CYPRUS document on class boundaries setting and normative definitions for the IC Mediterranean GIG, Rivers (R-M4) – UPDATE 27 March 2007

27 March 2007 (based on 8 June 2006 document)
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for the Ministry of Agriculture, Natural Resources and Environment of Cyprus

Country	**Cyprus**
Classification System:	**STAR Intercalibration Common Metric Index (STAR_ICMi), type specific**
General Description	Selection of Reference sites for the IC exercise The selection of reference sites was done according to REFCOND Guidance criteria (see REFCOND criteria table provided) and is based on pressure analysis, which included information on: water chemistry, (hydro)-morphology, general degradation and land use. In Med_GIG, Cyprus is involved in R-M4 type only, that corresponds to small/medium Mediterranean mountain streams. These streams represent the main source of (surface) water for the Cyprus Island and mostly originate from the area around the Troodos Mountains. No particular problems were encountered in finding Reference sites, due to the high level of environmental conservation of some parts of Cyprus (i.e. the pine forest areas). In Cyprus, standard classification methods based on invertebrates are presently unavailable. Thus, the best option to inter-calibrate with other MSs is to derive class boundaries in one of the indices used in the European Intercalibration process, so that comparability of results from Cyprus is fully granted. Among all the ICM indices tested for the Med_GIG in Cyprus rivers, the one showing the best relationships with pressure information is the STAR_ICMi (Buffagni et al., 2005). In addition, this index is being used by Central/Baltic GIG and Nordic GIG for the formal IC process: its use can thus guarantee a total comparability with the largest part of European MSs. For this reasons, the method here proposed for IC purposes is the STAR_ICMi. If other methods will be derived for Cyprus rivers in the future for classification, their class boundaries will be set to be totally coincident with the harmonized STAR_ICMi values. Within the Mediterranean GIG, a pool of different Intercalibration Common Metrics indices was tested. The results obtained with the Mediterraenan Quantitative and the STAR ICMi are very similar and usually, at least in Cyprus, the STAR_ICMi performs better in relation to pressures. Thus, to ensure a direct comparability with the CB GIG, and to avoid possible doubts about the validity of the boundaries adopted in the Mediterranean GIG, the STAR_ICMi was selected by the Med GIG as the only index to be used for official comparison within the GIG. Further information on the Intercalibration Common indices developed and preliminarily used within the Mediterranean GIG

	different from the STAR_ICMi can be find in the documents previously submitted from Italy and other MS for the IC process (June/July 2006). <u>Description of the STAR Intercalibration Common Metric Index (STAR_ICMi) (Buffagni et al., 2005; 2006)</u> The STAR_ICM index was explicitly designed for European IC purposes and it represents one of the indices used in various GIGs for the comparison and harmonization of class boundaries of different MSs. Its WFD compliancy has been discussed and demonstrated elsewhere (Wasson & Buffagni, 2005). The index was built to assess the overall (i.e. general) degradation of a river site, not being aimed at detecting the impact of single stressors on invertebrates (i.e. it is not a stressor-specific system). The STAR_ICMi is directly calculated in the form of Ecological Quality Ratio (EQR), in accordance with WFD requirements for classification systems. Three aspects of the used methodology to derive class boundaries have to be considered for intercalibration purposes and to check compliancy with normative definitions: a) the sampling technique b) the calculation formula c) the conversion of STAR ICMi values into quality judgement (i.e. class boundaries setting). a) the sampling technique Before sampling, a depositional-transport sequence was identified at each site, which roughly corresponds to what is usually referred to as a pool-riffle sequence.The method for the macroinvertebrate collection was then a 'multi habitat sampling' procedure. Ten individual samples were distributed according to microhabitats occurrence in the riffle unit, taken and merged into a sample. A second merged sample was always obtained, following the same criteria, from the pool area for each site.Two taxa lists were thus attained for each site, for the depositional and transport units respectively. The identification level used was Family, as required by the Intercalibration exercise. An open Surber sampler was used to collect macroinvertebrates (area 0.05 m^2; mesh size 0.5 mm). All samples were collected in a quantitative way i.e. all specimens were picked up and brought to the lab for identification. In some cases for particularly abundant taxa, sub-sampling in the field was used. The identification level for the application of the STAR_ICMi is Family. b) the calculation formula The STAR ICMi is a multi-metric index and is composed of six metrics, which account for the main aspects present in the WFD Normative definitions (see below): ASPT, Log_{10}(sel_EPTD+1), 1-GOLD, N-taxa, EPT and Shannon-Weiner diversity. The ICMi value is calculated by the sum of all the ICMs, after attributing a weight to each metric. Hereafter, the list and category of each metric is provided (Table 1). After their normalization, the metrics are combined into the ICM index. Metrics are grouped into three groups, providing information on three major response areas: Tolerance, Abundance/Habitat and Richness/Diversity. A different weight is attributed to the metrics within each group, giving greater importance to the metrics based on the whole community (Buffagni et al., 2004). To obtain the final multimetric score, the same weight is attributed to each of the three metric groups (0.333).

