OCENA STANU EKOLOGICZNEGO WÓD ZLEWNI RZEKI WEL

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University of Warmia and Mazury in Olsztyn

Norweski Instytut Badania Wody
Norwegian Institute for Water Research

OCENA STANU EKOLOGICZNEGO WÓD ZLEWNI RZEKI WEL

WYTYCZNE DO ZINTEGROWANEJ OCENY STANU EKOLOGICZNEGO RZEK I JEZIOR NA POTRZEBY PLANÓW GOSPODAROWANIA WODAMI W DORZECZU

ECOLOGICAL STATUS ASSESSMENT OF THE WATERS IN THE WEL RIVER CATCHMENT

GUIDELINES FOR INTEGRATED ASSESSMENT OF ECOLOGICAL STATUS OF RIVERS AND LAKES TO SUPPORT RIVER BASIN MANAGEMENT PLANS

pod redakcją:
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Spis treści

Wprowadzenie

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Ramowa Dyrektywa Wodna, przyjęta przez Parlament Europejski i Radę UE w grudniu 2000 r., zasadniczo zmieniła podejście krajów europejskich do zagadnień gospodarowania wodą, w tym do oceny i klasyfikacji wód. Systemy użytkowej klasyfikacji wód, bazujące przede wszystkim na parametrach fizycznych i chemicznych, okazały się niewystarczające w nowoczesnym gospodarowaniu wodami. Ramowa Dyrektywa Wodna wymaga oceny całego ekosystemu wodnego w kategoriach ekologicznych, niezależnie od sposobu użytkowania wód. Ocena stanu ekologicznego części wód musi odzwierciedlać strukturę i funkcjonowanie całego ekosystemu, a jej podstawą powinny być tzw. elementy biologiczne, czyli zespoły organizmów zasiedlających wody. Cechy fizyczno-chemiczne oraz hydromorfologiczne mają w tej ocenie znaczenie wspomagające. Stan ekologiczny oceniany jest przez pryzmat odchylenia od warunków referencyjnych, które powinny być ustalone dla każdego elementu biologicznego oraz wspomagającego, w odniesieniu do poszczególnych kategorii i typów wód. Celem Ramowej Dyrektywy Wodnej jest osiągniecie co najmniej dobrego stanu ekologicznego wszystkich wód powierzchniowych w krajach unijnych, poprzez wdrażanie planów gospodarowania wodami w dorzeczach.

Problematyka prezentowanej monografii jest inspirowana wymogami RDW w zakresie oceny i klasyfikacji wód. Opracowanie zawiera wyniki projektu „Rozwój i walidacja metod zintegrowanej oceny stanu ekologicznego rzek i jezior na potrzeby planów gospodarowania wodami w dorzeczu", realizowanego w ramach Polsko-Norweskiego Fundu-

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szu Badań Naukowych i dofinansowanego ze środków Funduszu na podstawie Umowy finansowej nr PNRF – 220 – AI -1/07. Celem projektu było przeprowadzenie zintegrowanej, zgodnej z wymogami RDW, oceny stanu ekologicznego cieków i jezior położonych w przykładowej zlewni. W realizacji projektu uczestniczyły następujące instytucje polskie: Instytut Ochrony Środowiska - Państwowy Instytut Badawczy (lider konsorcjum), Instytut Rybactwa Śródlądowego im. Stanisława Sakowicza w Olsztynie, Instytut Meteorologii i Gospodarki Wodnej - Państwowy Instytut Badawczy Oddział we Wrocławiu, Uniwersytet Przyrodniczy w Poznaniu oraz Uniwersytet Warmińsko-Mazurski w Olsztynie. Ze strony norweskiej w realizacji projektu uczestniczył Norweski Instytut Badania Wody (NIVA).

Podstawą opracowania były dane zebrane w trakcie szeroko zakrojonej kampanii badawczej przeprowadzonej w 2009 r. w zlewni nizinnej rzeki Wel, położonej w centralnej Polsce. Obiektem badań było 16 części wód rzecznych oraz 10 części wód jezior. Duża część zlewni znajduje się w granicach Welskiego Parku Krajobrazowego. Obszar ma znaczenie turystyczno-rekreacyjne (szlak kajakowy, szlaki turystyki pieszej, ośrodki wczasowe, pola biwakowe, indywidualna zabudowa rekreacyjna). Teren zlewni ma głównie charakter rolniczy, a jej wody są obiektem gospodarki rybackiej.

