Institut für Binnenfischerei e.V. (IfB)
Potsdam-Sacrow
Im Königswald 2, 14469 Potsdam

FISCHBASIERTE SEENBEWERTUNG IN DEUTSCHLAND

Vertretung Deutschlands im Interkalibrierungsprozess, Übernahme der Leitung der Central-Baltic Gruppe und Publikation des deutschen Verfahrens

Projekt-Nr. O 3.13

Bearbeitung: Dr. David Ritterbusch

Im März 2014

INHALT

Zielstellung 1
Methodik 1
Ergebnisse 2
zu 1 und 2): Kapazitäten in den Mitgliedstaaten und Ausgangssituation. 2
zu 3 und 4) Treffen und Interkalibrierungsstrategie 3
zu 5) Interkalibrierung und Kommunikation 3
zu 6) Typologie der Seen 4
zu 7) Publikation des deutschen Verfahrens 4
Nutzen für den wasserrechtlichen Vollzug 4
Literatur 5
Anhang 1 - CB Lake Fish System descriptions, comparability and WFD compliance 9
Introduction 9
Overviews 10
WFD compliance 16
Intercalibration feasibility 18
Annex zu Anhang 1 24
Anhang 2 - Second Central Baltic LakeFish Intercalibration Meeting 24./25.10.2013 63
Anhang 3 - Proposal of an index to approach the total anthropogenic pressure intensity (TAPI) 65
Anhang 4 - A typology for fish-based assessment …. 72
Anhang 5 - Fischbasierte Seenbewertung im alpinen Bereich 87
Einleitung und Hintergrund 87
Datenbasis und Datenerhebungen 88
Typologie und Rahmenreferenzen 89
Metrics und Punktevergabe 91
Diskussion 97
Kurzdarstellung und Nutzung der Excel-Vorlage 98
Short description of the German system for the fish-based assessment of the ecological status of alpine lakes (DELFI-SITE) 100
Anhang DeLFI Alpin 103

ZIELSTELLUNG

Das Institut für Binnenfischerei hat gemeinsam mit Partnern und in enger Abstimmung mit den Mitgliedern des VDFF Arbeitskreises „Fischereiliche Gewässerzustandsbewertung“ für Deutschland ein Verfahren zur Bewertung des ökologischen Zustandes von Seen anhand der Fische entwickelt. Damit wird der Forderung der Wasserrahmenrichtlinie (WRRL 2000) nach einer fischbasierten Seebewertung nachgekommen. Ziel des hier vorgestellten Vorhabens ist es, den Vorschlag zu veröffentlichen um so die Anwendung und Prüfung des Verfahrens zu ermöglichen. Dazu gehören die Verfahrensbeschreibung und eine Excel-Vorlage zur praktischen Anwendung.

Das zweite Hauptziel des Vorhabens ist die Fortführung der Interkalibrierung. Auf europäischer Ebene wird die fischbasierte Seenbewertung seit 2008 interkalibriert, d.h. es wird geprüft, ob die nationalen Verfahren auf europäischer Ebene zu vergleichbaren Ergebnissen führen. Mitarbeiter des Instituts sind als deutsche Vertreter in der sog. Phase II bis 2011 am Interkalibrierungsprozess beteiligt gewesen. Von 2009 bis 2011 übernahm Deutschland die Leitung der Central Baltic GIG (geographischen Interkalibrierungsgruppe der „Länder des zentralen Flachlands und Ostsee-Anrainer“). Bis dahin konnten erhebliche Fortschritte erzielt werden, die Interkalibrierung wurde jedoch nicht abgeschlossen. Ursachen waren die späte Entwicklung nationaler Verfahren (teilweise erst im Sommer 2011) und Besonderheiten des Elements „Fische in Seen“. Beispielsweise zeigen Fische als integrierendes Element nur undeutliche Reaktionen auf einzelne Belastungen aber gute Zusammenhänge zur Gesamtbelastung. Ein Abgleich der Reaktionen entlang eines einzelnen Belastungsgradienten war so nicht sinnvoll. Damit waren die methodischen Vorgaben zum Ablauf der Interkalibrierung (CIS 2011) nur begrenzt anwendbar. Zu Anfang des Jahres 2012 gab Deutschland die Leitung der Central Baltic GIG ab. Da kein anderer Mitgliedsstaat die Leitung übernahm, fanden in diesem Jahr keine Tätigkeiten im Bereich der Interkalibrierung statt. Auch der Kontakt innerhalb der GIG brach weitgehend ab. Ende des Jahres 2012 wurde entschieden, die Fristen für die Interkalibrierung zu verlängern. Dabei sind Zeiträume bis 2016 im Gespräch. In Anbetracht der neuen Situation wurde das Institut für Binnenfischerei gebeten, erneut die Vertretung Deutschlands im Interkalibrierungsprozess und die Leitung der entsprechenden geographischen Gruppe zu übernehmen.

METHODIK

Die Schwerpunkte des Vorhabens liegen in organisatorischen Tätigkeiten, Kommunikation, Literaturrecherchen und schriftlichen Ausarbeitungen bisheriger Entwicklungstätigkeiten. Erklärungsbedürftige Methoden wurden nicht angewendet.

ERGEBNISSE

Die Kernziele des Vorhabens O 3.13 laut Vorhabensbeschreibung im Antragsverfahren sind:
Im Bereich der Interkalibrierung
1) Ermittlung des aktuellen Standes und der Kapazitäten in den Mitgliedsstaaten
2) Ermittlung Ausgangssituation
3) Start-Treffen
4) Strategie-Papier
5) Interkalibrierung und Kommunikation

Im Bereich der Veröffentlichung des deutschen Verfahrens
6) Typologie der Seen
7) Publikation des deutschen Verfahrens

Das Vorhaben war zunächst vom 01.04.2013 bis zum 31.03.2014 auf ein Jahr befristet. Das Gesamtvorhaben „Veröffentlichung des deutschen Verfahrens und Interkalibrierung“ war jedoch von Anfang an auf eine Gesamtlaufzeit von zwei Jahren ausgerichtet. Im Laufe des hier beschriebenen ersten Teils wurde es erforderlich, einige Inhalte zwischen den Vorhabensteilen zu verschieben. Zur Fertigstellung des vorliegenden Berichts war der zweite Projektteil vom LAWA-AO bereits genehmigt, so dass die Gesamtziele des Vorhabens dadurch unbeeinträchtigt bleiben. Die o.g. Kernziele des Vorhabens resultierten in Texten für unterschiedliche Zielgruppen. Diese Texte werden dem vorliegenden Projektbericht in Originalform beigefügt, wobei alle Ergebnisse der Interkalibrierungstätigkeiten in Englisch verfasst sind.

ZU 1 UND 2): KAPAZITÄTEN IN DEN MITGLIEDSTAATEN UND AUSGANGSSITUATION.

Zu Beginn der Tätigkeiten wurden zunächst die Ergebnisse aus Phase II der Interkalibrierung gesichtet. Die vorhandenen Verfahrensbeschreibungen aus den Mitgliedstaaten der GIG wurden nach folgenden Kriterien zusammengefasst: Allgemeine Informationen, Literaturquellen, Verfahrenskonzept, Befischungsmethodik, Typologie, Metrics und Klassengrenzen, Berechnungen und Leistungsfähigkeit.
Im Anschluss wurden die Experten aus Phase II der Interkalibrierung kontaktiert und bezüglich ihrem Wunsch nach Fortführung der Tätigkeiten und ihren personellen Möglichkeiten befragt. Erfreulicherweise zeigten alle Mitgliedsstaaten Interesse daran, die Interkalibrierung fortzuführen. Daher wurde ihnen jeweils die nationale, aber vom Verfasser zusammengefasste Verfahrensbeschreibung mit der Bitte um Prüfung und Aktualisierung zugesandt. Als Ergebnis liegen aktuelle und vollständige Verfahrensbeschreibungen für alle Mitgliedstaaten der Central Baltic GIG vor, die eine fischbasierte Seenbewertung durchführen.
Anhand dieser Zusammenstellung wurde eine Übersicht der Verfahren erstellt. Zudem wurde eine Qualitätssicherung durchgeführt, wie sie die Richtlinie zur Interkalibrierung für Phase II vorgibt (CIS 2011). Dabei wurde geprüft ob die nationalen Verfahren die Vorgaben der WRRL erfüllen und ob eine Interkalibrierung im Grundsatz durchgeführt werden kann und Erfolg verspricht.
Die Interkalibrierung wird vom Joint Research Center (JRC) koordiniert. Im Jahresverlauf wurde dort eine unabhängige Prüfungskommission eingerichtet, die den Fortschritt der Interkalibrierung begleiten soll. Vom JRC wurde um einen Bericht der bisherigen Tätigkeiten gebeten. Dadurch war eine schriftliche Ausarbeitung der Verfahrensbeschreibungen, der Vergleiche sowie der Qualitätsprüfungen erforderlich. Auch eine Interkalibrierungsstrategie sollte dargestellt werden. Diese Ausarbeitung war im ursprünglichen Vorhaben Ende 2014 vorgesehen und führte zu Verzögerungen bei der Ausarbeitung des deutschen Verfahrens.

Anhang 1 dieses Dokuments beinhaltet Verfahrensbeschreibungen, Zusammenfassungen und Qualitätsprüfungen aller verfügbaren Bewertungsverfahren (in Englisch). Unter www.dropbox.com/sh/6b7jnraqwihjoht/iHjsPlZuso wurde ein Dropbox Online-Speicher eingerichtet, der dem Austausch von Informationen dient. Die dort enthaltenen Dokumente sind öffentlich abrufbar.

ZU 3 UND 4) TREFFEN UND INTERKALIBRIERUNGSSTRATEGIE

Zur Verbesserung der Kommunikation innerhalb der Interkalibrierungsgruppe und zur Erarbeitung einer gemeinsamen Interkalibrierungsstrategie wurde vom Institut für Binnenfischerei ein Treffen der Gruppe organisiert. Es fand am 25./26. Oktober 2013 im Umweltbundesamt in Berlin statt. Folgende Mitgliedstaaten waren vertreten: Belgien, Tschechien, Dänemark, Frankreich, Niederlande, Polen und Vereinigtes Königreich, zudem waren Vertreter des Instituts für Gewässerökologie und Binnenfischerei, des Umweltbundesamtes und des Joint Research Centers anwesend. Nicht teilnehmen konnten Estland, Lettland und Litauen. Bei dem Treffen wurden neuere Verfahren vorgestellt, die den Mitgliedstaaten außerhalb der o.g. Beschreibungen noch nicht bekannt waren. Zudem wurde über neue Entwicklungen informiert. Es wurde eine Interkalibrierungsstrategie entwickelt, die drei Ansatzpunkte verfolgt:

a) Die Entwicklung eines Belastungsindexes: Die Erfahrungen aus Phase II zeigen, dass die Nutzung von gemeinsamen Metrics oder die Abgleichung entlang einzelner Belastungsfaktoren bei Fischen nicht zielführend ist. Fische zeigen relativ schlechte Reaktionen auf einzelne Belastungsfaktoren, reagieren aber auf die Gesamtbelastung. Daher wurde vorgeschlagen, einen Index für die Gesamtbelastung zu entwickeln und diesen als Vergleichsgrundlage zu nutzen. Eine ähnliche Vorgehensweise funktionierte bei der Interkalibrierung der fischbasierten Verfahren für Seen im alpinen Bereich und in den nordatlantischen Ästuaren.
b) Die Nutzung des WISER Index: Als Ergebnis des WISER Projektes wurde anhand der Daten aus der Interkalibrierung ein fischbasiertes Bewertungsverfahren entwickelt. Dieses Verfahren wurde für Frankreich als nationales Verfahren übernommen und als europäisches Verfahren vorgeschlagen (ARGILLIER et al. 2013). Zwar hat sich gezeigt, dass spezielle nationale Verfahren in der Regel plausiblere Ergebnisse liefern als allgemeine Ansätze. Dennoch soll der Verfahrensvorschlag auf die Daten der Mitgliedsstaaten angewendet und die Eignung als Vergleichsmetric oder gemeinsames Verfahren geprüft werden.
c) Vom Verfasser des vorliegenden Berichtes soll ein alternativer Vorschlag ausgearbeitet werden. Dieser wird voraussichtlich ohne Belastungskorrelationen, nur auf Basis einer Einschätzung von Fischgemeinschaftsmerkmalen funktionieren.

Das Kurzprotokoll des Treffens ist in **Anhang 2** zu finden (in Englisch). Programm und Vorträge können unter www.dropbox.com/sh/6b7jnraqwihjoht/L5BzgFV8EG/2013_Meeting abgerufen werden.

ZU 5) INTERKALIBRIERUNG UND KOMMUNIKATION

Die Kommunikation in der Gruppe war dauerhafter Bestandteil der Tätigkeiten. Eine eigentliche Interkalibrierung, d.h. eine Anpassung der Klassengrenzen, konnte zum gegenwärtigen Zeitpunkt noch nicht durchgeführt werden. Die Entwicklung des oben unter a) genannten Belastungsindex‘ war eine Vorarbeit zu diesem Punkt. Der vom Institut für Binnenfischerei entwickelte Gesamtbelastungsindex beinhaltet 20 Belastungsmerkmale aus den sechs Kategorien

Eutrophierung, Versauerung, Umweltverschmutzung, hydrologische Veränderungen, morphologische Veränderungen und biologische Belastungen. Die Belastungsmerkmale werden zu einem Gesamtindex verrechnet. Den Mitgliedsstaaten der Interkalibrierungsgruppe wurden eine Verfahrensbeschreibung und eine Excel-Vorlage zur einheitlichen Anwendung zur Verfügung gestellt. Eine erste Prüfung mit einem Testdatensatz von deutschen Daten ergab eine gute Korrelation zwischen Gesamtbelastungsindex und EQR-Werten des typbasierten Verfahrensansatzes.

Die Verfahrensbeschreibung zur Berechnung des Belastungsindex‘ ist in **Anhang 3** dargestellt.

ZU 6) TYPOLOGIE DER SEEN

Der deutsche Verfahrensvorschlag enthält einen Typ-basierten und eine Gewässer-basierten Ansatz. Im Rahmen der Verfahrensentwicklung wurde eine spezielle Typologie entwickelt, die die Grundlage des Typ-basierten Ansatzes darstellt. Diese Typologie wurde in Form eines wissenschaftlichen Fachartikels beschrieben und bei der Zeitschrift Limnologica eingereicht.

Die Beschreibung der Fisch-spezifischen Typologie findet sich in **Anhang 4** (in Englisch).

ZU 7) PUBLIKATION DES DEUTSCHEN VERFAHRENS

Die Publikation des deutschen Verfahrens ist weit fortgeschritten, konnte aber bis März 2013 nicht erfolgen. Ursache sind zusätzliche Anforderungen aus der Interkalibrierungstätigkeit, die zu Verschiebungen in den Projektinhalten zwischen den Bearbeitungsjahren 2013 und 2014 geführt haben. Die Veröffentlichung soll zeitnah in der ersten Hälfte des Jahres 2014 erfolgen, voraussichtlich im Rahmen der Schriftenreihe des Instituts für Binnenfischerei. Dabei sollen eine vollumfängliche Verfahrensbeschreibung sowie Excel-Vorlagen zur einfachen Anwendung des Verfahrens zur Verfügung gestellt werden. Die bisherige Ausarbeitung ist nahezu fertig. Die Excel-Vorlage soll jedoch noch ins Deutsche übersetzt und eine Beschreibung zur Nutzung erstellt werden. Diese Tätigkeiten erfordern einen vergleichsweise geringen Aufwand. Der Zwischenstand der Bearbeitung ist aufgrund des großen Umfangs dem vorliegenden Projektbericht nicht beigefügt.
Für den alpinen Bereich wurde eine gesonderte Verfahrensbeschreibung angefertigt. Auch hier sind Dokument und Excel-Bewertungsvorlage weitgehend fertiggestellt, jedoch soll nach Rücksprache mit den für den Alpenraum zuständigen Fischereiverwaltungen noch eine statistische Prüfung der Rahmenreferenzen ergänzt werden. Auch diese Ergänzung ist wenig aufwändig, konnte jedoch nicht mehr bis Ende März 2014 abgeschlossen werden. Die nahezu fertiggestellte Verfahrensbeschreibung für den alpinen Bereich findet sich in **Anhang 5**.

NUTZEN FÜR DEN WASSERRECHTLICHEN VOLLZUG

Die im vorliegenden Bericht beschriebenen Tätigkeiten dienen unmittelbar der Durchführung wasserrechtlicher Maßgaben und ihres Vollzugs:

- Die Veröffentlichung des fischbasierten Verfahrens zur Bewertung des ökologischen Zustands von Seen ist die Grundlage einer zukünftigen Anwendung. Nur so können die Vorgaben der Wasser-Rahmenrichtlinie zur fischbasierten Bewertung von Seen umgesetzt werden.

- Die Beteiligung Deutschlands im europäischen Interkalibrierungsprozess ist ebenfalls durch die Wasser-Rahmenrichtlinie verpflichtend vorgegeben.
- Die Leitung der Central Baltic GIG durch Deutschland gewährleistet den Fortschritt im Interkalibrierungsprozess. Kein anderer Mitgliedsstaat sah sich zur Übernahme dieser Funktion in der Lage. Die Leitung erlaubt die Vertretung deutscher Interessen und Standpunkte im Gesamtprozess.

LITERATUR

2008/915/EC (2008): Commission decision establishing, pursuant to Directive 2000/60/EC of the European Parliament and of the Council, the values of the Member State monitoring system classifications as a result of the intercalibration exercise vom 30.10.2008. L 332 Seiten 20-44 ff.

2008/915/EG (2008): Entscheidung der Kommission zur Festlegung der Werte für die Einstufungen des Überwachungssystems des jeweiligen Mitgliedstaats als Ergebnis der Interkalibrierung gemäß der Richtlinie 2000/60/EG des Europäischen Parlaments und des Rates vom 30.10.2008. L 332 Seiten 20-44 ff.

2013/480/EU (2013): Commission decision of 20 September 2013 establishing, pursuant to Directive 2000/60/EC of the European Parliament and of the Council, the values of the Member State monitoring system classifications as a result of the intercalibration exercise and repealing Decision 2008/915/EC vom Official Journal of the European Union L 266.

APPELBERG, M., B. C. BERGQUIST & E. DEGERMAN (2000): Using fish to assess environmental disturbance of Swedish lakes and streams-a preliminary approach. Verhandlungen der Internationalen Vereinigung für Limnologie 27: 311-315.

ARGILLIER, C., S. CAUSSÉ, M. GEVREY, S. PÉDRON, J. BORTOLI, S. BRUCET, M. EMMRICH, E. JEPPESEN, T. LAURIDSEN, T. MEHNER, M. OLIN, M. RASK, P. VOLTA, I. J. WINFIELD, F. KELLY, T. KRAUSE, A. PALM & K. HOLMGREN (2012): Development of a fish-based index to assess the eutrophication status of European lakes. Hydrobiologia 704: 193-211.

ARGILLIER, C., S. CAUSSÉ, M. GEVREY, S. PÉDRON, J. BORTOLI, S. BRUCET, M. EMMRICH, E. JEPPESEN, T. LAURIDSEN, T. MEHNER, M. OLIN, M. RASK, P. VOLTA, I. J. WINFIELD, F. KELLY, T. KRAUSE, A. PALM & K. HOLMGREN (2013): Development of a fish-based index to assess the eutrophication status of European lakes. Hydrobiologia 704: 193-211.

BELPAIRE, C., R. SMOLDERS, I. V. AUWEELE, D. ERCKEN, J. BREINE, G. VAN THUYNE & F. OLLEVIER (2000): An index of biotic integrity characterizing fish populations and the ecological quality of Flandrian water bodies. Hydrobiologia 434: 17-33.

BRÄMICK, U., M. DIEKMANN, R. LEMCKE & T. MEHNER (2008a): Assessing shifts in fish assemblages of German large lakes by literature data and commercial catch statistics. Fundamental and Applied Limnology 171: 87-103.

BRÄMICK, U., M. DIEKMANN, R. LEMCKE & T. MEHNER (2008b): Assessing shifts in fish assemblages of German large lakes by literature data and commercial catch statistics. Fundamental and Applied Limnology. 171: 87-103.

BREINE, J., P. QUATAERT, M. STEVENS, F. OLLEVIER, F. A. M. VOLCKAERT, E. VAN DEN BERGH & J. MAES (2010): A zone-specific fish-based biotic index as a management tool for the Zeeschelde estuary (Belgium). Marine Pollution Bulletin 60: 1099-1112.

CAUSSÉ, S., M. GEVREY, S. PEDRON, S. BRUCET, K. HOLMGREN, M. EMMRICH, J. DE BORTOLI & C. ARGILLIER (2012): Fish indicators for ecological status assessment of lakes affected by eutrophication and hydromorphological pressures. WISER deliverable 3.4-4, CEMAGREF, Aix-en-Provence.

CIS (2003): River and lakes - Typology, reference conditions and classification systems - WG 2.3 REFCOND. 10, Common Implementation Strategy for the Water Framework Directive

(2000/60/EC) - Guidance Document, Luxembourg.
CIS (2011): Guidance document on the Intercalibration Process 2008-2011. ECOSTAT 14, Implementation Strategy for the Water Framework Directive (2000/60/EC) - Guidance Document.
DIEKMANN, M., U. DUßLING & R. BERG (2005): Handbuch zum fischbasierten Bewertungssystem für Fließgewässer (FIBS). Fischereiforschungsstelle Baden-Württemberg, Langenargen.
DUßLING, U. (2009): Handbuch zu fiBS - Hilfestellungen und Hinweise zur sachgerechten Anwendung des fischbasierten Bewertungsverfahrens fiBS. Schriftenreihe, 15, Verband deutscher Fischereiverwaltungsbeamter und Fischereiwissenschaftler e. V.
DUßLING, U., A. BISCHOFF, R. HABERBOSCH, A. HOFFMANN, H. KLINGER, C. WOLTER, K. WYSUJACK & R. BERG (2004): Verbundprojekt: Erforderliche Probennahmen und Entwicklung eines Bewertungsschemas zur ökologischen Klassifizierung von Fließgewässern anhand der Fischfauna gemäß EG-WRRL. Abschlussbericht, allgemeiner Teil: Grundlagen zur ökologischen Bewertung von Fließgewässern anhand der Fischfauna. Bundesministerium für Bildung und Forschung.
EMMRICH, M., S. BRUCET, D. RITTERBUSCH & T. MEHNER (2011): Size spectra of lake fish assemblages: responses along gradients of general environmental factors and intensity of lake-use. Freshwater Biology 56: 2316-2333.
EMMRICH, M., S. BRUCET, I. J. WINFIELD, E. JEPPESEN, T. LAURIDSEN, P. VOLTA, C. ARGILLIER, S. PEDRON, K. HOLMGREN, T. HESTHAGEN, D. RITTERBUSCH & T. MEHNER (2012): Changes in size structure of fish assemblages in European lakes along eutrophication and hydromorphological pressure gradients. WISER deliverable 3.4-2.
EN 14757 (2005a): European Standard: Water quality - Sampling of fish with multi-mesh gillnets vom 27.06.05. ICS 13.060.70; 65.150.
EN 14757 (2005b): Europäische Norm: Wasserbeschaffenheit - Probennahme von Fisch mittels Multi-Maschen-Kiemennetzen vom 27.06.05. ICS 13.060.70; 65.150.
FROESE, R. & D. PAULY (2014): FishBase (own extraction of ecological information on preferred habitats for selected fish species). www.fishbase.org, abgerufen.
GASSNER, H., G. TISCHLER & J. WANZENBÖCK (2003): Ecological integrity assessment of lakes using fish communities - Suggestions of new metrics developed in two austrian prealpine lakes. International Review of Hydrobiology 88: 635-652.
GASSNER, H., D. ZICK, G. BRUSCHEK, K. MAYRHOFER & I. FREY (2006): Fischbestandsaufnahme und Bewertung des ökologischen Zustandes der natürlichen und künstlichen Seen Österreichs (>50 ha) gemäß EU-Wasserrahmenrichtlinie. Bundesamt für Wasserwirtschaft - Institut für Gewässerökologie, Fischereibiologie und Seenkunde, Scharfling.
GASSNER, H., D. ACHLEITNER, M. LUGER, D. RITTERBUSCH, M. SCHUBERT & P. VOLTA (2014): Water Framework Directive Intercalibration Technical Report - Alpine Lake Fish fauna ecological assessment methods. JRC Technical Reports, S. Poikane.
HELMINEN, H., J. KARJALAINEN, M. KURKILAHTI, M. RASK & J. SARVALA (2000): Eutrophication and fish biodiversity in Finnish lakes. Verhandlungen der Internationalen Vereinigung für Limnologie 27: 194-199.
JAARSMA, N. (2007): Description of references and metrics for fish in lakes in the Netherlands (unpublished). Witteveen & Bos consulting engineers.
JENNINGS, M. J., J. LYONS, E. E. EMMONS, G. R. HATZENBELER, M. A. BOZEK, T. D. SIMONSON, T. D. BEARD & D. FAGO (1999): Toward the development of an index of biotic integrity for inland lakes in Wisconsin. In: T. P. Simon (Ed.) Assessing the sustainability and biological integrity of water resources using fish communities, pp. 541-562. CRC Press LLC, Boca Raton.
JEPPESEN, E., J. P. JENSEN, M. SØNDERGAARD, T. LAURIDSEN & F. LANDKILDEHUS (2000): Trophic structure, species richness, and biodiversity in Danish lakes: changes along

phosphorus gradient. Freshwater Biology 45: 201-218.
KARR, J. R., K. D. FAUSCH, P. L. ANGERMEIER, P. R. YANT & I. J. SCHLOSSER (1986): Assessing biological integrity in running waters - A method and its rationale. Illinois Natural History Survey, Champaign.
KOTTELAT, M. & J. FREYHOF (2007): Handbook of European freshwater fishes. Publications Kottelat, Cornol.
LAWA (2003): Arbeitshilfe zur Umsetzung der EG-Wasserrahmenrichtlinie. Länderarbeitsgemeinschaft Wasser.
MATHES, J., G. PLAMBECK & J. SCHAUMBURG (2002): Das Typisierungssystem für stehende Gewässer in Deutschland mit Wasserflächen ab 0,5 km^2 zur Umsetzung der Wasserrahmenrichtlinie. In: R. Deneke & B. Nixdorf (Eds.), Implementierung der EU-Wasserrahmenrichtlinie in Deutschland: Ausgewählte Bewertungsmethoden und Defizite, pp. 15-24. Eigenverlag der BTU Cottbus, Cottbus.
MATHES, J., G. PLAMBECK & J. SCHAUMBURG (2005): Die Typisierung der Seen in Deutschland zur Umsetzung der EG-Wasserrahmenrichtlinie. In: C. K. Feld, S. Rödiger, M. Sommerhäuser & G. Friedrich (Eds.), Typologie, Bewertung, Management von Oberflächengewässern, pp. 28-36. E. Schweizerbart'sche Verlagsbuchhandlung, Stuttgart.
MEHNER, T., M. DIEKMANN, X.-F. GARCIA, U. BRÄMICK & R. LEMCKE (2004): Ökologische Bewertung von Seen anhand der Fischfauna. Berichte des IGB 21: 202.
PALM, A., T. KRAUSE, A. JÄRVALT & M. SILM (2012): Cyprinids in Estonian small lakes: comparison between main water bodies. Balwois Proceedings 5: 1-9.
POIKANE, S. (2009): Water Framework Directive intercalibration technical report - Part 2: Lakes. Joint Research Center.
POIKANE, S., S. BIRK, J. BÖHMER, H. GASSNER, S. HELLSTEN, C. D. HOYOS, M. KELLY, A. L. SOLHEIM, M. OLIN, K. PALL, G. PHILLIPS, R. PORTIELJE, D. RITTERBUSCH, L. SANDIN, A. K. SCHARTAU, A. SOLIMINI, M. V. D. BERG, G. WOLFRAM & W. V. D. BUND (unpublished): Lake ecological assessment: comparing the incomparable?
RIEDMÜLLER, U., U. MISCHKE, T. POTTGIESSER, J. BÖHMER, R. DENEKE, D. RITTERBUSCH, D. STELZER & E. HOEHN (2013): Steckbriefe der deutschen Seetypen - Begleittext und Steckbriefe. Limnologie-Büro Hoehn.
RITTERBUSCH, D. (2010): First LakeFish Intercalibration Meeting30.11.-01.12.2010, Minutes, Berlin: 9.
RITTERBUSCH, D. & U. BRÄMICK (2008): Methode zur Bewertung des ökologischen Zustandes von Seen > 50 ha in der Ökoregion 14 anhand der Fischfauna nach den Vorgaben der EU-WRRL - überarbeitete Version Oktober 2008. Institut für Binnenfischerei e.V., Potsdam.
RITTERBUSCH, D., U. BRÄMICK & T. MEHNER (2010): Development of a German lake typology for fish-based assessments of ecological status/integrity. Institut für Binnenfischerei e.V., Potsdam-Sacrow.
SCHAARSCHMIDT, T., H. H. ARZBACH, R. BOCK, I. BORKMANN, U. BRÄMICK, M. BRUNKE, R. LEMCKE, M. KÄMMEREIT, L. MEYER & L. TAPPENBECK (2005): Die Fischfauna der kleinen Fließgewässer Nord- und Nordostdeutschlands - Leitbildentwicklung und typgerechte Anpassung des Bewertungsschemas nach EU-Wasserrahmenrichtlinie. Landesforschungsanstalt für Landwirtschaft und Fischerei Mecklenburg-Vorpommern.
SØNDERGAARD, M., E. JEPPESEN, J. P. JENSEN & S. L. AMSINCK (2005): Water Framework Directive: ecological classification of Danish lakes. Journal of Applied Ecology 42: 616-629.
SØNDERGAARD, M., T. LAURIDSEN, E. KRISTENSEN, A. BATTRUP-PEDERSEN, P. WIBERG-LARSEN, R. BJERRING & N. FRIBERG (2013): Biologiske indikatorer til vurdering af økologisk kvalitet i danske søer og vandløb. 59, Aarhus Universitet, Aarhus.
VAN DE BUND, W., W. BONNE, S. POIKANE & N. ZAMPOUKAS (2011): Method compliance checking: which methods can be included in the intercalibration exercise? Document

discussed at the ECOSTAT meeting of 30.03.2011 V 2.0, Joint Research Center.

WHITTIER, T. R. (1999): Development of IBI metrics for lakes in southern New England. In: T. P. Simon (Ed.) Assessing the sustainability and biological integrity of water resources using fish communities, pp. 563-582. CRC-Press.

WRRL (2000): Richtlinie 2000/60/EG des Europäischen Parlaments und des Rates zur Schaffung eines Ordnungsrahmens für Maßnahmen der Gemeinschaft im Bereich der Wasserpolitik vom 23.10.2000. ABl. L 327.

ZICK, D., H. GASSNER, P. FILZMOSER, J. WANZENBÖCK, B. PAMMINGER-LAHNSTEINER & G. TISCHLER (2006): Changes in the fish species composition of all Austrian lakes >50 ha during the last 150 years. Fisheries Management and Ecology 13: 103-111.

