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The Fish Disease Index: a method to assess wild fish disease data in the context of marine environmental monitoring

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ABSTRACT

Based on empirical data derived from the German long-term fish disease monitoring programme, a Fish Disease Index (FDI) has been developed that provides numeric information on the overall disease status of individual fish and on temporal changes in the disease status of fish populations. Furthermore, the FDI approach offers a method for regional assessments of FDI levels and trends and for regional comparisons thereof. Examples illustrating the construction and application of the FDI approach are given, using data on diseases of the common dab (*Limanda limanda*), the major target species in the North Sea and adjacent areas. The potential of the FDI approach in the context of international marine monitoring and assessment programmes such as the OSPAR Coordinated Environmental Monitoring Programme (CEMP) is highlighted.

Keywords: fish disease index, disease status, monitoring, assessment.

INTRODUCTION

Regular surveys on the occurrence of diseases in wild marine fish stocks are carried out by a number of ICES Member Countries as components of their national marine environmental monitoring and assessment programmes (Lang 2002). Present surveys in the North Sea and adjacent areas (Irish Sea, English Channel, western Baltic Sea) are carried out by Germany, The Netherlands and the UK. Studies on wild fish diseases are also carried out by other countries, however, on a less regular basis and focused more on research-oriented specific issues.

The methodologies applied in the regular surveys are largely based on guidelines developed through activities of the ICES Working Group on Pathology and Diseases of Marine Organisms (WGPDMO), including repeated practical sea-going workshops for intercalibration and standardisation of methodologies. Guidelines developed cover all aspects relevant for fish disease monitoring, e.g., methodologies for field sampling, selection of suitable target fish species and diseases, disease diagnosis, data reporting and data analysis (Dethlefsen et al. 1986, Anonymous 1989, Bucke et al. 1996, Feist et al. 2004, Wosniok et al. in preparation). Data generated according to these guidelines have been submitted to the ICES Data Centre since the beginning of the 1990s and have been statistically analysed and assessed repeatedly with respect to relationships between spatial and temporal patterns in disease prevalence and environmental factors suspected to be causally involved in the changes recorded (Lang and Wosniok 2000, Wosniok et al. 2000). At present, the database contains data on the health status and on accompanying host-specific information of approx. 620,000 individual dab.

Most of the fish disease surveys have been focused on diseases of the common dab (*Limanda limanda*), the most abundant flatfish species in the North Sea (Daan et al. 1990, Rijnsdorp et al. 1992, Knijn et al. 1993), and adjacent areas such as the English Channel, the Irish Sea and the western Baltic Sea. The assessment of the disease data recorded was, in the past, largely done on the basis of spatial and temporal patterns (trends) of single indicator diseases, and significant changes in disease prevalence were considered as an indication of the impact of environmental stressors affecting fish health (anthropogenic, incl. contaminants, and natural) (Wosniok et al. 1999; 2000, Lang and Wosniok 2000). However, since it is common sense that the overall disease status of an organism is a result of the sum and the severity of its diseases, ICES started to construct an index for fish health summarising relevant data, with the ultimate purpose to be used as an ecosystem health indicator for monitoring and assessment of the state of the marine environment. The initiative to develop a Fish Disease Index started in 2005, when the ICES Working Group on Pathology and Diseases of Marine Organisms (WGPDMO) recommended that a pilot study be carried out to determine the feasibility of constructing a fish disease index, using dab (*Limanda limanda*) disease data obtained from the North Sea, and to assess its suitability for use as an assessment tool (ICES 2005). This issue was taken up later in 2005 and further elaborated by the ICES/BSRP Sea-going Workshop on Fish Disease Monitoring in the Baltic Sea (WKFDM), in the course of which a Fish Health Index was constructed, in first instance based on disease data for Baltic flounder. The index was calculated using data on presence/absence of a range of diseases, their severity grades, disease-specific weighting factors and adjustment terms for size effects (ICES 2006a). Thus, this Fish Health Index constituted the basis for all further developments described herein.