Przeprowadzenie oceny stanu ekologicznego wód w Polsce nastręcza wiele trudności, ponieważ ciągle brakuje krajowych metod oceny odwołujących się, zgodnie z RDW, do specyficznych dla typu warunków referencyjnych. Nowe biologiczne metody oceny ciągle znajdują się w fazie opracowywania prawie we wszystkich krajach europejskich. Biologiczne systemy klasyfikacyjne, zgodnie z RDW, powinny odwoływać się do obfitości, składu taksonomicznego i różnorodności zespołów organizmów wodnych, wyrażonych różnymi wskaźnikami (metriksami). W Polsce opracowano dotąd jedynie metody oceny rzek oparte na makrofitach i fitobentosie, a jezior – na podstawie fitoplanktonu, makrofitów i fitobentosu. Niektóre z tych metod nie są dostatecznie zwalidowane i powinny być dokładnie sprawdzone przed ich włączeniem do rutynowych programów monitoringowych. Także w Norwegii, niektóre metody oceny stanu ekologicznego znajdują się ciągle w fazie opracowywania. Zatem partnerzy projektu, w celu oceny stanu badanych rzek i jezior, stanęli przed koniecznością przetestowania nowych wskaźników (metriksów) i opracowania sposobu oceny na podstawie tych elementów biologicznych, dla których brak jest oficjalnie przyjętych metod. Należy zdawać sobie sprawę, że w wielu przypadkach materiał zebrany w zlewni rzeki Wel, będący podstawą wypracowanych nowych metod jest zbyt ubogi, żeby metody te mogły być rekomendowane, w istniejącej formie, do oceny rzek i jezior w Polsce, bez przetestowania ich na większych zbiorach danych z całego kraju. Wypracowanie tych metod jest jednak znaczącym krokiem naprzód w procesie doskonalenia sposobów klasyfikacji rzek i jezior stosowanych w monitoringu wód w Polsce.

Obiektem szczególnego zainteresowania projektu była kwestia integracji „cząstkowych" ocen, na podstawie poszczególnych elementów biologicznych, w jedną spójną ocenę sumaryczną jeziora lub odcinka rzeki wyznaczonego jako jednolita część wód. Zasada „one out all out" („najgorszy decyduje"), promowana w Ramowej Dyrektywie Wodnej zakłada, że element biologiczny najsilniej zmieniony w odniesieniu do stanu referencyjnego określa ostateczną klasę stanu ekologicznego części wód. Ta zasada jest spójna z inną, tzw. zasadą przezorności („precautionary principle"), która zapewnia ochronę najbardziej wrażliwego na presję elementu ekosystemu. Jednakże Ramowa Dyrektywa Wodna pozwala na wykluczenie z oceny biologicznych i wspomagających elementów, charakteryzujących się niskim poziomem ufności, co oznacza, że jeśli metriks jest niedostatecznie pewny, może być pominięty w zintegrowanej ocenie. Zatem w projekcie analizowano niepewność na poziomie poszczególnych metriksów i metod oceny, a wyniki wykorzystano w testowaniu różnych scenariuszy integrowania ocen cząstkowych w całościową ocenę stanu ekologicznego części wód w zlewni rzeki Wel.

Plany gospodarowania wodami w dorzeczu powinny zawierać ocenę ryzyka błędnej klasyfikacji. Symptomy degradacji środowiska mogą pozostać niezauważone, jeśli część wód zostanie błędnie zakwalifikowana do lepszej klasy stanu. Z kolei, jeśli część wód zostanie mylnie przypisana do stanu gorszego, niż w rzeczywistości reprezentuje, może to pociągnąć za sobą marnotrawstwo środków finansowych wydanych na niepotrzebne działania. To zagadnienie, kluczowe z punktu widzenia gospodarowania wodami, zostało również poruszone w projekcie.

Monografia dotyczy oceny rzek i jezior w zlewni polskiej rzeki. Jednak wyniki przeprowadzonych prac mogą również być przydatne w Norwegii, w której, podobnie jak w Polsce, nie wszystkie problemy związane z wdrażaniem WFD zostały już rozwiązane.