ANHANG 1 - CB LAKE FISH SYSTEM DESCRIPTIONS, COMPARABILITY AND WFD COMPLIANCE

INTRODUCTION

This document provides overviews of the national LFI (**L**ake **F**ish **I**ndex: systems to assess the ecological status of lakes based on fish community data). The structure of this document is close to the Milestone reports of the IC Phase II (2008-2011). It includes the main steps that are suggested to be done before 'true' intercalibration according to the Phase II guidance (CIS 2011). You can find the summarized results of the system descriptions provided by the MS, as well as the analyses:

1) Overviews of the national LFI: concepts, typologies, metrics, scoring
2) The WFD compliance check - are all LFI in line with the WFD requirements?
3) The so called intercalibration feasibility check - is there any chance that IC might be successful?

The original descriptions can be found in Annex I, p. 24 onwards.

OVERVIEWS

Status of LFI assessment systems

By end of 2013, nearly all MS have developed national methods to assess the ecological status of lakes with fish (Tab. 1). Short descriptions of all systems are available in the annex. Comprehensive descriptions exist for DK (SØNDERGAARD et al. 2013) - in Danish, EE, FR (ARGILLIER et al. 2013) and NL (JAARSMA 2007). They are available for private use at https://www.dropbox.com/sh/6b7jnraqwihjoht/qLGFRgIt6J/Literature.

Tab. 1: Status of LakeFish assessment systems (no method / under development / intercalibrateable / official) and year of finalization or expected finalization.

MS	System Name	status	since/for	comment
BE-F		intercalibrateable	2012	
CZ	CZ-FBI	under development	2013	intercalibrateable but not official
DE	DeLFI	intercalibrateable	2011	finalized but not official
DK	Danish Lake Fish Index	intercalibrateable	2011	finalized but not official
EE	LAFIEE	intercalibrateable	2009	under improvement
FR	2IL	Intercalibrateable, national	2013/2014	
LT	LZIE	intercalibrateable	2013	finalized but not official
NL	VISMAATLAT	Intercalibrateable, national	2007	minor changes made in 2012.
PL	LFI+	intercalibrateable	2011	Two methods: one based on fisheries statistics (LFI+)
	LFI EN	intercalibrateable	2013	another developed for EN 14757
UK*		no method	unclear	
LV		under development	unclear	
SK		no method	not expected	

UK: England and Wales are part of the CB GIG. The Irish LakeFish system and the CB methods will be checked for applicability. Gillnet fishing is not an option because of public relation issues.

Fish sampling methods

The following Tab. 2 shows the methods used for fish stock assessment in the CB GIG. The randomized multi-mesh gillnet standard (EN 14757 2005a) is widespread, but not used in all MS.

Tab. 2: Fish sampling methods in the MS. Second column shows the gear used for metric calculation in the national LFI systems. EN is EN 14757, EN mod is comparable to EN 14757 but modified (explanations below). 'Database' shows if data was submitted to the CEMAGREF cross-GIG database with the number of lakes in parentheses. Additional gear shows methods used for sampling, but not for metrics in the national LFI.

MS	gear for LFI metrics	database	additional gear used
BE-F	fyke + electrofishing	No	
CZ	ENmod	No	Electrofishing, hydroacoustics
DE	EN / ENmod	Yes (75)	electrofishing
DK	EN	Yes (113)	electrofishing
EE	ENmod	Yes (24)	Fyke nets, electrofishing
FR	EN	Yes (40)	
LT	ENmod	Yes (46)	
LV	gillnets, trammel nets, statistics		
NL	Trawling, seine, electrofishing	No	
PL - LFI+	Fisheries statistics (seine, gillnet, fyke)	No	hydroacoustics, electrofishing
PL - EN	EN		
UK			Plans to use environmental DNA

Comments:

3) In DE some lakes were fished twice, in spring and autumn with half EN effort each. This is not done any more and a single full EN campaign is used to obtain fish data. Large mesh sizes are included in the netting. Electrofishing data is always present but not included in the system.

5) EE uses the EN standard with additional large mesh sizes.

7) LT uses the EN standard with reduced and modified mesh sizes: 14, 18, 22, 25, 30, 40, 50, 60 mm, nets are highly modified (see Annex, p. 45))

8) LV focuses on species of commercial or recreational fishing.

Typology

The typologies used in the CB GIG are shown in Tab. 3. DK and NL apply the common intercalibration types developed in IC phase I (POIKANE 2009). The other MS deviate from this typology, although the distinction between shallow polymictic and deep stratified lakes apparently is the most important criterion. For IC purposes, the MS agreed to adopt the German typology (1st CB IC meeting, 2010, Berlin).

Tab. 3: National typologies used in the CB LakeFish assessment.

MS	National types	Details and comments
BE-F	standing waters	Lakes, ponds and canals
CZ	Polymictic / stratified combined with Altitude (< 200 / 200-700 / > 700 m a.s.l.)	For HMWB and AWB (no natural lakes > 0.5 km²)
DE	POLY (polymictic)	functional
	STRAT (stratified)	functional; < 30 m max. depth
	DEEP (stratified, deep)	> 30 m max. depth
DK	L-CB1 (deep)	Stratified, 3-15 m mean depth, alkaline
	L-CB2 (shallow)	Polymictic, < 3 m mean depth, alkaline
	and 7 others (25%)	and others
Estonia	not stratified	Functional, avg. hardness
	stratified	
	soft and dark	
	soft and bright	
	and 4 others	
France	Not relevant because of site specific approach	
Lithuania	Shallow (LCB-2)	< 3 m mean depth
	interm. depth (LCB-1)	3-9 m mean depth
	deep, stratified (LCB-1)	> 9 m mean depth
Netherlands	shallow, buffered	< 3 m mean depth, 0.5 - 100 km², mineral
	deep, buffered	> 3 m mean depth, 0.5 - 100 km², mineral
	large, deep, buffered	> 3 m mean depth, > 100 km², mineral
	shallow, calcareous	< 3 m mean depth, 0.5 - 100 km², calcareous
	shallow, peat lake	< 3 m mean depth, 0.5 - 100 km², organic
Poland	Vendace	> 20 m max. depth, stratified
	Bream-Pikeperch	8-20 m max. depth
	Tench-Pike	< 8 m max. depth, polymictic
	Crucian Carp	Not in assessment system (too few)
Latvia, Slovakia		No typology

Metrics

Tab. 4: Metrics of LFI in the CB GIG and their assignment to the normative criteria of the WFD: spn: species' number, %N: percentage of total number, NPUE: number per unit of effort, W: weight, %W: percentage of total weight, WPUE: weight per unit of effort. As of October 2013.

MS	Species composition	Abundance	Sensitive species	Age structure
BE	- %N omnivorous - %N specialized spawner - %N piscivorous - %N invertivorous - %W Bream + Roach - %W benthivorous	-	- spn obligatory species - spn total - sum of tolerance values	- % recruiting species
CZ	- %W Bream - %W Perch - %N Ruffe - %W Rudd - %W Salmonidae	- WPUE (> 0+) - NPUE (> 0+)	see spec. comp.	Presence 0+ of 6 species
DE	- %W or %N Bream - %W White Bream - %W or %N Ruffe - %W Pikeperch - %W Perch - %W benthic net species - %W benthivorous	- WPUE (total)	- spn obligatory species	- median ind. W Bream, Perch, Roach - reprod. of stocked species is tested
DK	- %W Bream + Roach - %W piscivorous	- WPUE (per net)	see spec. comp.	- average individual biomass
EE	- %N Perch	- logNPUE/ (% non-pisciv.*shoredev)	- Simpson DW/log AreaLake	- % filled net sections
FR	- %N Omnivorous	- NPUE - WPUE	-	
LT	- %W White Bream - %N Perch - %W Benthivorous - %W perch+stenoterm. - %W non-native + translocated		- spn obligatory species	- avg. ind. W Roach
NL	- %W Bream - %W Perch+Roach/eurytopic - %W phytophilic species - %W low oxygen tolerant	←	- spn total	- %W Pikeperch > 40 cm

PL - LFI+	- %W Perch - %W Bream - %W White Bream - %W Tench - %W Pike - %W Crucian carp - % W large Bream / (Bream+Roach+White Bream)	*Total commercial catches?*	see spec. comp.	- %W large Bream / all Bream - %W large Roach / all Roach
PL - CEN	- %W Perch - %W Rudd - %W Bream - %W Ruffe - %W Bleak - %W Roach - %W Tench - %W Pikeperch	BPUE	see spec. comp.	

Literature

All MS have provided short but comprehensive descriptions of their national LFI-Systems which can be found in the annex of this document. Some of them follow a template, I had provided, while others follow distinct forms. Articles with more or less close relation to the national systems exist for some MS. Most of them are available at: https://www.dropbox.com/sh/6b7jnraqwihjoht/qLGFRgIt6J/Literature (for private use only!)

BE BREINE et al. (2010)
CZ
DE
DK SØNDERGAARD et al. (2013): Biologiske indikatorer… (national system description in Danish), SØNDERGAARD et al. (2005)
EE PALM et al. (2012), PALM, A. & KRAUSE, T. (2009)
FR ARGILLIER et al. (2012), Caussé et al. (2012)
LT
NL
PL
Some MS have national reports or short descriptions (same folder)

WFD COMPLIANCE

The so called WFD compliance check was a demand of the milestone reports in the IC Phase II and is also mentioned in the guidance document (CIS 2011). The compliance criteria should assure that the national systems are in line with the normative and conceptual contents of the WFD. The criteria of the milestone reports and the IC guidance are maintained without changes and summarized in Tab. 5.

Tab. 5: WFD compliance check for the Central Baltic fish systems.

Compliance criteria	Compliance checking conclusions
1. Ecological status is classified by one of **five classes** (high, good, moderate, poor, bad).	Yes for all systems
2. High, good and moderate ecological status are set in line with the WFD's **normative definitions** (**boundary setting procedure**)	Yes for all systems (although definitions like slight changes, moderate differences or signs of disturbance are unclear)
3. **All relevant parameters** indicative of the biological quality element are covered. If parameters are missing, Member States need to demonstrate that the method is sufficiently indicative of the status of the QE as a whole.	**species composition**: Yes for all systems **abundance**: Yes for all systems **sensitive species**: unclear (see Annex II) **age**: direct - No, indirect - yes for most systems (see Annex II)
4. A **combination rule** of parameters into assessment BQE is defined.	Yes for all systems
5. Assessment is adapted to **intercalibration common types** that are defined in line with the typological requirements of the WFD Annex II and approved by WG ECOSTAT	Yes: DK, LT, NL, no for others
6. The water body is assessed against **type-specific near-natural reference conditions**	Yes for most systems, FR uses site specific modelling.
7. Assessment results are expressed as **EQRs**	Yes for all systems.
8. Sampling procedure allows for **representative** information about water body quality/ ecological status **in space and time**	EN and trawl fishing information is representative in space (i.e. the whole lake). Temporal representativeness is under discussion/ investigation. Yes for time and space for Polish LFI+.
9. All data relevant for assessing the biological **parameters** specified in the WFD's normative definitions are covered by the **sampling procedure**	Taxonomic composition: Yes Abundance: Yes Sensitive species: No for EN only, Yes for multiple gear (NL, PL) Age: indirectly,
10. Selected taxonomic level achieves adequate **confidence and precision** in classification	Yes for all systems.

Comment to the WFD compliance check

Nr 2 normative definitions of the class boundaries: the normative definitions of WFD are pretty vague, of course. The Central Baltic LFI were developed to fulfil the demands of the WFD, and we should suppose that the class boundaries were set with orientation at the normative definitions. It will be a matter of the IC process to control for similar class boundary setting among the CB MS.

Nr 3 normative definitions of indicative BQE paramters: The Annex V, Nr. 1.2.2. of the WFD provides the normative definitions for high, good and moderate ecological status in lakes. For fish, high status is achieved if (unchanged citation):

1. Species composition and abundance correspond totally or nearly totally to undisturbed conditions.
2. All the type-specific sensitive species are present.
3. The age structures of the fish communities show little sign of anthropogenic disturbance and are not indicative of a failure in the reproduction or development of a particular species.

The normative definition comprises four main aspects of the fish community, i.e. species composition (relative values), species abundance (absolute values), type-specific sensitive species and age structure. As the Central Baltic LFI were developed to fulfil the demands of the WFD, a general compliance should be expected for all of them. However, critical aspects are can be found in the parameters 'sensitive species' and 'age'. The critical aspects are discussed in Annex II. No MS uses a 'real' age metric in the national LFI system. Metrics for age (or size or reproduction) are substituted by length or weight parameters. Scientific justification was provided by the CB GIG lead (see Annex II). On this basis, ECOSTAT decided to include national methods in the current intercalibration exercise even if they do not contain age structure metrics (VAN DE BUND et al. 2011).

Nr 5 intercalibration common types: The national typologies are compliant with type-setting criteria mentioned in Annex II of the WFD. Some MS use the IC typology approved by ECOSTAT. For the intercalibration, the CB LakeFish GIG decided to use another common typology. We do not accept that practical decisions from Phase I should be a decisive prerequisite for a WFD compliance (or successful intercalibration).

Nr 8 representativeness in space and time: The representativeness of different fish sampling gear in time and space is under heavy discussion. First results show that the national systems are able to account for the data variability and provide stable assessment results. We can affirm this point if we change the request for representative sampling to a request for representative assessment results. However, this point will be investigated in detail.

We conclude that a total WFD compliance is given.

INTERCALIBRATION FEASIBILITY

Similar to the compliance check, the milestone reports and the guidance for IC Phase II asked for an intercalibration feasibility check and provided a list of questions.

Typology as a restricting factor

According to the WFD, the assessment systems have to be based on some kind of typology. Type descriptors for lakes are given in the directive itself (Annex II): altitude (< 200, 200-800, > 800 m), mean depth (< 3, 3-15, > 15 m), size (0.5-1, 1-10, 10-100, > 100 km²), and geology (calcareous, siliceous, organic). Based on these criteria an official common typology was set for the Central-Baltic GIG (2008/915/EC 2008; POIKANE 2009). All types in the CB-GIG are lowland lakes < 200 m altitude. Hydrological water residence time was added to the typology. Three types were defined for the CB GIG:

L-CB1:	shallow, calcareous	(3-15 m, > 1 meq/l, 1-10 years of residence time)
L-CB2:	very shallow, calcareous	(< 3 m, > 1 meq/l, 0,1-1 years of residence time)
L-CB3:	shallow, small, siliceous	(3-15 m, 0,2-1 meq/l, 1-10 years of residence time)

The CB MS have based their national typologies mainly on the descriptors mean depth and alkalinity (Tab. 3). However, other descriptors are added in some cases (max depth, stratification yes/no). Some MS have a fish-specific typology, i.e. the typology is chosen in order to maximize statistical differences of corresponding fish community descriptors (DE, ??)

In order to develop a fish specific typology, Germany has done scientific statistical analyses. The analyses have shown that the functional criterion 'stratification' has the hugest impact on the fish community. A typology based on three types was developed (RITTERBUSCH 2010; RITTERBUSCH et al. 2010):

POLY:	polymictic lakes
STRAT:	stratified lakes
DEEP:	stratified lakes deeper than 30 m max depth

Estonia and Lithuania obtained similar results in their investigations. Unfortunately, the 3 m / 15 m mean depth threshold values of the 'official' common intercalibration types do not separate stratified lakes from non-stratified lakes. Therefore, the CB MS decided to use a typology with a stratification criterion. The typology suggested by Germany was adopted as fish-specific common intercalibration typology

Pressure criteria as restricting factors

All MS have developed systems that take the effect of eutrophication into account, which is the major human pressure in the CB GIG. In many systems additional pressures are evaluated, e.g. human use, shoreline degradation, water level regulation, connectivity …

Some human impacts do affect the fish community, but their relevance in the context of a WFD compliant assessment is still under discussion in CB the Fish group: alien species, translocated species, climate warming. Acidification is not considered relevant on the GIG level, despite some exceptions (e.g. mining lakes). It has to be taken into account, that pressures are highly intercorrelated and often have comparable effects. Intense use will lead to shoreline degradation and eutrophication which will destroy littoral habitat complexity (e.g. in urban areas). Water level regulation also will destroy habitat complexity. As has been mentioned elsewhere, fish are good indicators for ecological status, but comparably bad proxies for single pressures.

It is concluded that the fish assessment is reflecting total pressure intensity and therefore all fish systems are comparable towards their pressure indication.

Tab. 6: Pressures addressed by the national LFI.

Abb.	eutrophication	Water level regulation	Shoreline degradation	Combined	comment
BE-F				X	biotic integrity (habitat quality, water quality)
CZ	X	X	X	X	
DE	X		X	X	
DK	X				
EE	X				overfishing
FR	X				
NL	X	X	X	X	
PL	X			X	
LT	X				Fisheries pressure
UK					

Sampling comparability
Many MS follow European standard for multimesh-gillnet fishing (EN 14757 2005a): CZ, DE, DK, EE, FR, PL follow the EN 14757 more or less exactly, LT excluded small mesh sizes. Although differences might occur due to the deviating application of the EN procedure, the data is generally comparable.

BE-F, NL and PL use other methods (like trawl, fishery statistics). Data based on different gear is absolutely incomparable to EN data because:
a) Methods sample different habitats,
b) Active (trawl) and passive gears (nets) have different species-specific effectiveness,
c) Selectivity of gears to species or size-classes can not be converted to other gear,
d) Most systems work with percentages, deviation in one size/species impacts others,
e) The evidence of some species is restricted to certain methods (e.g. littoral species).

The fishing methods are not comparable throughout the GIG. This does not imply, that the assessment results are not 'intercalibrateable'. We do not want to compare metric values. We want to compare our assessment on a level of the final EQR values and their assignment to status classes. On the other hand, intercalibration methods based on common fish data can not be applied. Option 1 (common system) and Option 3 (same data acquisition, different systems) have to be ruled out.

Metric comparability
Species composition is included in all systems. Abundance is included in all methods either with absolute parameters. Sensitive species are included in most systems, either directly or indirectly. Age is not included or included indirectly. Fish systems generally assess the fish community as a whole, as an integrating BQE for time and place. The total assessment scores are comparable, but the individual metrics are not. Please see comments in Annex II.

Benchmarking: definition of reference conditions and class boundary setting

There have been three ways of benchmarking in the intercalibration procedures so far (POIKANE et al. unpublished):

- Reference benchmarking based on near-natural reference sites (no lakes in true abiotic reference conditions exist in the CB GIG)
- Alternative benchmarking based on sites at similar impairment level
- Continuous benchmarking using pressure-response gradients

Tab. 7: Benchmarking category and concept of reference condition applied in the national LFI.

MS	Benchmark, derivation of reference conditions
BE-F	Reference: historical data, lakes of the pike-tench-roach type represent the reference condition
CZ	Alternative: literature review and expert judgment
DE	Continuous/alternative: LDC sites and expert knowledge, pressure-response and site class distribution
DK	Reference: paleolimnological data (for trophic reference), equals LDC combined with expert judgment
EE	Reference: historical data, expert knowledge, LDC sites
FR	Continuous: site specific hindcasting method
LT	Reference: compared to LDC
NL	Reference: LDC sites and expert knowledge
PL	Reference: historical data and expert knowledge

Boundaries were set at national level. The boundary setting procedures are heterogeneous and differ between MS, lakes, or even metrics of individual systems (Tab. 8). Some possibilities are:

- regression lines (NL),
- definition of H/G boundary and consequent equidistant division (NL, FR)
- value distributions, discontinuities (DE, CZ)

In most cases, national expert judgment is included in the class boundary setting. There are no common agreements on abiotic parameters and threshold values representing H/G or G/M boundaries.

Tab. 8: National method of class boundary setting. metric: assignment of scores to metrics, EQR: combination rule for metric scores to obtain a total EQR, class: assigning ecological status classes to EQR values.

MS	Value	Setting of class boundaries
BE-F	Metric	Complex, see p. 24
	EQR	sum of metric scores is transformed to EQR
	Class	equidistant division of the EQR
CZ	Metric	discontinuities of metric values
	EQR	sum of metric scores is transformed to EQR
	Class	equidistant division of the EQR
DE	Metric	discontinuities of metric values
	EQR	sum of metric scores is transformed to EQR
	Class	least sum of squares between status class and combined pressure index/expert judgment
DK	Metric	Based on predefined impact classes
	EQR	sum of metric scores is transformed to EQR
	Class	Expert judgment
EE	Metric	EQR (reference is hindcasted)
	EQR	mean of metric EQR
	Class	H/G by expert judgment, others equidistant
FR	Metric	EQR (reference is hindcasted)
	EQR	mean of metric EQR
	Class	H/G by expert judgment, others equidistant
LT	Metric	EQR (reference is 75 % percentile in LDC lakes - see WISER)
	EQR	mean of metric EQR
	Class	Discontinuities in pressure-response-relationship, calibrated with expert judgment
NL	Metric	EQR (reference is based on LDC sites and expert judgment)
	EQR	weighted sum of metric EQR
	Class	Expert judgment based on shifts in fish communities G/M: loss of habitat for phytophilic fish - change from dominance of phytophilic to dominance of eurytopic; MP: shift from macrophyte to phytoplankton dominated - shift from dominance of perch/roach to dominance of bream
PL	Metric	EQR (reference is historic or based on LDC)
	EQR	mean of metric EQR
	Class	Expert judgment based on WFD definitions, calibrated against pre-classified sampling sites

Summary and conclusion

All CB methods are aware, that the fish community indication of ecological status summarizes local and temporal effects. All systems assess the ecology of the lake as a whole system (including littoral, benthic and pelagic fish). Therefore, habitat specific sampling or the selections of different community characteristics do not represent a major problem. All systems deal with the fact that due to size and complexity of the assessed water body, the ecological status will always be affected by multiple human pressures. Main pressures in CB lakes are eutrophication, human use, water level fluctuation… The pressures may be interdependent and self-enhancing; all of them affect the fish community to some extent. All systems are based on the comparison of the current status with a reference condition although benchmarking procedures differ). The intercalibration seems feasible in terms of assessment concepts.

The main challenges are:

- is the application of different fishing methods which interdicts the application of IC Option 1 (common system) and Option 3 (same data acquisition, different systems)
- the bad correlation between fish metrics and individual pressure parameters

At the 2nd IC meeting for Central Baltic Lake Fish Systems, we agreed that intercalibration should be feasible. However, the options 1 and 3 had to be dropped. The option 2 (different data acquisition, different numerical evaluation) was chosen. This option requires a common metric which clearly reacts to the pressures intercalibrated. Unfortunately, the reaction of fish community metrics to individual pressures usually is low. Furthermore, the development of a common metric/common system in phase II has turned out unsuitable for the huge geographical range of the CB GIG. Therefore we decided to make some major modification in comparison to the description in the phase II guidance: we will not intercalibrate against individual pressures, but against a total index based on all known pressures. Our plan is to use this combined pressure index as common metric.

Additionally, we will test the European lake fish index (ARGILLIER et al. 2013). Probably the site specific approach overcomes the geographical differences that are hindering from GIG-wide class boundaries. And third, we will develop an alternative approach, avoiding pressure-impact relationships by focussing on BQE metric values and the WFD normative definitions. Summarized, the CB LakeFish IC strategy stands on one main and two minor pillars:

- **Development of a common pressure-metric (suitable for all MS)**
- **ELFI (WISER) system (suitable for MS with gillnet data)**
- **Alternative option (suitable for MS with gillnet data)**

Annex I National descriptions of Lake fish assessment systems

Belgium-Flanders

Provided by Jan Breine in July 2013.

The fish protocol used in Flanders in lakes is 1 overnight fyke/ha for two successive days with a minimum of 4 and a maximum of 20 per lake combined with electric fishing along 250 m long shore transects per ha.

Index development

Fish were attributed to guilds based on literature review. Species were categorized according to their tolerance for oxygen deficiency and habitat structure degradation. Tolerance scores from 1 (tolerant) to 5 (intolerant) were given to each species. For each lake, gear specific metric values were calculated using reference species only.

Statistical analyses

We assessed the number of species and candidate metrics. To retrieve less-skewed distributions percentage metrics were square-root transformed and count metrics were log-transformed (logx+1). Diversity metrics were kept untransformed.
First correlation among pressure scores was assessed (measure of association, p (Fisher)) to avoid colinearity. Pearson correlation was applied to assess correlation between lake depth and lake surface (log x+1) transformed values.
The response of metrics to pressures (log transformed values) was analysed with linear mixed regression models. As some locations were sampled several times we added locality and year as random effects. We started with a full model including all pressures and applied a stepwise backward selection until only significant terms remained. Normality assumptions were assessed with residual plots. Redundancy of responsive metrics was analysed with a Pearson correlation. Model fit and expert judgment, when needed, was used to select one metric among the redundant ones. The statistical package used was R.2.15.2 (R Development Core Team, 2012).

Threshold value determination for the selected metrics followed Breine et al. (BREINE et al. 2010). First, the GEP class boundary was defined:

- For metrics assessing number of species 80% of the reference number was taken as the GEP status threshold value.
- For the relative percentage metrics (Mpi metrics) we calculated the ratio of the species occurrence included in a particular metric over the total number of species in the reference list. This value is used as the GEP threshold.

Once the GEP is defined the other integrity classes are defined by applying trisection with GEP values.

- The average value from the highest impacted sites (total pressure >7) was used to define the minimum percentage weight of benthivorous species (BenWei) and the bream and roach associated metric (AbrRut).

The sum of the metric scores obtained with each method gives the index of biotic integrity (IBI) score for a particular lake. To comply with the WFD

this score is transformed to an ecological quality ratio (EQR) calculated as a value between 0 and 1: EQR = (IBI -lowest IBI possible)/(maximum IBI possible-lowest IBI possible). The EQR for the MEP status is 1 under which four classes are defined: GEP (lower threshold value 0.75), moderate (0.5), poor (0.25) and bad (<0.25). The transformation to equal interval classes is obtained using following formula for each integrity interval (piecewise transformation):

T EQR = LV T EQR + (O EQR - LV O EQR)/(UV O EQR - LV O EQR)*0.25

O and T stand for original and transformed EQR value, UV and LV (upper and lower value of integrity class). When during one campaign more than one site is assessed within one lake, data obtained with same method is summed and transformed to catch per unit effort (i.e. per m^2 or per fyke day) to calculate the final EQR for the lake.

Allowing a class difference of one unit indices were validated by comparing the integrity class obtained per lake with its assessed pressure status. The pressure status appreciation is obtained by applying threshold to the pressure scores: bad (7-9), poor (4-6), moderate (3), GEP (2) and MEP (0-1). We assessed data of lakes used for the index development and an independent set of data consisting of fish data from eight lakes not included in the index development.

Metrics and threshold values

OblSpe: Obligate species
MpiOmn: relative percentage of omnivorous individuals
MpiSpa: relative percentage specialised spawners
ManRec: percentage of species that recruit
MpiPis: relative percentage piscivores
AbrRut: percentage weight of *Abramis brama* and *Rutilus rutilus*
MnsTot: total number of species
MpiInv: Percentage invertivorous individuals
BenWei: Benthivore species (% weight)
ManTol: Tolerance value

Lakes electric fishing					
	MEP	GEP	Moderate	Poor	Bad
metric - score	1	0.8	0.6	0.4	0.2
OblSpe (#)	7	6 or 5	4 or 3	2	< 2
MpiSpa (%)		< 28.5 ≥ 21.4	< 21.4≥ 14.2	< 14.3 ≥ 7.1	< 7.1 ≥ 28.5
ManRec (%)	100	< 100 ≥ 80	< 80 ≥ 53.3	< 53.3 ≥ 26.7	< 26.7
MpiPis (%)		< 50.4 ≥ 22.7	< 22.7 ≥ 15.2	< 15.2 ≥ 7.6	< 7.6 ≥ 50.4
AbrRut (% weight)		< 11.0 ≥ 9.5	< 16.7 ≥ 11.0	< 22.1 ≥ 16.7	< 9.5 ≥ 22.1
Lakes fyke nets					
metric - score	1	0.8	0.6	0.4	0.2
MnsTot (#)	21	< 21 ≥ 17	< 17 ≥ 11	<11 ≥ 6	<6
MpiOmn (%)		< 15.9 ≥7.9	< 31.7 ≥ 15.9	< 47.6 ≥ 31.7	<7.9 ≥ 47.6
MpiInv (%)		< 28.9 ≥ 13.0	< 13.0 ≥ 8.7	< 8.7 ≥ 4.3	< 4.3 ≥ 28.9
BenWei (% weight)		< 14 ≥ 7	< 28.0 ≥ 14.0	< 42.0 ≥ 28.0	< 7 ≥ 42.0
ManTol	50	<50 ≥40	<40 ≥27	<27 ≥13	<13
EQR	1	< 1 ≥ 0.75	< 0.75 ≥ 0.50	< 0.50 ≥ 0.25	< 0.25
Appreciation	MEP	GEP	Moderate	Poor	Bad

Additional explanations:
Mpi values are relative e.g. 100 individuals are caught and 5 of those are omnivourous then MpiOmn=5/100= 5%, this is so for all Mpi metrics (please note that the GEP boundary was determined by comparing the % of species to a reference list of species while the metric is calculated as the percentage of individuals in the total catch)
ManTol is the sum of the tolerance value (only species on the reference list are taken into account) of all species that are caught within one survey. E.g. 4 species were caught having a tolerance value of 5; 3 and 1; and one species not on the reference list than the ManTol value= 5+3 +1 or 8.

Czech Republic
Provided by Petr Blabolil in August 2013.

General

Name / abbreviation: Czech fish based index, CZ-FBI
System status: under development
System finalized in 2013

The Czech Republic does not have any natural lakes with fish. Fish data are available for 21 reservoirs. The national database has not been developed yet. Close cooperation with CEMAGREF is in progress.

Literature: A report for Ministry of the Environment of the Czech Republic is currently under the approval procedure = still unofficial. The report is only in Czech, all relevant information are translated and given below.

Concept

General concept: The concept of the ecological status assessment uses the system developed by the C/B GIG, i.e. assessment based on simple linear regression, expert judgment and literature. Main pressure is considered eutrophication and Total Phosphorus (TP) used as proxy of the stressor. Fish metrics were tested to their relation with the TP concentration. Only metric with good statistical fitting could be chosen for index calculation, moreover such fit had to be supported by literature and expert assumptions (elimination of randomly positive or negative relationships).

Reference conditions: Fish community was based on scientific literature review and expert judgment.

Class boundary setting: Based on expert judgment and document Central/Baltic Lake Fish intercalibration: Proposal of an alternative option to assurethat national good/moderate class boundaries correspond to comparable levels of ecosystem alteration. Draft proposal discussed at meeting on November 18, 2011 In The Institute of Inland Fisheries in Potsdam-Sacrow, Germany.

National typology for lakes > 50 ha

The national typology uses two categories (HMWB and AWB) which are subdivided according to altitude and average depth:

Heavily modified water bodies - HMWB: The category includes reservoirs and ponds. The ponds were excluded from the assessment because their fish community is heavily modified in order to fulfill their primary purpose - fish production.

Artificial water bodies - AWB: The category includes 4 artificial opencast mine lakes. The same criteria were used for categorization of AWB as those for the HMWB.

Altitude:
Lowland < 200 m a.s.l.
Middle 200-700 m a.s.l.
Mountain > 700 m a.s.l.

Average depth:
Polymictic < 5 m
Stratified > 5 m

Sampling gear

Benthic gillnets (BG) and pelagic gillnets (PG), EN 14757 extended by four larger mesh sizes (70, 90, 110 and 135 mm). Sampling design is not random and nets are deployed in order to
- cover longitudinal gradient (dam to tributary) of a reservoir (2 to 4 sampling localities dependent on a reservoir size) and
- whole depth profile (nets are deployed in each 3 m layer, separately for benthic and pelagic habitats).