Table 1. Intercalibration Common Metrics (ICMs) used in the STAR ICMi

Information type	Metric type	Metric name	Taxa considered in the metric	Literature reference	weight
Tolerance	Index	ASPT	Whole community (Family level)	e.g. Armitage et al., 1983	0.333
Abundance/ Habitat	Abundance	Log_{10} (Sel_EPTD +1)	Log(sum of Heptageniidae, Ephemeridae, Leptophlebiidae, Brachycentridae, Goeridae, Polycentropodidae, Limnephilidae, Odontoceridae, Dolichopodidae, Stratyomidae, Dixidae, Empididae, Athericidae & Nemouridae)	Buffagni et al., 2004; Buffagni & Erba, 2004	0.266
	Abundance	1-GOLD	1 - (relative abundance of Gastropoda, Oligochaeta and Diptera)	Pinto et al., 2004	0.067
Richness and Diversity	Taxa number	Total number of Families	Sum of all Families present at the site	e.g. Ofenböch et al., 2004	0.167
	Taxa number	number of EPT Families	Sum of Ephemeroptera, Plecoptera and Trichoptera taxa	e.g. Ofenboch et al., 2004; Böhmer et al., 2004.	0.083
	Diversity index	Shannon-Wiener diversity index	$D_{S-W} = -\sum_{i=1}^{s}\left(\frac{n_i}{A}\right)\cdot\ln\left(\frac{n_i}{A}\right)$	e.g. Hering et al., 2004; Böhmer et al., 2004.	0.083

c) Accordingly to the WFD requirements, the STAR ICMi class boundaries here presented for High/Good and Good/Moderate status are dedicated to R-M4 rivers i.e. they are type-specific. See next paragraph for details on technical options used to set class boundaries.

Principles of the classification

The used approach and thus the proposed values satisfy the requirements of the WFD: type-specific adaptation of reference conditions, use of an EQR scale, REFCOND approach for setting class boundaries. As far as normative definitions in terms of kind of information provided for invertebrates are concerned, i.e. ratio sensitive/insensitive taxa, diversity and abundance, the compliancy is guaranteed by the STAR_ICM index, which directly fulfils such obligations (Buffagni et al., 2005; Wasson & Buffagni, 2005). Also, the level of biological alteration evaluated by the STAR_ICMi values complies with normative definitions in terms of: "slight deviation" of taxa richness from reference conditions; presence of sensitive taxa; presence of major taxonomic groups. In Appendix, the relationship between the quality classes based on the proposed STAR_ICMi values and each of the componing biological metrics are shown for Reference and High to Poor quality classes. Also, the relationship between STAR-ICMi and selected pressures is shown in Appendix as well.