At the 2006 WGPDMO meeting, a Fish Disease Index (FDI) was introduced for diseases of the common dab (*Limanda limanda*). The term 'Fish Disease Index' replaced the previous term 'Fish Health Index' because it reflects more accurately what the index is about. The construction of the FDI was based on hypothetical data but subsequent calculations on trends and on adjustment terms for size effects were made, using empirical disease data from the German Fish disease monitoring programme in the North Sea and adjacent areas (ICES 2006b).

The finalisation of the Fish Disease Index in its present form was accomplished at the 2007 WGPDMO meeting. Empirical data on diseases in dab from the North Sea and adjacent areas (from the German fish disease monitoring programme only) were analysed by using the FDI approach and a newly developed robust and easy-to-communicate method for assessment of the disease status was suggested and applied, illustrating the results by a traffic light scheme and smiley face symbols (ICES 2007b).

The development of the FDI and related assessment criteria is of particular relevance for the international Regulatory Commissions since fish disease monitoring is part of the OSPAR Coordinated Environmental Monitoring Programme (CEMP) (OSPAR 2005) and, since the FDI approach has been adopted in the ICES/OSPAR WKIMON process, as component of an integrated monitoring and assessment (ICES 2007a). Furthermore, HELCOM is developing indicators of ecological quality and related targets for monitoring and assessment in order to meet the goals of the Baltic Sea Action Plan (HELCOM 2008) and has requested to develop a fish disease indicator to be used in the Baltic Sea in relation to the assessment of effects of hazardous substances (HELCOM 2006). Therefore, ICES advised OSPAR, HELCOM and ICES Member Countries to take note of the progress achieved in relation to the Fish Disease Index (FDI) and the related assessment criteria (ICES 2007c).

The current OSPAR CEMP encompasses, e.g., monitoring of contaminants and their general and contaminant-specific biological effects that should be carried out by OSPAR contracting parties either on a mandatory or on a voluntary basis. Fish disease studies are part of both the CEMP general biological effects monitoring and the PAH-specific biological effects monitoring (OSPAR 2005). At present, fish disease monitoring within OSPAR is on a voluntary basis. However, it is envisaged that it becomes mandatory as soon as accepted assessment criteria are in place. In this context, the Fish Disease Index is relevant because it offers a robust method to assess fish disease data in terms of prevalence levels as well as temporal trends.

MATERIAL AND METHODS

In the following, the components of the Fish Disease Index (FDI) in its present form, methods for the calculation of the FDI as well as methods for the assessment of the resulting data are described.

Components of the Fish Disease Index

The FDI is composed of the following components:

- Data on diseases of the common dab (*Limanda limanda*);
- Information on the presence or absence of a range of diseases monitored on a regular basis, categorised as externally visible diseases (9 key diseases, incl. 3 parasites), macroscopic liver neoplasms (2 key diseases) and liver histopathology (5 key diseases) (see Table 2);
- For most diseases, data on 3 severity grades (reflecting a light, medium or severe disease status) are included;
- Disease-specific weighting factors, reflecting the impact of the diseases on the host (assigned based on expert judgements);
- Adjustment factors for effects of size and sex of the fish as well as for season effects;

Methods for the combination of these components into the final FDI for an individual fish are described below.

Fish species

The FDI was constructed based on experience made in disease monitoring programmes using the common dab (*L. limanda*) as target fish species. Dab is the most abundant flatfish species in the North Sea and its diseases have been monitored in the North Sea and adjacent areas on a regular basis since more than 25 years. Data on diseases of dab have been submitted by Denmark, Germany, The Netherlands and the UK to the ICES fish disease database as part of the ICES Environmental Data Centre. Furthermore, dab is the main target species for monitoring of biological effects of contaminants in the context of the OSPAR Coordinated Environmental Monitoring Programme (CEMP) and its basis, the OSPAR Joint Assessment and Monitoring Programme (JAMP) (OSPAR 1997, 2003, 2005).

The WGPDMO stressed, however, that the construction principle of the FDI and the associated assessment procedure can easily be transferred to other assessment tasks (e.g., other fish species, other diseases), as long as sufficient data are available and an equivalent to the disease-specific weights can be provided. Therefore, the FDI approach is applicable for wider geographical areas, e.g. as part of the convention-wide OSPAR monitoring and assessment, or in other seas such as the Baltic Sea (ICES 2007c).

