
12	18. ICES Member countries submit their wild fish disease data generated according to ICES standard guidelines available in their national databases to the ICES Data Centre in order to facilitate a more comprehensive analysis and assessment of spatial patterns and trends in the health status of wild fish by applying the Fish Disease Index (FDI) approach.	ICES Member Countries
12	19. WGPDMO (T. Lang, W. Wosniok, S. Feist) makes contact with the ICES Data Centre in order to develop appropriate web-based products, providing results of fish disease data assessments to a wider audience in an easy-to-communicate way.	WGPDMO
12	20. ICES clarifies the questions regarding the addition of new data for disease datasets already existing in the ICES database.	ICES Data Centre

Annex 8: WGPDMO Terms of Reference for the 2011 meeting

The **Working Group on Pathogens and Diseases of Marine Organisms** (WGPDMO) chaired by Simon Jones, Canada, will meet in Lagnaro, Italy, 1–5 March 2011 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) review the information on Pacific oyster, Crassostrea gigas, mortality outbreaks reported in 2008 and 2009 in different UE Member States and the related implementation of the Council Directive 2006/88/EC;

d) 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.

e) provide a detailed review of information on disease-associated population effects of commercial and non-commercial fish and shellfish species;

f) provide an update on the status of ICES publications on pathology and diseases of marine organisms;

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

WGPDMO will report by 20 April 2011 (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 very high priority.

Scientific justification:

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 maintaine (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 fo other fish species is increasing and will use the same open net-pen technology, similar problems will likely occur. ICES WGPDMO will prepare a review on disease interactions between farmed and wild marine finfish species with emphasis on potential threats (T.A. Mo, D. Bruno, L. Madsen, S. Jones).

Term of Reference c)

Increased mortality in Crassostrea gigas oysters were reported in several are in EU Member States in 2008 and 2009. It was attributed to a combination adverse environmental factors together with the presence of bacteria of tl genus Vibrio and ostreid herpesvirus-1 (OsHV-1) including a newly describe genotype of that virus named OsHV-1 μVar. While the causes of the mortaliti still remain uncertain, the epidemiological investigations undertaken in Franc Ireland and the United Kingdom suggest that OsHV-1 μVar plays a significa role in the mortalities. In this context, the European Commission assumed th Members States were facing an emerging disease situation and decided thus implement the Council Directive 2006/88/EC through a commission regulatic consisting of specific measures to control increased mortality in C. gigas oyste in connection with the detection of OsHV-1 μVar. There remains a requireme for ICES Member states to share information regarding this emerging disea situation and the related implementation of the Council Directive 2006/88/E (T. Renault, D. Cheslett, L. Madsen).

Term of Reference d)

The Fish Disease Index (FDI) approach has been developed for the analysis an 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, suggestions have been made for the development of new assessme criteria 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 curre data on externally visible diseases) and new data analyses and assessments applying the FDI approach should be carried out if the data are considered to be sufficient. 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 s far in the ICES Data Centre - Environment Data (T. Lang, W. Wosniok, S. Feist, M. Podolska).

Scientific justification:	**Term of Reference e)** There is increasing information from studies in wild freshwater and marine fis 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 f)** 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. Feis L. Madsen, D. Bruno) **Term of Reference g)** This is in compliance with a request from the ICES Data Centre. (W. Wosniok, T. Lang)
Resource requirements	None required other than those provided by the host institute.
Participants	The Group is normally attended by 20–25 representatives of ICES Member Countries and guests with expertise in pathology and diseases of marine organisms.
Secretariat facilities	Required to a limited extent for data and publication issues.
Financial	No financial implications.
Linkages to advisory committees	ACOM
Linkages to other committees or groups	WGBEC, WGNAS, WGMAFC, WGMASC, WGEIM
Linkages to other organizations	BEQUALM, OIE, EU, OSPAR, HELCOM

Annex 9: RGMAR Technical Minutes

Compiled by Chair Pauline Kamermans (IMARES, Netherlands) May 16, 2010.

Reviewers

Nellie Gagné (Fisheries and Oceans Canada, Aquatic Animal Health, Canada)

Bob Furness (University of Glasgow, United Kingdom)

Perttu Koski (Finnish Food Safety Authority Evira, Fish and Wildlife Health Research Unit, Finland)

Fred Page (Fisheries and Oceans Canada, Aquatic Animal Health, Canada)

Request 2010_3 by OSPAR (Effect of mariculture on populations of wild fish)

While there is general agreement on the range of potential forms of interaction between farmed and wild stocks, there is much less agreement on the current and future significance of these interactions for wild stocks.

OSPAR ask ICES:

To provide advice on the current state of knowledge on the interaction of finfish mariculture on the condition and wild fish populations (both salmonid and non-salmonid) both at a local and regional scale, including from parasites, escaped fish and the use of fish feed in mariculture. Advice is requested on how the interactions will change as a result of an expansion of mariculture activities.

OSPAR suggest that this should be addressed through a risk analysis approach, making best use of both quantitative and qualitative methodologies, and that an important aspect of the outcome will be clear identification of the specific aspects of the risk analysis where additional research effort may best be targeted to reduce the uncertainty in the risk analysis.

Four expert groups (WGPDMO, WGEIM, WGAGFM and WGEIM) were asked to work on the OSPAR request during their meetings in 2010. The expert groups have considered:

1) Impacts due to disease transfer, especially with respect to sea lice (covered by WGPDMO);
2) Impacts on wild fish stocks due to their being used as raw material to provide fish oil and protein for fish feed (covered by WGEIM);
3) Impacts due to interbreeding of escapees and escaped gametes and wild fish and gametes; and (covered by WGAGFM);
4) Impacts due to interactions between wild and farmed fish due to competition, and other ecological processes (covered in part by WGNAS, WGEIM).