	Definition of Reference values and dataset used The invertebrate and pressure data used were explicitly collected for the IC exercise by CNR-IRSA (Italy) within a project funded and coordinated by the Ministry of Agriculture, Natural Resources and Environment of Cyprus – Water Development Department. Invertebrate samples were collected to cover the full degradation gradient observed in the area selected for the study (catchments of the Kargotis, Diarizos, Xeropotamos, Kouris, Kryos, Stavros tis Psokas and Gialia rivers) i.e. from Poor status to Reference sites. No sites of Bad status class were found. In total, 60 samples collected in 2005 and 2006 were used, including 16 samples from 8 Reference sites. As far as quality classes are concerned, the samples considered for the IC were classified as: 18 High, 16 Good, 26 lower classes. Samples collected in pools and riffle (see 'sampling technique', above) were normalized accordingly i.e. reference conditions – in terms of absolute metric values – were defined independently for the two series of samples. Data were then combined after calculating EQRs for each of the two river areas. Reference sites were selected and screened on the basis of the REFCOND criteria, with the more in-depth suggestions provided by CB_GIG. To calculate STAR_ICMi values, the normalization was based on the median values obtained at reference sites, for single metrics as well as for the index itself. The main stressors acting on invertebrate communities in the studied rivers are land use and diffuse pollution, morphological degradation and urban (local) waste. Boundary setting approach *Definition of High /Good boundary* The High/Good class boundary was set accordingly to an ideal 3-step procedure. 1) First, a possible value for the H/G boundary is set to correspond to the STAR_ICMi value equal to the 25th percentile of the reference sites, which is considered to be a minimal and simple approach in line with WFD requirements → REFCOND approach 2) The values of the STAR_ICMi observed at REF sites are tested against an independent, benchmark dataset, the AQEM/STAR Benchmark dataset (as described in Buffagni et al., 2005; 2006; 2007; Buffagni & Erba, 2006). The result of the test, if no differences are observed, should guarantee the similarity to scientifically set (and thus ecologically sound) boundaries. 3) If needed, the boundary is adjusted, so that differences possibly found at step 2) are eliminated. A final value is thus selected as the final H/G boundary. *Definition of Good/Moderate boundary* The Good/Moderate class boundary was set accordingly to an ideal 3-step procedure as well. 1) The G/M boundary is set to correspond to the H/G boundary (see above) multiplied by 0.75. I.e., the range covered by STAR_ICMi values comprised between 0 and the 25th percentile of the STAR_ICMi observed at reference sites was partitioned into 4 equally spaced classes, Good status being the highest in terms of STAR_ICMi. A 25% deviation from reference sites value is assumed to be, in general terms, a slight deviation → REFCOND approach

2) The values of the STAR_ICMi observed at Good status sites as defined at point 1) are tested against an independent, benchmark dataset, the AQEM/STAR Benchmark dataset (same as for H/G boundary).
3) If needed, the boundary is adjusted, so that differences possibly found at step 2) are eliminated. A final value is thus selected as the final G/M boundary (same as for H/G boundary).

Point 1) for preliminary H/G and G/M boundary setting does not need any further explanation, because it simply makes use of an arithmetical separation into 4 equal classes. Nonetheless, such a simple option risks generating numerical results (i.e. boundaries) that are not ecologically sound. That's why point 2) and 3) checking was adopted. The values obtained in point 1) ('REFCOND approach') represent the starting point (for each of the two boundaries) for finally setting the class boundaries.
For point 2), a statistical comparison was executed between the STAR_ICMi values found in the AQEM/STAR benchmark dataset - which is assumed to enclose WFD compliant classifications (Buffagni & Erba, 2006) - and the same observed in Cyprus R-M4 dataset for the High status class as defined by using point 1) approach. The procedure is explained in details in Buffagni et al., 2005; 2006; 2007. Because Cyprus R-M4 samples did not significantly differ from benchmark ones i.e showed median values similar to benchmark ones, the H/G boundary obtained in point 1) was accepted as final. Step 3) was not necessary for the H/G boundary.
In the same way as for the H/G boundary, the boundary G/M was considered and the procedure of statistical comparison between Good status classes, as it was carried out for High status, was repeated. Again, no statistically significant differences with benchmark were observed and the G/M boundary obtained by step 1) was accepted as final, with step 3) being unnecessary.

In Table 2, the boundaries for STAR_ICMi as calculated by step 1) and statistically tested against the AQEM/STAR benchmark are provided for all classes.

Table 2. Cyprus R-M4, STAR_ICMi (EQR) scale. Boundary values reported are the lowest limit of each quality class.