Diseases

The FDI involves three disease categories (externally visible diseases, macroscopic liver neoplasms, liver histopathology), each consisting of a number of diseases/lesions (see Table 2). These categories reflect the OSPAR requirements for general and for PAH-specific monitoring defined in the CEMP and the JAMP guidelines (OSPAR 1997, 2003, 2005). The majority of the diseases is in line with published ICES guidelines for fish disease surveys (ICES 1989, Bucke et al. 1996, Feist et al. 2004). Some other diseases were added since they were considered useful for monitoring purposes.

Severity grades

The inclusion of information on severity grades in the construction of the FDI was considered useful since not only the presence of diseases but also their severity reflect the health status of a fish. Severity grades (1-3) have been defined for most of the externally visible diseases (Bucke et al. 1996), however, not yet for macroscopic liver neoplasms or liver histopathology. This will be a future task for the BEQUALM programme (http://www.bequalm.org/fishdisease.htm).

Assignment of disease-specific weighting factors

Disease-specific weighting factors were introduced owing to the fact that some diseases have a more severe impact on the general health of an individual than others. The assignment of disease-specific weighting factors is critical because the decision regarding the ranking of the diseases based on their importance for the well-being of the host and the resulting assignment of numeric weighting factors have a major impact on the final FDIs. For instance, if a single disease known to increase (or decrease) in prevalence over time is assigned a particularly high weighting factor, the resulting FDI might be dominated to a large extent by this disease and will very likely increase (or decrease), especially if only few diseases were taken into account or were present.

Table 2: Disease categories and key diseases to be used for calculating the Fish Disease Index for dab (*Limanda limanda*) (ICES 2006b)

Externally visible diseases	Macroscopic liver neoplasms	Liver histopathology
Lymphocystis	Benign neoplasms	Non-specific lesions
Epidermal hyperplasia/papilloma	Malignant neoplasms	Early non-neoplastic toxicopathic lesions
Acute/healing skin ulceration		Pre-neoplastic lesions (FCA)
X-cell gill disease		Benign neoplasms
Hyperpigmentation		Malignant neoplasms
Acute/healing fin rot/erosion		
Stephanostomum baccatum		
Acanthochondria cornuta		
Lepeophtheirus pectoralis		

In order to reach a broad consensus on the weighting factors, the assignment of weighting factors was done on the basis of expert judgement, where the Bradley-Terry approach (Bradley and Terry 1952, Rao and Kupper 1967, Agresti 2002) was used to derive a joint assessment from individual statements. Independent expert judgements were provided by selected WGPDMO members and other specialists with a background in disease monitoring in dab or other flatfish with similar diseases.

The experts had been asked to assess for each pair of diseases the relative severity of the pair's members. Possible statements were (i) “first disease more severe than the second”, (ii) "second disease more severe than the first", (iii) "both diseases are similarly severe" and (iv) "cannot give an assessment". These statements served as input for the Bradley-Terry approach to compute the disease-specific weights given in Table 3. The rationale behind the Bradley-Terry approach is to compute weights w_i, (i = 1, 2, …, I, index for disease) from the expert input such that the input assessments can be reproduced by comparing the weights: $w_i > w_j$ corresponds to the expert statement "disease i is more severe than disease j". If the input (the expert assessments) contains inconsistencies or contradictions, no set of weights can reproduce the input perfectly, however, the Bradley-Terry approach finds a set of w_i that generates the best possible approximation to the expert assessment. Table 3 contains the weights obtained by the Bradley-Terry approach, scaled to the range 1–9 to secure comparability with earlier reports.