Realizacja projektu i przeprowadzenie tak szeroko zakrojonych badań możliwe było tylko dzięki współpracy licznego zespołu specjalistów, którym, jako koordynatorzy projektu, składamy serdeczne podziękowania za wkład pracy i udział w przygotowaniu publikacji. Wyrazy wdzięczności kierujemy również do Dyrektora Welskiego Parku Krajobrazowego, Krzysztofa Główczyńskiego, za wszechstronną pomoc w realizacji badań.

Wykonawcy projektu serdecznie dziękują Waldemarowi Kozłowskiemu, Adamowi Mańko, Janowi Roli, Stanisławowi Sidorskiemu, Krzysztofowi Skockiemu, Grzegorzowi Soszce, Annie Szostek, Justynie Święszkowskiej, Piotrowi Traczukowi, Krzysztofowi Wittbrodtowi oraz pracownikom Polskiego Związku Wędkarskiego Okręgu Ciechanów za pomoc w pracach terenowych.

Summary

The problems considered in the present monograph were inspired by the EU Water Framework Directive (WFD) requirements concerning water assessment and classification. The study presents the results of the Project "Development and validation of methods for integrated assessment of ecological status of rivers and lakes to support river basin management plans", carried out within the framework of the Polish-Norwegian Research Fund and co-financed with the resources of the Fund under the Financial Agreement No. PNRF – 220 – AI -1/07. The aim of the Project was to develop new and validate existing assessment methods for the biological quality elements in freshwater ecosystems. The approach to meet this aim was to conduct an integrated, WFD-compliant assessment of ecological status of watercourses and lakes in a demonstration river catchment. The following Polish institutions participated in the Project: the Institute of Environmental Protection – National Research Institute (the consortium leader), the Stanisław Sakowicz Inland Fisheries Institute in Olsztyn, the Institute of Meteorology and Water Management – National Research Institute, the Branch in Wrocław, the Poznań University of Life Sciences and the Warmia and Mazury University in Olsztyn. Norway was represented in the consortium by the Norwegian Institute for Water Research (NIVA).

The study was based on data collected in an extensive survey campaign in the demonstration river catchment of the lowland Wel River, situated in central Poland. The survey was performed in 2009 in 16 river water bodies and 10 lake water bodies. The assessment of the ecological status of the waters in the surveyed river catchment was a challenging task, since there are no national methods to date which are based on type-specific reference conditions in accordance with WFD requirements. To date, in Poland only methods for river assessment based on macrophytes and phytobenthos have been developed, and so have lake assessment methods based on phytoplankton, macrophytes and phytobenthos. Thus, in order to assess the status of the surveyed rivers and lakes, the Project Partners attempted to test new indices (metrics) and to develop assessment methods for those biological elements for which there are no officially approved methods.

The Wel River is a left-hand and largest tributary of the Drwęca River. Its sources are in the Dylewskie Hills at about 210 m above sea level. The river is 107.5 km long and it

drains into the Drwęca at the locality of Bratian, at about 84 m above sea level. The surface area of the catchment is 822 km^2. In the catchment natural and semi-natural areas occupy a surface area of 222 km^2 (27%); areas of extensive agriculture 97 km^2 (12%); areas of intensive agriculture 496 km^2 (60.3%); agglomerations and industrial areas 7.6 km^2 (0.9%).

Eleven river water bodies had been officially designated in the catchment. However, on the basis of field surveys, several of them were divided, whereas others turned out to be insignificant and, as a result, they were rejected in further analyses. This resulted in 16 river water bodies which were covered by the survey (Table 5 page 21). The survey also covered the 10 largest lakes in the river catchment, with a surface area at least 50 ha (Table 6 page 28).

The ecological status of the river and lake water bodies in the Wel River catchment was assessed on the basis of all the biological elements, as well as the supporting physicochemical and hydromorphological elements required by the WFD.

The assessment of river water bodies

The macrophyte-based ecological status assessment of the river water bodies was carried out on the basis of the Macrophyte Index for Rivers (MIR) as an indicator. In 2008, the MIR Index gained the status of the official national method for river assessment. The Macrophyte Index for Rivers uses 153 macrophyte taxa to which an indicator value is assigned, indicating the mean trophic status of the environment where a given taxon occurs, and so is the so-called weight coefficient, which is a measure of the ecological tolerance of a species.