Electrofishing and quantitative acoustic assessment data are also available, but it was not used yet.

Pressures addressed

All metrics should react to general degradation of ecosystem. Most of them are strongly related to eutrophication, one to shoreline degradation (percentage of biomass rudd).
For eutrophication TP is used as proxy. TP is defined as the average phosphorus concentration; averaged per seasons from April to October; per 3-4 sites on longitudinal gradient of a reservoir; and per three years (year of sampling plus two previous years).

Metrics and scoring

Polymictic Reservoirs	gear	poor	moderate	good	crit
total fish (older than 0+) - BPUE [kg.1000 m^{-2}] *	all BG	> 116	60-116	< 60	abund.
		> 60	30-60	< 30	
Bream (older than 0+) - %W	all BG	> 39,5	20-39,5	< 20	spec. comp.
Perch (older than 0+) - %W	all BG	< 5	5-10,3	> 10,3	spec. comp.
Ruffe (older than 0+) - %N	all BG	> 20	10-20	< 10	spec. comp.
Presence of 0+ fish of 6 common species - spn (bream, roach, bleak, ruffe, perch, pikeperch)**	all BG and PG	< 2	2-3	> 3	age

* the first class boundaries is for reservoirs < 200 m a.s.l., the second one for reservoirs > 200 m a.s.l.
** Not included if percentage of perch biomass in all gillnets is > 20 %

Stratified Reservoirs	gear	poor	moderate	good	crit.
total fish (older than 0+) in dam part - BPUE [kg.1000 m^{-2}]	PG 0-5 m	> 35	17-35	< 17	abund.
total fish (older than 0+) in tributary part - BPUE [kg.1000 m^{-2}]	PG 0-5 m	> 70	35-70	< 35	abund.
total fish (older than 0+) - NPUE [ind.1000 m^{-2}]	all BG	> 600	300-600	< 300	abund.
Bream *Abramis brama* (older than 0+) - %W	all BG	> 10	5-10	< 5	spec. comp.
Ruffe *Gymnocephalus cernua* (older than 0+) - %N	all BG	> 20	10-20	< 10	spec. comp.
Perch *Perca fluviatilis* (older than 0+) - % W	all PG	< 10	10-20	> 20	spec. comp.
Rudd *Scardinius erythrophthalmus* (older than 0+) - %W	all BG and PG	< 1	1-5	> 5	spec. comp.
Salmonidae (older than 0+) - % W for lakes >700 m a.s.l. only	all BG and PG	< 2		> 2	spec. comp.
Presence of 0+ fish of 6 common species - spn* (bream, roach, bleak, ruffe, perch, pikeperch)	all BG and PG	< 2	2-3	> 3	age

* Not included if percentage of perch biomass in all gillnets is > 20 %

Mathematics

The class boundaries were set based on expert judgment and document Central/Baltic Lake Fish intercalibration: Proposal of an alternative option to assurethat national good/moderate class boundaries correspond to comparable levels of ecosystem alteration. Draft proposal discussed at meeting on November 18, 2011 In The Institute of Inland Fisheries in Potsdam-Sacrow, Germany.

Scoring: The metrics get 1/3/5 points. The total EQR = $(score-score_{min})/(score_{max}-score_{min})$

The EQR-range of values from 1-0 was divided into 25 % quintiles for classification of ecological potential:

HIGH:	HMWB and AWB can not reach the class
GOOD:	1.00-0.75
MODERATE:	0.74-0.50
POOR:	0.49-0.25
BAD:	0.24-0.00

'Performance' of the fish assessment system

The EQR was correlated with a Pressure index (R^2 = 0,639). The Pressure index is composed of intensity evaluation of stressors as eutrophication, water level fluctuation, shoreline modification, fisheries management, recreation use, percentage of biomass (older than 0+) nonnative fish species.

Long-term stability of the developed EQR was tested. Seven reservoirs were sampled more than once between years 2004-2012. EQR values reached in five of those reservoirs did not cross over ecological potential class boundaries, i.e. they belonged to the same ecological class for all years in which data are available.

Denmark
Provided by Torben Lauridsen in July 2013.

General

Name/Abbreviation: Danish Lake Fish Index
System status: Almost finalized, intercalibrateable, still unofficial but authorities are testing/using the index on their lake systems.
System is expected to be finished in 2013

Fish data included in the common database at the CEMAGREF: 116 lakes (113 with fish EN data)

Literature (peer review): (SØNDERGAARD et al. 2005)
Literature (reports): (SØNDERGAARD et al. 2013) www.dmu.dk/Pub/SR59.pdf

Concept

General concept: The Danish system focuses on the indication of eutrophication. The status classes of the lakes were pre-classified using thresholds for TP and Chl-a. The class boundaries for the metrics are calculated using the predefined status classes and is being evaluated on an independent dataset in combination with expert judgement.

Reference conditions: High and Good status of lakes were defined using thresholds of TP and Chl-a based on representative paleolimnological records dated back to approx. 1850 and defined as *"least disturbed condition"*. The high/good class boundary for the fish metrics is the average between the median of metric values for the high status of chl-a and TP. The Danish concept for reference status equals a under current conditions "least disturbed condition" combined with an expert judgment of what is acceptable and what not. Reference is partly a historical status but not a status without human impacts.

Class boundary setting**:** The class boundaries for the metrics are the mean values between the medians of the metric values for the predefined status classes. Therefore, the class-boundary setting for the metrics is based on a previous class boundary setting of the impact intensity. However, the outcome of the class-boundary setting is also evaluated on independent data in combination with expert judgment.

Sampling gear

EN 14757 (in some lakes reduced number of nets were used but else the same principles)
Additionally electric gear is used for qualitative information (without using the results for the fish system).

National typology for lakes > 50 ha (for Danish lakes >5 ha)

Status	TP [mg/l]	Chl-a [µg/l]
High	≤ 0.025	≤ 11
Good	≤ 0.05	≤ 23
Moderate	≤ 0.1	≤ 56
Poor	≤ 0.2	≤ 90
Bad	> 0.2	> 90

Type	Description	Nr. of lakes in your country
L-CB 1	Deep (3-15 m mean depth), stratified, alkaline	Approx. 150 (> 5 ha)
L-CB 2	Shallow (< 3 m mean depth), polymictic, alkaline	Approx. 306 (> 5 ha)
+ 7 other types which altogether are less than 25 % of lake numbers		

Metrics and scoring

Metrics for shallow lakes	gear	0	1	2	3	WFD crit
NPUE (per net)	EN	> 158	< 158	< 66	< 52	Abund.
% W piscivores > 10 cm	EN	< 25	> 25	> 29	> 58	spec.comp
% W roach+bream	EN	> 68	< 68	< 64	< 35	spec.comp
Average individual biomass	EN	< 30	> 30	> 52	> 79	Age

Metrics for deep lakes	gear	0	1	2	3	WFD crit
NPUE (per net)	EN	> 76	< 76	< 66	< 50	Abund.
%W piscivores > 10 cm	EN	< 30	> 30	> 38	> 53	spec.comp
% W roach+bream	EN	> 51	< 51	< 45	< 30	spec.comp
Average individual biomass	EN	-	-	> 42	> 44	Age

Pressures addressed

The Danish system focuses on eutrophication:

- NPUE: high numbers shows high productivity as a consequence of eutrophication
- Piscivores: biomass decreases with increasing eutrophication (well known for perch, pike diminishes if littoral structures decrease, pikeperch percentages are low at high levels of eutrophication)
- Roach, Bream and roach/bream hybrids: biomass of the two/three species are increasing with eutrophication
- Individual biomass: size/biomass decreases because of an increase of small fish species and stunted growth

Mathematics

The class boundaries for the metrics are the mean values between the medians of the metric values for the predefined status classes.

Scoring: The metrics get a 0/1/2/3-points score similar to the IBI concept. The total score is calculated by summing the 4 metrics scores. The total score is then translated into a status class or can be translated into an EQR value from 0 to 1.

Status classes: the total score for the 4 metrics is directly translated into a status class or into an EQR4 value by dividing the total score by the potential maximum score of 12.

Total score	Status class of lake	EQR4
11/12	HIGH	> 0.85
8-10	GOOD	> 0.6
6/7	MODERATE	> 0.45
4/5	POOR	> 0.25
0-3	BAD	

'Performance' of the fish assessment system

This is being tested right now at an independent data set. So far fish experts agree on the results from the Fish Index/EQR4.

Estonia
Provided by Anu Palm and Teet Krause in July 2013.

General

System status: Finalized, intercalibrateable (but not official?)
System was finalized in 2009
Name/abbreviation: LaFiEstA if first three metrics are used (evaluates the water column) and LAFIEE if all four are used (evaluates the whole lake)
Fish data included in the common database at the CEMAGREF: 22 lakes + 2 lakes for WISER

Literature (peer review): (PALM et al. 2012) - can be found in the Dropbox\Literature folder
Literature (reports): Palm, A., Krause, T. (2009): Preliminary indicators of the state of fishes fauna in lakes and the boundaries between quality classes (part of a longer report with a lot of authors, originally in Estonian with an unofficial translation in 2013) - can be found in the Dropbox\Literature folder

Concept

General concept: The main water ways are dammed nearby the sea, so we consider eutrophication as the main pressure. The water level has been lowered for most of the lakes and small littoral species like loaches vanished or are rare. First we tried to add their occurrence into the calculations, but later on abandoned. To electrofish even a less than 50 ha lake for the occurrence of loaches takes a whole day and is even then subjective if no loaches found. It is hard to electrofish in waters with extremely low connectivity usual in lakes that start a river i.e. fed mainly by rain. To be intercalibratable we chose indices also used in Sweden, Danish and Finnish assessment systems, but to get any acceptable result at all we had to modify them adding hydromorphological parameters of the lake into the formula. Littoral part of a lake is usually sampled by mini-fyke nets, these data used in one out of four indices.

Reference conditions: Historical data (about 1950-60, list of species, published) for lakes include too many species per lake (probably all species ever seen around). So we've found reference conditions according to calculations - the highest results.

Class boundary setting: For LaFiEstA the boundary setting of EU assessment system was overtaken. For those 22 lakes, which data were sent to CEMAGREF, the assessments by LaFiEstA and EU system were extremely similar. For LAFIEE we decided to overtake B/C-set boundary i.e. high and good over 0,17 and moderate, poor, bad for smaller values (the more detailed borders also exist).

Sampling gear

Estonia uses a modified EN 14757 procedure
- 1.5*30 m-pelagic nets to cover pelagic zone in shallow lakes (type norden multi-mesh) and 'normal' 6*30 m pelagic nets to cover deeper lakes – data in all metrics
- additional to EN multimesh norden benthic nets (data used in all metrics) Estonia uses 1.5*30 m nets with one single mesh size (30, 35, 40, 45…70, 75) **–** data used to calculate % non-piscivorous fish and % perch (percids)
- all depth strata covered, but net numbers are not strictly like the EN guideline (usually less)
- no nets in anoxic hypolimnion (empty benthic nets are eliminated from calculations)
- mini-fyke nets in the littoral area – we use the data while calculating
- by now we have electrofishing data on few (probably two lakes); we would have used the data in two metrics like those of mini-fyke netting. Neither Teet Krause nor I have a equipment for electrofishing – in addition to that I personally consider electrofishing as a reproduction preventing device (the best shown by the decline of salmonids in sample-elecrofished brooks). Probably denied by those who electrofish. In addition, the effiency of electrofishing depends on the conductivity of the water.

National typology for lakes > 50 ha

Type	Description	Nr. of lakes in your country
not stratified		??
stratified		??
soft and dark		??
soft and bright		??
and 4 others		
	total	90 lakes

Metrics

metric	gear	high	good	moderate	poor	WFD crit
Simpson DW / log AreaLake	ENmod					Spec. comp., diversity index
logNPUE/ (% non-pisciv.*shoredev)	ENmod					Abundance.
% filled sections	ENmod					Age
% perch (we've also tried 'percids')	ENmod					Indicator species

Explanations

The metrics of the Estonian system are not type specific as only two species - white bream and bleak have been shown to avoid certain type of waters (see the report).

At first we used both NPUE and BPUE, but found later on that biomasses are more indicative in the Simpson index and did not want to overemphasize it by repeated use.

Shoredev is shoreline development (lake shoreline length / circumference of a circle of the same area) - probably indicative only for lakes with smaller area than 50 ha (most of lakes in Estonia)

% filled net sections: Maximum is 12 (= 100 %). At least one fish in the section over all samples of the lake equals a filled net section. It's a metric for the presence of a year class and a simplification for length-class-measurement. Ageing is extremely time-consuming, although we've done it for several projects.

Pressures addressed

Eutrophication: log NPUE/(% non-pisciv.*shoredev)

Anthropogenic pressures including eutrophication and overfishing: Simpson DW/log AreaLake; % perch

Overfishing (also the reproductive success): % filled sections, also indicates conditions for reproduction

Mathematics

The class boundaries are equidistant division of the EQR modified by expert judgement

Scoring: In the Estonian system, 3 metrics get individual scores from 0 to 1
- Simpson DW / log AreaLake
- logNPUE/(% non-piscivorous*shoredev)
- % filled sections (at least one individual in a section)

Then the arithmetic mean of the 3 scores is calculated. The reciprocal of this mean value is multiplied with the % *Perca fluviatilis*.

Class boundaries for total EQR and status classes

HIGH:
GOOD:
MODERATE:
POOR:
BAD:

'Performance' of the fish assessment system

We have had no opportunity for relationship-based checking of our systems against any pressures - so it's been the expert judgement
Parts of the indices have been shown in literature to be pressure-impact related.

Metrics explanation, ecological background, and indicative value

Metric 1: 'Simpson DW / log AreaLake' – taken from Kerstin Holmgren's EQR8, should show how stable the fish community is. Most hard for me to interpret correctly, the highest and least values should show the least equilibrity.

Metric 2: 'logNPUE/(% non-piscivorous*shoredev)' – 'LogNPUE is taken from Dannish method', but gave for our data better results, (probably because most of our studied lakes are less than 50 ha in area) after deviding by 'shoredev'. '% non-piscivorous' is taken from Finnish system and added to recalculate the real number of fish i.e. the real load of nutrients incorporated in fish if not consumed by piscivores. As corfficients for this metrics have not found yet, it overestimates the nutrient load if piscivores are well represented (lakes with the interest for fishermen).

Metric 3: '% filled sections' explained in 'Metrics' section. Is with the most controversial ecological background and least calibrated as a metric. The initial idea was to show the anthropogenic pressure of fishing as mesh sizes larger than 30 mm are empty in overfished lakes. Does also show the suitability of the lake/year for reproduction (if mesh sizes 5 and 6,25 mm catch fish). Most common fish (roach not studied yet, one work should be finished by next May) does not exceed 12 years of age in Estonian small lakes. For example, perch 10 to 13 years of age are caught with the mesh size 55 mm (reports of years 2004 to 2013 on the fish composition of Estonian small lakes, in Estonian).

Metric 4 (only in LAFIEE): '% perch' - it indicates the state of the bottom of the lake the best if both weight and numbers are averaged. From the 'nutrient load' point of view perch alone characterizes mesotrophic waters and with cyprinids eutrophic waters. Swedish EQR8 uses the ratio percids vs. cyprinids that gives sometimes for Estonian lakes unbelievably small values hard to handle in a formula. In lakes with pikeperch (ca. 30) this metric is substituted with '% percids' that also includes ruffe.

France
Provided by Christine Argillier in September 2013.

General
System status: Finalized, intercalibrateable, but not official
System finalized in 2013
Name/abbreviation: 2IL

Fish data included in the common database at the CEMAGREF: 40 lakes

Literature (peer review):
(ARGILLIER et al. 2012) - available in the Dropbox\Literature folder

Literature (reports):
(CAUSSÉ et al. 2012) - available in the Dropbox\Literature folder
Ruiz, P., C. Argillier & M. Logez (2013): Méthodes de bioindication pour les plans d'eau: Indices Ichtyofaune Lacustre. Rapport convention Onema/Irstea 2012. Irstea Aix-en-Provence.

Sampling gear: Metrics are calculated using EN 14757 (EN 14757 2005a) benthic nets.

National typology: The French typology was not used since the method is site specific.

Metrics and scoring: Three metrics: CPUE, BPUE, CPUE_OMNI, boundaries see below.

Pressures addressed: Eutrophication, all metrics increase with the pressure

Concept

General concept: Use of the EN standard method for sampling fish in lakes using multi-mesh gillnets has allowed collection of data on fish assemblages in 445 European lakes in 12 countries. The lakes were characterised by environmental drivers and eutrophication proxies (TP and Non natural land cover). Following a site-specific approach including a validation procedure, by modeling, a fish index including two abundance metrics (catch per unit effort expressed in number and biomass) and one functional metric of composition (abundance of omnivorous fish) was developed. The index is the mean of the 3 metrics.

Reference conditions: The lake-specific reference values of each selected metric were determined using a hindcasting procedure following Baker et al. (2005) and Kilgour et al. (2006). The models obtained for the selected metrics were applied to the whole dataset after artificially setting the pressures to null values. This arithmetic procedure provides site-specific expectation values of the metrics in the absence of anthropogenic pressures.

Class boundary setting: The option consists in first fixing the high good boundary and then divided the remaining part of the regression between the index and the proxi of the pressure (non natural land cover) into four equal parts. The H/G boundary was defined by the 25 percentile of the values measured on reference sites

List of criteria used to select the reference sites

	Criteria	**Thresholds**
Eutrophication	% land use « natural »	>80% (Rejection threshold* = 70%)
	Population density	10 hab.km^{-2} (Rejection threshold* at 30hab/km²)
	Ptot (µg/l)	20 (Rejection threshold* at 50µg/l)
Acidification	pH	> 6 & if <6, expert judgement on the natural origin
Hydromorphology	Impoundment upstream	absence
	Loss of connectivity downstream	absence
	Water level fluctuation	no significant
	Shoreline Bank modification	<10% of shoreline modified
Activity on the lake	Urban/industrial discharge	absence
	Stocking	absence
	Biological or chemical manipulation	absence
	Fishing activities	no significant
	Others activities	no significant

*Rejection thresholds have been fixed in order to not exclude too many lakes in case of missing values. If two of the three parameters reached the reference threshold then it was possible to accept a value up to the rejection threshold for the third parameter.

Mathematics

Class boundaries were set as described above.

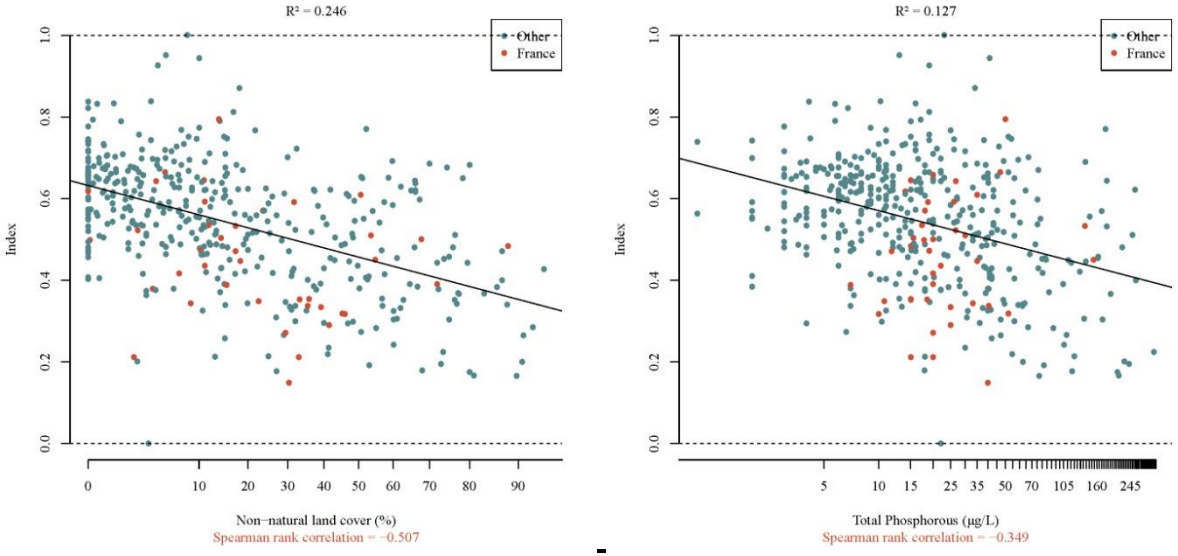
For each metric, the values are transformed to EQR with specific formulas. The index value is the mean of the metric EQR values.

The status classes are assigned to the index value as follows:

Index value	Classes
[1.00 - 0.55]	HIGH
] 0.55 - 0.41]	GOOD
] 0.41 - 0.27]	MODSERATE
] 0.27 - 0.14]	POOR
] 0.14 - 0]	BAD

'Performance' of the fish assessment system

Was checked with pressure-impact relationships



Germany

General

Name/Abbreviation: German Lake Fish Index - DeLFI
System status: Finalized, intercalibrateable, unofficial
System was finished in 2011

Fish data included in the common database at the CEMAGREF: 75 lakes

Literature (peer review): -
Literature (reports): -

Concept

General concept: The German system works with the catches of benthic nets in EN 14757 fishing campaigns. It identifies the ecological effect of all pressures reflected in the fish community. The metrics used cover all normative criteria of the WFD. The DeLFI assesses frequently occurring species.

Reference conditions: The reference conditions in the DeLFI are thresholds for the metric values. There are no true unimpacted reference sites for lakes in Germany. Therefore, metric-values should only rarely indicate reference conditions. The reaction of the DeLFI metrics to anthropogenic pressures is known. Class boundaries are set at discontinuities in the metric value distribution. The 'best of the best' metric values are the reference values with a fine-tuning by expert judgment.

Class boundary setting: The other class boundaries are set at discontinuities in the metric value distribution, too. Background is the knowledge of the distribution of ecological status classes along the German lakes: reference is very rare to absent, good is frequent, moderate is frequent, poor is rare, bad is very rare to absent (in lakes > 50 ha).

Sampling gear

EN 14757 (in earlier times, we divided the full standard in two half-standard campaigns, but this is not done any more)
Additionally electric gear is used (without using the results for the DeLFI).

National typology for lakes > 50 ha

POLY	polymictic lakes
STRAT	stratified lakes <= 30 m maximum depth
DEEP	stratified lakes > 30 m maximum depth

Metrics and scoring

metric	n.a.	5 points	4 points	3 points	2 points	1 point
LakeType POLY						
obligatory species		all present	-	one missing	-	> one missing
WPUE [kg/m²]	≤ 0.031	≤ 0.05	≤ 0.10	≤ 0.20	≤ 0.30*	> 0.30
benthic net species %W		≤ 60	≤ 85	≤ 95	< 100	= 100
benthivorous species %W		≤ 20	≤ 50	≤ 80	≤ 95*	> 95
Bream %W	= 0	≤ 10	≤ 35	≤ 60	≤ 85*	> 85
Ruffe %W	= 0	≤ 4.5	≤ 6.0	≤ 7.5	≤ 9.0*	> 9.0
White Bream %W	= 0	≤ 10	≤ 20	≤ 40	≤ 50*	> 50
Pikeperch %W		≤ 4	≤ 20	≤ 36	≤ 52*	> 52
Perch %W		≥ 40	≥ 15	≥ 5	≥ 0	= 0
LakeType STRAT						
obligatory species		all present	-	one missing	-	> one missing
BPUE [kg/m²]	≤ 0.011	≤ 0.03	≤ 0.05	≤ 0.08	≤ 0.10*	> 0.10
benthic net species %W		≤ 45	≤ 60	≤ 75	≤ 90*	> 90
benthivor. species %W		≤ 10	≤ 20	≤ 30*	≤ 40	> 40
Bream %N	= 0	≤ 0.6	≤ 3	≤ 5	≤ 7*	> 7
Ruffe %W	= 0	≤ 1.0	≤ 4.0	≤ 7.0*	≤ 9.0*	> 9.0
LakeType DEEP						
obligatory species		all present	-	one missing	-	> one missing
BPUE [kg/m²]	≤ 0.012	≤ 0.02	≤ 0.032	≤ 0.044	≤ 0.066*	> 0.066
benthic net species %W		≤ 45	≤ 60	≤ 75*	≤ 90	> 90
benthivorous species %W		≤ 13	≤ 23	≤ 33*	≤ 43	> 43
Bream %N	= 0	≤ 0.5	≤ 2	≤ 3.5	≤ 5*	> 5
Ruffe %N	= 0	≤ 10	≤ 20	≤ 30	≤ 40	> 40

metric	n.a.	5 points	4 points	3 points	2 points	1 point
All Types						
Median weight			Total score is worst individual score of Perch, Bream and Roach			
Perch > 6 g		12-15	< 30	< 45	< 60*	≥ 60
			< 12	< 9	-	-
Bream > 10 g		50-100	< 250	< 400*	?	?
			< 50	< 15	-	-
Roach > 14 g		40-55	< 100	< 145*	< 190	> 190
			< 40	< 18	-	-

Pressures addressed

The main pressures affecting the German lakes are eutrophication and the consequences of intensive use (shoreline degradation, disturbance). The DeLFI does not aim at disentangling the effects of the different pressures, but provides an assessment of the ecological status of the whole lake as a consequence of all pressures taking place. However, some of the metrics are more sensitive to eutrophication, others to other pressures.

Mathematics

Scoring: The metrics get a 1/2/3/4/5-points score similar to the WFD concept. The total score is calculated by summing the metrics scores and then translated into an EQR value between 1 and 0.

Status classes: The class boundaries are

≥ 0.98 high
≥ 0.80 good
≥ 0.60 moderate
≥ 0.40 poor

'Performance' of the fish assessment system

The performance was intensively tested by comparing the assessment results with both expert judgment, single pressure-impact relations and quantitative multiple pressure-indexes. The results had been very good. Details will be added later.

Lithuania

General

Name/Abbreviation: **LZIE** (Lietuvos Žuvų Indeksas Ežerams / Lithuanian Fish Index for Lakes)
System status: Finalized, intercalibrateable, not official
System was finished in 2013

Fish data included in the common database at the CEMAGREF: yes, 46 lakes

Literature (peer review): -
Literature (reports): -

Concept

General concept: The system is type-specific with three types. To assess the ecological status, metrics of the fish community in current condition are compared to reference conditions. Metric values at reference conditions were estimated based on least disturbed (near natural) sites.

Reference conditions: Reference values for metrics were set as 75th percentile in potentially reference lakes (least disturbed conditions).

Class boundary setting: Expert judgment based on WFD definitions, calibrated against pre-classified sampling sites.

Sampling gear

Metrics are calculated using EN 14757 benthic nets. Nets are modified, no small mesh sizes below 14 mm. Net height is 3 instead of 1.5m and length 40m instead of 30m. Nets have 8 panels with 5m each instead of 12 panels with 2.5 m each. Mesh sizes 14/18/22/25/30/40/50/60 without small mesh sizes of EN (5/6.25/8/10/12.5). Pelagic nets and electrofishing are not used

Typology

The official Lithuanian typology for lakes is based only on average depth.

Type	Description	Nr. of lakes in your country
Shallow (LCB-2)	< 3 m mean depth	93
Intermediate depth (LCB-1)	3-9 m mean depth	149
Deep, stratified (LCB-1)	> 9 m mean depth	43

For the fish bases assessment of lakes Lithuania adopted the typology proposed for IC at the first CB LakeFish meeting in Berlin (end of 2011).

Metrics and scoring

Type POLY

Metric	gear	high	good	moderate	poor	WFD crit
Blicca bjoerkna %W	EN mod	< 4	<11	<19	<26	Spec comp
Perca fluviatilis %N	EN mod	>25	>17	>9	>4	Spec comp
benthivorous species %W	EN mod	<20	<35	<47	<61	Spec comp
Obligatory species number	EN mod	6	5	4	<4	Spec comp
Non native and translocated species %W (only when Nb of ind. >1)	EN mod	0	0	<1	<6	Spec. comp., Abund.

Type STRAT

Metric	gear	high	good	moderate	poor	WFD crit
Blicca bjoerkna %W	EN mod	< 2.5	<9	<17	<26	Spec comp
P.fluviatilis + stenotermic %W	EN mod	> 30	>17	>9	>4	Spec comp
Avg. weight *Rutilus rutilus*	EN mod	> 50	>34	>23	>14	Age
benthivorous species %W	EN mod	< 16	<29	<45	<61	Spec comp
Obligatory species number	EN mod	6	5	4	<4	Spec comp
Non native and translocated species %W (only when Nb of ind. >1)	EN mod	0	0	<1	<6	Spec. comp., Abund.

Type DEEP

Metric	gear	high	good	moderate	poor	WFD crit
Avg. weight *Rutilus rutilus*	EN mod	> 50	>34	>23	>14	Age
benthivorous species %W	EN mod	< 12	<27	<41	<56	Spec comp
P.fluviatilis + stenotermic %W	EN mod	> 35	>24	>14	>4	Spec comp
Obligatory species number	EN mod	8	>4	4	>4	Spec comp
Non native and translocated species %W (only when Nb of ind. >1)	EN mod	0	0	<1	<6	Spec. comp., Abund.

Pressures addressed

Relevant pressures are eutrophication and fisheries impact. %W of Blicca bjoerkna and benthivorous species increase with eutrophication. Reaction of metrics *Perca fluviatilis* %N and *P.fluviatilis + stenotermic %W* is of opposite direction. Metrics Avg. weight *Rutilus rutilus* and Obligatory species number decrease together with eutrophication and fishing pressure. %W of non-native/translocated species (*C.gibelio, C. carpio, S. lucioperca*) increases with eutrophication and stocking for fisheries. Metrics derived based on analysis of national dataset and literature analysis.

Mathematics

Scoring: For each metric, the values are transformed to EQR with specific formulas. EQR values are clipped at 1 and 0. Total EQR for the lake is the mean of the metric EQR values.

Status classes: The class boundaries are

≥ 0.86 high
≥ 0.61 good
≥ 0.37 moderate
≥ 0.18 poor

'Performance' of the fish assessment system

Relationships between LZIE EQR and content of phosphorous and chlorophyll *a* (EQR) were analyzed. Relationships are significant (phosphorus: R= -0.59 ; chlorophyll *a*: R= 0.63).

Netherlands
Provided by Eddy Lammens in July 2013

In 2012 the Dutch assessment system for lakes has been improved adapted (improved). For the lakes the only changes are the deletion of the metric 'number of species' and the inclusion of the metric '%W pikeperch > limit' for all lakes. The later metric is only neutral of negative, that is if more than 50% of the pikeperch stock is composed of specimens > 40 cm it is neutral, if it is less than 50% it is increasingly negative. In the text I will make clear what the changes are. See page 5.

General
Name/abbreviation: VISMAATLAT
System status: finalized, intercalibrateable, official
System was developed in 2007 with improvement in 2012.

No data included in the common database at the CEMAGREF because fishing was not done according to EN 14757.

Literature (peer review):

Literature (reports):
JAARSMA, N. (2007): Description of references and metrics for fish in lakes in the Netherlands (unpublished). Witteveen & Bos consulting engineers. (this document is partially outdated, due to the system improvement in 2012)
The improved VISMAATLAT has been described in Dutch and is part of 'Referenties en maatlatten voor natuurlijke watertypen voor de KRW 2015-2021' (391 pages), which is available as pdf-file:
http://krw.stowa.nl/Publicaties/Referenties_en_maatlatten_voor_natuurlijke_watertypen_voor_de_KRW_2015_2021.aspx?eId=5510&pId=1843

Concept

General concept: The fish stock of the lake is modelled using all fish data available. The metrics used are correlated with the different habitats. All habitats are included in the assessment system. The habitats can be impacted by eutrophication, water level fluctuation and shoreline degradation. The Dutch concept is to assess the effects of multiple pressures by evaluating a whole fish community.