	EQR scale			
Class boundary	STAR_ICMi values according to REFCOND approach	STAR_ICMi values after testing with benchmark	**final STAR_ICMi boundary**	final decision criteria
High/Good 25%ile REF	0.972	0.972	**0.972**	REFCOND and testing against benchmark
Good/Moderate	0.729	0.729	**0.729**	REFCOND and testing against benchmark
Moderate/Poor	0.486	nc	**0.486**	REFCOND
Poor/Bad	0.243	nc	**0.243**	REFCOND

The ecological soundness of the two selected boundaries, H/G and G/M, was then validated, in terms of Normative definitions, by looking at the distribution of the WFD-compliant metrics composing the STAR_ICMi as a function of the proposed classification. They are reported below, and support the adherence of the classification to Normative definitions for invertebrates.

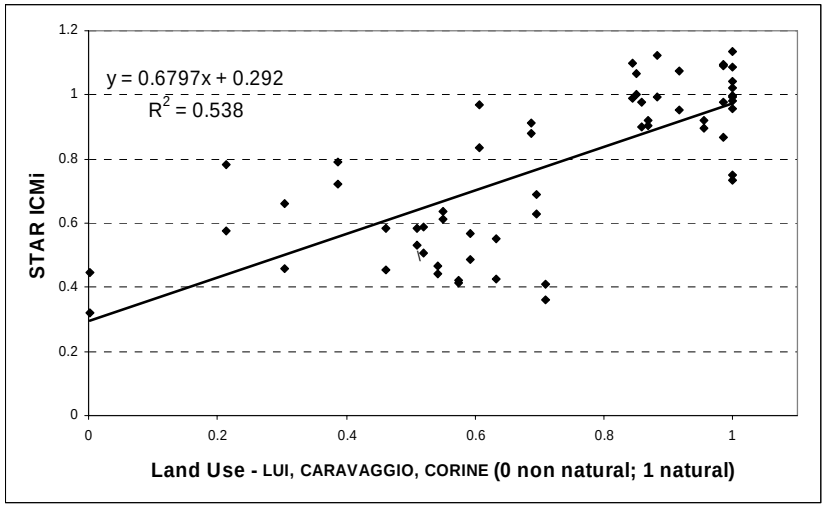
Future revision of the classification

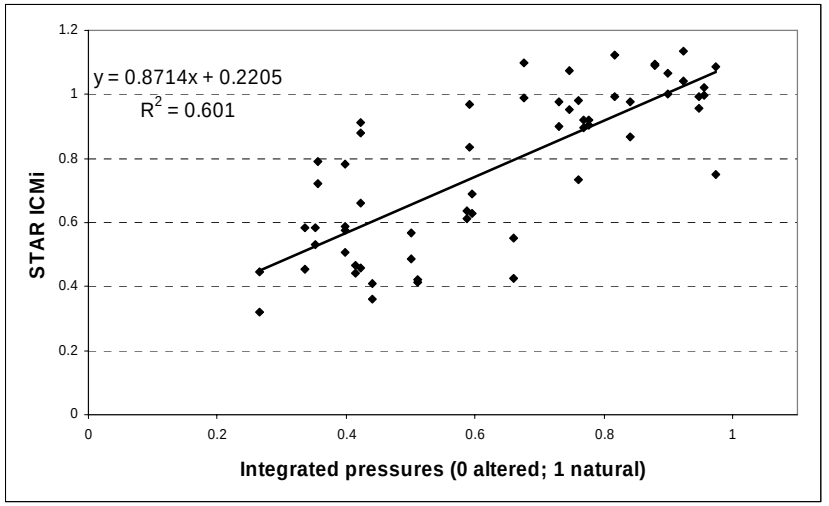
Possibly, new invertebrate samples and pressure data will be collected in 2007 and 2008 and the list of reference will include further sites. Thus, also in relation to the definition of an improved typology for Cyprus rivers, some refinements of boundaries might be required and/or desirable.

Relationship between the STAR_ICMi and pressure indices (detail)

The relationship between the STAR_ICMi and pressures was investigated in further detail, because the STAR ICMi was selected as a proxy for a National assessment method in Cyprus.

The relationship between land Use Index (LUI) and Integrated pressures versus the STAR_ICMi are showed below.