It was found that the surveyed river water bodies in the Wel River catchment belonged to three ecological status classes. High status was demonstrated by 4 sites, good status by 12 and moderate status by 5 river water bodies (Table 5 page 48, App. 1). The probability of misclassification of ecological status of river water bodies on the basis of macrophytes was very low in most cases, often at a level of a few percent only. The maximum probability of misclassification was 40%.

Just as in many European countries, the phytobenthos-based assessment method officially adopted for routine river monitoring in Poland is based on diatom communities (the Diatom Index IO for rivers) rather than on the whole phytobenthos assemblage. The Diatom Index assesses the trophic status (TI module), the saprobic status (SI module) and the degree of deviation from the reference community for a given river type – the GR module. The value of 1 is assigned to each reference species, whereas the value of GR is the sum of the relative abundances of the reference species and varies from 0 (no refe-

rence species in the community) to 1 (all the species have the reference character). The IO Index is the arithmetic mean of these three modules.

The ecological status of the Wel River and its tributaries as assessed by means of diatom phytobenthos is high or good, with the exception of the Płośniczanka which was found to be in moderate status (Table 7 page 77, App. 1). Note should be taken of the high status of the Wel River downstream of the outflows from lakes compared with the good status in the upper and lower parts of this river. In turn, the ecological status of the surveyed tributaries is good, with the exception of the Płośniczanka, already mentioned above, with moderate status and the tributary from Mroczno with high status. In order to estimate the analytical uncertainty related to the results obtained, the analyses was carried out for the procedure of identifying diatom taxa and valves counting. Out of six samples (sites), 4 subsamples (permanent slides) were prepared and microscopic analyzes done. Based on the results of the analytical uncertainty estimation the assessment made by using the IO Index were found to involve very low error and the risk of misclassification does not exceed 5%. However, there are other sources of uncertainty for phytobenthos in rivers, such as spatial and temporal uncertainty, but these uncertainty components were not estimated in this study.

In Poland, work still continues on the macroinvertebrate-based method for river assessment. Therefore, for the purposes of the assessment of the ecological status of the watercourses in the Wel River catchment, the usefulness (i.e. the response to pressures) of many generally known metrics was tested, and on this basis a multimetric index was developed which was best correlated with the pressure gradient.

The proposed new benthic macroinvertebrate-based index (MBI) is the weighted mean of four metrics: the German Saprobic Index (SI_{GI}) with the highest weight, the Average Score per Taxon– PL based on the modified BMWP PL (ASPT-PL), the Evenness index E and the percentage share of Ephemeroptera, Trichoptera and Plecoptera (EPT). The proposed multimetric index MBI is characterised by a good correlation with the degree of organic water pollution (expressed by TOC). When assessed on the basis of this index, almost all the river water bodies in the Wel River catchment were found to have good ecological status (Table 3 page 96, App. 1). Only the upper course of the Wel River was found to have high status. The developed index does not depend on the sampling method and the sampling period (in the spring or the autumn). Despite substantial temporal and sampling method variability in the number of taxa and the number of specimens taken in different seasons using different methods (with coefficients of variation in the order of 10-40%), the value of the index itself hardly varies (with the coefficient of variation from 0.0 to 6.5%), showing that the MBI is quite a robust multimetric index.

To date, no WFD-compliant method has been officially adopted in Poland for assessing ecological status of rivers based on ichthyofauna assemblages. The European

Fish Indices EFI and EFI+, elaborated in successive pan-European projects (FAME, EFI+), were tested and the EFI+ was chosen to assess the rivers in the Wel River catchment. It turned out that the usefulness of EFI and EFI+ indices for the part of sites (3 water bodies on the lake-connecting Wel River stretches), where cyprinid fish dominated ichthyofauna in its natural condition, was limited. Accordingly, the Index of Biotic Integrity (IBI) was applied for the assessment of the ecological status of these sites, using the version of the IBI which had originally been developed for the Nida River catchment. This IBI version accepts the domination of cyprinid fish as a natural element of the fish community. The use of the IBI Index for the assessment of the fish assemblages in some parts of the Wel River catchment should be treated as a trial application of this method to assist the expert assessment.