Reference conditions: In reference conditions for shallow lakes, zones with clear open water, zones with submerged vegetation and marsh zones are present. Each of these zones has a specific fish community, the fish community of a lake as a whole reflects the (weighted) presence of these habitats. The reference conditions are based on a combination of least disturbed conditions and expert judgment. For phytophilic/low oxygen tolerant: reference conditions can be found in lakes where flooding still occurs (Danube Delta in Romania).

Class boundary setting: The class boundaries are an expert judgment based on shifts in fish communities. The theoretical background is:
G/M: change from dominance of phytophilic to dominance of eurytopic as a result of water level regulation causing disappearance of floodplain areas and marshes and thus loss of habitat for spawning and juveniles of phytophilic fish;
M/P: change from dominance of perch/roach to dominance of bream as a result of eutrophication and the consequential disappearance of submerged vegetation, shift of the lake status from macrophyte to phytoplankton dominated system

Sampling gear

The methods used for the calculation of metrics are:
- trawling in open water of larger lakes;
- electrofishing in the littoral zone of smaller lakes;
- seine netting in smaller lakes.

There are detailed guidelines for sampling effort, habitats, period and catch efficiency for the Dutch fish investigations (Netherlands Handbook on fish monitoring and assessment, STOWA 2003, in Dutch).
Attention: The Dutch metrics are not gear specific! Instead, a total standing stock is calculated [kg/ha] based on all the gear used. First, the standing stock per habitat is calculated using the gear specific efficiency for species and length classes. Then the relative area of each of the habitats is calculated. Finally a total standing stock is calculated with a weighted average of the specific habitats.

National typology for lakes > 50 ha

In the Netherlands, 29 lake types are defined, 19 of them are natural. For LakeFish assessment only the freshwater lakes are relevant. Soft water lakes are not assessed with Fish. The buffering capacity of the remaining lake types is 1-4 meq/l. The remaining Lake-Types > 50 ha are shown in the next table.

Code	Type	Description	Nr. of lakes
M 14	shallow, buffered	< 3 m mean depth, 0.5 - 100 km², mineral	
M 20	deep, buffered	> 3 m mean depth, 0.5 - 100 km², mineral	
M 21	large, deep, buffered	> 3 m mean depth, > 100 km², mineral	
M 23	shallow, calcareous	< 3 m mean depth, 0.5 - 100 km², calcareous	
M 27	shallow, peat lake	< 3 m mean depth, 0.5 - 100 km², organic	

Metrics

The same set of metrics is used to assess the ecological status of all lake types. All metrics can be assigned to the WFD normative criterion species composition:

% W Abramis brama
% W (roach+perch)/eurytopic spec.
% W phytophilic
% W low oxygen tolerant

For most metrics, the scores are type-specific.

M 14, M 27 - Type-specific class boundaries for shallow lakes

Indicator	Weight	Bad	Poor	Moderate	GES	HES (max)
% W *Abramis brama*	0.25	50-100	25-50	8-25	2-8	0,5-2 (0)
% W (roach+perch)/euryt.	0.25	0-10	10-20	20-30	30-35	35-40 (100)
% W phytophilic	0.25	0-8	8-20	20-40	40-65	65-80 (100)
% W low oxygen tolerant	0.25	0-1	1-3	3-10	10-20	20-30 (100)
EQR		0-0.2	0.2-0.4	0.4-0.6	0.6-0.8	0.8-1.0

M 20, M 23 - Type-specific class boundaries for deep lakes

Indicator	Weight	Bad	Poor	Moderate	GES	HES (max)
% W *Abramis brama*	0,25	60-100	45-60	25-45	15-25	5-15 (0)
% W (roach+perch)/euryt.	0,25	0-15	15-25	25-35	35-45	45-55 (100)
% W phytophilic	0,25	0-2	2-5	5-10	10-15	15-25 (100)
% W low oxygen tolerant	0,25	0-0,5	0,5-1	1-2	2-3	3-5 (100)
EQR		0-0.2	0.2-0.4	0.4-0.6	0.6-0.8	0.8-1.0

M 21 - Type-specific class boundaries for large deep lakes

Indicator	Weight	Bad	Poor	Moderate	GES	HES (max)
% W *Abramis brama*	0.4	60-100	45-60	25-45	15-25	5-15 (0)
% W (roach+perch)/euryt.	0.4	0-15	15-25	25-35	35-45	45-55 (100)
% W phytophilic	0.1	0-1	1-2	2-3	3-5	5-10 (100)
% W low oxygen tolerant	0.1	0-0,1	0,1-0,5	0,5-1	1-1,5	1,5-2 (100)
EQR		0-0.2	0.2-0.4	0.4-0.6	0.6-0.8	0.8-1.0

Deep lakes have a fifth metric; the %weight share of pikeperch >40cm in the total population.
share pikeperch > 40 cm < 5 % ➞ -0.2 EKR
share pikeperch > 40 cm 5-25 % ➞ -0.1 EKR
share pikeperch > 40 cm 25-50 % ➞ -0.05 EKR
share pikeperch > 40 cm >50 % ➞ no correction

Pressures

The concept of the Dutch system is to assess the whole fish community which reacts to all pressures. Therefore the overall pressure intensity is addressed.
% W Abramis brama: eutrophication
% W (roach+perch)/eurytopic spec: eutrophication
% W phytophilic: shoreline degradation/water level regulation
% W low oxygen tolerant: shoreline degradation/water level regulation
% pikeperch > legal length limit: fishery intensity

Mathematics

Per (group of) lake type(s) boundary values are defined. Within one quality class the score changes linearly. Values exceeding the upper boundary of the high state are classified as 1. Weight factors show the weight that each metric has on the final judgement. The final (EQR) score is calculated by multiplying each of the metric scores with its weight and then summarise the outcomes.

The class boundaries for the total EQR are:

HIGH:	0.8
GOOD:	0.6
MODERATE:	0.4
POOR:	0.2
BAD:	

Metrics explanation, ecological background, and indicative value

Relative biomass of bream
Bream is one of the best metrics for eutrophication. There is a very strong correlation between the abundance of bream and the percentage of submerged plant cover. The density of plants is strongly related to the degree of eutrophication of a lake.

Relative biomass of roach+perch to all eurytopic species (bream, carp, eel etc.)
Another metric for the open water is the biomass of roach and perch as a percentage of all eurytopic species. In turbid waters, the eurytopic community is usually dominated by bream, carp and pike-perch. In clearer water perch and roach become more abundant. This metric is especially meant for lakes (or areas of a lake) that are generally too deep for plant growth.

Relative biomass of phytophilic species (pike, rudd, tench, crucian carp etc.)
Relative biomass of low oxygen tolerant species (tench, crucian carp and weatherfish)
The metric phytophilic species is especially sensitive for the quality of the littoral zone and the presence and relative area of marsh zones and/or floodplains are found in the group of phytophilic species. The low oxygen species are a subgroup of the phytophilic species. Both have declined mainly because of water level regulation and embankment of littoral zones of lakes.

Information taken from:
JAARSMA, N. (2007): Description of references and metrics for fish in lakes in the netherlands (unpublished). Witteveen & Bos consulting engineers.

Poland
Provided by Hanna Witold Biolokoz and Hanna Draszkiewicz-Mioduszewska in July 2013

General

Name/abbreviation: LFI+ and LFI-CEN
System status: Poland has two Lake Fish Index systems; the LFI+ is based on commercial catches and fishery statistics, the LFI-EN is based on EN 14757 multimesh sampling. LFI+ system has been tested since 2011 and the main problem is intercalibration because of lack compatible materials in other countries. Our results could be only compared to the results of estimation other biological and chemical indicators.
System finalized in: Both methods are presently finalized. LFI+ method is still modified, but will be finalized in 2013.

No fish data is included in the common database at the CEMAGREF.

Literature peer review: none yet
Literature reports: internal

Concept

General concept: The system is based on the known relationships between the structure of fish fauna and trophic state (the state of the environment, the effects of pressure) (among others Colby, Hartmann, Carlson, Persson, Bnińska, Leopold).
The LFI + is based on a comparison of the structure of fish fauna top lakes in historic times (from about 200 lakes, since the fifties of the last century) to the present structure of fish fauna in a particular lake. The data are the results of long-term, systematic, commercial fishing.
The LFI-EN is based on a comparison of the structure of fish fauna specific to the structure of fish fauna of lakes in the best and worst (rather 10 and 90 percentiles) of the available assemble of surveyed lakes (32 lakes scattered in the lake district). The data are the results of one-time fishing many-mesh Nordic gill net, according to the EN standards.

Reference conditions:
LFI+: Calculated as the average percentage of species correlated with indicators of pressure (mainly Carlson TSI) in the best lakes in historic times.
LFI_EN: Calculated as the average percentage of species correlated with indicators of pressure (mainly Carlson TSI) in the best lakes from lakes caught by EN.

Class boundary setting: The class boundaries are set on the basis of the WFD normative definition and compared to the results of estimation other biological and chemical indicators.

Sampling gear

LFI+ is based on long-term results commercial fisheries (seine, gillnet, fyke) and local history review
LFI-EN is based on EN 14757 and local history review.

National typology for lakes > 50 ha

System	Type	Description	Number of lakes
LFI+	Stratified deep	Stratified, > 30 m max. depth,	69
	Stratified shallow	Stratified, < 30 m max. depth	68
	nonstratified	Polymictic	62
LFI_EN	Stratified		19
	Polymictic		13

Metrics

LFI+
All metrics are calculated on the basis of average of ten years of total commercial catch.
Multimetric calculated from multiple regression equations in which the independent variables xi are percentages and the dependent variable Y is calculated LFI index between 0 and 1
Independent variables were selected separately for different types of lakes:
- stratified deep: perch, bream, small bream, tench, % of the catches of large bream in the total catches of bream;
- stratified shallow: perch, pike, tench, crucian carp, perch, large bream and % of the catches of large bream in the total catches of bream, roach large, white bream.
- nonstratified: perch, pike, tench, crucian carp, perch, % of the catches of large roach in total roach catches.

LFI_EN
Stratified: tench, bream, roach, rudd, bleak, perch, ruffe
Polymictic: bream, roach, rudd, bleak, perch, pike-perch, ruffe

The class boundaries are set on the basis of the WFD Normative definitions and comparisons with expert judgment and the results of the evaluation of other biological and chemical elements.

Pressures addressed

Eutrophication and degradation - Combined Carlson's TSI (phosphorus, chlorophyll, visibility) and literature data.

In general, together with the deterioration of the lake (in the type) are rising expansive carp fishes, especially small and becoming dwarfed, and decreasing percentage of perch, littoral species (tench, pike, rudd) and the share of large bream and roach in the total catches of these species.

Mathematics

The class boundaries are set based on expert opinion, comparing the state of the fish fauna of lakes assessed with WFD normative definitions and results of the assessment of other biological and chemical elements.

I have doubts about the state of weak state, as our worst lakes appropriate for the type of lakes still have quite acceptable living conditions (except in cases of poisoning).

Each metric is scored as an EQR-value in range 0-1$(x-x_{min})/)x_{max}-x_{min})$, total score is the mean

In this manner rated selected metrics modeling phase, rejecting the earlier extreme 10 percentile observations. Then, in order to facilitate the calculation of assessments based on raw data from the catches, the results mathematicised, yielding a multiple regression equation:

EQR = b0 + b1 metric1 + b2 metric2... + bn metricn

b0-bn - the regression coefficients,
metric1 - metric n - the percentages in the catch of fish considered as metric
b0-bn may have a sign - or +, depending on the direction of changes in the shares of fish with increasing pressure

The class boundaries are:

Ecological status	EQR LFI-EN / LFI +
Very good	> 0.70
Good	> 0.45
Moderate (measured)	> 0.25
Poor (low)	> 0.10
Bad (very low)	

‘Performance’ of the fish assessment system

The performance was checked in in many ways:

EQR comparison with expert assessment of fish fauna of lakes assessed the WFD normative definitions, comparing the results of the assessment of other biological and chemical elements and the composite Carlson’s TSI. We also compared the results obtained with the German and common metrics. In general, the rate obtained from the formulas corresponds with the expected, but there are the number of cases in which the EQR assessment is incorrect because of faulty data on fish fauna, the fishing results do not reflect the actual composition of the fish fauna of lake:

The LFI + - due to unsystematic or selective fishing activities on the lake;

The LFI-EN - primarily due to defects arising from a set of Nordic single time fishing.

For this reason, you should strongly recommend carrying out evaluations only by experts, able to assess the input and output data.

UK
Provided by Willie Duncan at August, 2nd, 2013

Our plan in GB is to build a lake fish assessment tool using environmental DNA, and we are currently trying to get this set up- although I am having to deal with a number of very tiresome bureaucratic issues. We have taken this approach for the following reasons:

- Lake fish sampling is expensive/resource intensive,
- In terms of cost benefit analysis the additional information that you get back from sampling lake fish over other biological elements is limited, thus we need to find a cost effective means of meeting this WFD obligation.
- We do not have a tradition of lake fish sampling, thus little useful historic data is available. Therefore method development would also have a significant data gathering requirement.
- In England & Wales the Environment Agency faces significant pressures from anglers not to gill net.
- Hydro-acoustics has to be used in tandem with gill netting, thus all of the above also applies to Hydro-acoustics- albeit to a lesser degree

So the plan is as follows:

- Undertake some further assessment of the e-DNA method- e.g. how well does it work in large unproductive lochs.
- Assuming we get a positive outcome from this, take forward a wider sampling campaign, and gather data, our hope is that we would be able to work with the following metrics- Species composition, and relative species abundance, there are other sub-metrics that can be derived from these. I appreciate there are risks with this approach, but the reality is that other sampling methods provide only limited amounts of other data- e.g age class, and gill net selectivity raises questions about how easy it is to use this data.
- Build an assessment procedure.
- Inter-calibrate, our hope is that method development would proceed at a rate that would allow us to participate in the Inter-calibration process and influence the boundaries, but if that is not possible we would simply follow the new/revised method guidance that JRC are currently consulting on.

Annex II: comments on the compliance criteria 'age' and 'sensitive species'

This following chapter represents my (David's) opinion concerning the metrics age structure and sensitive species. Both metric categories are part of the normative definitions of the WFD for LakeFish (Annex V, 1.2.2.). Their application has some inherent problems.
This document does not represent a GIG-wide opinion.
Last update: February 2014

Age structure

The normative definition of the WFD for HIGH status is:
The age structures of the fish communities show little sign of anthropogenic disturbance and are not indicative of a failure in the reproduction or development of a particular species.

The description of this trait is in the WFD is obscure. Strictly speaking, it is impossible to assess the age structure of a fish community. It would be possible to identify the age structure of selected species but some fundamental problems exist with this indicator:

- 'True' age structure can only be assessed for a few very frequent species (e.g. Bream, Roach, and Perch). For other fish species, the number of individuals caught usually is too low to identify structural deficits, even if methods are combined. Frequent species are mostly insensitive. A reaction to pressures by changes in age structure or failure of reproduction is not expected except for very high levels of pressures.
- 'Direct' age data, i.e. aging with scales or otolithes is highly time consuming, expensive and uncertain. The gain of knowledge usually is low.
- The main point in this definition is not age, but the indication of a failure in reproduction or development. This is often misunderstood as aging must not necessarily be the best method to indicate such failures. Other metrics might be used to cover this part of the normative definitions.
- Fish are mobile and can avoid local pressures. They will successfully reproduce as long as any suitable habitat remains within the whole lake. The natural over-production of offspring will hide pressure effects.
- The natural variability of reproductive success is very high. Single depressions of natural reproduction should not lead to a downgrade of ecological status class, as they might well be of natural origin. A reproductive failure caused by human impacts can be distinguished from natural variation by the fact, that it should exceed the natural resilience, i.e. the potential to counterbalance natural oscillations. Such an enduring anthropogenic influence will be shown in species abundance, not age structure.
- The catch data is unreliable and strongly depends on small difference of date and place. Chance or unknown factors might also play a major role (catch a shoal of juveniles or not). Gear specific age/length sampling makes the results incomparable (e.g. EN net catches underestimate YOY and 1+ as well as old/big individuals).
- It is doubtful that size proxies of age are applicable and represent the intention of the WFD.

Summarized, age structure is of minor suitability to assess the ecological status of lakes in the CB GIG. Some MS tested the metric age structure but no clear reaction to human impacts was found (DE, BE, unpublished results). Our experiences show, that all major age classes (YOY, juvenile, adult) of the more common species are always present in lakes.
Size metrics can to some degree replace direct age metrics and indicate certain pressures. The absence of large individuals can show intensive fisheries (as done in NL). In EE the absence of large individuals directly reflects the allowed mesh sizes. Additionally large individuals indicate a good quality of deeper waters, which is their main habitat (A. Palm, pers. comm). Mean or median individual weight can be used as growth parameter and indicator for eutrophication (DK, DE).
Summarized, size parameters can be used as metrics and serve as proxies for 'direct' age measurement. But they seem to be of minor validity and of limited applicability, e.g. type-specific within a smaller geographical range. In the WISER project, reliable relationships between size metrics and pressures were not found (CAUSSÉ et al. 2012; EMMRICH et al. 2011; EMMRICH et al. 2012).

However, the interpretation of the WFD's intention of the 'age' parameter should be that resident fish species ought to reproduce naturally and sufficiently for the maintenance of the standing stock. Such an interpretation is found in the Belgic system, which uses reproductive success of tench and pike (and in the German approach). In lakes, the successful natural reproduction of fish species is usually shown be the mere presence in the catches. This does not apply for stocked species. Therefore, the need to investigate age structure (better success of reproduction) is limited to some species that are or might be stocked. Relevant species are (for Germany): Carp, Pike, Pikeperch, and Whitefish. Eel is not mentioned here because its population is purely dependent on stocking and thus does not indicate the ecological status.
If stocking takes place, human influences might impact the species' presence and abundance. This way, effects of lake degradation might be masked. However, many investigations show that stocking rarely increases the abundance of fish species like pike, pikeperch or vendace (no citations at this place).

I conclude that aging is of minor value to indicate failure in reproduction and development. Additionally, failure in reproduction and development are less suitable to reflect anthropogenic degradation as their consequences, which are changes in abundance and composition.

The comment on age structure is generally supported by BE, FR, but seen critical by EE
Comments of the following MS were included: BE, FR, EE

Result: The previously described point of view towards the suitability of age metrics was submitted as a scientific explanation of the specific challenges of the assessment of lakes with fish. The points were discussed in the ECOSTAT meeting of 30-31 March 2011. The conclusion was: 'It is agreed to include national methods even if they do not contain age structure metrics for the current intercalibration exercise'. The citation refers to VAN DE BUND et al. (2011): Method compliance checking: which methods can be included in the intercalibration exercise? Document discussed at the ECOSTAT meeting of 30-31 March 2011.

Sensitive species
The normative definition of the WFD for HIGH status is:
All the type-specific sensitive species are present.

The terminus 'sensitive species' according to the WFD could have two meanings:
a) any species reacting to a pressure i.e. being sensitive to it or
b) a rare or highly specialized species, mostly of particular conservational interest.
In the first case sensitive species are included in all of the existing systems and approaches. However, all MS of the CB GIG agreed at the Berlin-meeting in December 2010 that the second definition reflects the original intention of the WFD. In this case it is very difficult to include sensitive species in LakeFish assessment systems. Main reasons are:

- Methodology, i.e. the insufficient possibility to reliably catch rare fishes. It is nearly impossible to prove the absence of a rare species. This is especially relevant when relying on single fishing methods, e.g. gillnet catches. Systems based on the combination of multiple fishing gear and systems based on modelled fish communities (e.g. by information provided from fishermen or anglers and expert knowledge) can include information on rare species, but the second concept is absent in the CB GIG.
- There are doubts that 'sensitive fish species' as meant by the WFD do exist. Fish are mobile and species only become extinct from a lake when pressures affect the whole lake in high intensities. Therefore they are not sensitive in the meaning of reacting to minor pressures in restricted areas.
- The normative definition refers to a presence/absence criterion. The expected reaction is a decrease of species numbers with increasing pressures. However, this must not be the case (WHITTIER 1999). Analysis of German data has shown that species do NOT disappear until very intense levels of pressures are reached (meeting moderate status or worse). On the contrary, species numbers increase with increasing pressures, e.g. because changes of the shoreline can enrich the structural diversity (e.g. artificial beaches, stone packages - RITTERBUSCH, unpubl. results). A unimodal distribution of species number with increasing trophic status has also been observed (HELMINEN et al. 2000; JEPPESEN et al. 2000).
- Sensitive fish species are never type specific, but habitat specific, in contradiction to the normative definition. They occur in all lake types. As they are usually rare, they do not occur in all lakes of an individual type (they are not type specific). When referring to a certain lake type, sensitive species have a type-specific probability of occurrence, but a site specific expert judgment or modelling is necessary to evaluate if a sensitive species is expected or not. This strategy contradicts the concept of type specific approaches used in most MS of the CB GIG.

At all, sensitive species can not be applied in a type specific German assessment system because these species are rare and not sensitive to the dominant pressures in a way corresponding to the intention of the WFD.

The above mentioned arguments do not imply that sensitive species are generally unsuitable for status indication. If the fish sampling is done with the appropriate gear, intensity and frequency they can show pressures that affect the whole lake, e.g. acidification, water level regulation and

migration barriers. However, because of the pressures and the fishing methodology, sensitive species are of minor relevance for most lake assessment LFI.
Additionally, percentages of sensitive/intolerant/tolerant species are more promising then presence/absence traits, especially if species with higher abundance but lower ‘sensitiveness’ are chosen, e.g. pike or tench (APPELBERG et al. 2000; BELPAIRE et al. 2000; JAARSMA 2007; WHITTIER 1999). Abundances or percentages of the semi-sensitive species pike and tench are used in some CB assessment systems (BE, NL). These species can be caught in sufficient numbers to allow quantitative comparison (but not with multimesh nets) and indicate the structural quality of littoral macrophytes.

The comment on sensitive species is generally supported by BE, but seen critical by EE
Comments are included from: BE, EE
EE: perch, tench and rudd are good indicators for good water quality - as the highest water quality is fishless as well as the worst one.

ANHANG 2 - SECOND CENTRAL BALTIC LAKEFISH INTERCALIBRATION MEETING 24./25.10.2013

German Federal Environment Agency, Bismarckplatz 1, 14193 Berlin, Room Nr. 1042

Introduction

The meeting consisted of three main sections:

a) The presentation of newly developed systems and information about improvements of existent ones.
b) A summary of intercalibration options and the agreement on a common way forward.
c) Discussion on various challenges.

The minutes will shortly summarize the sections b) and c). Information about the systems should be taken from the presentations which are made available to all Member States on the dropbox-folder.

Intercalibration options

The three main intercalibration options from Phase II, as delineated by the CIS Guidance are not directly transferable to intercalibration process in the CB LakeFish group. Reasons are:

- Same data sampling, same LFI system (option 1): IC is a class boundary adjustment. This option is not feasible because there are very different systems in the GIG.
- Same data sampling, different LFI systems (option 3): IC is done by direct comparison. Would be an option for those MS that use gillnet fishing according to CEN 14757. Direct comparisons with the German system in Phase II indicate that an additional installation of geographical subgroups within the GIG might be needed. This procedure excludes BE and NL from intercalibration. At all, option 3 is challenging and not the first choice.
- Different sampling, different systems (option 2): IC is done by comparison with the help of a common metric. The CB systems do not have a common biological metric. We decided to develop a common abiotic metric. This was shown to be useful by the NEA Transitional Fish Group and has the big advantage that all MS can be included.

We considered option 2 (common pressure index) to be the most promising and decided to simultaneously test the suitability of the ELFI-system, which was developed during the WISER project. By calculating the ELFI assessment results with national data, we can test the suitability of the system for either use as common system and use as common metric. As a last option, an alternative that David developed in Phase II will be checked. This option needs a clear explanation and an independent review to assure a conceptual properness.

The list below provides an overview of the CB LakeFish Intercalibration strategy to be followed:

- **Development of a common pressure-metric (suitable for all MS)**
  - Provide a proposal of relevant pressure metrics and preliminary class boundaries (David, Jan, end of November)
  - Comments and feasibility check (all MS, end of Year)
  - Collect data (all MS)
  - Develop abiotic EQR, correlate to national EQR (all MS, February)
  - Gather results and present at next meeting (May)
  - If successful → intercalibrate
- **ELFI (WISER) system (suitable for MS with gillnet data)**

- Excel-Template for application of ELFI (Maxime)
- Calculate ELFI EQR (all MS)
- Check correlation with national system (all MS)
- Gather results and present at next meeting (May)
- If successful use as common system or common metric and → intercalibrate

- **Alternative option (suitable for MS with gillnet data)**
  - Explain strategy (David, December)
  - Independent review (?)
  - If successful apply to data and → intercalibrate

Other options like the establishment of geographical subgroups, methodological subgroups or the exclusion of Member states have severe disadvantages and will only be taken into account if the options mentioned above do not lead to convincing results.

Miscellaneous results of the discussions

- Although there are no reference lakes in the Central Baltic, we should not exclude the **H/G boundary** from our intercalibration efforts unless it becomes necessary.
- The **variability** of fish sampling could limit the representativeness of LFI systems in time. First analyses indicate that the national LFI systems nevertheless provide acceptable similarity if applied to multiple sampling of individual lakes. Such data is present for CZ, NL, DK and DE. We will summarize the information to get a picture about the general reliability of LFI systems (David will request the MS for contributions, should be done within 2015)
- **Age metrics** are absent in most systems. In some systems, size metrics are included and used as proxies for age. The investigations of Matthias in the WISER project provided new insights in the suitability of size metrics. The results show very complex and often unexpected reactions. The size metrics investigates did not show reactions to pressures data. The results suggest that unspecific size metrics are not suitable to show the effects of pressures on reproduction or growth. Focussing on species-specific metrics and small geographic ranges might improve the suitability, but evidence is still missing. David will include these arguments in a scientific justification why all systems deviate from normative WFD requirement for age assessment and send it to the MS for comments. **Size metrics** are not directly required by the WFD, but turned out to be suitable to indicate fishing pressures.
- **eDNA** is a very promising sampling strategy. It provides information on species composition and abundances. The sampling effort is low compared to traditional fishing methods and the fish don't die. It might possibly replace the current fishing methodology in future. Investigation on this topic is done in many MS. The colleagues will send national addresses to Graeme (UK), who will be our common point of contact in this topic.
- Within the IC process, we will not update the **common database** with additional fish data and new or additional pressure data. Reason is the effort and time needed for this purposes. Some MS will contact the IRSTEA directly to provide their fishing data and participate in the future scientific cross-boundaries work.
- Comparisons of Fish to other BQE with respect to costs or ecological validity of bioassessment systems are counterproductive and not within the integrating concept of the WFD. They might be discussed on a national level, but will not be part of the CB intercalibration process.

Next meeting is planned for May 2014 in Aix en provence
Special thanks to Christine for this hospitable and attractive offer!

ANHANG 3 - PROPOSAL OF AN INDEX TO APPROACH THE TOTAL ANTHROPOGENIC PRESSURE INTENSITY (TAPI)

Introduction

At the second intercalibration meeting in October 2013, the IC options for the Central/Baltic LakeFish Group were discussed. The GIG decided to develop a common index for the total anthropogenic pressure intensity (abbreviated TAPI-index). This index is a comparable measure for the pressure intensity throughout the GIG. It makes the assessment results comparable. A similar intercalibration procedure was successfully used in Phase II by the NEA GIG and the LakeFish Alpine group.

The intercalibration process aims at comparing the levels of ecosystem alteration by the pressures, not at comparing the pressure intensities. Therefore, the ecological effects of pressures are essential part of the scoring in the TAPI index.

Document history

First draft by David on January 15, 2014
Comments by Jan on January 17, 2014
Sent to MS by David on January 31, 2014

Scoring

The TAPI index should be applicable to most lakes in the Central Baltic region to guarantee a good dataset for the intercalibration.

We decided to select 6 pressures and 20 metrics to describe the pressures. Some pressures are addressed by multiple metrics.

The metrics are scored on a 5-step WFD compliant scale, if possible. Metrics get a high score of 5 for low pressure intensity; a low score of 1 is assigned for very intense pressures. The class boundaries are mostly set with a normal distribution in mind; narrow boundaries at the edges, extended ones in the middle. In our understanding the classes 5 and 1 should be nearly absent in reality. The score 5 represents a pristine reference condition which is not present for lakes > 50 ha in the Central Baltic. The score 5 is restricted to extreme pressures, e.g. a polytrophic urban water body with a few highly resistant fish species. This value should be very rare for lakes > 50 ha.

In many cases the assignment of 5 classes to the pressure intensity will be impossible or unwanted because of missing information. In this case, a 3-step classification close to the IBI concept is used (1/3/5 points).

score	general explanation for 3-step assignment
5	very low pressure intensity - the pressure is absent, negligible or will only have minor effects on lake ecology / fish ecology
3	significant - the pressure intensity is assumed to be high enough to noticeable change lake ecology / fish ecology (see above)
1	extreme - the pressure intensity is assumed to be high enough to intensively change lake ecology / fish ecology

score	general explanation for 5-step assignment
5	very low pressure intensity - the pressure is absent or negligible
4	minor pressure intensity - the pressure intensity is low and no noticeable effect on the lake ecology / fish ecology is observed or expected
3	Significant pressure intensity - the pressure intensity is assumed to be high enough to - alter the fish abundance and/or - alter the species composition and/or - reduce the number of sensitive species and/or - reduce the reproductive success. The pressures can influence the fish community both directly or indirectly via changing the lake ecology.
2	High pressure intensity - the pressure intensity is assumed to be high enough to intensively change the above mentioned criteria for fish/lake ecology.
1	Extreme pressure intensity - the pressure intensity is very high and should lead to a fish community with very high or very low abundances, strong dominance of single species, a very low number of fish species, the absence of sensitive species and the absence of reproduction for most species

Pressures and metrics

We selected the metrics in order to get a complete overview of pressures affecting the lake. The metrics should be easy to determine by educated people that have been at the lake. Otherwise, they should be assessable by more or less simple methods (e.g. Google Earth, available information at environmental agencies). The metrics are shortly explained below, a measure and the class boundaries are described.

Pressure eutrophication

Eutrophication is the most important pressure in the Central Baltic. Nearly all lakes are affected by some kind of nutrient surplus and this pressure affects the ecology of the whole lake in complex interactions. Four metrics are suggested for this pressure. They can all be used, but some of them are redundant and only one of the metrics is needed for calculation of the TAPI index (but it should be avoided to use land use intensity only).

Metric 1: land use intensity

Human activities in the catchment area are the main source of nutrients in lakes. The intensity of non-natural land-cover is a proxy for the eutrophication of the lake. I suggest a 5-step quantitative classification of the % of non-natural land use in the catchment area. The data requires GIS analyses of catchment area and Corine Land Cover data, but for many countries this data is already present in the IRSTEA database. The use of pressures in the catchment area as proxy for pressures to the lake has some inherent problems (see annex). The data is present for many MS in the IRSTEA database and we can decide about the inclusion later.