Table 3: Weighting factors assigned to diseases of common dab (*Limanda limanda*) based on the expert judgement (ICES 2007b)

Disease/parasite	Disease-specific weighting factor
Lymphocystis	1.99
Epidermal hyperplasia/papilloma	1.98
Acute/healing skin ulceration	2.12
X-cell gill disease	9.00
Hyperpigmentation	1.99
Acute/healing fin rot/erosion	6.01
Stephanostomum baccatum	1.00
Acanthochondria cornuta	1.90
Lepeophtheirus pectoralis	1.89

Adjustment for effects of size, sex and sampling season

Size and sex are factors well-known to have an impact on the prevalence of diseases. In order to be able to compare sampling areas with differences in the population structure with regard to size and sex composition, adjustment terms for both entities were included in the calculation of the FDI. Adjustment terms are calculated based on empirical data on the prevalence of each of the diseases by length group (cm total length) for male and female fish separately. The relationship between length and disease prevalence may differ considerably between sexes. The adjustment term depends on the empirical relationship between disease prevalence and length. It is assigned a value of '1' for the length associated with the lowest prevalence and a value of '-1' for the length associated with the highest prevalence. It is '0' for the mean empirical prevalence. These three conditions establish mathematically a power relationship between adjustment term and prevalence:

$$\text{adjustment} = 1-2*((\text{prevalence}-\text{prevalence minimum})/(\text{prevalence range}))^c$$

In this equation, 'prevalence' depends on length via a smooth function obtained by a LOESS smoother, and the constant 'c' is chosen such that the adjustment term becomes '0' if the mean prevalence is entered on the right hand side. The adjustment term is further designed so that, also after adjustment, fish with disease grade 2 (or 3) still get a higher resulting score than fish with disease grade 1 (or 2), independent of their length. That means that the effect of length adjustment cannot exceed the effect of the basic grades.

An adjustment term for season effects was introduced to remove possible season effects and sampling artefacts due to changes in the time of sampling. Season adjustment terms are calculated separately for each sampling area (e.g., ICES statistical rectangle) by fitting a regression model to the sex/length adjusted FDI time series in each area, where year and season (3 classes) served as explaining factors. Estimated season effects were then subtracted from the input time series, resulting in an FDI series adjusted for sex, length and season effects.

Calculation of the Fish Disease Index

The calculations involved in the FDI approach result in scores for each of the diseases considered. These are summed up to give the final individual FDI for a single fish. The disease scores are composed of the product of a value representing the presence or absence of each of the diseases (values are either ‘1’ or ‘0’), multiplied by the severity grade (values can be ‘1’, ‘2’ or ‘3’) and multiplied by the disease-specific weighting factor (see Table 3). Furthermore, the adjustment terms (see above) compensating for effects of length, sex and sampling season are added.

The FDI is scaled in a way that values can range from 0 to 100, with low values representing healthy and high values representing diseased fish. The maximum value of 100 can only be reached in the (purely theoretical and unrealistic) case that a fish is affected by all diseases at their highest severity grades.

From the individual FDIs, mean FDIs for a sample from a fish population in a given sampling area can be calculated (see Fig. 1).

Assessment of Fish Disease Index data

The FDI is meant to be used for the assessment of disease patterns on a regional basis, where, e.g., ICES statistical rectangles or a union of these can serve as geographical units. The outcome of the assessment is a classification of the disease situation in the region into one of three categories (low, medium, high; representing a good, moderate or poor health status). These categories can easily be communicated by using colours (green/yellow/red) and/or symbols (up/down arrows or smiling/ frowning faces).

For the FDI approach chosen, the boundaries which divide the range of mean FDI values into categories are defined on the basis of FDIs previously observed in the area. The boundaries divide the empirical range of mean FDIs into 3 subdivisions using tertiles (the 33% and 66% percentile) as cut points, such that each subdivision contains one third of all observations. Values in the lower third are desirable (and achievable) values in that area (green range), values in the upper third give reason for concern and further inspection (red range), values in the middle third have no clear characterisation (yellow range) (see Fig. 1). This approach can be used to assess changes in an area on a longer-term basis based on mean FDI levels (means taken over all observations in an area at one point in time).