15 out of the 16 surface water bodies in the Wel River catchment were assessed on the basis of fish: 12 using the EFI+ and 3 – using the IBI. In the case of one site the assessment was impossible due to the existence of one species only. 9 water bodies were found to be in good status, three in moderate status, one in poor and two in bad status (Table 6 page 115, App. 1).To a much larger extent than in the case of other biological elements, the fish-based assessment of the ecological status of running waters reflects the hydromorphological modifications of the river environment, such as the regulation of the river channel, changes in the flow rate, the character of the substrate, and the fragmentation of the habitat by transverse barriers. Moreover, fish are subject to direct human interference through angling, fish stocking and poaching. As a result of the above, the discrepancy of the results of the ecological status assessment based on fish and other biological elements can be expected.

In order to carry out an uncertainty analysis for the fishing method, the sites were grouped on the basis of the similarities of the ecological parameters and the fish species composition. Within the groups of sites thus designated, treated as samples taken from similar habitats, the uncertainty related to the fishing method was assessed again. The results of both analyses demonstrated substantial variability of the basic catch parameters among the sites, irrespective of the method for grouping the sites (according to the water bodies and on the basis of similarity analysis).

15 out of 16 river water bodies designated in the Wel River catchment were surveyed also by using physicochemical quality elements as supporting parameters. The surveys were carried out 10 times in a year, from February to November. In order to determine the quality class of each water body, the values of the surveyed physicochemical indicators were compared with the boundary values laid down in Annex 1 to the Regulation of the Minister of the Environment of 20 August 2008 on the classification of the status of surface water bodies (Official Journal of the Laws of 2008, No. 162, Item 1008). The worst recorded concentration was used for the assessment. In the particular months of 2009,

most of the surveyed physicochemical indicators of water quality showed low values corresponding to Quality Class I, whereas only total organic carbon, nitrate nitrogen, Kjeldahl nitrogen and total phosphorus demonstrated higher values periodically or in single cases, mostly exceeding the boundary values set out for Quality Class I and, less frequently, those for Quality Class II. Eleven water bodies were assigned to Class II (good status), whereas four water bodies represented a status worse than good (Table 3 page 121, App. 1).

The assessment of hydromorphological modifications of the watercourses in the Wel River catchment was based on the River Habitat Survey (RHS) system, which, particularly in last ten years, was tested in many European countries, including Poland. It is widely used by different researchers to evaluate river habitats and as an auxiliary tool in the biological surveys of the different groups of aquatic organisms. In Poland, no method has been officially adopted for the hydromorphological assessment of rivers. The River Habitat Survey is a method to characterise the river channel and, to a lesser extent, the river valley. In this method, the class of the hydromorfological status of a river habitat is defined on the basis of the Habitat Quality Assessment and the Habitat Modification Score. A synthetic assessment of the class of the hydromorphological status of the water bodies surveyed demonstrates that five water bodies are characterized by Class One of hydromorphological quality. Three water bodies were assigned to Class Two in good hydromophological status. The other watercourse sections were classified below good hydromorphological status (Table 4 page 138, App. 1).

The assessment of lake water bodies

In accordance with the WFD, the phytoplankton-based assessment of the ecological status of lakes should take into account the assemblage abundance, the taxonomic composition and the presence of blooms. At present, in Poland officially the assessment criteria in effect are those based only on the chlorophyll a in water as a measure of phytoplankton abundance. In 2009 the phytoplankton-based method for the assessment of the ecological status of lakes was developed (the Phytoplankton Metric For Polish Lakes - PMPL), which, apart from chlorophyll *a*, also accounts for the total phytoplankton biomass and the biomass of blue-green algae (this index covers the biomass of blue-green algae and their share in the total phytoplankton biomass; therefore, it may be treated as an element of the assessment of the taxonomic composition). This method was the basis for the assessment of the lakes in the Wel River catchment. Using PMPL, one lake is assessed as high ecological status, two lakes as moderate status, six reservoirs as poor status and one as bad status (Table 6 page 158, App. 1). The uncertainty in the phytoplankton-based assessment of the ecological status of lakes using the PMPL multimetric

index arise from the error related to the determination of the chlorophyll concentration, total algal biomass and blue-green algal biomass, as well as from spatial and temporal variability in the phytoplankton community in a lake. The relative error of the chlorophyll a concentration at the particular sites varied between about 2% and more than 14% (the mean relative error was ±7.6%), the relative error involved in the determination of phytoplankton biomass varied between 11.8% and 24.5% (with the mean value of ± 17.9%), while the relative error involved in the determination of blue-green algal biomass fell within the range of 20.4%-25.6% (with the mean value of ±22.7%). The assessment uncertainty, i.e. the probability of misclassification of ecological status due to analytical and operator uncertainty varies depending on the value of the multimetric index; it is the highest where the index values are close to the ecological status class boundaries and lowest where the value of the multimetric is close to the middle of a status class. Depending on the lake, the probability of misclassification based on analytical and operator uncertainty varied from 5% to 40%.