For chemical compounds, the ones better correlated to STAR ICMi are Chloride and Nitrates. Nonetheless, the correlation is not very high, mainly because this biological index represents an overall picture of all factors acting at a site (i.e. 'general degradation').

Essential bibliography

Buffagni, A., S. Erba, M. Cazzola & J. L. Kemp, 2004. The AQEM multimetric system for the southern Italian Apennines: assessing the impact of water quality and habitat degradation on pool macroinvertebrates in Mediterranean rivers. In: *D. Hering, P.F.M. Verdonschot, O. Moog & L. Sandin (eds), Integrated Assessment of Running Waters in Europe. Kluwer Academic Publishers. Printed in the Netherlands.* Hydrobiologia 516: 313-329.

Buffagni A. & Erba S. 2006. Contribution to the CentralGIG Intercalibration activities. Notes on a possible Benchmark /Independent dataset for the IC process. CB_GIG Document, 36pp.

Buffagni A., Erba S., Birk S., Cazzola M., Feld C., Ofenböck T., Murray-Bligh J., Furse M. T., Clarke R., Hering D., Soszka H. & W. van de Bund, 2005. 'Towards European Inter-calibration for the Water Framework Directive: Procedures and examples for different river types from the E.C. project STAR'. 11th STAR deliverable. STAR Contract No: EVK1-CT 2001-00089. *Quad. Ist. Ric. Acque* 123, Rome (Italy), IRSA, 468 pp.

Buffagni A., Erba S., Cazzola M., Murray-Bligh J., Soszka H. & Genoni P. 2006. 'The STAR Common Metrics approach to the WFD Intercalibration Process: full application across Europe for small, lowland rivers'. Hydrobiologia 566: 379-399.

Buffagni A., Erba S. & M. T. Furse, 2007. A simple procedure to harmonize class boundaries of assessment systems at the pan-European scale. *Environmental Science & Policy* (in press).

REFCOND Guidance - Wallin, M., Wiederholm, T. & R. K. Johnson. 2003. Guidance on establishing reference conditions and ecological status class boundaries for inland surface waters. Produced by CIS working group 2.3 – REFCOND. 2003-03-05, 93 pp.

Wasson J.G. & Buffagni A., 2005. Does the ICMi approach ensures the consistency with the WFD normative definitions? River Intercalibration - Discussion paper for the Central/Baltic GIG. Steering group & GIGs coordinators meeting, Lyon, 18-19th May 2005, 8pp.

Criteria for Boundary Setting	**High/Good boundary**	**Good/Moderate boundary**
Taxonomic composition and abundance **(see Appendix below)**	The Total Number of taxa, the number of EPT taxa, Abundance of selected EPTD taxa and 1-GOLD account for Taxonomic composition. Abundance of selected EPTD taxa and Shannon-Wiener index are based on abundance of, respectively, selected and whole community taxa. These metrics show - in High status samples - values that are in general equivalent or even higher than those observed at reference sites.	For the same metrics, the deviation from reference sites values is slight. **(see Appendix below)**
Ratio of disturbance sensitive to insensitive taxa **(see Appendix below)**	The sensitive to insensitive taxa ratio is reflected by the number of EPT taxa, the ASPT metric and 1-GOLD. Also, Abundance of selected EPTD taxa contributes useful information on the presence of sensitive taxa. In High status samples, these metrics show values often higher than those observed at reference sites.	For the same metrics, the deviation from reference sites values is slight **(see Appendix below)**
Level of diversity **(see Appendix below)**	The diversity is reflected by the Total Number of taxa, EPT taxa and by Shannon-Wiener diversity index. In High status samples, these metrics show values that are in general equivalent or even higher than those observed at reference sites.	For the same metrics, the deviation from reference sites values is slight **(see Appendix below)**
Global STAR_ICM index	The High/Good boundary was set according to the procedure described in the text above, which is performed on the index values after the combination of the composing metrics. Nonetheless, the relationship of each single metric included in the index show a good or very good discriminatory power among quality classes. In High status samples, the STAR_ICMi shows values equal or higher than those observed at reference sites. (see Appendix)	The Good/Moderate boundary was set according to the procedure described in the text above, which is performed on the index values after the combination of the composing metrics. Nonetheless, the relationship of each single metric included in the index show a good or very good discriminatory power among quality classes (see Appendix)