The metrics 2-4 use type specific thresholds, as the impact of nutrients is strongly dependent on the lake stratification. The following types are applied (see first meeting of the CB GIG):

POLY: polymictic lakes (functional)
STRAT: stratified lakes
DEEP: stratified lakes with a maximum depth > 30 m

Metric 2: total phosphorous

The increase of total phosphorous is the most direct sign of nutrient increase in the cause of eutrophication. I suggest a 5-step quantitative classification of TP [µg/l] which is close to a

German system (but looks like being transferable to all CB MS). There are no specific demands on the methodology of TP measurement and it will easily be possible to assign one of the five classes with existent data. For many countries this data is already present in the IRSTEA database.

Metric 3: trophic index
This is applied if the lakes are already assessed with a national or international index of eutrophication. As an example, the German index accounts for TP spring, TP summer, Chlo-a and Secchi-depth. By combining multiple parameters, the indexes might be more stable then TP only. I suggest a 5-step qualitative classification. The metric is again dependent on the depth/stratification of the lake. I give no rules for obtaining the data. If many MS use this eutrophication metric, we will have to check if the trophic classes are comparable.

Metric 4: trophic change
This metric takes a specialty of trophic parameters into account: reference values deviate from 0 and there is a wide natural range. In some cases, the modeled TP background levels might be known and can be compared with the present TP level to get a true picture of eutrophication (and not of trophic status). I suggest a 5-step quantitative classification of the TP surplus in comparison to the reference condition. It is based on a German national trophic index but I assume it is transferable. The metric again depends on the depth/stratification of the lake. Data quality will depend on the national modeling approach (no common rules).

Pressure acidification
Metric 5: acidification
Acidification is an important pressure in many European countries, especially in Scandinavian countries. In the Central Baltic GI, acidification is of minor (if any) relevance and restricted to few water bodies like mining lakes or peat bogs. I suggest a 3-step qualitative classification which is a very rough estimation (no description of demands on data quality). **Please note**: the acidification has to be of human origin. For many countries this data is already present in the IRSTEA database.

Pressure pollution
This pressure is assessed with 4 metrics. It is possible to use only some of them if information is not available. I suggest a 3-step qualitative classifications for all metrics. I expect the metrics to be of low/minor intensity in most cases.
Metric 6: chemical pollution
This metric estimates the chemical pollution as defined by the criteria of the EC directive for environmental quality standards (2008/105/EC). The classification refers to Annex I of the directive. The information should be available from the reporting to EU by the corresponding national ministry of environment or by a person in charge of monitoring chemicals in the MS. In case no monitoring is available, expert judgment might be used.

Metric 7: visible pollution
The metric assesses the visible impairments of the fish community by urban discharge, industrial discharge and others. Examples are oil, wastewater, cooling water… I suggest a 3-step classification. The data can be obtained by expert's estimation during the fishing campaigns. For many countries this data is already present in the IRSTEA database as a YES/NO parameter 'urban/industrial discharge'.

Metric 8: visible trash
The metric estimates the amount of trash at the shoreline (plastics, cans…). It is a proxy for both

pollution and lake use intensity. I suggest a 3-step classification. The data can be obtained by expert's estimation during the fishing campaigns.

Metric 9: biological effects of pollution:
The metric estimates the intensity of proved or supposed effects of pollution on biota (not only fish). Examples are shifts in sex ratio, lack of reproduction, reduced growth, infections or diseases). I suggest a 3-step classification. The information can be obtained during the fishing campaign (clues) or with specific investigations (proofs).

Pressure hydrological alteration
Metric 10: water level fluctuation/regulation
The metric compares the present water level with the expected situation without human impacts. It includes the total water level amplitude and also temporal deviations (e.g. water is retained in summer). I suggest a 5-step classification. The data requires knowledge on the current water levels and their development throughout the year as well as knowledge in the historical situation. If data is absent, expert knowledge is needed.
Water level fluctuation might be 'natural' (= normal) in reservoirs. The applicability in reservoirs should be evaluated by corresponding MS (CZ, FR). Eventually it is reasonable to compare the current situation with a potential regime that would be good for fish (good potential).

Pressure morphological alteration
This pressure is described by 5 metrics. The metrics 12-15 are proxies for the presence of people at the lake and their direct impact. They are somewhat redundant and not all parameters will be necessary.

Metric 11: connectivity
The metric estimates the impact of human barriers on fish species migrating from/to the lake. The metric is not focused on long-distance migrators (salmon, eel) but is meant to assess conditions for species like lake trout, Leuciscus spp., bream or pikeperch which frequently spawn in tributaries or outflows. I suggest a 3-step qualitative classification. The classification is based on expert judgment as there is no common standard for estimation of barrier effects.
The connectivity is important for a limited number of fish species which usually have lower abundances. We want to assess the pressures affecting the lake ecology/whole fish community. Therefore, it is not possible to assign 'high' or 'extreme' to this pressure's intensity. **Please note**: the metric is applicable only for lakes that are fully connected in reference conditions.

Metric 12: shoreline modification
Shoreline modification describes the direct alteration of the shoreline bank by humans. Modified structures can be: marinas, walls, stony shores, footbridges, beaches, cattle troughs. I suggest a 5-step classification of the % of shoreline bank modified. The data can be estimated with aerial pictures, e.g. Google Earth. It will be possible to virtually assign one of the chosen classes without time consuming measurements. For many countries this data is already present in the IRSTEA database, I adopted the class boundaries.

Metric 13: population density
The metric population density is proposed as a proxy for use intensity (not for eutrophication). It refers to a 'catchment area' of human use, i.e. the range in which people come to the lake for recreation. This area must be estimated. I propose a 5-step quantitative classification. Maps of population densities might be present at the national agencies dealing with statistics of demography. Therefore a quick assignment of the classes should be possible. **Please note**: this is NOT the metric population density in the catchment area used in the IRSTEA database.

Metric 14: lake use

Lake use is a metric for estimation of the direct impact of recreational and professional use of the water body: bathing, boating/sailing, boating/shipping, water skiing/diving and intense use in all categories. I adopted a 3-step classification from the IRSTEA database. Each category includes intense use in the previous categories. The data is an expert's judgment based on investigations, field observations and experiences.

Lake use mainly affects the pelagic surface waters habitats. An effect on the lake ecology will take place at high intensities only, especially in big or deep lakes. It is important to carefully estimate the ecological effects of the use and assign the corresponding classes; e. g. a single diver is not a significant pressure in a big lake. For many countries lake use data is present in the IRSTEA database as a low/moderate/strong parameter, but I doubt that this classification considered the ecological effects. MS will have to check, if their assignment was correct.

Metric 15: habitat heterogeneity

The metric assesses the reduction of habitats. To obtain the data, the number of habitats in undisturbed conditions is estimated and compared to the present number of habitats. 11 examples for habitats are: sand, gravel, stones, wood, submersed plants, swimming plants, reeds, inflow/outflow (all littoral), benthic with plants, benthic without plants but with oxygen, pelagic. I suggest a 5-step classification based on experts judgment (however, the missing habitats can be named, so this decision is traceable).

Please note: human made habitats like beaches, stone packages or marinas increase the habitat number. They are not rated negative unless they are so extended that they reduce the number of natural habitats.

Biological pressures

The biological pressures are somewhat critical as they directly change the fish community. The problem is that we do not want to assess the status of the fish community but of the lake ecology. Therefore, the intensity of biological pressures must be high enough to both change the fish community AND have notable secondary effects on the lake ecology.

Metric 16: fishing

This metric assesses the ecological effects of selective fish removal by commercial fisheries and/or angling. I suggest a 3-step classification. The data is based on expert judgment.

Please note: other potential effects of fishery and angling like stocking, disturbance, shoreline degradation or nutrient input are assessed with other metrics.

For many countries fish exploitation data is present in the IRSTEA database as a low/moderate/strong parameter, but I doubt that this classification considered the ecological effects.

Metric 17: stocking of native species

This metric assesses the ecological effects of selective fish input by commercial fisheries and/or angling. It refers to the input of 'native' species, i.e. the species that would be present in an undisturbed condition. The input itself is not a pressure if no ecological consequence is assumed, e.g. stocking of pike or pikeperch will rarely increase their abundance to an extent that the trophic interactions are significantly changed. I suggest a 3-step classification. The data is based on fisheries/anglers data of stocking and expert judgment of the ecological consequences.

For many countries stocking data is present in the IRSTEA database as a YES/NO parameter, but I doubt that this classification considered the ecological effects.

Metric 18: alien fish species number
The metric assesses the number of all fish species that would be absent in undisturbed conditions (true aliens and translocated species). I suggest a 5-step classification. It is based on the experts assumption, that the presence of 4/5 alien fish-species will have a significant impact on the ecology of the fish community, on other biological elements and therefore on the lake ecology (see 'significant pressure'). If the alien species are known to be infertile, have low abundances and do not impact the lake ecology simply choose a lower category and make a note. The data is based on the scientific fishing campaigns eventually supported by fisheries statistics or queries.

Metric 19: alien fish species abundance
The metric assesses the percentage of aliens and translocated species in the scientific fish catches. The estimation can be supported by statistics of commercial fisheries and anglers. I suggest a 5-step classification based on the experts assumption, that a weight-percentage of 16 % alien fish-species will have a significant impact on the ecology of the fish community, on other biological elements and therefore on the lake ecology (example for significant pressure).

Metric 20: impact of non-native non-fish species
The metric assesses the impact of non-fish aliens (like mussels, crustaceans, plants). I suggest a 3-step classification of the ecological effect based on an expert's evaluation. If aliens have adverse ecological effects, this will usually be known and an assignment to one of the classes will be possible.

Mathematics and Excel-template
The TAPI index addresses six pressures with 20 metrics.
Each metric gets a score from 1 (bad ecological status) to 5 (very good status).
For pressures with multiple metrics the worst score of the corresponding metrics is used for scoring the pressure.
The six pressure-scores are summed up and translated into a quality ratio ranging from 0 to 1:

TAPI = (score-min) / (max-min) min = 6; max = 30

The following table provides an overview of the combination rules:

Metric score	Pressure score		
Land use TP Trophic index Trophic change	worst of		
acidification	as is		
Chem. poll Visible poll. Trash Biol. effects	worst of		
Water regulation	as is	total sum	EQR
Connect Shoreline Pop. density Lake use Habitats	worst of		
Fish removal Fish input Alien spn Alien %W Non-fish aliens	worst of		

If using the excel template, you will need to score at least one metric for each pressure. Otherwise the calculation is incorrect (but we can modify this, if necessary).

Annex: Pressures not included in the TAPI and some comments

Population density in the catchment area: is frequently used as a proxy for eutrophication. Human activities in the catchment area are the main source of nutrients in lakes. However, for pop density it seems not suitable to refer to the catchment. Especially in lowland lakes catchment areas can be huge compared to lake areas and often are very diverse. It is doubtful that same values for this driving force will have comparable impacts on a European scale, e.g. because of different quality of sewage treatment. The metric would be quite different for isolated vs. connected lakes. Many CB representatives argue that lake fish assessment should focus on the lake, not on the catchment area or connected rivers. Therefore we focus on metrics with a more direct relation to eutrophication. *Strictly speaking, similar arguments apply for the land use in the catchment area.*

Aquaculture: aquaculture is a method of fisheries management and might influence the lake ecology, e.g. via nutrient input or escaping fish. In contrast to commercial fishing and angling, the effects are indirectly affecting the fish community. I suggest that the impact of aquaculture is already accounted for in other metrics (like TP or alien species surplus).

The TAPI assesses metrics that affect the lake ecology in a negative manner. Some pressures affect the lake ecology, but lead to fish communities that would be typical for lakes in a better ecological status. These pressures are not included in the index.

Cormorants eat abundant fish of small to intermediate size in benthic/pelagic habitats. In lakes > 50 ha, their presence can change the fish community to a situation indicating a better status: decreased total abundance, fewer cyprinids, more big fish, more predators, higher percentage of shoreline species. Therefore cormorants should not be included in a list of pressures that negatively affect the lake ecology as indicated by the fish community. Please note: This is a statement referring to the total lake ecology, not to the impact of cormorants on fish communities and fisheries.

Biomanipulation is usually done by changing the fish community directly using catch and stocking measures. It aims at improving the ecological status and will lead to fish communities that would be typical for 'better' lakes. Therefore, biomanipulation cannot be included in a list of negative pressures. Similar arguments are valid for chemical manipulation.

There are some pressures included in the TAPI which have critical aspects.
TP: All existing assessment systems address eutrophication as the most important human pressure and all of them have used TP as a measure. But none differentiates between anthropogenic and natural shares of TP (as far as I know). The natural background level of nutrients is so variable that type-specific approaches are erroneous.
Stocked fish and aliens: many MS consider these to be components of the fish community which can show pressures (not being a pressure themselves). In the CB GIG, stocking has negligible effects on the lake ecology in most cases (UK is an exception).

ANHANG 4 - A TYPOLOGY FOR FISH-BASED ASSESSMENT ….

… of the ecological status of lowland lakes with description of the reference fish communities

David Ritterbusch[a*], Uwe Brämick[a], Thomas Mehner[b]

Abstract

We compared the potential of different lake typologies to discriminate fish communities in least disturbed sites. The typologies tested were based on morphometric and geographical descriptors. The best discrimination was achieved by distinguishing three lake types according to depth and mixis regime: polymictic lakes, stratified lakes with less than 30 m of maximum depth and deep, stratified lakes with maximum depths above 30 m. We conclude that the proposed typology is appropriate for a system to assess the ecological status of German lakes with the fish fauna according to the Water Framework Directive and might well be transferable to other European assessment systems. The fish communities in all lake types were similar and dominated by few fish species. Perch and roach were the most abundant ones, followed by ruffe, bream, rudd and pike. The fish communities in least disturbed sites might be used as reference conditions in future fish-based assessment systems.

Keywords

Water framework directive; lake types; fish based assessment system

1 Introduction

The Water Framework Directive (WFD, 2000) has implemented an ambitious goal: all European water bodies should achieve a good ecological status until 2015. As a prerequisite for estimating the need for improvement of a water body, its current ecological status has to be assessed. According to the directive, this is to be done with systems using so called biological quality elements: phytoplankton, macrophytes, macroinvertebrates and fish.

The surface water bodies listed in the WFD are rivers, lakes, transitional and coastal waters. In addition to this classification, the WFD stipulates the use of a typology for each of the water bodies. The subdivision into types has two important advantages for the element-based assessment of the ecological status. First, using type-specific traits of the biological elements allows a more customized indication of the ecological status. Second, a type-specific numerical evaluation of similar traits can be used to counterbalance natural differences of value ranges between the types. A typology in the context of the WFD is a pragmatic tool to achieve reliable assessment results. It is not a comprehensive description of abiotic preconditions, ecological networks or biological community structures in nature.

In the context of the WFD, 'ecological status' exclusively refers to anthropogenic impacts ('pressures'). Therefore, a typology used as basis for biological assessment systems is inherently limited. The descriptors of the typology must not include potential pressures nor is it allowed to include any trait of the biological elements themselves. WFD-compliant typologies are based on abiotic descriptors, which are unlikely to be altered by human impacts. Annex II of the WFD and various European guidelines give suggestions on possible descriptors and typologies (CIS, 2003; Poikane, 2009).

The present paper elucidates the development of a typology as basis for the assessment of German lakes with the biological element fish. It is well known that morphometric, chemical, structural and functional descriptors modify the fish community composition in lakes. The descriptors with strongest effects so far are lake area, depth and nutrient concentrations (Browne, 1981; Brucet et al., 2013; Jeppesen et al., 2000; Persson et al., 1991; Sondergaard et al., 2005).

For the German part of the ecoregion central plains, distinct lake fish communities had been related to depth. A cyprinids lake type with mean depths from 6-8 m was contrasted to deeper vendace/perch lake types (Mehner et al., 2005). Comparable results were obtained by Diekmann et al. (2005) and Garcia et al. (2006), but they used a maximum depth of 11 m as main separating

descriptor.
Thus, a typology based on abiotic lake descriptors may foster the development of assessment systems because fish communities may differ fundamentally between lakes of different types. The aim of our study is to compare potential abiotic descriptors and find the most appropriate typology. For this purposes we first pre-classified the lakes into types. Then we tested the suitability of the pre-classifications to discriminate fish communities which are undisturbed by anthropogenic pressures. In a final step we describe the type-specific fish communities and reveal some challenges for subsequent fish-based status assessment.

2 Materials and methods

2.1 Selection of least disturbed sites

The lake typology is developed as basis for a fish-based assessment of the ecological effects of human pressures. For this purpose, human pressures themselves should not influence the result of the typology. Therefore, we based the typology on selected lakes with low levels of human pressures, abbreviated LDC for 'least disturbed conditions' (CIS, 2011). For the selection of LDC lakes we considered shoreline degradation, human lake use and eutrophication as anthropogenic pressures.
The impacts of shoreline degradation and human lake use on the fish community were estimated by experts on a four-step scale (no, low, intermediate, strong/very strong). The experts were dealing with investigations of fish communities and limnology, had scientific training and good knowledge of the lakes. The pressure 'shoreline degradation' included the estimation of relative abundance of artificial beaches, footbridges/marinas, woody erosion control, rip rap revetment and sheet pile walls. 'Human lake use' included the amount of people swimming, boats without motors, surfing/sailing, motorboats and commercial shipping. Only lakes rated to have no or low anthropogenic impacts in both shoreline degradation and lake use were assigned to the set of LDC sites.
To estimate the intensity of eutrophication, we used a German Trophic Index (TI). The TI can be modeled for undisturbed conditions (reference index TI_{ref}) and for the present situation (actual index TI_{act}). TI_{ref} is modeled using morphometric properties of the lake: volume, area, depth, length and width. TI_{act} is calculated by four weighted descriptors (total phosphorus concentration in spring, total phosphorus concentration in summer, chlorophyll-a concentration and secchi depth). The linear difference between both indices (Δ TI) was used as a measure for anthropogenic eutrophication: $\Delta TI = TI_{act} - TI_{ref}$. Lakes with a $\Delta TI < 1.0$ were included in the LDC dataset. This value equals the transition from oligo- to mesotrophic or from meso- to eutrophic conditions. The calculations of TI_{ref} and TI_{act} follow guidelines of the German Working Group on Water Issues (LAWA, 1998).
The impacts of other pressures were assessed by literature survey, queries and on site during the fishing campaigns. Acidification, chemical pollution and water level fluctuation were absent or of low intensity and we supposed that these potential pressures had no impacts on the fish community in the LDC lakes. The same holds true for the effects of fisheries, stocking or presence of alien species; the catches showed no signs of unnatural species inventory or composition. However, these pressures were not quantified for the selection of LDC sites.

2.2 Typology

We used different approaches for the pre-classification of the lakes. River catchment and the German federal states were used as geographical descriptors. For the assignment of thresholds for quantitative morphometric descriptors we tested proposals provided by the WFD, the German Working Group on Water Issues - LAWA (LAWA, 2003, 2005; Mathes et al., 2002) and preceding results of related investigations (Mehner et al., 2005; Mehner et al., 2004). Table 1 provides an overview of the groups chosen. While most descriptors are self-explaining, 'depth gradient' and 'LAWA-typology' need description. The depth gradient is the maximum depth

divided by a theoretical depth of the epilimnetic layer, which is calculated by length and width of the lake (LAWA, 1998). Lakes with depth gradients above 1.5 usually are steadily stratified in summer, i.e. the depth gradient is a proxy of the stratification conditions. The LAWA-typology was developed to implement the requirements of the WFD. For the German area of the Central Lowlands, five LAWA lake-types exist:

- type 10: stratified, catchment area is large when compared to lake volume;
- type 11: polymictic, catchment area is large when compared to lake volume;
- type 12: polymictic, catchment area is large when compared to lake volume, water residence time between 3 and 30 days;
- type 13: stratified, catchment area is small when compared to lake volume;
- type 14: polymictic, catchment area is small when compared to lake volume.

The catchment area is denoted as large, if the ratio of catchment area to lake volume is above 1.5 m^2/m^3. The LAWA lake types 10 and 11 describe sites with a bigger risk of eutrophication because they are exposed to a large catchment area and thus to an increased number of potential sources of nutrient pollution. In the LDC dataset, type 11 was represented by one lake only. Type 12 describes flushed lakes and no such lake was included in the LDC dataset.
It became evident during the analyses that stratification is a very important descriptor for a potential fish-specific typology. However, the stratification criterion of the LAWA-typology did not always reflect the real or dominant situation in the lakes. This was caused by assigning the stratification descriptor indirectly, based on the depth gradient or by distinct morphometric features, e.g. the presence of stratification in limited areas of a lake. However, the fish community structure depends on the dominating lake properties, not on features of smaller lake parts. Therefore, we introduce the concept of a 'functional stratification'. Each lake was carefully checked using literature (e.g. lake profiles provided by federal environmental agencies) and asking experts who knew the location. For example, information like 'stratified in limited areas' lead to an assignment to a functionally polymictic type. Lakes consisting of two connected basins were assigned to the stratification type of the larger one. In fact, the determination of the functional stratification was clear except of one lake with two basins of similar extent (see **Annex B: Identification of polymixis in deeper lakes** for details).
The WFD and the LAWA suggest some additional descriptors for lake typologies which are not mentioned here, since all lakes in our dataset shared them. These are lake category (all natural), ecoregion (all 14 - Central Plains), altitude (all lowland < 200 a.s.l.) and geology (all calcareous).

2.3 Fish sampling

Fish data were available for 38 lakes which fulfilled the LDC criteria mentioned above. The lake areas range from 50 to 2,000 ha and the maximum depths from 1 to 70 m. The fishing campaigns were performed in the summers between 1999 and 2006 with only two lakes investigated before 2001.
Electric fishing was done in all lakes following a European standardized procedure (EN 14011, 2003). All structurally different littoral habitats in the lakes were investigated in order to catch specimens of all species present.
Different methods were used to obtain information on the benthic and pelagic fish community. Nordic multimesh gill nets were set in 27 lakes in a random stratified sampling design following the European standard procedure (EN 14757, 2005). The number of nets increased with lake size and depth. The nets were set before dusk and lifted after dawn. Pelagic nets were also set, except of seven lakes with maximum depths below 6 m. For details of lake descriptors and the sampling procedures see MEHNER et al. (2005). For seven lakes located in the federal state of Schleswig-Holstein, the standardized netting procedure was applied, but only for two hours during daytime. To obtain a complete species inventory, information from queries of the fisheries managers (both

commercial and anglers) was added.
In four lakes located in the federal state of Schleswig-Holstein, fishes were caught with large trawls by local commercial fishermen. The trawl-nets were put at daytime into the lake by boat and then pulled towards the shoreline using a motorized winch. Depending on lake size and effort, considerable areas between 20 and more than 200 ha were sampled.

2.4 Analyses

For the analyses of the fish communities, we assumed that both net fishing according to the EN 14757 standard and the trawls provide reliable information on the fish species inventory in the benthic and pelagic areas of the lakes. In combination with the results of electric fishing, we consider having obtained reliable data on the species inventory. This was the case for 38 lakes.
The catches of the electric fishing describe the fish community in the littoral zones of the lakes. Data could be compiled for 27 lakes, where the number of dips with the anode as common specification of effort was present. We standardized the catches by calculating the number of individuals per dip for every species (fish biomasses were not measured as fish were released alive directly after length measurement). For the gillnetting results of the full CEN procedure, we standardized the species-specific catch as number or weight per 100 m² of net. We referred to one night including dusk and dawn without a correction for the number of hours settled, as this causes bias (Prchalová et al., 2010). It was not possible to calculate comparable standardized catches for the short day-time netting or for the trawl fishing. Passive, stationary multi-mesh nets rely on the activity of fishes which is highest in the times of twilight. Daytime settlement does not provide comparable information. Trawl fishing is an active method. Species composition, abundance and size distribution in trawls differ decisively from gillnet catches (Jurvelius et al., 2011; Olin and Malinen, 2003) and cannot be converted to a comparable catch per effort.
All in all, six descriptors of the fish community were compiled as matrices with specific information on lake and species:

1. SI_{lake} species inventory (presence/absence) of the lake (38 lakes, 31 species)
2. $NPUE_{lit}$ number per unit of effort in catches with electric fishing (27 lakes, 24 species)
3. $NPUE_{bent}$ number per unit of effort in 100 m² of benthic nets (27 lakes, 26 species)
4. $WPUE_{bent}$ weight …
5. $NPUE_{pela}$ number per unit of effort in 100 m² of pelagic nets (20 lakes, 15 species)
6. $WPUE_{pela}$ weigth …

The six matrices characterized the fish communities of the lakes. Statistical tests were used to identify, how well the pre-classified lake typologies were reflected in differences of fish communities. We applied the mean similarity testing procedure (van Sickle, 1997), which compares the homogeneity in the groups with the homogeneity between the groups. Decisions on the suitability of a chosen typology were based on the mean similarity M, which is the ratio B/W (B: mean distance between the groups, W: mean distance in the groups). A lake typology can be regarded as useful to assess the fish fauna, if the fish fauna is homogenous within each of the lake types and heterogeneous between them. This is indicated by high values of M. The tests were based on a permutation procedure with 9,999 iterations. The statistical significance of the values could be calculated. The matrices for quantitative fishing results (NPUE and WPUE) were compared using the SÖRENSEN-distance. For the species inventory, the JACCARD-distance was used because of its enhanced suitability for binary data.
In a second step, a combined matrix was created. The intention was to describe a unified fish community for each lake, rather than habitat-specific descriptions by electric fishing, benthic or pelagic nets and number or weight, respectively. For this purpose, the 20 LDC lakes represented in all five quantitative matrices were selected (NPUE and WPUE matrices). A total number of 25 fish species occurred in these lakes. Each matrix was rank-transformed, by giving the fish species

with the highest number or weight the highest rank (25). The ranks of each species in all matrices were summarized and arranged as a new 'combined matrix'. The SÖRENSEN-distances were calculated for the combined matrix. Afterwards, the mean similarity M was calculated for the lake types specified by maximum depth, mean depth and LAWA typology. Subsequently we checked if the assignment of the lakes to only two types provided higher M values. The following two-sided typologies were tested:

- polymictic lakes vs. stratified lakes (LAWA-typology, reduced)
- lakes with a mean depth < 3 m vs. > 3 m (WFD-typology, reduced)
- lakes with a maximum depth < 10 m vs. >10 m (as suggested by Mehner et al. (2004))

Additionally, a typology combining functional stratification and maximum depth was tested (polymictic / stratified < 30 m maximum depth / stratified > 30 m maximum depth).
In a last step, the lake typology was compared with a biological classification of the LDC lakes by their fish community. To find a common descriptor of the fish community, the four matrices of net fishing results were unified to a combined matrix and underwent a rank transformation like described above (done for 20 lakes with data for electrofishing, benthic nets, and pelagic nets). The data was processed with a hierarchical cluster analysis with the SÖRENSEN-distance and a flexible $\beta = -0.25$ procedure (McCune et al., 2002).

2.5 Description of fish communities

After having classified the lakes into types, we provide a short description of the corresponding fish communities in undisturbed conditions. We chose three characteristics.
First, we calculated the number of lakes of a certain type inhabited by a species divided by total number of lakes of that type. This percentage of type-specific occurrence (% TSO) describes how likely it is to find a given species in a given lake-type. A complete species inventory was present for 38 lakes (see SI_{lake} in previous section). We focus on species with a %TSO above 50 %.
Second, we calculated the type-specific and species-specific percentages of number in catches with benthic nets of the CEN 14757 standard (% NB). We chose benthic nets to describe the fish community because it is the most widespread method, applied in all lake types, and shows the highest values for mean similarity for all typologies in the gear specific matrix (Tab. 2). Data for 27 lakes was present for %NB (see $NPUE_{bent}$ in previous section).
Third, we did the same for species-specific percentages of weight (%WB). Again, data for 27 lakes were present.
In the description of fish communities, we use common names for the species. Scientific names and an ecological characterisation of the preferred habitat of each species can be found in the annex. The ecological characterisation is based on information from the FishBase website (Froese and Pauly, 2014), but we translated it into a characterisation that fits to the three gears used: electric fishing (littoral), benthic nets and pelagic nets. So we use littoral for the FishBase description 'demersal in vegetated lakes', benthic for 'demersal', pelagic for 'benthopelagic in open waters' and multiple habitats for 'benthopelagic'. A detailed analysis of fish traits is beyond the scope of the present paper. Therefore we focus on the presentation of benthic nets, compare simple means and do not apply statistical analyses.
Three species were excluded from the descriptions although their TSO exceeded 50 %. Eel is a widespread species in Germany and occurs in nearly all lakes. Its natural upstream migration of the juveniles is severely hindered by barrier cascades and the populations in the lakes investigated are dependent on stocking. Neither occurrence nor percentages of eel indicate ecological conditions. Carp is frequent in German polymictic lakes, but it is usually stocked and reproduction rarely is successful in the investigated area. Spined Loach is common in the lakes, too, but net fishing is not an appropriate method to estimate its abundance because of the small body size and the bottom dwelling living of the species.

3 Results

3.1 Suitability of typologies assessed by six fish community descriptors

In a first step, we controlled the potential of pre-classified typologies to discriminate the six species-specific trait matrices (see section 'analyses'). The typologies are shown in Table 1.

Table1: Descriptors and boundary values used for the development of a typology for German lakes in the ecoregion 14 (without reduced or combined typologies).

descriptor	groups	boundaries	comments
area [ha]	3	50-100	WFD, refined
		100-500	originally 100 / 1,000 ha
		> 500	
mean depth [m]	3	< 3	WFD, changed
		3-10	originally 3 und 15 m
		> 10	
maximum depth a [m]	3	< 10	MEHNER et al. 2004, extended
first classification		10-20	originally 2 groups (< 10 / > 10 m)
		> 20	
maximum depth b [m]	3	< 10	MEHNER et al. 2004, extended
second classification		10-30	originally 2 groups (< 10 / > 10 m)
		> 30	
depth gradient	3	< 1.5	New
		1.5-3.0	
		> 3.0	
federal state	4	Brandenburg	New
		Mecklenb.-Vorp.	
		Niedersachsen	
		Schleswig-Holstein	
river catchment	6	Elbe	WFD
		Oder	
		Warnow/Peene	
		Schlei/Trave	
		Eider	
		Ems	
LAWA-typology	4	type 10	LAWA
		type 11	
		type 13	
		type 14	

All typologies listed in Table 1 lead to statistically significant discrimination of the corresponding fish communities, except of lake area. However, number and quality of significant discriminations differed (Tab. 2 - higher values of M indicate a better discrimination).

Table 2: Mean similarity M values for six fish community matrices in 'least disturbed lakes' as results of different typologies. Bold format marks permutation tests with $P < 0.01$. Details for the typologies are given in the previous Table 1, the contents of the matrices are explained in section 'analyses'.