The macrophyte-based method for the assessment of the ecological status of Polish lakes uses the macrophyte index called the Ecological State Macrophyte Index (ESMI), which is an official assessment method in Poland. This method was applied for the assessment of the lakes in the Wel River catchment. In accordance with the requirements of the WFD, the ESMI method takes into account two main aspects of aquatic vegetation: the taxonomic composition (Pielou index) and the macrophyte abundance (colonisation index) . On its basis, one lake was classified as having high status, whereas the other lakes as having good status. This classification does not reflect the distinct variability of vegetation found in the lakes in the Wel River catchment. Based on the non-parametric Spearman test, no statistically significant relationship was found between the lake status class and the pressure parameters (e.g. Total P). This indicates that although the absolute values of the ESMI Index show significant relationship with the water quality parameters (R^2=0,88 with TP), the boundary values of the ecological status classes officially adopted in the Regulation are too lax (with the too wide range of the index values for good ecological status). For this reason, more stringent class boundaries were tested on the Wel lakes dataset. With the proposed new boundary values, the ecological status classes of the lakes in the Wel River catchment demonstrated statistically significant, strong relations with total phosphorus (with the Spearman correlation coefficient r=0.81, p=0.004), After the application of new class boundaries, one lake continued to demonstrate high ecological status, another lake was classified as good, seven lakes as moderate and one as poor (Table 9 page 181, App. 1). In order to estimate the operator uncertainty related to the assessment by the ESMI method, the lakes in the Wel River catchment were surveyed by two or three independent researchers. The uncertainty analysis carried out on this basis for the assessment demonstrated that the risk of

misclassification of lakes varied from 8.4% in the case of Lake Kiełpińskie to more than 40% in the case of Lake Lidzbarskie.

The first version of the method for the assessment of lakes based on the phytobenthos assemblage (diatoms only), developed in Poland in 2006, was recently validated on the basis of the results of the national monitoring in 2008-2009. The new Polish method (the Diatom Index for Lakes – IOJ) was submitted for the 2nd phase of the pan-European intercalibration exercise. It was used for the assessment of the lakes in the Wel River catchment. The IOJ Index is the weighted mean of two modules: the trophic module Z_{TJ} and the reference species module $GR_{J.}$ The assessment of the lakes in the Wel River catchment on the basis of the Diatom Index assigned two lakes to high status, six to good status and the other two to moderate status (Table 6 page 198, App. 1). In order to estimate the operator uncertainty related to the procedure of identifying diatom taxa and valves counting microscopic analyses of fives samples (sites) were carried out, including replicates 4 (permanent slides) for each of them. The results show that the values of the IOJ Index had a very small operator-dependent error. The risk of misclassification on the basis of operator and analytical uncertainty of the analyses of the diatom phytobenthos (the IOJ Index) is slight and does not exceed 5%. However, there are many other components of uncertainty not estimated in this project, e.g. spatial and temporal uncertainty which will increase the risk of misclassification for this index.

To date, in Poland no method based on benthic macroinvertebrates has been developed for lake assessment. Therefore, in order to assess the lakes in the Wel River catchment on the basis of macroinvertebrates, it is necessary to develop a new WFD-compliant biotic index. The survey of macroinvertebrates in the Wel lakes covered littoral benthos, extra-littoral benthos and integrated samples of the Chironomidae assemblage (using pupal exuviae). Subsequently, new metrics were calculated, taking into account taxonomic composition, abundance, diversity, and taxon sensitivity to hydromorhological alterations and/or eutrophication. Altogether, the tests covered 128 metrics based on littoral invertebrates, 5 metrics based on extra-littoral invertebrates and 144 ones based on chironomid pupal exuviae. Because of the limited number of data available and insignificant correlations with pressure, as expressed by water trophic indices, the tests showed that it was impossible to elaborate metrics based on littoral and extra-littoral invertebrates. In contrast, the results of the tests of metrics based on integrated samples of chironomid pupal exuviae demonstrated great usefulness in assessing ecological status related to eutrophication. For the purposes of assessing the lakes in the Wel River catchment, two metrics demonstrating the strongest response to chlorophyll a and total phosphorus were chosen: the CPET index, which constitutes the mean trophic value of the Chironomidae taxa present in the sample, and the proportion of taxa belonging to the Chironomini tribe. The two selected biotic indices were integrated