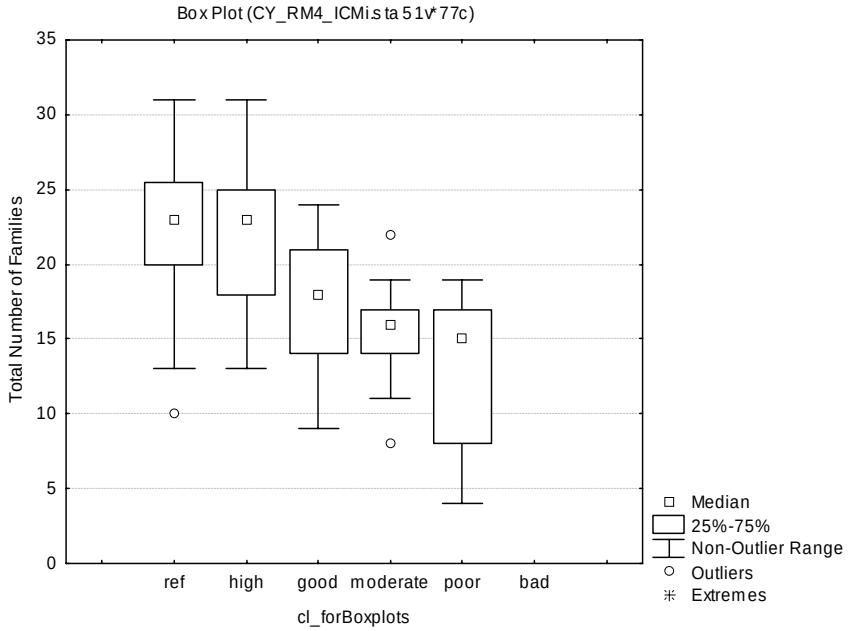
Appendix (CYPRUS)

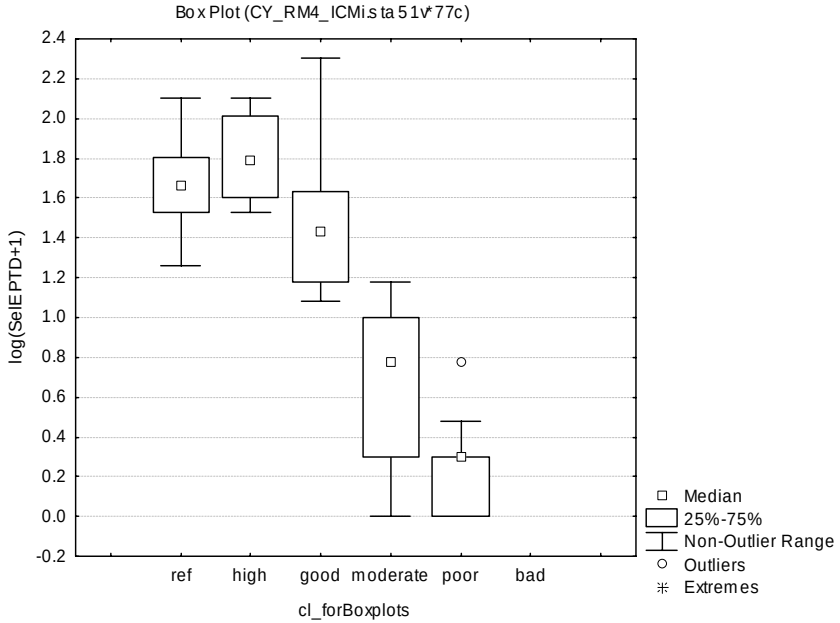
To briefly describe the response of the biological metrics included in Cyprus classification index (i.e. STAR_ICMi), which are able to fulfil the WFD definitions for aquatic invertebrates in rivers, the six component metrics are shown below, according to the main definition categories in the WFD. The distribution of values for each metric in the 4 Ecological Status classes (Bad status samples are missing from the dataset) based on the STAR_ICMi boundaries and at Reference sites is shown in the form of Box&Whiskers plots.