However, as FDI values may exhibit considerable random fluctuation even after the adjustments for size, sex and season described above, the joint consideration of not only mean FDI levels, but additionally of their trends is advisable in an assessment. This approach is considered particularly useful to assess recent changes in FDI patterns. For that purpose, a joint test statistic is proposed, calculated in the following way, separately for each region:

- define a starting time for 'recent' trends (e.g., 01 January, 2000, see Fig. 1),
- count the number of FDI means in each of the three ranges (marked in green, yellow and red),
- weight these counts such that higher ranges get a higher weight (e.g. ‘1’ for the upper third, ‘0’ for the middle third, ‘-1’ for the lower third),

- the sum of these weights, scaled to lie in the range (-1, +1), serves as the level component of the test statistic,
- for the same FDI means, calculate the scaled Mann-Kendall trend test statistic (high values indicate an increasing trend, low (negative) values indicate a decreasing trend (the scaled version has values in the range (-1, +1), as the level component),
- then calculate the FDI assessment statistic as (0.5*level component + 0.5*trend component). The factor 0.5 is introduced only to arrive at test statistic with values in the interval (-1,+1), i.e. for aesthetical reasons.

This assessment statistic has a small negative value if jointly the trend points downwards and mean values are low. Correspondingly, a high positive value is a consequence of an increasing trend combined with high means. If the same increasing trend took place in the range of already high mean FDI values, the test statistic is larger than if the same trend occurred in the low FDI range. In this way it is clearly signalled if two adverse conditions, high FDI levels plus increasing trend, occur jointly. To test if this assessment statistic has a value compatible with the null hypothesis of no trend, but only random fluctuation around the mean FDI, the statistical distribution of the statistic is determined by Monte Carlo simulation. This simulation generates many (n=10,000) sequences of hypothetical mean FDI values of the same length, mean and standard deviation as the data to assess, but based on the assumption of no trend. For each sequence the FDI assessment statistic is calculated. The empirical distribution of all the assessment statistics is used for the summarizing assessment as follows:

- If the observed test statistic is smaller than the 2.5% quantile of the simulated distribution, then this is considered to signal a desirable FDI level and trend ('green smiling face'),
- if the observed test statistic is larger than the 97.5% quantile of the simulated distribution, then this is considered to signal an undesirable FDI level and trend ('red frowning face'),
- in all other cases the test statistic is interpreted as giving an indifferent signal ('yellow neutral face').

This smiley approach generates information not only on the current disease level in a region compared to the long-term status, but also on recent changes (= trends). For instance, in two hypothetical areas were the majority of mean FDIs has been in the green range within the past 5 years, the area that does exhibit a statistically significant upward trend will be assigned a more 'negative' smiley than the area that does not exhibit a trend, because the upward trend (even if it is in the green range) is causing the alarm bell to ring. The smiley faces can be placed on a map and provide a geographical overview of levels and trends in overall disease status (see Fig. 2).

RESULTS

Figure 1 shows examples for temporal changes of the mean FDI values over time for three regions (ICES statistical rectangles). Only externally visible diseases (see Tab. 2) were considered. As described above, the colour bands are created so that one third of all observation points lie in each of the bands. It is emphasised that the size of the green, yellow and red areas is not representative of the health status of the fish. The smiley faces inserted in the right upper corners of graphs indicate the results of the level and trend assessment statistic described above.