Typology	**SI_{lake}**	**$NPUE_{lit}$**	**$NPUE_{bent}$**	**$WPUE_{bent}$**	**$NPUE_{pela}$**	**$WPUE_{pela}$**	**mean**
Area	1.037	1.016	1.075	1.091	0.986	1.026	1.039
mean depth	**1.095**	1.042	**1.306**	**1.232**	1.150	1.170	1.166
max. depth a	**1.083**	-	**1.226**	**1.160**	**1.205**	**1.148**	1.164
max. depth b	**1.104**	**1.044**	**1.240**	**1.182**	**1.266**	**1.188**	1.171
depth gradient	1.037	1.016	**1.204**	**1.148**	**1.170**	1.090	1.111
federal country	**1.199**	1.045	**1.240**	**1.252**	0.945	0.918	1.100
river catchment	**1.148**	1.030	0.934	0.963	1.019	1.102	1.033
LAWA-type	**1.114**	1.027	**1.323**	**1.262**	1.110	**1.168**	1.167
Mean	1.102	1.031	1.194	1.161	1.106	1.101	

To estimate the total suitability of the typologies, we calculated mean M values of all matrices. A typology based on maximum lake depth provided the highest mean M and significantly discriminated all matrices at a $P < 0.01$ level. The M-values of version b of the lake-maximum depth typology was higher than those of version a (Table 2).
The LAWA-typology was the second best and had high values for M and a good number of discriminated matrices (4 of 6). Grouping the lakes by their mean depth lead to high M values only for benthic nets, but did not significantly discriminate the littoral and pelagic fish matrices. If possible, the typology should be reflected in all habitats. Therefore, this typology was considered less suitable. Lake area, depth gradient, federal state and river catchment were less effective in discriminating the fish community matrices.
Summarized, two typologies showed the most effective discrimination of the fish communities; a three-types classification based on maximum depth (< 10 m / 10-30 m / > 30 m) and the four-type LAWA classification (stratified with large catchment area (c.a.) / polymictic with large c.a. / stratified with small c.a. / polymictic with small c.a.).
Independent on the typology chosen, the differences of the fish communities were best reflected in the matrices with standardized catches of number and weight in the benthic nets. They showed the highest number of significant discriminations and the highest means of M-values for all typologies.

3.2 Suitability of typologies if fish community matrices are combined

The typologies that well differentiated the six individual fish matrices also significantly discriminated the combined fish community matrix. However, the highest M-values were obtained by dividing the lakes into two types only (Table 3).

Table 3: Values of mean similarity M for a combined fish community distance matrix in 'least disturbed lakes' for different typologies.

Typology	N types	M	P
maximum depth b (< 10 / 10-30 / > 30 m)	3	1.180	0.0003
LAWA-types (10 / 11 / 13 / 14)	4	1.183	0.0001
maximum depth reduced (< 10 / > 10 m)	2	1.228	0.0003
LAWA-reduced (stratified yes/no)	2	1.270	0.0001
mean depth (< 3 m / > 3 m)	2	1.091	0.0210
functional stratification and und max. depth (polymictic/stratified ≤30 m/stratified > 30 m)	3	1.245	0.0001

The best discrimination was obtained by the reduced LAWA-typology. A two-type division of the lakes according to their maximum depth also provided high values for M. Both typologies overlap to a certain degree, because stratification correlates with a lake maximum depth of 10-11 m (Garcia et al., 2006). Because of the higher M value, a stratification-based typology was chosen. Mean depth again showed a lower suitability to discriminate fish communities; it had lower M values and apparently lower significances.

The reduced typology based on the LAWA proxy for stratification provided the best discrimination of the combined fish community matrix. A typology based on maximum depth (b) provided the best discrimination of the six individual fish community matrices, most of them being gear-specific. Therefore, we also analysed a combination of both stratification and maximum depth. For this approach we replaced the LAWA proxy for stratification by the direct evaluation of stratification. This combination resulted likewise in high values for M. Therefore we suggest the following typology as a suitable basis to assess the ecological status of natural lakes larger than 50 ha in ecoregion 14:

POLY: polymictic
STRAT: stratified, less than 30 m maximum depth
DEEP: stratified, deeper than 30 m maximum depth

3.3 Comparison of typologies and a biological classification

The cluster analysis split the 20 lakes into three groups (Fig. 1, groups marked with boxes). The first division of the dendrogram separates the DEEP lakes. The second division separates the STRAT from the POLY lakes. In 17 of 20 lakes, the fish community class is in accordance with the lake type suggested before.

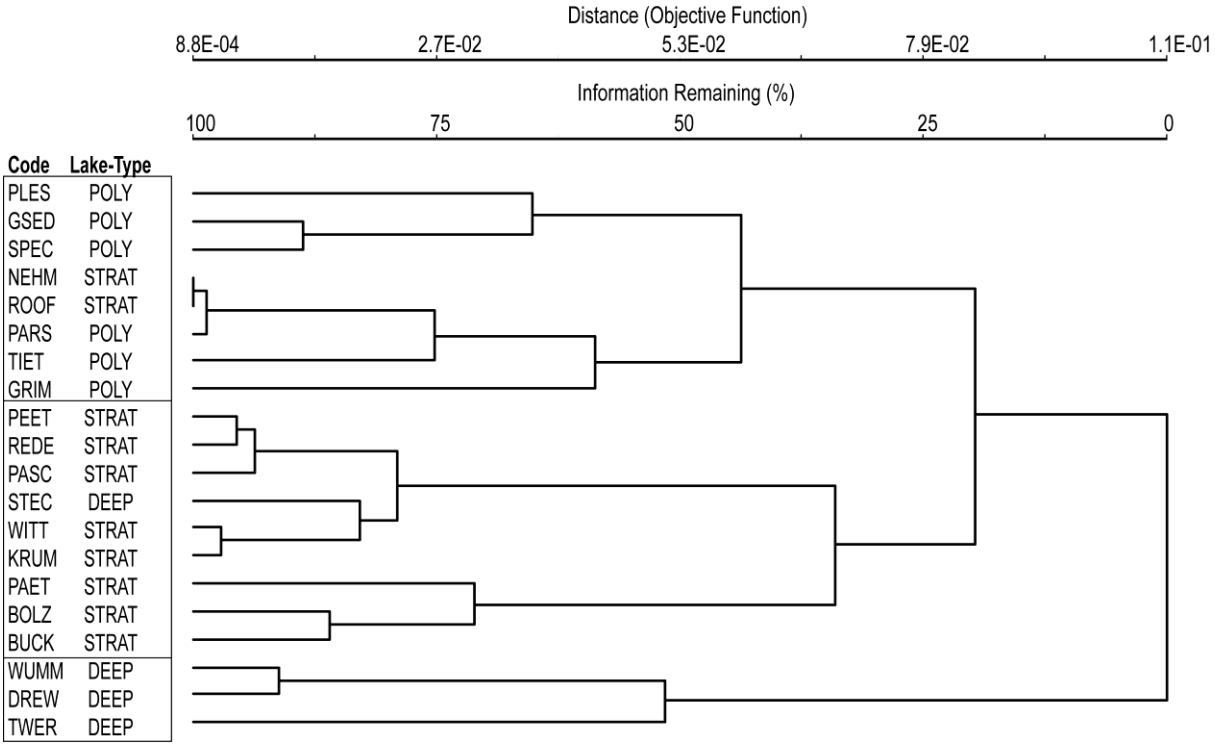


Fig. 1: Cluster dendrogram of fish communities in 20 lakes with least disturbed conditions based on rank-transformed standardized catches in benthic and pelagic nets. Boxes on the left side indicate three biological classes and provide information on lake code and type.

3.4 Fish communities in the lake types

In the following section we provide a picture of type-specific fish communities in least disturbed lakes using selected descriptors (Table 4).

Species that occur in all least disturbed lakes of a specific type (100% TSO) are denoted ‘mandatory’. At all, six species are mandatory for all lake types: perch, roach, ruffe, bream, rudd, and pike. Type-specific mandatory species are exclusively found in DEEP lakes; the pelagic species vendace and bleak as well as the littoral tench.

The percentages in the catch with benthic nets are clearly dominated by perch and roach. The abundance of each of these two species is more than threefold higher than the abundance of any other species in both number and weight except % of weight for bream in POLY lakes.

Table 4: Species-specific descriptors of type-specific fish communities. For species abbreviation see Annex I. For each species, the type-specific percentage of occurrence (%TSO), the percentage by number and by weight in catches with benthic nets are given (%NB, %WB). The data are sorted by %TSO followed by %NB. The last row (n) gives the number of lakes included in the calculation.

	POLY				STRAT				DEEP		
Species	**%TSO**	**%NB**	**%WB**	**Species**	**%TSO**	**%NB**	**%WB**	**Species**	**%TSO**	**%NB**	**%WB**
Perch	100	41.1	24.9	Perch	100	58.0	38.7	Perch	100	42.6	35.1
Roach	100	28.1	28.1	Roach	100	31.9	33.9	Roach	100	33.2	26.6
Ruffe	100	9.8	1.9	Ruffe	100	3.5	0.5	Vendace	100	8.6	5.6
Bream	100	7.0	25.2	Bream	100	1.9	9.2	Ruffe	100	6.7	1.8
W.Bream	100	4.3	5.6	Rudd	100	1.6	3.4	Bleak	100	3.7	1.1
Rudd	100	0.4	2.0	Pike	100	0.5	10.9	Rudd	100	1.8	7.8
Pike	100	0.1	2.9	Tench	80	0.3	0.7	Pike	100	0.6	7.6
Pikeperch	83	1.5	3.1	W.Bream	60	0.9	0.5	Tench	100	0.4	5.0
Bleak	78	7.1	1.8	Vendace	60	0.3	0.3	W.Bream	100	0.5	0.5
Tench	78	< 0.1	0.3	Bleak	53	0.8	0.3	Bream	100	0.3	4.6
Belica	61	0.1	< 0.1					Smelt	60	1.2	0.2
Gudgeon	51	0.4	0.1					Whitefish	60	0.1	2.5
								Burbot	60	0.1	0.9
n	18	13	13		15	10	10		5	4	4

4 Discussion

We developed a typology for German lakes in the ecoregion of the central plains which provides a suitable basis for a WFD-compliant procedure to assess the ecological status with fish-based systems. The results can serve as a basis for the development of a future system, but might also be adopted by other states within the ecoregion. Apart from this, the paper describes the development of a typology where the suitability was tested with data of the biological element without using the element itself as the starting point.

The results highlight the dominant influence of stratification and depth on the fish community composition, as documented in previous investigations (Diekmann et al., 2005; Garcia et al., 2006; Gassner et al., 2005; Mehner et al., 2005; Mehner et al., 2004; Mehner et al., 2007). The ecological effects of stratification and depth on the fish community are well known. Polymictic (or shallow) lakes provide a more or less homogenous habitat resembling a productive, warm littoral water body throughout the vegetation period. In contrast, stratified lakes develop a cool hypolimnetic water volume and thus provide suitable conditions for cold-water fish (Diekmann et al., 2005; Mehner et al., 2005). The hypolimnetic regions may temporarily be characterized by oxygen depletion, again providing special habitat conditions. Stratified lakes have an increased share of the pelagic habitat which favours the relative abundance of species like bleak or vendace. The extension of the pelagic habitat is indirectly taken into account in the maximum depth criterion of the typology.

The findings are important in the context of WFD-compliant assessment systems because it stipulates the use of depth in the specific typology but neither the directive nor additional guides provide explanatory statements on the biological rationale for descriptors and thresholds of the proposed typologies. The present investigation supports the use of depth as a suitable descriptor for a specific typology for fish, but on the other hand replaces the threshold of 3 m given in the WFD by the functional criterion ‘stratification’. The use of functional criteria is unusual in

existent typologies and mostly replaced by a distinct threshold of an abiotic descriptor. MEHNER et al. (2005; 2004) discriminated two types of fish communities at a threshold of 10-11 m of maximum depth; GARCIA et al. (2006) found a separation at 3 m mean depth. In the present dataset, the thresholds for mean depth (3 m) and maximum depth (10 m) are close to mean values of polymictic lakes (see Annex II). Therefore, they do not separate polymictic lakes from stratified ones. We expected that a bimodal functional stratification criterion would discriminate fish communities better than a threshold along a continuous depth descriptor. This expectation was corroborated by the results of the statistical discrimination of fish communities. The good concordance between the proposed functional/abiotic typology and the biological classification indicates an effective choice of abiotic descriptors. As shown in Fig. 1, the assigned lake type and the fish cluster differ for three lakes: Nehmitzsee (NEHM), Roofensee (ROOF) and Stechlinsee (STEC). The three lakes are located close to each other and connected by canals. It is possible that the 'misclassification' is caused by particular geographical features. For example Nehmitzsee and Roofensee show high catches of *Abramis brama* and *Blicca bjoerkna* if compared to mean values of other STRAT lakes.

Beside depth, the WFD stipulates the use of ecology, altitude, geology, and size as obligatory descriptors for the typology of lakes and provides thresholds. We did not analyse the influence of the first three descriptors as all lakes were of the same group: ecoregion 14 (central plains), below 200 m and of calcareous origin. However, we considered the size of the lakes in the development of a typology. Grouping lakes based on their area did not provide a significant discrimination for any of the six fish matrices although the LDC lakes in our dataset differed in size from 50 - 2,210 ha. For the standardized catches, no correlation to the lake area was expected because the scientific fish sampling is habitat-specific. We refrained from correcting the specific catch for the habitat extension, i.e. calculate a catch or percentage for the whole lake. This would have led to a multiplication of gear-specific bias (see below).

The results show that the descriptors proposed by the WFD for a typology are to some extent useful (depth) and to some extent unnecessary (area) for a fish based assessment of the ecological status in the central plains. The WFD descriptors and thresholds are not ideal in terms of the best differentiation of least disturbed conditions for fishes. We conclude that the performance of a fish specific assessment system benefits from a fish-specific typology that may differ from the proposal of the Directive.

For a comprehensive handling, lake types are often designated using specific dominant or frequent species. For the central European region the species bream, perch, pike, pikeperch, ruffe, tench and vendace have been used for characterisation (Mehner et al., 2005; Mehner et al., 2004; Mehner et al., 2007; Müller, 1966). Our typology was developed by comparing the suitability of abiotic descriptors to discriminate least disturbed fish communities. The typology of choice showed the highest discrimination; nonetheless the similarities between the fish communities are more obvious than the differences. For all types, species inventories and catches are dominated by a few mandatory species which inhabit virtually every undisturbed lake. Of these few species, perch and roach clearly dominate. Together they make up over 70 % of number in the catch and over 50 % of weight, respectively. For a description of our lake types, perch and roach are pointless as they clearly dominate the fish community of all types. The DEEP lake-type is the only one with type-specific mandatory species; vendace and bleak can be found in all DEEP lakes but neither in all STRAT nor in all POLY lakes. For a verbal description of the type-specific fish communities, we chose a threshold level of 5 % of total weight. In this case, the following characteristic fish species would be assigned to the types (besides perch and roach):

POLY:	bream, white bream
STRAT:	bream and pike
DEEP:	vendace, rudd, pike and tench

After having developed a typology, the next challenge will be the development of a fish based assessment system. The assessment of the ecological status is usually done by comparing the current status with a reference condition. The fish communities of lakes in least disturbed conditions are close to the reference conditions and the data provided in Table 5 might provide a starting point.

5 Acknowledgements

The publication of the results was made possible by the Program of the German Federal Countries for Financiation of Research and Development for Water, Soil and Waste (Länderfinanzierungsprogramm "Wasser, Boden und Abfall").

6 Literature

Browne, R.A., 1981. Lakes as islands: biogeographic distribution, turnover rates, and species composition in the lakes of central New York. J. Biogeog. 8, 75-83.

Brucet, S., Pédron, S., Mehner, T., Lauridsen, T.L., Argillier, C., Winfield, I.J., Volta, P., Emmrich, M., Hesthagen, T., Holmgren, K., Benejam, L., Kelly, F., Krause, T., Palm, A., Rask, M., Jeppesen, E., 2013. Fish diversity in European lakes: geographical factors dominate over anthropogenic pressures. Freshw. Biol. 58, 1779-1793.

CIS, 2003. River and lakes - Typology, reference conditions and classification systems - WG 2.3 REFCOND. Common Implementation Strategy for the Water Framework Directive (2000/60/EC) - Guidance Document. European Commission, Luxembourg.

CIS, 2011. Guidance document on the Intercalibration Process 2008-2011. Implementation Strategy for the Water Framework Directive (2000/60/EC) - Guidance Document. European Commission, Luxembourg.

Diekmann, M., Brämick, U., Lemcke, R., Mehner, T., 2005. Habitat-specific fishing revealed distinct indicator species in German lowland lake fish communities. J. Appl. Ecol. 42, 901-909.

EN 14011, 2003. European Standard: Water quality - Sampling of fish with electricity, ICS 13.060.70; 65.150.

EN 14757, 2005. European Standard: Water quality - Sampling of fish with multi-mesh gillnets, ICS 13.060.70; 65.150.

Froese, R., Pauly, D., 2014. FishBase (own summary of ecological information on preferred habitats for selected fish species). www.fishbase.org, last access 24.01.2014.

Garcia, X.-F., Diekmann, M., Bramick, U., Lemcke, R., Mehner, T., 2006. Correlations between type indicator fish species and lake productivity in German lowland lakes. J. Fish Biol. 68, 1144-1157.

Gassner, H., Wanzenböck, J., Zick, D., Tischler, G., Pamminger-Lahnsteiner, B., 2005. Development of a fish based lake typology for natural Austrian lakes >50 ha based on the reconstructed historical fish communities. Internat. Rev. Hydrobiol. 90, 422-432.

Jeppesen, E., Jensen, J.P., Søndergaard, M., Lauridsen, T., Landkildehus, F., 2000. Trophic structure, species richness, and biodiversity in Danish lakes: changes along phosphorus gradient. Freshw. Biol. 45, 201-218.

Jurvelius, J., Kolari, I., Leskelä, A., 2011. Quality and status of fish stocks in lakes: gillnetting, seining, trawling and hydroacoustics as sampling methods. Hydrobiologia 660, 29-36.

LAWA, 1998. Gewässerbewertung - stehende Gewässer. Vorläufige Richtlinie für eine Erstbewertung von natürlich entstandenen Seen nach trophischen Kriterien. Länderarbeitsgemeinschaft Wasser.

LAWA, 2003. Arbeitshilfe zur Umsetzung der EG-Wasserrahmenrichtlinie. Länderarbeitsgemeinschaft Wasser.

LAWA, 2005. Rahmenkonzeption zur Aufstellung von Monitorprogrammen und zur Bewertung des Zustandes von Oberflächengewässern. Länderarbeitsgemeinschaft Wasser.

Mathes, J., Plambeck, G., Schaumburg, J., 2002. Das Typisierungssystem für stehende Gewässer in Deutschland mit Wasserflächen ab 0,5 km^2 zur Umsetzung der Wasserrahmenrichtlinie, in: Deneke, R., Nixdorf, B. (Eds.), Implementierung der EU-Wasserrahmenrichtlinie in Deutschland: Ausgewählte Bewertungsmethoden und Defizite. Eigenverlag der BTU Cottbus, Cottbus, pp. 15-24.

McCune, B., Grace, J.B., Urban, D.L., 2002. Analysis of ecological communities. MjM Software Design, Gleneden Beach (Oregon, USA).

Mehner, T., Diekmann, M., Brämick, U., Lemcke, R., 2005. Composition of fish communities in German lakes as related to lake morphology, trophic state, shore structure and human-use intensity. Freshw. Biol. 50, 70-85.

Mehner, T., Diekmann, M., Garcia, X.-F., Brämick, U., Lemcke, R., 2004. Ökologische Bewertung von Seen anhand der Fischfauna. Berichte des IGB 21, 202.

Mehner, T., Holmgren, K., Lauridsen, T.L., Jeppesen, E., Diekmann, M., 2007. Lake depth and geographical position modify lake fish assemblages of the European 'Central Plains' ecoregion. Freshw. Biol. 52, 2285-2297.

Müller, H., 1966. Eine fischereiwirtschaftliche Seenklassifizierung Norddeutschlands und ihre limnologischen Grundlagen. Verh. Internat. Verein. Limnol. 16, 1145-1160.

Olin, M., Malinen, T., 2003. Comparison of gillnet and trawl in diurnal fish community sampling. Hydrobiologia 506-509, 443-449.

Persson, L., Diehl, S., Johansson, L., Andersson, G., Hamrin, S.F., 1991. Shifts in fish communities along the productivity gradient of temperate lakes - patterns and the importance of size-structured interactions. J. Fish Biol. 38, 281-293.

Poikane, S., 2009. Water Framework Directive intercalibration technical report - Part 2: Lakes. Joint Research Center, European Commission.

Prchalová, M., Mrkvicka, T., Kubecka, J., Peterka, J., Cech, M., Muska, M., Kratochvíl, M., Vasek, M., 2010. Fish activity as determined by gillnet catch: A comparison of two reservoirs of different turbidity. Fish. Res. 102, 291-296.

Sondergaard, M., Jeppesen, E., Jensen, J.P., Amsinck, S.L., 2005. Water Framework Directive: ecological classification of Danish lakes. J. Appl. Ecol. 42, 616-629.

van Sickle, J., 1997. Using Mean Similarity Dendrograms to Evaluate Classifications. Journal of Agricultural, Biological and Environmental Statistics 2, 370-388.

WFD, 2000. Directive 2000/60/EC of the European Parliament and the Council of 23 October 2000 establishing a framework for Community action in the field of water policy, Official Journal of the European Communities, pp. 1-72.

Annex A: Scientific names and abbreviations of species

Table A 1: Common names, latin names and preferred habitat of the relevant fish species. The habitat assignment is based on FishBase information (Froese & Pauly, 2014).

Common name	Scientific name	habitat
Belica	*Leucaspius delineatus*	littoral
Bleak	*Alburnus alburnus*	pelagic
Bream	*Abramis brama*	multiple
Burbot	*Lota lota*	benthic
Eel	*Anguilla anguilla*	benthic
Gudgeon	*Gobio gobio*	multiple
Perch	*Perca fluviatilis*	multiple
Pike	*Esox lucius*	littoral
Pikeperch	*Sander lucioperca*	pelagic
Roach	*Rutilus rutilus*	multiple
Rudd	*Scardinius erythrophtalmus*	littoral
Ruffe	*Gymnocephalus cernua*	benthic
Tench	*Tinca tinca*	littoral
Smelt	*Osmerus eperlanus*	pelagic
Spined Loach	*Cobitis taenia*	benthic
W(hite) Bream	*Blicca bjoerkna*	benthic
Whitefish	*Coregonus spp.*	-
Vendace	*Coregonus albula*	pelagic

Annex B: Identification of polymixis in deeper lakes

The typology presented is based on mixing characteristics, which is a functional criterion. Some lakes are deep and stratified, but only in restricted areas and thus functionally polymictic. We investigated 116 German lakes with information on mean depth, maximum depth and functional mixing characteristics. The descriptor stratified yes/no is not replaceable by single thresholds of maximum depth or mean depth (Table B 1).

Table B 1: Values of maximum and mean depth for German lakes of different mixing characteristics, given as mean (minimum - maximum).

	polymictic lakes		**stratified lakes**	
maximum depth	9.0	(1.0 - 39.0)	29.5	(11.3-53.0)
mean depth	3.3	(0.6 - 7.1)	11.0	(4.0-28.6)
n lakes	63		53	

However, mean depth and maximum depth can help to isolate lakes, where the assignment of mixing characteristic might need further support, e.g. by the help of knowledge of the place or depth profiles of temperature (Fig. B 1):

- polymixis: lakes with maximum depths below 11 m are polymictic OR lakes with mean depths below 4.0 m are polymictic;
- stratification: lakes with mean depths above 7.1 m are stratified (max. depth doesn't provide additional information)
- individual check needed: an individual assignment is needed for lakes with max. depths above 11 m AND mean depths between 4.0-7.1 m.

The values given were obtained lakes of the German lowlands and should be validated, if functional mixing characteristics are to be identified in other ecoregions.

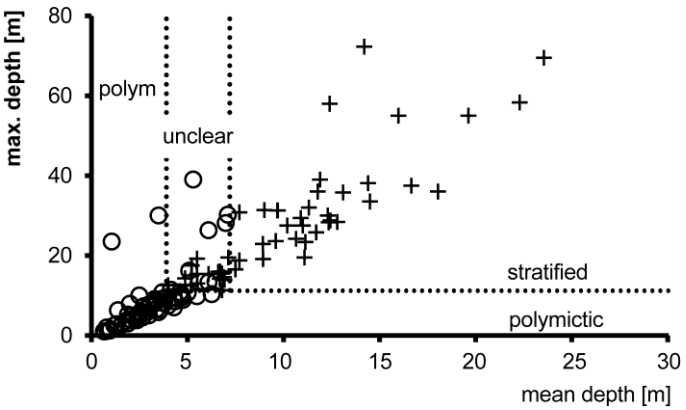


Fig. B 1: Isolating lakes where mixing characteristics can clearly be identified by mean and maximum depth. Further explanations can be found in the text.

ANHANG 5 - FISCHBASIERTE SEENBEWERTUNG IM ALPINEN BEREICH

Verfahrensvorschlag für einen Gewässerspezifischen Bewertungsansatz
- DeLFI-Site -

David Ritterbusch, Uwe Brämick (Institut für Binnenfischerei e.V. Potsdam-Sacrow)
Michael Schubert (Bayerische Landesanstalt für Landwirtschaft, Institut für Fischerei)
Alexander Brinker, Uwe Dußling (Landwirtschaftliches Zentrum für Rinderhaltung, Grünlandwirtschaft, Milchwirtschaft, Wild und Fischerei Baden-Württemberg (LAZBW), Fischereiforschungsstelle)
Bernhard Gum (Bezirk Oberbayern, Fachberatung Fischerei)

Einleitung und Hintergrund

Im Jahr 2000 trat die für alle Mitgliedsstaaten der EU verbindliche Wasserrahmenrichtlinie (WRRL) in Kraft. Sie fordert, bis zum Jahr 2015 alle europäischen Gewässer in einen guten ökologischen Zustand zu versetzen. Der ökologische Zustand der Gewässer ist durch ein Monitoring zu überwachen um eventuellen Handlungsbedarf anzeigen und ggf. Maßnahmenpläne aufstellen zu können. Daher gibt die WRRL die Bewertung des Zustandes von Oberflächengewässern anhand der biologischen Qualitätsmerkmale Phytoplankton, Makrophyten, Makroinvertebraten und Fische vor.

Um den Forderungen der WRRL nachzukommen, entwickelte das Institut für Binnenfischerei ein deutsches Verfahren zur fischbasierten Bewertung des ökologischen Zustands von Seen. Im Laufe der Entwicklung wurde deutlich, dass für ein solches Bewertungssystem innerhalb Deutschlands verschiedene Datengrundlagen zugrunde gelegt werden müssen. Es umfasst daher zwei Ansätze. Der typspezifische Index (DeLFI-Type[1]) beruht auf Standardbefischungen mit Multimaschen-Netzen (EN 14757 2005b). Er wurde anhand von Daten für Seen des Norddeutschen Tieflands entwickelt und zeigt dort sehr gute Ergebnisse. Im alpinen Bereich Deutschlands liegen keine Daten aus Stellnetz-Standardbefischungen vor. Hier wird der gewässerspezifische Index des Verfahrens eingesetzt (DeLFI-Site). Er beruht auf Modellierungen der Fischgemeinschaft. Dafür sind genaue Kenntnisse der historischen und der gegenwärtigen Fischgemeinschaft erforderlich, die aber nicht mit Standard-Netzbeprobungen gewonnen werden müssen. Der DeLFI-Site wurde in Zusammenarbeit mit den bayerischen und den baden-württembergischen Kollegen sowie im Rahmen der Interkalibrierung optimiert. Er zeigt für die bisher geprüften alpinen Seen sehr plausible Ergebnisse.

Die nachfolgende Darstellung des DeLFI-Site bezieht sich auf die Anwendung des Verfahrens im alpinen Bereich.

Das vorliegende Dokument ist als Auszug aus dem Gesamtverfahren zu verstehen. Es wurde erstellt um auf die spezifischen Gegebenheiten des alpinen Raums einzugehen und eine verständliche Handreichung zur Anwendung des Verfahrens zur Verfügung zu stellen. Notwendige Aspekte des theoretischen Überbaus werden hier wiederholt, auf die Darstellung des DeLFI-Type wird jedoch verzichtet. Eine Gesamtbeschreibung des Verfahrens wird im Jahr 2014 im Rahmen der Schriften des Instituts für Binnenfischerei erstellt.

Der nachfolgend dargestellt DeLFI-Site wurde und wird in Bayern und Baden-Württemberg geprüft. Dabei wurden bisher sieben natürliche und ein künstlicher See getestet. Die Ergebnisse

[1] De - Internationale Kennung Deutschland, LFI - Lake Fish Index, Type - type specific, Site - site specific

waren bisher plausibel. Mit der geringen Anzahl an Testbewertungen ist der DeLFI-Site aber weiterhin ganz klar in der Erprobungsphase. Mit einer zunehmenden Anzahl von Testbewertungen können unter Umständen Änderungen im Verfahren erforderlich werden.

DATENBASIS UND DATENERHEBUNGEN

Der DeLFI-Site beruht auf einem Vergleich der aktuellen Fischgemeinschaft mit dem potenziell natürlichen Referenzzustand. Für beide Zustände wird ein gewässerspezifisches Arteninventar mit artspezifischen Häufigkeiten modelliert. Alle zur Verfügung stehenden Informationen fließen in die Beschreibung der Fischgemeinschaft ein. Es sind Informationen zu allen potenziellen Lebensräumen erforderlich: Litoral, Pelagial und Benthal/Profundal.

Zur Modellierung der **aktuellen Fischgemeinschaft** können Fischbestandserhebungen, Fangstatistiken der Erwerbsfischerei und semiquantitative Informationen herangezogen werden. Hierbei werden Daten und Angaben aus dem jeweiligen WRRL-Bewirtschaftungszeitraum von 6 Jahren genutzt. Wenn sich die fischereiliche Bewirtschaftung auf wenige Zielarten oder wenige Fangmethoden beschränkt, sind ergänzende Informationen erforderlich. Folgende Fanggeräte werden für die Befischungen der Habitate empfohlen, wobei mindestens eins der Geräte je Habitat zum Einsatz kommen sollte:

- Litoral: Reuse, Strandwade, Elektrofischerei
- Benthal/Profundal: Stellnetz, Zugnetz, Großreuse
- Pelagial: Stellnetz, Schleppnetz (vorzugsweise nachts), Ringwade

Die ergänzenden Informationen sollten in mindestens zwei Jahren des oben genannten 6-Jahres-Zeitraumes aufgenommen werden. Tab. 9 zeigt die Überführung von Literaturangaben und Daten der verschiedenen Fanggeräte in die Häufigkeitsklassen des Bewertungsverfahrens. Die Werte sind als vorläufige Orientierung anzusehen. Sie wurden in Absprache zwischen den Autoren festgelegt, ihre Anwendbarkeit wird aber in zukünftigen Praxistests noch zu prüfen sein.

Tab. 9: Zuordnung der Häufigkeitsklasse von Arten auf Basis verschiedener Datenquellen.

Häufigkeits-klasse	Befischungen % Anzahl	Fangstatistik kg/ha	Semiquantitative Informationen
3	> 5 %	> 1	häufig
2	1 - 5 %	0,1 - 1	regelmäßig
1	< 1 %	< 0,1	selten, ggf. längere Abstände
0	fehlt	fehlt	fehlt

Die Zuordnung von Befischungsdaten zu den Häufigkeitsklassen in Tab. 9 gibt die artspezifische Individuenzahl im Vergleich zur gesamten Individuenzahl der jeweiligen Methode an. Bei der auf gezielten **Befischungen** basierenden Zuordnung der fischartspezifischen Häufigkeitsklassen ist jeweils die Fangmethode mit dem höchsten artspezifischen Fangerfolg zu Grunde zu legen. Für ufergebundene Arten (Hecht, Rotfeder, Schleie) ist der relative Anteil bei der Elektro- oder Reusenfischerei maßgeblich. Für Arten des Freiwassers (Kleine Maräne, Ukelei, Stint) werden Anteile in Stell- oder Schleppnetzen zur Klassifizierung genutzt. Die Klasse 1 wird auch vergeben, wenn bei der Befischung kein Individuum der Art nachgewiesen wurde, das Vorkommen aber für den Bewertungszeitraum von 6 Jahren durch andere Nachweise belegt ist.