into one cumulative biotic index (MBI_CPET) by averaging the values of the two metrics. Prior to the integration, the EQR values of the indices were normalised and four ecological status class boundaries were set. Three lakes in the Wel River catchment were classified as representing moderate ecological status, five lakes as having poor status and two as showing bad status (Table 3 page 214, App. 1). Thus, no lake in the Wel River catchment meets the environmental objectives according to this classification, i.e. no lake achieves at least good ecological status. On the basis of an expert opinion, it seems, however, that the status class boundaries are too stringent. In the future, after a larger number of data has been collected, it would be desirable to adjust the proposed boundary values. These boundaries of ecological status classes may also be changed after the intercalibration exercise is completed in 2011, if the assessment of lakes based on chironomid pupal exuviae significantly deviates, at the European scale, from the assessments based on other benthic invertebrate metrics.

Given the nature of the data available, the uncertainty analysis was limited to the determination of uncertainty related to the spatial variability of Chironomidae assemblages. The values of the MBI_CPET Index obtained at two sites in two lakes indicated that the spatial variability was a minor component of the variability of the index values. Given that the national assessment method is at the initial stage of development and limited number of data available, the method proposed above for the lake assessment based on benthic invertebrates involves large uncertainty. Hence, when integrating the lake assessment based on MBI_CPET with the results achieved for other biological elements, this element should be underestimated with respect to other elements that seem to produce the more reliable assessments.

The Lake Fish Index (LFI) developed in Poland assesses the ecological status of lakes using data on long-term commercial catches. Unfortunately, such data are not available for most lakes in the Wel River catchment. In order to assess their ecological status, we therefore attempted to develop a new WFD-compliant method for the assessment based on the results of catches using the so-called Nordic gillnets, in accordance with the standardised CEN method. The weight shares of individual fish species in catches were considered partial variables capable of describing the ecological status of the lakes surveyed. The best metrics were selected by modelling, testing the correlation of different variables with the pressure factors, particularly Carlson's Trophic State Index. On the basis of the tests, the variables that correlated best with the pressure indicators for the Wel lakes, and whose distinct responses to changes in environmental conditions were identified in the literature, were selected. The best metrics were: the weight shares of perch, rudd, common bream and the functional group of sensitive species, in which the total share of crucian carp, tench and perch was included. For these metrics, the ranks and rank sums were calculated and normalised to the interval of 0 to 1. The best scores

were given to Lakes Kiełpińskie, Dąbrowa Mała and Dąbrowa Wielka, whereas the lowest ones – to Lake Tarczyńskie. However, this assessment is not strictly WFD compliant as the selected metrics do not refer to type-specific reference conditions, and thus is only valid for comparing the lakes in the Wel river catchment, setting the unified hierarchy of the lakes rather than their real ecological status. The present assessments were achieved on the basis of just ten lakes, and there were too few lakes per type to allow the performance of reasonable statistical analyses. Therefore, the credibility of this assessment is limited. In particular, for the lakes assigned to the worst class, this assessment did not match with expert judgement. Even in Lake Tarczyńskie, which received the worst score, all the fish species characteristic of the lake type were found to live and reproduce normally. The ecological status of the lakes was also assessed indirectly, using the well-known relations between the Polish Lake Fish index (LFI) and the pressure indicators (TSI and the scores of the Lake Quality Assessment System – SOJJ). The LFI assessments estimated from these relations indicate that most lakes in the Wel River catchment have good status, some of them – moderate status, with none of them having poor and bad status (Table 13 page 232, App. 1). These assessments may be closer to reality; all the more so as they were calculated from different fish lake type-specific regressions. The work on the method for fish-based lake assessment must be continued in Poland using a much larger database, covering a full spectrum of lake quality.