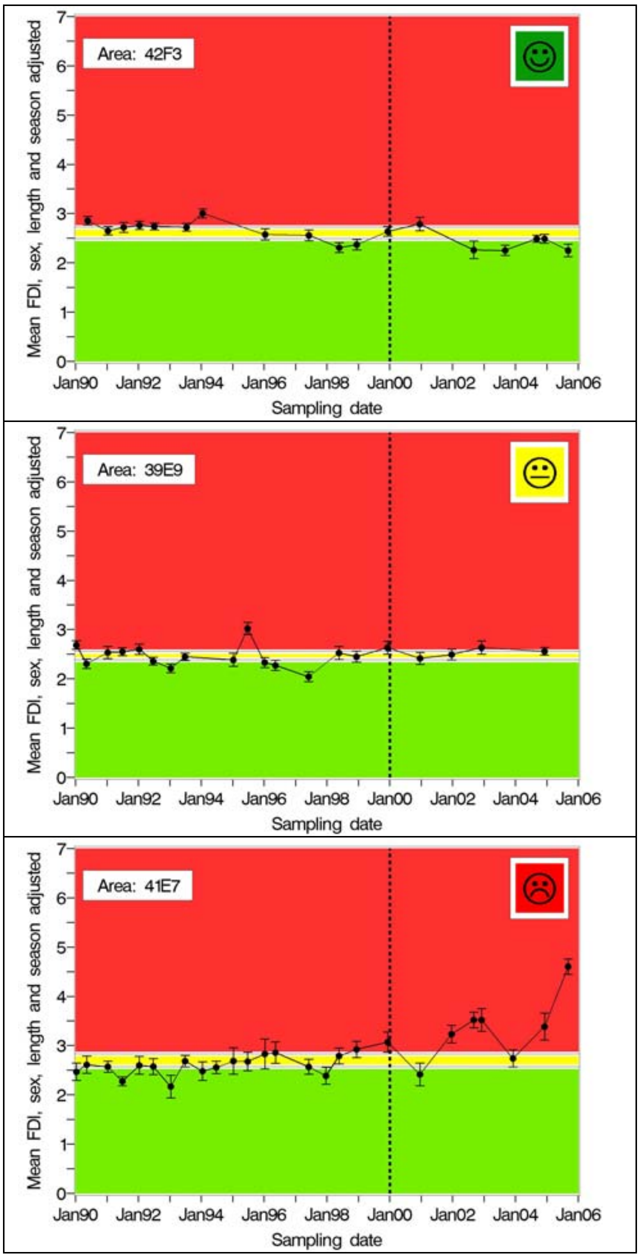

Figure 1: Changes in mean FDI values (with 95% confidence intervals) in dab (*L. Limanda*) from three North Sea regions (ICES statistical rectangles) in the period 1990-2005 (German data only); assignment of green, yellow and red colour bands, representing a good, moderate and bad health status; the dashed vertical line denoted the starting point (1990) for assessments of FDI levels and trends leading to smiling, indifferent and frowning faces (see explanations in the text) (ICES 2007b) (**Note:** The size of the red, yellow or green colour bands does not represent the assessment and can, thus, be neglected).

Figure 2 gives a map of the North Sea with the ICES statistical rectangles and the smiley faces for rectangles with a sufficient amount of disease data (see Material and Methods).These smiley faces provide a visual general assessment of levels and trends in overall disease status. Again, only externally visible diseases (see Tab. 2) are considered.

The results of the assessment illustrated in Fig. 2 reveal that the health status (with respect to externally visible diseases only) improved in one out of 11 North Sea sampling areas, while it decreased in five areas. For the rest of the sampling areas there was no clear trend.

It has to be noted that the assessment procedures applied *per se* cannot provide information on possible causes of the observed FDI levels and trends. They only serve as an alarm bell, highlighting areas of concern where more research is needed in order to identify causes of the negative trends in the health status of the fish.