Taxonomic composition and abundance

The Total Number of taxa (here Families) found in a sample can be considered one of the major indicators for taxonomic composition (see figure below, left). The shift from 23 (REF and High) to 18 (Good status) in the Number of Families is considered a slight change in the composition of the invertebrate community.

The EPT taxa metric as well contributes to taxonomic composition of the community (see graph in 'Ratio of disturbance sensitive to insensitive taxa').





The abundance-based metric included in the STAR_ICMi i.e. Sel EPTD_taxa properly accounts for the Normative 'abundance' of invertebrate taxa (see above, right). The shift from ca 1.7 (REF) to ca 1.45 (Good status) in Sel EPTD_taxa is considered a slight change in the composition and abundance of the invertebrate community. In fact, the taxa enumerated in this metric are nearly absent in Poor status samples (i.e they are sensitive taxa, expected to

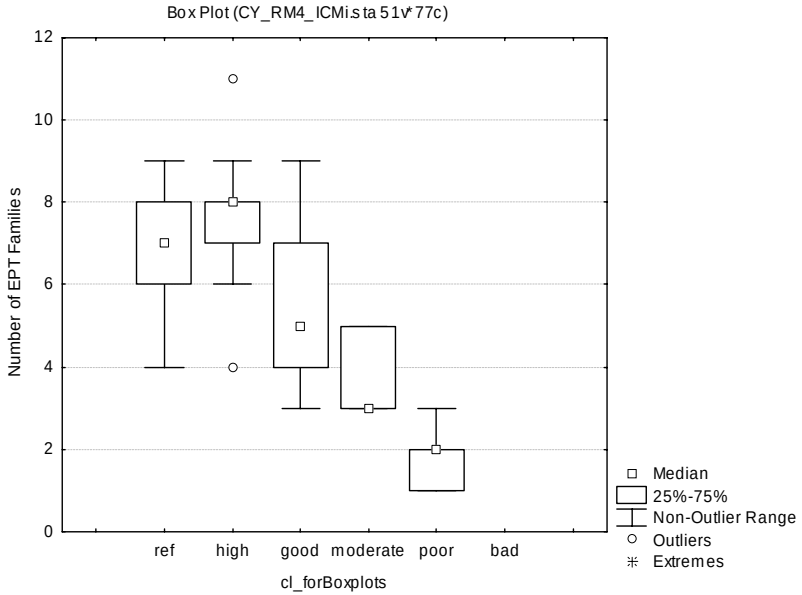
disappear at altered sites) and they show an abrupt decrease while shifting from Good to Moderate status. Among the two classes, this metric show a very good discriminatory power.

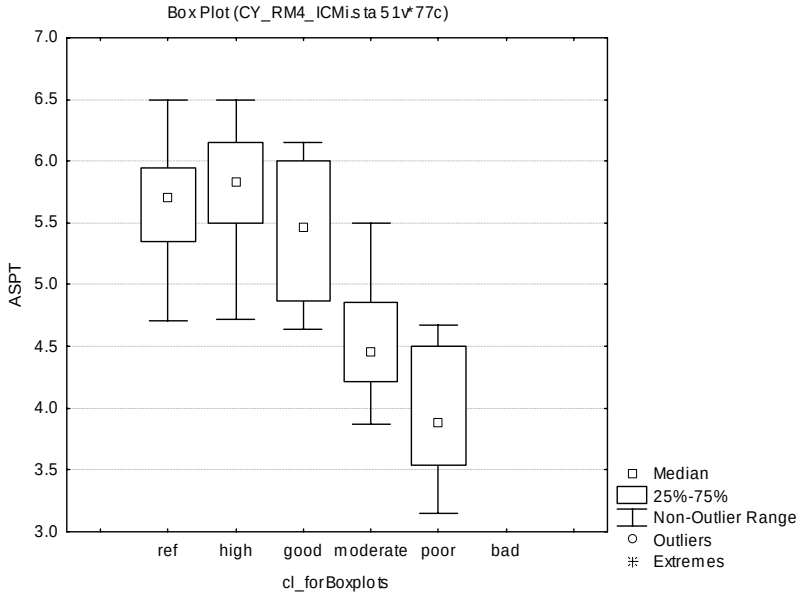
Abundance is also used in Shannon-Wiener index calculation (see 'Level of diversity').