Die Einteilung wurde aus dem Interkalibrierungsprozess übernommen. Sie hat sich bei der Klassifizierung und Bewertung österreichischer Daten mit dem deutschen Verfahren als praktikabel erwiesen. Für die Zuordnung von Angaben aus **Fangstatistiken** zu Häufigkeitsklassen werden Grenzen bei Flächenerträgen von 1,0 bzw. 0,1 kg/ha festgelegt. Seltene Arten der Klasse 1 werden ggf. ohne quantitative Angaben genannt.

Die Zuordnung von **semiquantitativen Informationen** wie Literaturdaten oder persönlichen Mitteilungen erfolgt sinngemäß. Befragungen oder persönlichen Mitteilungen liefern oft Hinweise auf das Vorkommen seltener Fischarten.
Alle artspezifischen Häufigkeitsklassen sollten durch eine Expertise auf Plausibilität geprüft werden um fehlerhafte Zuordnungen zu vermeiden. Beispiele sind verfälschende Effekte von Massenfängen oder von nicht repräsentativen Befischungsmethoden, in denen z.B. Kleinfischarten fehlen.

Zur Modellierung der **Referenzfischgemeinschaft** werden Daten und Fachliteratur bis 1940 verwendet. Expertisen sind zulässig wenn keine historischen Angaben zum Fischbestand verfügbar sind. Sie können als Erfahrungswerte für einzelne Seen oder als Analogieschlüsse aus vergleichbaren Gewässern einfließen. Sofern Artnachweise und Häufigkeitsklassen allein auf Expertenwissen basieren, ist dies entsprechend zu dokumentieren.

Die im Verfahren genutzten Häufigkeitsklassen beziehen sich auf die einzelnen Fangmethoden und damit auch auf das Habitat der entsprechenden Art. Sie entsprechen nicht immer der intuitiven Benutzung der Begriffe häufig, regelmäßig oder selten. Bei der Modellierung muss die berücksichtigt werden. Beispielsweise kann eine ufergebundene Art am Ufer häufig sein, in großflächigen alpinen Seen mit geringen Litoralflächen aber dennoch einen geringen Anteil am Fischbestand haben.
Die Klassengrenzen in Tab. 9 sind vorläufig und werden in einem Praxistest von den zuständigen Fischereibehörden in Bayern und Baden-Württemberg geprüft. Zukünftig soll die einheitliche Klassifizierung für alle Befischungsergebnisse mit methodenspezifischen Klassengrenzen präzisiert werden.

TYPOLOGIE UND RAHMENREFERENZEN

Nach dem Wortlaut der WRRL soll die Bewertung von Gewässern auf der Basis einer geeigneten **Typologie** stattfinden. Eine Typologie ist die Gruppierung von Seen anhand von abiotischen Kriterien wie Fläche, Tiefe oder Lage. Nutzbare Kriterien werden in Annex II der WRRL genannt und in mehr oder weniger verbindlichen Begleitdokumenten dargestellt (2008/915/EG 2008; CIS 2003; LAWA 2003; POIKANE 2009). Der hier vorgeschlagene DeLFI-Site verfolgt einen gewässerspezifischen Ansatz. Der Sollzustand der Fischgemeinschaft (die Referenz) wird nicht für Seetypen modelliert sondern für jeden See einzeln. Eine solche gewässerspezifische Festlegung der Referenzzustände ist im Zusammenhang mit der WRRL akzeptiert. Sie wird in den Verfahren von Österreich, Italien und Frankreich genutzt (ARGILLIER et al. 2012; GASSNER et al. 2003; GASSNER et al. 2006). Die Interkalibrierungsergebnisse der durchweg gewässerspezifischen Verfahren in der alpinen Gruppe (Österreich, Italien, Deutschland) fanden Eingang in die Entscheidung der Kommission (2013/480/EU 2013). Auch die deutsche fischbasierte Bewertung von Fließgewässern erlaubt die gewässerspezifische Modellierung der Referenz (DUßLING 2009) und wurde erfolgreich interkalibriert.

Für den Gewässer-spezifischen Ansatz zur fischbasierten Bewertung alpiner Seen ist eine Typologie nicht erforderlich. Dennoch kann sie hilfreich sein. Sie fasst abiotisch ähnliche Seen

zusammen, damit sollten auch die entsprechenden Fischgemeinschaften ähnlich. Die Typologie kann so Hinweise für die Modellierung des Referenzzustandes liefern.
Für die Anwendung des DeLFI-Site wird auf die in Deutschland etablierte LAWA-Typologie zurückgegriffen. Für den alpinen Bereich werden folgende vier Typen unterschieden (MATHES et al. 2002, 2005; RIEDMÜLLER et al. 2013):

Typ 1 Polymiktischer Alpen- und Voralpensee
Typ 2 Geschichteter Voralpensee mit relativ großem Einzugsgebiet
Typ 3 Geschichteter Voralpensee mit relativ kleinem Einzugsgebiet
Typ 4 Geschichteter Alpensee

Für die LAWA-Typen wurden **Rahmenreferenzen** auf der Basis von Literaturquellen, aktuellen Fangdaten und Expertisen von den Autoren erstellt. Die Rahmenreferenzen geben für jeden Typ eine Vorgabe der zu erwartenden Fischarten und ihrer Häufigkeiten, wie sie sich für Gewässer der entsprechenden LAWA-Typendefinition erwarten lassen (Tab. 10).
Dabei ergaben sich Schwierigkeiten. Für einige Gewässer zeigte sich, dass die modellierten Referenzen nicht mit den Rahmenreferenzen des entsprechenden LAWA-Typs übereinstimmen. Daraus muss geschlossen werden, dass die aktuelle LAWA-Typisierung der alpinen Seen aus fischökologischer Sicht in einigen Fällen falsch ist (Details sind in Bearbeitung).
Zudem ist die LAWA-Typologie für die Beschreibung von vergleichbaren Fischgemeinschafts-Gruppen nur begrenzt geeignet. Die Fischgemeinschaften werden auch von anderen abiotischen Faktoren geprägt, z.B. von der Höhenlage. Zudem unterscheiden sich die Fischgemeinschaften in alpinen Seen auch innerhalb von Typen, beispielsweise durch häufige, aber endemische Arten.

Daher sind die Rahmenreferenzen der LAWA-Typen ausdrücklich als Orientierungshilfe bei der Referenzerstellung gedacht. Sie sind keine fachliche Vorgabe. Der DeLFI-Site sieht explizit vor, die Referenzen anzupassen und für jedes Gewässer auch besondere, seltene oder schlecht nachweisbare Fischarten berücksichtigen.

Für die Großmaränen gehen die verschiedenen Formen mit ihren deutschen Bezeichnungen und ggf. auch verschiedenen ökologischen Ansprüchen in das Bewertungsverfahren ein. Die Systematik des Formenkreises wird aktuell detailliert untersucht. Die taxonomische Zuordnung wird für das Bewertungsverfahren vorgenommen, wenn neue und eindeutige Erkenntnisse vorliegen. Zu den Rahmenreferenzen der LAWA-Typen 2, 3 und 4 gehören Arten aus dem Formenkreis der Großen Maräne. Ihnen wird jeweils die Häufigkeit 3 zugeordnet. In der Excel-Vorlage sind sie jedoch nicht bei den Rahmenreferenzen berücksichtigt, da in jedem Fall eine genauere Angabe der Art erforderlich ist.

Tab. 10: Rahmenreferenzen für die fischbasierte Bewertung von Seen der Alpen und Voralpen nach LAWA-Typologie.

Fischart	**Typ 1 Alpen/Voralpen polymiktisch**	**Typ 2 Voralpen geschichtet großes EZG**	**Typ 3 Voralpensee geschichtet kleines EZG**	**Typ 4 Alpensee geschichtet**
Schleie	regelmäßig	selten	selten	selten
Rotauge (Plötze)	häufig	regelmäßig	regelmäßig	regelmäßig
Brachse (Blei)	häufig	regelmäßig	regelmäßig	regelmäßig
Rotfeder	regelmäßig	selten	selten	selten
Güster	selten	selten	selten	selten
Ukelei	regelmäßig	häufig	häufig	regelmäßig

Barsch	häufig	häufig	häufig	regelmäßig
Hecht	selten	selten	regelmäßig	regelmäßig
Quappe		regelmäßig	regelmäßig	regelmäßig
Wels	selten	selten	selten	selten
„Großmaräne“		häufig	häufig	häufig
Seeforelle		regelmäßig	regelmäßig	regelmäßig
Seesaibling		regelmäßig		häufig
Döbel		selten	selten	selten
Hasel		selten	selten	
Elritze		selten	selten	regelmäßig
Westgroppe		selten		regelmäßig

Fischarten, die in ihrem Lebenszyklus ganz oder teilweise auf Fließgewässer angewiesen sind werden für die Bewertung herangezogen wenn sie natürlicherweise auch in den Seen vorkommen. Im Konzept des Verfahrens ist die Anbindung an umliegende Fließgewässer ein Bestandteil des ökologischen Zustandes von Seen wenn sie im unbeeinflussten Zustand gegeben war. Rheophile Langdistanzwanderer werden jedoch nicht berücksichtigt. Ihr natürliches Aufkommen ist durch Wanderhindernisse beeinträchtigt, die nicht mehr mit dem ökologischen Zustand der Seen zusammenhängen. Hierzu gehören die Arten Lachs, Meerforelle, Flussneunauge und der Aal (FROESE & PAULY 2014; SCHAARSCHMIDT et al. 2005).
Der Aal kommt zwar in einigen Seen vor, wird aber im Wesentlichen durch Besatz in die Gewässer eingebracht. Besetzte Individuen lassen sich nicht von den natürlich aufgestiegenen Exemplaren unterscheiden, so dass diese Art nicht zur Anzeige des ökologischen Zustands geeignet ist.
Ausgestorbene Fischarten wie der Bodensee-Kilch gehen ebenfalls nicht in die Bewertung ein. Diese Arten können aktuell nicht mehr im See vorkommen, damit erlaubt ihr Fehlen keine Aussage über den ökologischen Zustand des Sees.
Die genannten Arten lassen sich in der Bewertungsvorlage eingeben um vollständige Informationen zum Referenz-Fischbestand aufzunehmen. Die Häufigkeit für die Referenz muss dann aber auf 0 gesetzt werden.

METRICS UND PUNKTEVERGABE

Übersicht

Die WRRL gibt in Annex V sogenannte „normative Begriffsbestimmungen zur Einstufung des ökologischen Zustands von Seen“ vor. Demnach gelten drei Hauptkriterien für die Fischfauna eines Sees in sehr gutem Zustand (die Klammern geben die nachfolgend genutzte Abkürzung an):

- Zusammensetzung und Abundanz der Arten entsprechen vollständig oder nahezu vollständig den Bedingungen bei Abwesenheit störender Einflüsse („Abundanz“)
- Alle typspezifischen störungsempfindlichen Arten sind vorhanden („sensible Arten“)
- Die Altersstrukturen der Fischgemeinschaften zeigen kaum Anzeichen anthropogener Störungen und deuten nicht auf Störungen bei der Fortpflanzung oder Entwicklung irgendeiner besonderen Art hin („Entwicklung“).

Generell nutzen Bewertungsverfahren sog. Metrics, d.h. Merkmale der Biokomponente die den ökologischen Status des Gewässers anzeigen. Das DeLFI-Site-Verfahren zielt darauf ab, fischbasierte Metrics für die drei genannten normativen Kriterien einzusetzen und so die Vorgaben der WRRL eindeutig zu erfüllen. Die Metrics wurden teilweise am Institut für

Binnenfischerei entwickelt, teilweise sind sie aus anderen Verfahren entlehnt. Hierbei wurde auf das deutsche Verfahren zur Fließgewässer-Bewertung (DUßLING 2009; DUßLING et al. 2004) und auf den österreichischen Ansatz zur Seebewertung zurückgegriffen (GASSNER et al. 2003; GASSNER et al. 2006; ZICK et al. 2006). Die Metrics wurden in früheren Untersuchungen geprüft (BRÄMICK et al. 2008a; MEHNER et al. 2004; RITTERBUSCH & BRÄMICK 2008).

Dabei werden die Fischarten in Abhängigkeit von ihrer Häufigkeit unterschiedlich gewichtet. Fischarten, die nach den Kriterien in Tab. 9 in der Referenzfischgemeinschaft häufig sind, kommt eine besondere Bedeutung zu. Fehlen Arten aktuell, die im Referenzzustand häufig sind, so zeigt das mit hoher Wahrscheinlichkeit eine Störung des ökologischen Zustands. Die häufigen Fischarten entsprechen in ihrer Bedeutung den Leitarten anderer Bewertungsverfahren.
Regelmäßig vorkommende Fischarten der Referenzfischgemeinschaft zeigen ebenfalls Beeinträchtigungen des ökologischen Zustands, allerdings mit abnehmender Deutlichkeit. Ihre Bedeutung im Bewertungsverfahren entspricht den typspezifischen Arten. Seltene Fischarten haben die geringste Aussagekraft bezüglich des ökologischen Zustands des Gewässers und entsprechen den Begleitarten anderer Verfahren. Trotz der hohen konzeptionellen Entsprechungen wurde die Terminologie von fiBS oder österreichischen Verfahren nicht übernommen, da teilweise andere Klassengrenzen vorliegen.

Das DeLFI-SITE Verfahren beinhaltet acht verbindliche Metrics, die immer in die Gesamtbewertung einfließen. Ein Metric (Reproduktion relevanter Arten) ist ein Modifikator, der die Bewertungen der acht verbindlichen Metrics beeinflusst. Zudem existieren zwei optionale Metrics die nur in die Gesamtbewertung einfließen, wenn die Datengrundlage ihre Anwendung zulässt. Die nachfolgende Tab. 11 zeigt eine Übersicht der Metrics des DeLFI-Site, ihrer Bedeutung für das Verfahren, die Zuordnung zu den normativen Kriterien der WRRL und ihre Kategorie im DeLFI-Site. Weitere Erklärungen finden sich im Anschluss.

Tab. 11: Metrics im DeLFI-Site Bewertungsvorschlag für alpine Seen.

Metric	Relevanz	WRRL Kriterium	DeLFI Kategorie
Anzahl häufige Arten	Verbindlich	Sensible Arten	Arteninventar
Anzahl regelmäßige Arten	Verbindlich	Sensible Arten	
Anzahl seltene Arten	Verbindlich	Sensible Arten	
Anzahl Reproduktions-Gilden	Verbindlich	Sensible Arten	Gildeninventar
Anzahl Habitat-Gilden	Verbindlich	Sensible Arten	
Abundanz häufige Arten	Verbindlich	Abundanz	Artenabundanz
Abundanz Reproduktions-Gilden	Verbindlich	Abundanz	Gildenabundanz
Abundanz Habitat-Gilden	Verbindlich	Abundanz	
Reproduktion relevanter Arten	Modifikator	Entwicklung	Reproduktion
Maximale Masse Brachsen	Optional	Entwicklung	Wachstum
Anzahl Wanderarten	Optional	Sensible Arten	Vernetzung

Metrics aus dem Bereich sensible Arten

Arteninventar - Anzahl häufige Arten

Nur sehr massive Beeinträchtigungen der Gewässerökologie führen zum Verschwinden einer häufigen Fischart. Daher wird das Fehlen von einer Art, die im Referenzzustand häufig ist, stark abwertend beurteilt.

Arteninventar - Anzahl regelmäßige Arten

Fehlen Arten, die im Referenzzustand regelmäßig vorhanden sind, wird eine ökologische Degradation des Sees angezeigt. Auch hier führt das Fehlen einer Art in der Regel zu einer

Abwertung, allerdings nicht so deutlich wie bei den häufigen Arten.

Arteninventar - Anzahl seltene Arten
Auch das aktuelle Fehlen von referenzgemäß seltenen Arten zeigt eine ökologische Degradation. Die Nachweisbarkeit seltener Arten ist naturgemäß geringer als die von häufig oder regelmäßig vorkommenden. Daher ist aus methodischen (nicht aus ökologischen!) Gründen die Aussagekraft der seltenen Arten bezüglich des ökologischen Zustandes geringer. In diesem Metric führen erst deutliche Hinweise zur Abwertung.

Gildeninventar - Anzahl Habitatgilden
Der Metric prüft, ob sich der Zustand wichtiger Habitate im See auf das Vorhandensein von Arten auswirkt. Fischarten lassen sich entsprechend der bevorzugten Habitate in sog. Gilden einteilen:

Litorale	bevorzugen Flachwasserbereiche in Ufernähe
Benthische	bevorzugen den Gewässerboden
Epilimnische	bevorzugen das Freiwasser oberhalb der Temperatursprungschicht
Hypolimnische	bevorzugen das Freiwasser unterhalb der Temperatursprungschicht

Fehlen aktuell Gilden, die im Referenzzustand vorhanden sind, so deutet dass auf eine deutliche Beeinträchtigung des Habitates hin. Es kommt zur Abwertung. Dabei wird berücksichtig, ob eine Gilde nur durch eine oder durch mehrere Arten im Gewässer vertreten ist. Die Zuordnung der Habitatgilden für die bewertungsrelevanten Arten findet sich im Anhang auf S. 103.

Gildeninventar - Anzahl Reproduktions-Gilden
Der Metric prüft, ob sich der Zustand wichtiger Strukturen für die Vermehrung auf das Vorhandensein von Fischarten auswirkt. Fischarten lassen sich entsprechend des bevorzugten Laichsubstrats in folgende Gilden einteilen:

Phytophile	laichen bevorzugt an Pflanzen
Lithophile	laichen bevorzugt an / über Hartsubstrat wie Steinen, Kies Die Gilden litho-pelagophil und speleophil (Quappe) sind mit nur einzelnen Arten vertreten und werden hier eingeschlossen
Psammophile	laichen bevorzugt auf Sand. Die Gilde ostracophil ist hier eingeschlossen (nur Bitterling)
Phyto-lithophile	laichen an/über Pflanzen und Hartsubstrat (anspruchslose Arten bezüglich des Laichsubstrates)

Fehlen aktuell Reproduktionsgilden, die im Referenzzustand vorhanden sind, so deutet das auf erhebliche Einschränkungen bei der Strukturvielfalt von Laichsubstraten hin. Es kommt zur Abwertung. Auch hier wird berücksichtig, ob eine Gilde nur durch eine oder mehrere Arten im Gewässer vertreten ist. Die Zuordnung der Reproduktionsgilden für die bewertungsrelevanten Arten findet sich im Anhang auf S. 103. Ariadnophile Arten (Stichlinge) werden nicht berücksichtigt.

Optionaler Metric Vernetzung - Anzahl Wanderarten
Der Metric bewertet das Vorkommen von Arten, die von einer Anbindung des Sees an umliegende Fließgewässer profitieren. Es handelt sich um Arten, die wandern, strömungsliebend sind oder für die eine Anbindung an Fließgewässer die Vorkommenswahrscheinlichkeit erhöht. Der Metric ist nicht vergleichbar mit Bewertung der Wanderdistanzen im fiBS.
Der Metric ist nur auf Seen anwendbar, die im Referenzzustand an umliegende Fließgewässer

angebunden sind und in denen dementsprechend auch wandernde bzw. rheophile Arten vorkommen sollten. Im alpinen Bereich sollte das für die Seen über 50 ha gegeben sein.
Zur Bewertung werden sechs Kriterien herangezogen, die sich auf das Vorkommen von Arten, Formen oder Artengruppen beziehen: Bachforelle, Gründling, Quappe, Seeforelle, Zander und „rheophile Cypriniden des Freiwassers“ (mindestens eine der Arten Aland, Döbel, Hasel oder Rapfen). Der Metric wird derzeit geprüft und kann bei unplausiblen Ergebnissen aus der Gesamtbewertung ausgeschlossen werden.

Metrics aus dem Bereich Abundanz

Abundanz häufige Fischarten

Der Metric prüft, ob die in der Referenz häufigen Arten auch aktuell noch häufig sind. Eine Abnahme der Abundanzklasse zeigt Änderungen der ökologischen Rahmenbedingungen und führt zur Abwertung.

Gildenabundanz Habitatgilden

Die Habitatgilden sind aus bestimmten Arten zusammengesetzt, die wiederum bestimmte Häufigkeiten haben. Die Artenhäufigkeiten lassen sich zu Häufigkeits-Kennzahlen für die Gilden zusammenfassen. Der Metric vergleicht die Gilden-Häufigkeiten von Referenzzustand und aktueller Situation. Unterschiede deuten auf eine Verschiebung zwischen den Habitaten und damit auf eine Beeinträchtigung des ökologischen Zustandes hin.
Die Berechnungen sind mit Beispiel im Anhang detailliert erklärt (ab S. 105).
Die Zuordnung der Habitatgilden (litoral, benthisch, epilimnisch oder hypolimnisch) für die bewertungsrelevanten Arten findet sich im Anhang auf S. 103.

Gildenabundanz Reproduktions-Gilden

Der Metric bezieht sich vergleichbar zum Vorgänger auf die Reproduktions-Gilden. Unterschiede in den Gildenhäufigkeiten deuten auf Verschiebungen bei der Bedeutung der entsprechenden Strukturen. Die Berechnungen sind mit Beispiel im Anhang detailliert erklärt (ab S. 105). Die Zuordnung der Reproduktionsgilden für die bewertungsrelevanten Arten findet sich im Anhang auf S. 103.

Metrics aus dem Bereich Entwicklung

Die normative Begriffsbestimmung der WRRL gibt vor, dass die Altersstruktur der Fischgemeinschaft zu bewerten ist, um besondere Störungen bei Fortpflanzung oder Entwicklung zu identifizieren. Die Altersbestimmung bei Fischen ist sehr aufwändig, ungenau und zudem nicht immer für die genannte Fragestellung geeignet. Daher wird im DeLFI-Verfahren auf Metrics ausgewichen, die Störungen bei der Fortpflanzung und Entwicklung direkt anzeigen. Es ist allerdings unmöglich, das für die gesamte Fischgemeinschaft durchzuführen.

Modifikator Reproduktion potenziell besetzter Arten

In den meisten Fällen kann davon ausgegangen werden, dass sich der Bestand der Fischarten in einem See in seiner aktuellen Ausprägung auf natürliche Weise aufrecht erhält und dass sich die vorhandenen Arten auch reproduzieren. Die Kriterien Fortpflanzung und Entwicklung können also über Metrics aus den Bereichen Inventar und Abundanz bewertet werden, wie es auch für alle Fischarten erfolgt. Ausnahme sind Fischarten, die besetzt werden. Durch das anthropogene Einbringen von Fischen können Störungen in Fortpflanzung und Entwicklung überlagert werden, so dass sie sich nicht mehr in Inventar und Abundanz zeigen.
In den größeren Seen Deutschlands werden in der Regel nur wenige Fischarten besetzt. Zudem reproduzieren sich auch die besetzten Arten in den meisten Fällen regelmäßig selbst. Dazu gehören die Kleine Maräne, Arten aus dem Formenkreis der Großen Maräne, die Raubfischarten Hecht und Zander, die Seeforelle sowie die Schleie.

Für die Bewertung der Reproduktion werden die genannten bewertungsrelevanten und potenziell besetzten Arten herangezogen. Für diese Arten wird zunächst geprüft, ob sie im Referenzzustand und aktuell vorkommen. Ist das der Fall wird anhand von Informationen aus Berufs- und Angelfischerei eingeschätzt, ob die Art besetzt wird. Ist das auch der Fall, wird geprüft, ob eine natürliche Reproduktion der Art im Gewässer existiert (der Bestand also nicht vom Besatz abhängig ist). Der Nachweis eines natürlichen Jungfischaufkommens kann schwierig sein und erfordert ggf. spezielle Befischungsmethoden oder -zeitpunkte.
Völlig besatzabhängige Fischarten würden ohne den direkten anthropogenen Einfluss nicht vorkommen. Daher wird ihre aktuelle Häufigkeit auf „fehlt" gesetzt.
Der Metric wird nicht direkt bewertet und fließt nicht als Mittelwert in die Berechnung ein. Er modifiziert jedoch die Ergebnisse fast aller anderen Berechnungen indem er die aktuelle Abundanz der entsprechenden Art auf „fehlt" setzt. Dadurch wird die aktuelle Fischgemeinschaft im Arteninventar, im Gildeninventar und in den jeweiligen Abundanzklassen beeinflusst. Der Metric kann sich deutlich auf die Bewertung des ökologischen Zustandes auswirken.
Da unter Umständen keine ausreichenden Informationen vorliegen, kann dieser Metric abgewählt werden. Nach Möglichkeit sollte er aber berücksichtigt werden, um die ausschließlich durch Besatz erhaltenen Fischarten nicht fälschlicherweise in den Metrics zu berücksichtigen und um den normativen Anforderungen der WRRL gerecht zu werden.

Optionaler Metric Wachstum Brachsen
Nur wenige Fischarten kommen für die Anwendung von Wachstumsmetrics in Frage. Es werden Arten benötigt, die in möglichst vielen Seen in möglichst großen Häufigkeiten vorkommen. Nur so werden ausreichend Individuen nachgewiesen, um überhaupt Wachstumsstörungen zu erkennen. Weiterhin muss ein Zusammenhang zwischen Wachstum und anthropogener Beeinflussung existieren.
Für diese Fragestellung ist der Brachsen die am besten geeignete Fischart. Die Bestände nehmen mit der Trophie zu und sind ein guter Metric für Eutrophierung. Bei sehr hohen Beständen kann es zur Verbuttung kommen, d.h. einem Massenaufkommen von Fischen, die durch Nahrungsmangel schlecht wachsen.
Für den Metric werden die Körpermassen der 5 größten gefangenen Brachsen gemittelt. Niedrige Mittelwerte deuten auf ein schlechtes Wachstum hin und führen zu schlechteren Bewertungen. Da dieser Metric für einige Seen nicht verfügbar ist und zudem in vielen Fällen keine Relevanz hat, kann er abgewählt werden.

Übersicht Klassengrenzen und Punktevergabe
Die Bewertung erfolgt in Anlehnung an das Konzept des „index of biotic integrity" (JENNINGS et al. 1999; KARR et al. 1986). Die Metrics werden dreistufig bewertet und erhalten Punkte entsprechend des angezeigten ökologischen Zustandes:

- 5 Punkte: die aktuelle Ausprägung des Metrics zeigt keine anthropogene Beeinträchtigung des ökologischen Zustandes
- 3 Punkte: der Metric zeigt eine merkliche Beeinträchtigung
- 1 Punkt: der Metric zeigt eine sehr starke Beeinträchtigung

Die Klassengrenzen der Metrics wurden empirisch anhand von Werten der Fischfauna in den 25 größten Seen Deutschlands ermittelt (BRÄMICK et al. 2008b). Dazu wurden die Seen hinsichtlich ihres aktuellen ökologischen Zustandes von Experten in 5 Klassen vorgruppiert (entsprechend den Zustandsklassen sehr gut bis schlecht). Danach wurde die Schwankungsbreite der einzelnen Indikatoren innerhalb jeder Zustandsklasse analysiert. Schließlich erfolgte für jeden Indikator die Festlegung eines Grenzwertes zwischen benachbarten Klassen, in dem die Übereinstimmung zwischen der Vorgruppierung der Seen und der Zuteilung zu Zustandsklassen anhand der

Grenzwerte für den jeweiligen Indikator maximiert wurde. Eine Übersicht der Klassengrenzen für die Metrics liefert Tab. 12.

Tab. 12: Klassengrenzen für die Bewertung der Metrics im DeLFI-Site, verbindliche Metrics mit 3-stufiger Bewertung oben, optionale 5-stufige metrics unten. Details im Text.

Verbindlicher Metric	**Sehr gut 5 Punkte**	**Mäßig 3 Punkte**	**Schlecht 1 Punkt**
Artenzahl „häufige“	Alle	-	≥ 1 fehlt
Artenanzahl „regelmäßige“	> 90 %	75-90 %	< 75 %
Artenanzahl „seltene“	> 50 %	26-50 %	≤ 25 %
Anzahl Habitatgilden	Alle	1 Gilde (1 Art) fehlt	1 Gilde (>1 Art) fehlt oder > 1 Gilde fehlt
Anzahl Repro-Gilden	Alle	1 Gilde (1 Art) fehlt	1 Gilde (>1 Art) fehlt oder > 1 Gilde fehlt
Abundanz „häufige“	Alle Arten „häufig“	50-99 % „häufig“	< 50 % „häufig“
Abundanz Repro-Gilden	MW Gildenpunkte > 4	MW Gildenpunkte > 2 - 4	MW Gildenpunkte ≤ 2
Abundanz Habitatgilden	MW Gildenpunkte > 4	MW Gildenpunkte > 2 - 4	MW Gildenpunkte ≤ 2

Optionaler Metric	**5 Punkte**	**4 Punkte**	**3 Punkte**	**2 Punkte**	**1 Punkt**
Max. Masse Brachsen [kg]	> 2	1,5-2,0	1,0-1,5	0,5-1,0	< 0,5
Wanderarten	> 3	3	2	1	0

Die Gesamtpunktzahl wird durch Addition der Punkte aller Metrics ermittelt. Die minimale Punktzahl im DeLFI-Site schwankt zwischen 8 und 10, abhängig von der Berücksichtigung der abwählbaren Metrics Wachstum Brachsen und Wanderarten. Die maximale Punktzahl liegt zwischen 40 und 50.

Anschließend wird ein EQR (ecological quality ratio) berechnet. Dadurch wird die Endbewertung auf den Bereich zwischen 0 und 1 normiert und auch international vergleichbar:

$EQR = (X-X_{min})/(X_{max}-X_{min})$

Mit X_{min} = minimale erreichbare Punktzahl
und X_{max} = maximale erreichbare Punktzahl

EQR-Werte nahe 0 zeigen einen schlechten, nahe 1 einen sehr guten Zustand. Abschließend wird den EQR-Werten eine der fünf ökologischen Zustandsklassen nach WRRL zugeordnet (Tab. 13).

Tab. 13: Zuordnung der EQR-Werte als Ergebnisse der Bewertungen zu fünfstufigen ökologischen Zustandsklassen nach WRRL.

EQR-Werte	Zustandsklasse
≥ 0,85	Sehr gut
≥ 0,69	Gut
≥ 0,50	Mäßig
≥ 0,25	Unbefriedigend
< 0,25	Schlecht

Der Metric Reproduktion bekommt keine eigene Bewertung und fließt somit nicht in die Anzahl der berücksichtigten Metrics oder die Gesamtpunktzahl ein. Der Metric wird als Modifikator einbezogen, der die Ausgangstabelle mit artspezifischen Häufigkeiten beeinflusst. Kann die natürliche Reproduktion der potenziell besetzten Arten plausibel gemacht werden, ändert sich am Bewertungsergebnis nichts. Die aktuelle Häufigkeit von Arten wird jedoch auf 0 gesetzt, wenn die entsprechenden Bestände ausschließlich durch Besatz erhalten werden.