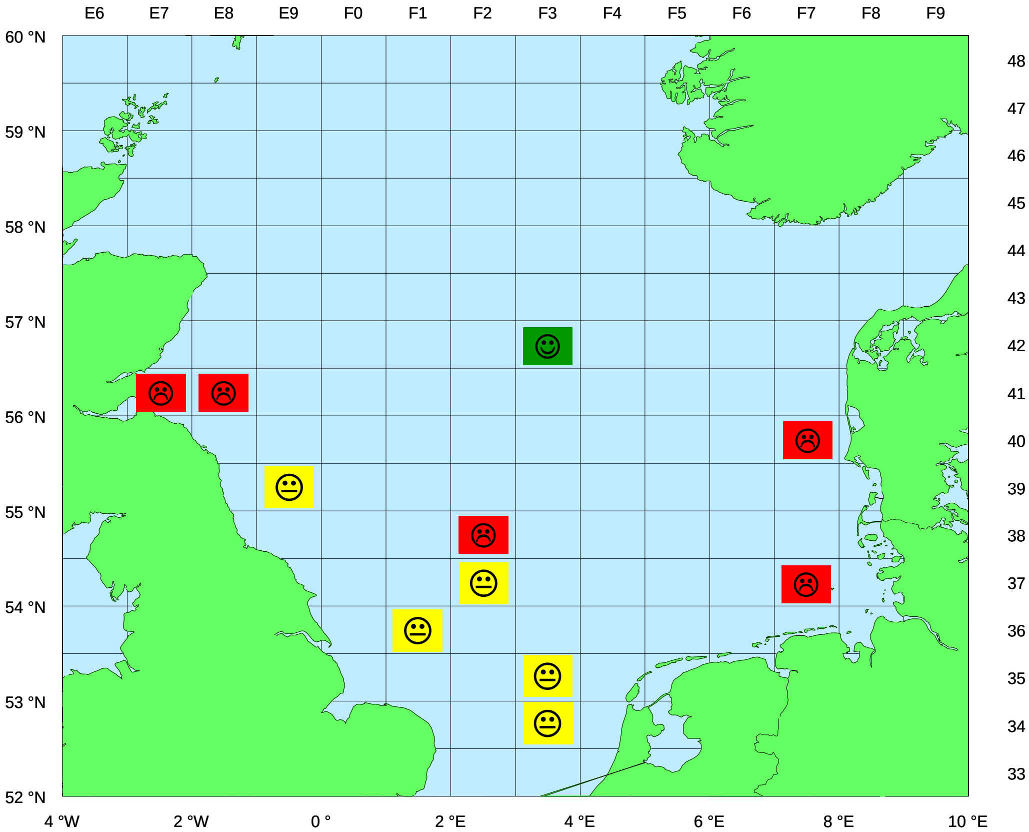

Figure 2: Representation of recent Fish Disease Index assessment statistics in North Sea dab (*Limanda limanda*) by smiley symbols (German data only). Green, yellow and red symbols indicate a good, moderate or bad health status, resp., since January 1, 2000. The FDI means are assessed with respect to trend direction and also to FDI level (see explanations in the text) (ICES 2007b)

DISCUSSION AND OUTLOOK

The present paper provides information on an approach developed through ICES activities that combines disease data derived from standardised fish disease surveys in order to obtain a numeric index (the Fish Disease Index, FDI) reflecting the overall health status of individual fish. The individual FDIs can be combined into a mean FDI that reflects the health status of a sample of fish taken from a population by using standard statistics. Furthermore, the paper describes a way how to analyse the indices in terms of their levels and their temporal trends and, thus, enabling an assessment of changes in the health status of fish populations, potentially indicating changes in marine ecosystem health. The components of the FDI, the methods used for the data assessments and some results are exemplified by using data obtained in studies on diseases of the common dab (*Limanda limanda*) from the North Sea carried out as part of the German long-term fish disease monitoring programme in the North Sea and adjacent areas. These data are part of the ICES fish disease database.

The results of the study reveal that there is no general trend in the North Sea indicating a positive or a negative change in health status. However, it is interesting to note that in 5 out of 11 ICES statistical rectangles there was a significant negative trend while the health status improved only in one of the areas. Reasons for this finding are so far unknown and more research is clearly needed. It has to be noted that the FDIs calculated were only based on data on externally visible diseases/parasites. Data on macroscopic liver neoplasms (tumours) and on liver histopathology were not included at this stage but their inclusion might have changed the picture considerably. Furthermore, the results may become different when all disease data in the ICES fish disease database, including those submitted by other ICES Member Countries, are considered. This will be a task for further activities of the ICES Working Group on Pathology and Diseases of Marine Organisms (WGPDMO).

It is felt that the FDI approach described offers an appropriate and robust method required for marine environmental monitoring and assessments such as that carried out by OSPAR via its Coordinated Environmental Monitoring Programme (CEMP) but also for other regional programmes, e.g., HELCOM for the Baltic Sea. However, the following important principles of the FDI approach and the assessment involved have to be noted:

- FDIs according to the original construction can only be calculated if sufficient data on the presence and severity of a defined set of diseases and on length and sex of the fish examined for diseases as well as on sampling season is available. This implies that disease monitoring has to strictly follow a standard protocol such as that developed and recommended by ICES (Bucke et al. 1996). Furthermore, an assessment of the effects of the diseases on the host should be possible, e.g. based on expert judgment.
- It is well known that disease prevalences as well as severity grades and, thus, the FDIs calculated for a give fish species differ considerably and consistently between regions due to the impact of host-specific and region-specific factors. Therefore, it is not feasible to define 'universal' natural background/reference or target FDI values that can be applied on a larger geographical scale (e.g., for the whole North Sea or even for the whole OSPAR maritime area) as the basis of health assessment.
- Consequently, the assessment of the FDIs has to be done on a regional basis and is based on existing longer-term fish disease data from these regions. The regional longer-term data are needed to establish region-specific assessment criteria (e.g., into good, moderate, poor health status).
- This implies that an assessment based on the present FDI approach can only be done in regions where diseases have already been monitored regularly (preferably at least once per year) for a longer period (5-10 years).
- In order to assess fish disease data generated in exploratory monitoring (in areas never sampled before), either disease data from adjacent areas would be needed for comparison or the definition of the assessment criteria would have to be modified.
- In cases of missing data (e.g., specific diseases or severity grades), the FDI can easily be modified. However, it is emphasised that the lack of data on certain key diseases and on other FDI components might change the FDIs and the assessment results significantly.

In 2008, the ICES WGPDMO was given the task to provide an assessment of fish disease in the OSPAR maritime area for inclusion in the OSPAR Quality Status Report (QSR) 2010 to the extent possible by testing the fish disease index developed by ICES and reported at WKIMON III through application in an evaluation of data collected by OSPAR Contracting Parties. (OSPAR request 2008/13). The assessment should consider the prevalence of externally visible fish diseases, macroscopic liver neoplasms and liver histopathology in common dab (*Limanda limanda*) (ICES 2008).The WGPDMO carried out the assessment requested (results not shown in the present paper) and, based on its results, the following conclusions were drawn (ICES 2008):

- From the application of the Fish Disease Index (FDI) to the ICES fish disease data there is evidence that the FDI approach is an appropriate tool for the analysis and assessment of fish disease data generated within monitoring programmes according to established ICES guidelines. It is considered ready for application in the OSPAR CEMP context.

- There is evidence that a considerable amount of disease data available in national databases is still missing in the ICES fish disease database This is partly due to the fact that data have not yet been submitted (e.g., data on liver histopathology) or due to problems related to conversion or submission of data using the ICES Integrated Environmental Reporting Format 3.2.3.
- The fish disease data submitted to the ICES Data Centre so far are not sufficient to conduct an overall assessment of levels and trends as planned by using the full FDI approach with all of its components. Reasons were (a) national data cover different time periods and different sets of diseases, (b) lack of data on severity grades, (c) patchy regional coverage. However, since the FDI can technically be modified in a way that still enables an assessment (i.e., by reducing the number of diseases considered, neglecting disease severity grades and considering the three disease categories externally visible diseases, macroscopic liver neoplasms, liver histopathology separately), an analysis and assessment is possible with the data available, the results of which have to be considered as preliminary, however.
- The results of the assessment using different approaches (set of diseases included in the construction of the FDI) clearly show that the temporal changes in the FDI and the resulting assessment of the disease status strongly depend on the set of diseases included in the construction of the FDI, because the diseases show a different behaviour in terms of levels and trends. Therefore, it is not sufficient to consider only few diseases. In contrast, it is advisable to include as many diseases as possible in the FDI because only then a comprehensive assessment of the overall disease status is possible.
- A decision on the most appropriate FDI approach and a more comprehensive assessment of the fish disease data will only be possible once all data available in national databases have been submitted to the ICES Data Centre and have been analysed. Ways will be explored with data originators and the ICES Data Centre as to how this can be achieved in a timely fashion in order to meet the OSPAR requirements for the QSR 2010. It is anticipated that WGPDMO will revisit this issue at its 2009 meeting.

In order to evaluate the applicability of the FDI approach for the OSPAR assessments, ICES constituted a Review Group which undertook a thorough review of the technical details of the FDI (ICES 2008). According to the results of the review, a number of methodological modifications of the FDI approach are in preparation at present. Based on these modifications and on the completion of the ICES fish disease database by national data that have so far not been submitted, an analysis and assessment of the ICES fish disease data will be carried out in the coming year. The results of this assessment will be the basis for the chapter on fish diseases in the OSPAR QSR 2010. It is further planned to apply the FDI approach on disease data from other fish species both from the North Sea and the Baltic Sea.

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