The reviewers were given very limited time to carry out their review. As a result not all EG reports were reviewed by all reviewers.

Summary of review

Impact:	1. Disease transfer	2. Depletion of stock for feed production	3. Interbreeding	4. Interactions
Technically correct	Yes, for sea lice transfer to wild salmon and sea trout. Does not cover other species or other diseases.	Yes	Yes, but voluntarily skips salmonids literature. The genetic implications are not reviewed.	Yes
Scope and depth	Not much detail reported, rather general overviews.	Very good	Good, considering the paucity of specific information on interbreeding of non-salmonids.	Combining both WGNAS and WGEIM, very good. The material in WGNAS is particularly well presented and up to date and so where there is overlap the WGNAS material may be preferred. WGNAS review on means of identifying escaped salmon is very good.
Prediction of change vs mariculture expansion	Yes, for transfer of sea lice vs increased mariculture.	Briefly touched, in the sense that sustainability will be the main factor for those fisheries.	Were not made, although they are obvious and similar to the other impacts.	Yes, greater impact expected
Risk analysis approach	Not done in a useful way	Excellent work, focus was on this approach	Not done	Partial, only discussed, not done systematically
Identification of additional research needed to reduce uncertainty	Yes, but missing some	Missing, but the knowledge review seem to indicate that the uncertainty level regarding this question is low.	Yes – basic research on popn diversity needed to evaluate the potential impact of interbreeding.	Yes, research need identified but not in link to reduction of uncertainty.
Additional research recommended by reviewers	Other diseases and fish species. More information needed on the impact of the sea lice transfer on wild populations. More on sea lice treatment alternatives.		More research on low cost tagging methodologies to trace escaped fish (and origin)	More research to evaluate impact for a river under its reproductive baseline. Development of cage technologies (reducing escape potential)

Detailed review of reports and their responses

1) Impacts due to disease transfer, especially with respect to sea lice; **(covered by WGPDMO)**

Overall, Section 9 and Annex 6 (ToR j) were the section of the WGPDMO report to consider. As stated in the report, it is agreed that disease origin from wild animals and appear in farmed animal, but it is hard to evaluate the importance of disease transfer from farmed to wild animals once a disease is introduced in a farm, or the reintroduction of disease from wild to farmed animals thereafter.

The recommendation to monitor or increase disease monitoring and standardise reporting in ICES member countries seem appropriate as a way of evaluating the risk of this interaction, especially if combined with stock assessment i.e. it would provide a better evaluation of disease impact at the population level.

Concerning sea lice transfer to wild salmons, it is of great concern that resistance to treatment and the absence of alternatives concurs with pressure to expand mariculture. However, although it is recognised that sea lice are transferred from farmed fish to wild stocks, it is noteworthy that "Despite the efforts to understand the complex interactions between sea lice and wild and farmed fish there is so far comparatively little information available on effects on populations of wild salmonids, e.g., on the relative contribution of the parasite interactions to the decline in the stock of Atlantic salmon." This lack of information on the impact of the sea lice transfer should be part of the recommendation for more research. It is assumed however that the impact should be negative for susceptible species.

Concerning the recommendation "i) In order to reduce the risk of sea lice interactions between farmed and wild fish, ICES member countries establish salmon mariculture production thresholds, based on capacity to produce salmon louse larvae, in coastal ecosystems presently or potentially occupied by salmon mariculture." The reviewers were concerned to know why thresholds should be set based on this impact – there are many other impacts to consider. Capacity or not to control sea lice should be evaluated. The reviewers liked the concept of "sentinel salmon" to quantify the rate and risk of transfer of louse (and other disease), but did not see this approach as a recommendation unfortunately.

WGPDMO Section 9 is the relevant part of that report, plus Annex 6. Section 9 is very poor. All it says is that there is a lack of data, and more studies are needed. This is not at all helpful. Also, the recommendations presented in Section 9.7 appear not to be relevant to the terms of reference set by OSPAR, and are not supported by data or text in earlier parts of Section 9. So the scientific case behind these recommendations is quite unclear to the reader. The reviewers expressed surprise that WGPDMO have only considered salmon lice in their response for OSPAR. According to WGNAS section 6.2 it was agreed within ICES that the Working Group would consider "impacts due to disease transfer". This is wider than just sea lice, yet there is nothing in WGPDMO Section 9 on any other diseases. So there seems to be a deficiency here in terms of the coverage of the subject matter allocated to WGPDMO.

Annex 6 of WGPDMO is a very clearly presented and careful review of sea lice on farmed and wild salmon. This review paper seems very good. Annex 6 of WGDMO should be considered technically correct and to give a good general view of the state of the knowledge on the role of mariculture in sea louse threat to wild Atlantic Salmon (and Sea Trout). But the main comment could be that the expert group should continue its work on other diseases and fish species. At present WGDMO includes only an example of the knowledge on these interactions. In fact Annex 8 point b) might mean that this will happen.

Comments for Annex 6 of WGPDMO

1) Section "Evidence for mariculture-derived salmon lice infections in wild salmonids" The first line of the second paragraph says "could be reduced". It is suggested that this should be "could be induced"? If so, the meaning is very different. Reducing a decline in lice numbers would be bad news. Inducing a decline is good!

2) In the same paragraph there is a reference "Penston *et al.*, 2009". It might be "Penston and Davies, 2009" or otherwise the reference is missing from the reference list.