Within the project, the pilot study on the use of hydroacoustic methods for ecological status assessment of lakes was also carried out. Preliminary results of acoustically measured parameters, such as abundance of fish, macrophyte maximum colonization depth, macrophyte coverage area (%), and the density of gas bubbles (which could be treated as a measure of anoxic conditions) were considered as promising metrics and were highly correlated with some pressure elements such as chlorophyll a and visibility (correlation coefficient $r>0.65$). However, the number of studied lakes (four in case of fish and two in case of macrophytes) was too small to enable any classification of ecological status. It was only possible to order the lakes from the best to the worst, and this hierarchy was in agreement with other methods used , especially those based on macrophytes or phytoplankton.

In accordance with the WFD, the physicochemical elements, supporting the assessment of the ecological status of lakes, should include the indicators of eutrophication, salinity, acidification and thermal and oxygenation conditions. The type-specific boundary values of the supporting physicochemical elements for good and moderate status to be used for the assessment of Polish lakes were laid down by the Regulation of the Minister of the Environment of 20 August 2008 on the classification of the status of surface water bodies (Official Journal of the Laws of 2008, No. 162, Item 1008). The assessment of the lakes was carried out on the basis of the mean values of the physico-

chemical indicators from the growing season. In relation to the physicochemical elements, most Wel lakes meet the criteria for at least good ecological status. In the case of four lakes the low transparency of waters corresponds to worse than good status in accordance with the assessment based on the biological elements (Table 3 page 252, App. 1).

To date, no method for the assessment of hydromorphological modifications of lakes has been officially adopted in Poland for the purposes of routine monitoring. The British Lake Habitat Survey method (LHS) was tested in the country, and after small adjustments to the national conditions, it can be used to assess Polish lakes. This method was applied to assess the hydromorphological modifications of ten lakes in the Wel River catchment. The survey on hydromorphological conditions by the LHS method covers the littoral, shore and riparian zones. Pressures are recorded (e.g. buildings, roads, marinas, platforms) and so are the degree of bank modification, intensive uses of the riparian areas and the lake itself, as well as the presence of the natural cover of the riparian zone (e.g. wetlands, trees and shrubs, forests of relatively large naturalness). The hydromorphological lake assessment by the LHS method also takes into account hydrological information (e.g. water level variations in the lake, the presence of hydro-engineering structures in the lake and the related watercourses), as well as geomorphological characteristics. The data collected in accordance with the LHS procedure serve to calculate a synthetic lake modification index (Lake Habitat Modification Score – LHMS). The LHS results indicate that the lakes in the Wel River catchment have been only slightly modified in hydromorphological terms (App. 1).

An integrated assessment

The WFD requires the ecological status of each water body to be assessed according to the "one out all out" (OOAO) rule, which means that the worst biological quality element determines the status of the whole water body. In accordance with such an approach, eight running water bodies in the Wel River catchment should be assigned to good status, five to moderate status, one to poor status and two to bad status None of the surveyed lakes meets the criteria for high and good status, two are classified as moderate, five as poor and three as bad (Table 1 page 266, App. 1). The OOAO rule is a precautionary solution intended to protect the most vulnerable biological elements, preventing the misclassification of a water body in moderate or worse status (requiring, in consequence, mitigation measures) to good or better status (where there is no need for mitigation measures). However, the WFD also recommends that quality elements involving high uncertainty should be excluded from the assessment. Within the project four different approaches to the integration of metrics were analysed: 1) the application of the OOAO

rule, 2) the application of the OOAO rule, but excluding the most uncertain biological element, 3) the averaging of the status classes determined on the basis of the particular biological elements, 4) weighted averaging of the assessments, down-weighting the most uncertain biological element. The obtained results indicate that the integration methods based on average or weighted average values are favourable from a statistical point of view, because they make better use of the information available than the "one out all out" rule. Moreover, these solutions were more resilient to higher uncertainty of biological metrics: the level of uncertainty did not seem to affect the proportion of misclassification to worse status (compared with the misclassification to better status). However, the averaging of the assessment results in practice can be complicated and there is also the risk that the weighted average-based approach can be misused to obtain "desirable" results in order to avoid the need to implement expensive mitigation measures. The OOAO rule usually causes the least risk of misclassification to better status class, but also a greater extent of misclassification to worse status under the conditions of higher uncertainty (which, in consequence, would require the implementation of mitigation measures when they are not really needed). The exclusion of a BQE (given its high uncertainty) prior to the application of the OOAO rule may reduce the overall risk of misclassification.

Finally, the monograph contains the guidelines for an integrated assessment of the ecological status of rivers and lakes which emerged as the effect of the discussion among Project Partners on the basis of the project results.