Die Untergrenzen der Zustandsklassen „mäßig“ und „unbefriedigend“ sind im alpinen Raum Deutschlands wenig bzw. gar nicht mit Daten entsprechend belasteter Seen belegbar. Es existieren hier keine Seen über 50 ha für die die Zuweisung eines derartig schlechten Zustands gerechtfertigt wäre. Damit bleiben die Grenzen eher theoretischer Natur.

Die Berechnungen des DeLFI-Site mit EQR-Wert und Zuordnung einer von fünf ökologischen Zustandsklassen hält sich eng an die Vorgaben der WRRL.

DISKUSSION

Mit dem DeLFI-Site liegt ein WRRL-konformes System zur Bewertung des ökologischen Zustandes von Seen anhand der Fische vor. Folgende Vorgaben der WRRL werden erfüllt:

- Metrics aus den Bereichen a) Zusammensetzung und Abundanz der Arten, b) Vorhandensein der typspezifischen störungsempfindlichen Arten und c) Störungen in Fortpflanzung und Entwicklung,
- die Berechnung eines EQR Wertes,
- die Zuordnung einer von fünf ökologischen Zustandsklassen.

Damit ist es möglich, alpine Seen anhand des Qualitätselementes Fische zu bewerten und so den Anforderungen der WRRL nachzukommen. Das Verfahren wurde bisher auf acht süddeutsche, 13 österreichische und fünf italienische Seen angewendet. Es zeigt bisher plausible Ergebnisse, d.h. die Verfahrensergebnisse stimmen mit Experteneinschätzungen der ökologischen Gewässerzustände sehr gut überein. Zudem zeigt es auch eine hohe Übereinstimmung mit den Ergebnissen anderer alpiner Bewertungsverfahren (GASSNER et al. 2014). Als herausragende Eigenschaft des DeLFI-Site kann die Möglichkeit zur Bewertung auf sehr unterschiedlicher Datenbasis gesehen werden. Durch die Modellierung der Fischgemeinschaft können u.a. historische Daten, Daten der Berufsfischerei und Standard-Netzmethoden zur Bewertung herangezogen werden. Für die acht bisher bewerteten deutschen Seen zeigt das Verfahren gute und sehr gute ökologische Zustände an. Bei den Bewertungen der Datensätze innerhalb der alpinen Ländergruppe zeigte sich, dass stärkere degradierte Seen auch im deutschen Verfahren als mäßig oder unbefriedigend bewertet werden. Demnach ist nicht von einer mangelnden

Sensibilität des DeLFI-Site gegenüber anthropogenen Einflüssen auszugehen, trotz der bisher ausschließlich guten Ergebnisse.
Allerdings ist das Verfahren aufgrund der geringen Anzahl bisher getesteter Seen ganz deutlich als Vorschlag für zukünftige Testbewertungen und nicht als abgeschlossenes Verfahren für den alpinen Raum anzusehen. Im Nachgang einer kommenden Anwendungsphase ist mit Modifikationen zu rechnen.

Der DeLFI-Site zeigt den ökologischen Zustand des Gewässers anhand der Fische an. Fische sind vergleichsweise mobil und langlebig, sie reagieren als zeitlich und räumlich integrierendes biologisches Element auf die Gesamtheit der Belastungen. Eine direkte Zuordnung von anthropogenen Ursachen einer eventuellen schlechten Bewertung durch den DeLFI ist daher nur durch eine Fachanalyse der abwertenden Metrics möglich. Diese können allerdings deutliche Hinweise liefern: die Berechnungsvorlage gibt in den meisten Fällen Klarwerte aus. Es ist schnell erkennbar, ob Arten oder Gilden fehlen bzw. häufige Arten der Referenz aktuell nicht mehr häufig sind. Für die Gildenabundanz-Metrics werden Kennwerte ausgegeben, die interpretierbar sind (5 = keine Beeinträchtigung, 1 = starke Beeinträchtigung). Anhand der Artenliste in der Bewertungsvorlage ist nachvollziehbar, welche Arten mit geänderter Abundanz im Vergleich zum Referenzzustand vorkommen. Mögliche anthropogene Belastungen können dann über die ökologischen Ansprüche der Arten identifiziert werden.

KURZDARSTELLUNG UND NUTZUNG DER EXCEL-VORLAGE

Zur Anwendung des DeLFI-Site Verfahrens wurde eine Excel-Vorlage erstellt. Nach Eingabe des Arteninventars und der Häufigkeitsklassen in Referenzzustand und aktueller Situation werden alle Berechnungen durchgeführt. Anhand der Vorlage wird nachfolgend die Funktionsweise des DeLFI-Site für alpine Gewässer in Kurzform erklärt.

Allgemeines zur Nutzung

- Die Bewertungsvorlage hat die Versionsnummer 3.00 (Feb. 2014). Um die Vorlage zu erhalten sollte jeder See zuerst mit der „Speichern unter“-Funktion als eigene Datei gesichert werden. Es empfiehlt sich eine Benennung nach dem Schema DeLFI_Site_300_Seename um die Version nachvollziehbar zu lassen.
- Die Daten werden in das Blatt [LFI] eingegeben. Mit jeder Excel-Mappe bzw. Datei kann nur ein See bewertet werden. **Das Blatt LFI darf nicht kopiert werden** um mehrere Seen in einer Arbeitsmappe zu bewerten. Die Ergebnisse sind dann falsch.
- Die Mappe enthält zwei sichtbare Arbeitsblätter: [Info] mit Kurzinformationen und [LFI] mit der Bewertungsmaske.
- Die Mappe enthält drei ausgeblendete Arbeitsblätter: [Refdef] mit Rahmenreferenzen, [Gilde] mit Gildenzuordnungen und [Rechne] mit Berechnungen. Diese Arbeitsblätter lassen sich einblenden, es sollten jedoch hier nichts geändert werden.
- Die Arbeitsmappe und alle Blätter sind geschützt um versehentliche Änderungen auszuschließen. Eingaben können in den grün hinterlegten Feldern gemacht werden. Sollten Änderungen erforderlich werden, kann der Schutz mit dem Passwort „Site-Alpin“ aufgehoben werden. Möglicherweise werden dann aber die Berechnungen falsch und die Ergebnisse lassen sich nicht mehr mit anderen DeLFI-Site Bewertungen vergleichen.

Blatt LFI - Eingaben

- **Kopfbereich**: Im oberen Eingabebereich werden
  1. Angaben zum Gewässernamen und Bearbeiter gemacht,
  2. Kommentare zur Nachvollziehbarkeit gegeben (z.B. für den Bewertungszeitraum)
  3. und der LAWA-Gewässertyp des zu bewertenden Sees gewählt (eine Liste der LAWA

Typen für alpine Seen steht im Anhang S. 107).

- **Arten des LAWA-Typs**: In Abhängigkeit vom zugeordneten LAWA-Typ erscheint hier eine Rahmenreferenz von Fischarten mit Richtwerten der zugehörigen Abundanzklassen.
  4. Spalte [Referenz]: Die Richtwerte werden für den See geprüft und ggf. angepasst. Bei Unterschieden zwischen Rahmenreferenz und gewählter Abundanzklasse erscheint eine Notiz in der Spalte [Rahmen?]. Die Arten können nicht entfernt werden, ggf. werden die Abundanzklassen auf 0 gesetzt.
  5. Spalte [Aktuell]: Für die Fischarten der Rahmenreferenz werden aktuelle Abundanzklassen eingegeben.
- **See-spezifische Arten**: Eingegeben werden Fischarten der Referenz-Fischgemeinschaft, die in den Rahmenreferenzen fehlen. So werden die Besonderheiten des Gewässers berücksichtigt. Es ist erforderlich
  6. das komplette Arteninventar des Referenzzustandes anzugeben. Das geschieht in der Spalte [weitere Arten] über die lateinischen Artnamen.
  7. die jeweiligen Abundanzklassen für den Referenzzustand anzugeben - Spalte [Referenz]
  8. und jeweiligen Abundanzklassen in aktueller Ausprägung anzugeben - Spalte [Aktuell]

Blatt LFI - Auswertung

Das Verfahren bewertet den ökologischen Zustand des Sees als Ergebnis eines Vergleichs zwischen der Fischgemeinschaft im Referenzzustand und ihrer aktuellen Ausprägung. Die bewertungsrelevanten Merkmale der Fischgemeinschaft werden als M*etrics* bezeichnet. Die verbindlichen Metrics sind:

1. **Anzahl häufige Arten** (fehlen aktuell Arten mit der Referenz-Abundanzklasse 3?)
2. **Anzahl regelmäßige Arten** (entsprechend für Klasse 2)
3. **Anzahl seltene Arten** (entsprechend für Klasse 1)
4. **Anzahl Habitatgilden** (fehlen aktuell Gilden, die in der Referenz mit mindestens einer Art belegt sind)
5. **Anzahl Reproduktions-Gilden** (ebenso)

6. **Abundanz der häufigen Arten** (wie viele Arten, die im Referenzzustand die Häufigkeitsklasse 3 haben, haben aktuell auch Häufigkeitsklasse 3)
7. **Abundanz der Habitatgilden** (Vergleich der Artenzahlen für jede Häufgkeitsklasse in den einzelnen Gilden der Gildengruppe in Referenz und aktuellem Zustand, Änderungen führen zu einer schlechten Bewertung)
8. **Abundanz der Laichpräferenzen** (ebenso)

Modifikator-Metric Reproduktion potenziell besetzter Arten: Unterhalb der verbindlichen Metrics wird ausgewählt, ob der Metric Reproduktion potenziell besetzter Arten berücksichtigt werden soll. Die Spalte [Kontrolle] gibt an, ob die entsprechende potenziell besetzte Art im Gewässer aktuell vorkommt und daher der Einfluss von Besatz geprüft werden muss. In der Spalte [2 - Besetzt] wird angegeben, ob die Art besetzt wird bzw. wurde. In der Spalte [3 - Reproduziert] wird angegeben, ob die Art nachweislich im See reproduziert, der Bestand also besatzgestützt aber nicht besatzabhängig ist. Den Arten ohne eigene Reproduktion wird in den Berechnungen die aktuelle Abundanzklasse 0 zugewiesen.

Des Weiteren können in der Gesamtbewertung zwei optionale Metrics berücksichtigt werden.

9. **Optional: Maximale Gewichtklasse Brachsen** (hier wird ausgewählt, ob der der Metric berücksichtigt werden soll und wie schwer der Brachsen im See wird).
10. **Optional: Anzahl Wanderarten** (hier wird ausgewählt, ob der See im Referenzzustand an

umliegende Gewässer angebunden ist und ob der Metric berücksichtigt werden soll).

Im unteren Bereich der Auswertung befindet sich rot umrandet die Gesamtbewertung des ökologischen Zustands. Die Metrics werden mit 1 - 5 Punkten bewertet. Dann wird ein EQR Wert berechnet, dem eine der 5 ökologischen Zustandsklassen zugeordnet wird. Details zu den Berechnungen werden ab S. 95 dargestellt.

Im Bereich Kommentare und Kontrolle können weitere eigene Kommentare eingegeben werden. Zudem werden hier die Ergebnisse von Prüfungsroutinen ausgegeben, die doppelte oder fehlende Eingaben erkennen.

Der Druck der ersten zwei Seiten gibt die gerahmten Bereiche von Eingabe und Auswertung aus.

SHORT DESCRIPTION OF THE GERMAN SYSTEM FOR THE FISH-BASED ASSESSMENT OF THE ECOLOGICAL STATUS OF ALPINE LAKES (DELFI-SITE)

The following section provides an overview. For details see GASSNER et al. (2014).

System concept

The German site-specific system to assess the ecological status of lakes with their fish fauna (DeLFi-SITE) compares the fish communities of lakes in the reference/historical situation with the current situation. The fish communities are described by a complete species inventory and one out of four abundance classes (absent, rare, regular, and frequent) assigned to each species.

Fish community modelling

The reference fish community is modelled using all available information. Main sources are historical records, scientific literature and long-time fisheries statistics. The reference fish community is completed by expert knowledge based on the historical species inventory of nearby water bodies, evidence in the catchment area and general species ecology.
For the current situation, the fish community composition is modelled with fishery statistics or scientific gear. Data and information of the precedent six years is used. For the modelling procedure a complete picture of all lake habitats is needed. Therefore it is recommended to include information on at least one of the following fishing gears for each habitat:

Littoral: electrofishing, fyke net, beach seine
Benthic: (multimesh-) gillnet, bottom trawl, extended fyke net
Pelagic: (multimesh-) gillnet, trawl, purse seine

If information is missing, additional scientific investigation becomes necessary.

A comprehensive description of the fish community of a lake usually is based on a number of different gear and sources. The data of the species' abundance is transferred into abundance classes (Tab. 14). For the scientific samples, the values of the gear with the highest species-specific percentages are taken. This will usually be electrofishing for shore-bound species (pike, tench) and pelagic nets for species of the open water (smelt, vendace).

Tab. 14: Assignment of abundance classes based on different sources of information. Scientific samples (electrofishing, CEN 14757) refer to % number in the gear with the highest percentage of the corresponding species.

Abundance class	Scientific samples % number	Fisheries statistics	Informational sources
3	> 5 %	> 1 kg/ha	frequent, common, plenty
2	1 - 5 %	0,1-1 kg/ha	regular, steady
1	< 1%	< 0,1 Ind/km²	rare, sporadic
0	-	-	-

Lake typology
The DeLFI-SITE system is a site specific approach, i.e. the reference conditions are modelled for each lake individually (in contrast to type specific standard values). This allows including lake specialties and rare or endemic species. The lake type is not essential for the assessment system. However, a well-established German lake typology exists which differentiates four alpine lake types according to their stratification and size of the catchment area. This typology was adopted and defaults for specific fish communities are given. The type-specific defaults provide a starting point for the fish community modelling, but species' inventory and abundances must be controlled and can be modified.

Metrics
Eight regular metrics are used to assess the ecological status:
- frequent species number: good score if all species that are frequent in reference condition are also frequent in current conditions
- regular species number: likewise for regular species
- rare species number: likewise for rare species
- Habitat guilds: good score if all guilds present in reference condition are also present in current conditions (guilds are littoral, benthic, epilimnetic, hypolimnetic).
- Spawning guilds: likewise (guilds are lithophilic, psammophilic, phyto-lithophilic, phytophilic)
- frequent species abundance: good score if all species that are frequent species in reference condition are also frequent in current conditions
- Abundance of habitat guilds: scores the distribution of species-specific abundance classes within the habitat guilds (e.g. littoral species are frequent in reference condition, but regular today)
- Abundance of spawning guilds: likewise

Three optional metrics complete the system. They can be deselected for the assessment but it is recommended to only exclude them if necessary.
- Reproduction of potentially stocked species: for certain species it has to be checked if they are stocked and if it they reproduce naturally. Species which persist by stocking only are treated as if they were absent.
- Growth of bream: bream is a widespread and frequent species. Large individuals show good growth, smaller ones indicate deficiencies of food resources caused by high population densities and/or eutrophication.
- Migrating species: good score if a certain number of rheophilic species is present. This metric is only applied in lakes that are connected in reference conditions.

Class boundaries and scoring: Regular metric are scored 1, 3 or 5 points; according to the WFD compliant status classes poor, moderate or high. The class boundaries are described in Tab. 15.

Scoring is done stepwise for the two metrics 'abundance of habitat and spawning guilds'. First, the abundance classes within a guild are scored (e.g. littoral-rare, littoral-regular, littoral-frequent). This is done using the absolute values of the log(current species number/reference species number). Afterwards the three values are combined to a guild score using the mean (e.g. littoral). Finally, the preferences are combined to a score of the guild group (habitat or spawning) like described in the table.

The metric scores are summed to obtain a total score. The total score is translated into an EQR value: EQR = (Score-Min) / (Max-Min). Ecological classes are assigned to the EQR values with boundaries at ≥ 0.85/0.69/0.50/0.25, beginning with HIGH. The values of class boundaries are the result of the alpine intercalibration process (GASSNER et al. 2014).

Tab. 15: Class boundaries of the DeLFI-SITE metrics. The description always refers to the present situation in comparison to the reference condition.

Metric	**5 (high)**	**3 (moderate)**	**1 (poor)**
frequent species number	All present	-	≥ 1 missing
Regular species number	> 90 %	75-90 %	< 75 % present
Rare species number	> 50 %	25-50 %	< 25 % present
Habitat guild	All present	1 guild (1 species) absent	1 guild (> 1 species) or > 1 guild absent
Spawning guild		likewise	
Frequent species abundance	All frequent	50-99 %	< 50 %
Abundance of habitat guilds	guild score > 4	guild score 2-4	guild score < 2
Abundance of spawning guilds		likewise	

Anhang 1: Artenliste und Gilden

In der nachfolgenden Tab. 16 stehen die Arten des DeLFI-Site Verfahrens mit den zugeordneten Habitat- und Reproduktionsgilden. In die Bewertungsvorlage werden die lateinischen Artnamen eingegeben. Für den Formenkreis der Großen Maräne sind die taxonomischen Zusammenhänge in der Überarbeitung; bis auf Weiteres werden die deutschsprachigen Bezeichnungen der Lokalformen übernommen. Die Gildenzuordnung ist in dieser Zusammenstellung unveröffentlicht. Sie basiert auf den Verteilungen der Fischarten in den Fanggeräten nach Erfahrungen der Bearbeiter (MEHNER et al. 2004) auf verschiedenen Literaturquellen (FROESE & PAULY 2014; KOTTELAT & FREYHOF 2007) und dem fiBS (DIEKMANN et al. 2005; DUßLING 2009).

Tab. 16: Artenliste und Gildenzuordnung im DeLFI-Site.

Artname latein	Artname deutsch	Habitatgilde	Repro-Gilde
Abramis ballerus	Zope	littoral	phytophil
Abramis brama	Blei	littoral	phyto-lithophil
Alburnoides bipunctatus	Schneider	littoral	lithophil
Alburnus alburnus	Ukelei	littoral	phyto-lithophil
Ameiurus nebulosus	Zwergwels	littoral	phyto-lithophil
Anguilla anguilla	Aal	littoral	-
Aspius aspius	Rapfen	epilimnisch	lithophil
Barbatula barbatula	Schmerle	littoral	psammophil
Blicca bjoerkna	Güster	littoral	phytophil
Carassius carassius	Karausche	littoral	phytophil
Carassius gibelio	Giebel	littoral	phyto-lithophil
Chalcalburnus chalcoides mento	Mairenke/Seelaube	epilimnisch	lithophil
Cobitis taenia	Steinbeißer	littoral	phytophil
Coregonus albula	Kleine Maräne	hypolimnisch	lithophil
Coregonus 'Ammersee-Kilch'	Ammersee-Kilch	profundal	lithophil
Coregonus 'Blaufelchen'	Blaufelchen	hypolimnisch	lithophil
Coregonus 'Bodensee-Kilch'	Bodensee-Kilch	profundal	lithophil
Coregonus 'Gangfisch'	Gangfisch	hypolimnisch	lithophil
Coregonus 'Große Maräne'	Große Maräne allg.	profundal	lithophil
Coregonus 'Kilch'	Kilch	profundal	lithophil
Coregonus 'Ostseeschnäpel'	Ostseeschnäpel	littoral	lithophil
Coregonus 'Peipus-Maräne'	Peipus-Maräne	hypolimnisch	lithophil
Coregonus 'Sandfelchen'	Sandfelchen	profundal	lithophil
Coregonus 'Schaalsee-Maräne'	Schaalsee-Maräne	profundal	lithophil
Cottus gobio	Westgroppe	littoral	lithophil
Cottus poecilopus	Ostgroppe	profundal	lithophil
Cyprinus carpio	Karpfen	littoral	phytophil
Esox lucius	Hecht	littoral	phytophil
Gasterosteus aculeatus	Dreist. Stichling	littoral	-
Gobio gobio	Gründling	littoral	psammophil
Gymnocephalus cernua	Kaulbarsch	littoral	phyto-lithophil
Leucaspius delineatus	Moderlieschen	littoral	phytophil

Artname latein	Artname deutsch	Habitatgilde	Repro-Gilde
Leuciscus cephalus	Döbel	littoral	lithophil
Leuciscus idus	Aland	littoral	phyto-lithophil
Leuciscus leuciscus	Hasel	littoral	lithophil
Lota lota	Quappe	littoral	lithophil
Misgurnus fossilis	Schlammpeitzger	littoral	phytophil
Oncorhynchus mykiss	Regenbogenforelle	littoral	lithophil
Osmerus eperlanus	Stint	epilimnisch	lithophil
Pelecus cultratus	Ziege	epilimnisch	lithophil
Perca fluviatilis	Barsch	littoral	phyto-lithophil
Phoxinus phoxinus	Elritze	littoral	lithophil
Platichthys flesus	Flunder	littoral	-
Pungitius pungitius	Zwergstichling	littoral	-
Rhodeus amarus	Bitterling	littoral	psammophil
Rutilus frisii meidingeri	Perlfisch	profundal	lithophil
Rutilus rutilus	Plötze	littoral	phyto-lithophil
Salmo trutta far.	Bachforelle	littoral	lithophil
Salmo trutta lac.	Seeforelle	epilimnisch	lithophil
Salvelinus alpinus	Seesaibling	hypolimnisch	lithophil
Sander lucioperca	Zander	epilimnisch	phyto-lithophil
Scardinius erythrophtalmus	Rotfeder	littoral	phytophil
Silurus glanis	Wels	littoral	phytophil
Telestes souffia	Strömer	littoral	lithophil
Tinca tinca	Schleie	littoral	phytophil
Vimba vimba	Zährte	littoral	lithophil

Anhang 2: Berechnung der Gildenabundanz-Metrics

Die Bewertung der Gildenabundanzen erfolgt in mehreren Schritten, die nachfolgend dargestellt werden. Der Abschnitt dient der Darstellung der Rechenroutine. Es existiert eine Excel-Vorlage, die die Schritte automatisch durchführt. Zur praktischen Bewertung von Seen muss die mathematische Prozedur also nicht zwingend nachvollzogen werden.

1) Zunächst wird für die einzelnen Gilden zusammengestellt, wie viele Arten in den entsprechenden Häufigkeitsklassen vorhanden sind. Das wird für den Referenzzustand und für den aktuellen Zustand gemacht.

Beispiel für die Reproduktions-Gilden: Wie viele lithophile Arten haben die Abundanzklasse „häufig", „regelmäßig", „selten"? Wie viele phytophile Arten haben die Abundanzklasse „häufig", „regelmäßig", „selten"?

2) Für jede Gilde werden für jede Häufigkeitsklasse die Artenzahlen von Referenzzustand und aktuellem Zustand verglichen und nach folgendem Schema bewertet:

5 Der Betrag des log des Quotienten aus aktueller und Referenz-Artenzahl in der jeweiligen Abundanzklasse ist ≤ 0,33

3 ebenso, aber der Betrag des log ist > 0,33 und ≤ 0,66

1 ebenso, aber der Betrag des log ist > 0,66.

Abundanzklassen der Gilden, die

- in der Referenz vorkommen, aber aktuell fehlen, werden mit 1 Punkt bewertet
- in der Referenz fehlen, aber aktuell vorkommen, werden nicht berücksichtigt

Die Bewertung der Habitatgilde ist der Mittelwert der Bewertung der einzelnen Abundanzklassen 1,2 und 3.

Beispiel: Für den Referenzzustand wurde für die lithophilen Arten folgende Verteilung in den Abundanzklassen modelliert: 2 häufige Arten, keine regelmäßige, 3 seltene Arten. Aktuell finden sich 2 häufige lithophile Arten, 1 regelmäßige und 1 seltene. Daraus ergibt sich folgende Bewertung: häufige Arten 5 (2/2 = 1, log(1) = 0), regelmäßige Arten nicht berücksichtigt und seltene Arten 3 (3/1 = 3, log(3) = 0,47). Für die Bewertung der Habitatgilde „lithophile" ergibt sich ein Mittelwert von 4.

3) Die Gesamtbewertung der Gildenabundanz Lebensraum-Gilden richtet sich nach dem Mittelwert der Einzelbewertungen der Lebensraum-Gilden:

- Mittel > 4 entspricht einer Gesamtbewertung von 5
- Mittel > 2 bis ≤ 4 entspricht einer Gesamtbewertung von 3
- Mittel ≤ 2 einer Gesamtbewertung von 1

In Tab. 17 ist beispielhaft eine Bewertung des Metrics Gildenabundanz der Lebensraum-Gilden dargestellt. In dem Beispielsgewässer sind aktuell 6 lithophile Arten in der Abundanzklasse 1 nachgewiesen. In der Referenzartengemeinschaft gab es nur 1 lithophile Art mit der Abundanz 1. Berechnet man den Betrag des log aus dem Quotienten 6:1, erhält man mit 0,78 einen Wert >0,66, was 1 Indexpunkt entspricht. Die Gilde der psammophilen Arten war in der Referenz durch keine Art in der Abundanzklasse 1 besetzt. Aus diesem Grund entfällt für diese Gilde die Berechnung eines Indexwertes für die Abundanzklasse 1. Für die Gilden phyto-lithophiler sowie phytophiler Arten ergeben die Berechnungen 0,48 bzw. 0,10, was nach dem Bewertungsschlüssel 3 bzw. 5 Indexpunkten entspricht. Anschließend werden für die Abundanzklassen 2 und 3 die Indexwerte nach gleichem Muster errechnet. Die nachfolgende Mittelwertbildung aus den vergebenen Indexpunkten innerhalb der Gilden ergibt Werte zwischen 2,3 und 4,3. Als Mittelwert der 4 Werte erhält man 3,0 - das entspricht einer Gesamtbewertung des Metrics von 3 (mäßig).

Tab. 17: Fiktive Bewertung des Metrics Abundanz der Reproduktionsgilden (Ak: Abundanzklasse, Az: Artenzahl)

Gilde	Ak	Az akt	Az Ref	Quot	|Log|	Wertung	MW	MW ges	Gesamt
lithophil	1	6	1	6,00	0,778	1	**2,3**	**3,0**	**3**
	2	1	4	0,25	0,602	3			
	3	3	7	0,43	0,368	3			
psammophil	1	1	0	0,00		entfällt	**3,0**		
	2	1	5	0,20	0,699	1			
	3	1	1	1,00	0,000	5			
phyto-litho	1	1	3	0,33	0,477	3	**2,3**		
	2	1	5	0,20	0,699	1			
	3	2	5	0,40	0,398	3			
phytophil	1	4	5	0,80	0,097	5	**4,3**		
	2	1	4	0,25	0,602	3			
	3	4	4	1,00	0,000	5			

Anhang 3: Die alpinen Seen > 50 ha

Tab. 18: Liste der natürlichen alpinen Seen Deutschlands mit Flächen > 50 ha (J. Schaumburg, pers. Mitt. 2013). Angegeben werden LAWA-Typ, das Bundesland, der ökologische Zustand nach DeLFI-Site und Kommentare. Die Typzuordnung kann sich ändern.

Typ	Name	Land	DeLFI	Bemerkung
Typ 1	Buchsee	BY		
Typ 1	Federsee	BW		Moorsee (verlandet)
Typ 1	Hofstätter See	BY		
Typ 1	Hopfensee	BY		
Typ 1	Rohrsee	BW		
Typ 2	Abtsdorfer See	BY		
Typ 2	Großer Ostersee	BY		
Typ 2	Haarsee	BY		
Typ 2	Hartsee	BY		
Typ 2	Langbürgner See	BY		
Typ 2	Mindelsee	BW		
Typ 2	Pelhamer See	BY		
Typ 2	Pilsensee	BY		
Typ 3	Bannwaldsee	BY		
Typ 3	Ilmensee	BW		
Typ 3	Niedersonthofener See	BY		
Typ 3	Riegsee	BY		
Typ 3	Simssee	BY		
Typ 3	Staffelsee	BY		
Typ 3	Tachinger See	BY		
Typ 3	Waginger See	BY		
Typ 3	Weißensee	BY		
Typ 3	Wörthsee	BY	sehr gut	
Typ 4	Walchensee	BY	gut	Evtl. HMWB
Typ 4	Alpsee bei Füssen	BY		
Typ 4	Alpsee bei Immenstadt	BY		
Typ 4	Ammersee	BY	sehr gut	
Typ 4	Barmsee	BY		
Typ 4	Bodensee	BW/BY	sehr gut	
Typ 4	Chiemsee	BY	gut	
Typ 4	Eibsee	BY		
Typ 4	Großer Alpsee	BY		
Typ 4	Kochelsee	BY		
Typ 4	Königssee	BY	gut	
Typ 4	Schliersee	BY		
Typ 4	Starnberger See	BY	gut	ehem. Typ 3
Typ 4	Tegernsee	BY		
Typ 4	Weitsee	BY		

Anhang 4: Ergebnisse der Interkalibrierung

Das DeLFI-Site Verfahren wurde in Interkalibrierungsphase II innerhalb der Alpinen Gruppe mit den Verfahren von Österreich und Italien verglichen. In die Interkalibrierung flossen acht deutsche Gewässer ein (Tab. 19). Als Vergleichsstrategie wurde die Mehrfachbewertung von Gewässern mit den Verfahren der Mitgliedsstaaten gewählt. Dabei waren die Übereinstimmungen der Verfahren sehr gut.

Im Ergebnis der Interkalibrierung wurde das deutsche Verfahren von den Klassengrenzen ein wenig nach unten angepasst, d.h. es wurde entschärft. Die Klassengrenze zwischen „sehr gut" und „gut" wurde von 0,90 auf 0,85 herabgesetzt, die Grenze zwischen „gut" und „mäßig" von 0,75 auf 0,69. Davon sind zwei Seen betroffen: Der Ammersee wird nun mit sehr gut bewertet (vorher gut), der Chiemsee mit gut (vorher mäßig).

Für insgesamt acht alpine Seen kann der DeLFI-Site als interkalibriert gelten. Die Interkalibrierungsergebnisse wurden von der GIG Leitung (H. Gassner, Österreich) an die Koordinierungsstelle (JRC) übermittelt. Die Ergebnisse wurden als Technical Paper veröffentlicht (GASSNER et al. 2014) und fanden Eingang in die Entscheidung der EU-Kommission zur Festlegung von Klassengrenzen (2013/480/EU 2013). Diese Veröffentlichung bedeutet, dass der alpine DeLFI-Site für einige Seen geprüft und interkalibriert wurde. Allerdings ist die Eignung des Verfahrens innerhalb Deutschlands noch nicht abgesichert. Möglicherweise wird es zu Modifikationen des Verfahrens kommen. Dann wäre abzuklären von welchen Parametern der Gewässer oder der Fischgemeinschaften die Eignung des DeLFI abhängt und wie diese Ergebnisse im Zusammenhang mit der bisherigen Interkalibrierung einzuschätzen sind.

Tab. 19: Ökologischer Status alpiner Seen nach DeLFI-Site und Vergleich mit Expertisen.

See	Land	DeLFI EQR	DeLFI Klasse	Modellierung Fische	Status Experte
Wörthsee	BY	0,94	5	M. Schubert	4
Starnberger	BY	0,75	4	M. Schubert	4
Chiemsee	BY	0,69	4	M. Schubert	4
Ammersee	BY	0,88	5	M. Schubert	4
Bodensee-Obersee	BW	0,94	5	U. Dußling	5
Königssee	BY	0,81	4	M. Schubert	4
Walchensee	BY	0,75	4	M. Schubert	4
Brombachsee	BY	1,00	5	M. Schubert	5