Ratio of disturbance sensitive to insensitive taxa (and missing major taxonomic groups)

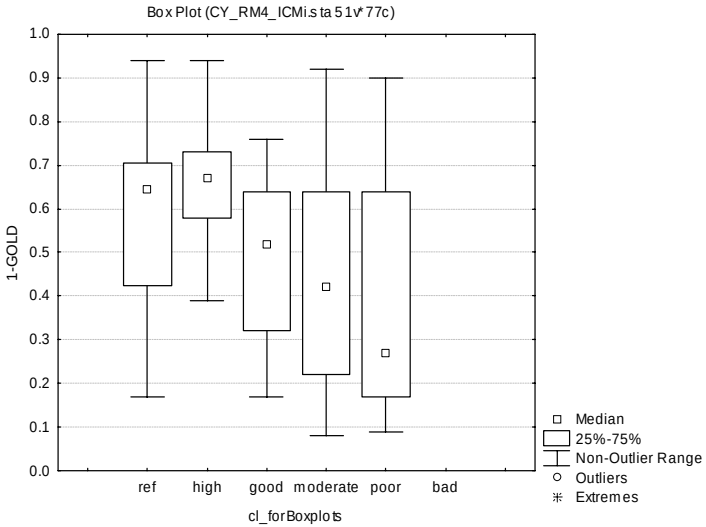
EPT-Taxa can be seen as the most sensitive taxonomic groups in R-M4 river type. A positive value of this metric indicates that at least one of the three most sensitive major taxonomic groups is present in the community.

In Cyprus R-M4dataset, 4 EPT Families are encountered at 75% of Good status samples, and they are never below 3 (below, left). The total disappearance of EPT Families was never experienced (but Bad status sites were not found). It appears than clearly how the most sensitive major taxonomic groups are always present in Good status samples according to the proposed boundaries.



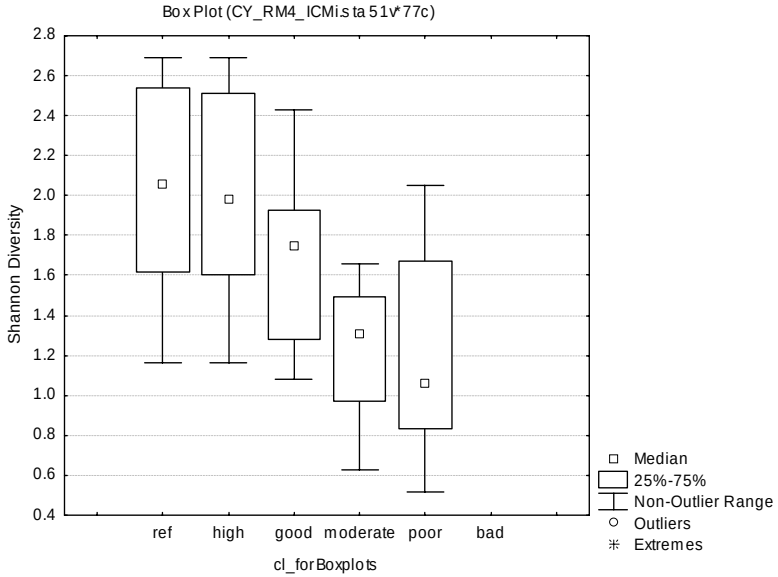


The ASPT metric is also shown, which undoubtedly accounts for the Ratio of disturbance sensitive to insensitive taxa (figure above, right). For the Good status class, it shows a slight deviation from the level observed at Reference sites (ca 0.5 units of variation for median value).


Box Plot (CY_RM4_ICMi.sta 51v*77c)
1-GOLD
1.0
0.9
0.8
0.7
0.6
0.5
0.4
0.3
0.2
0.1
0.0
ref
high
good
moderate
poor
bad
cl_forBoxplots
Median
25%-75%
Non-Outlier Range
Outliers
Extremes

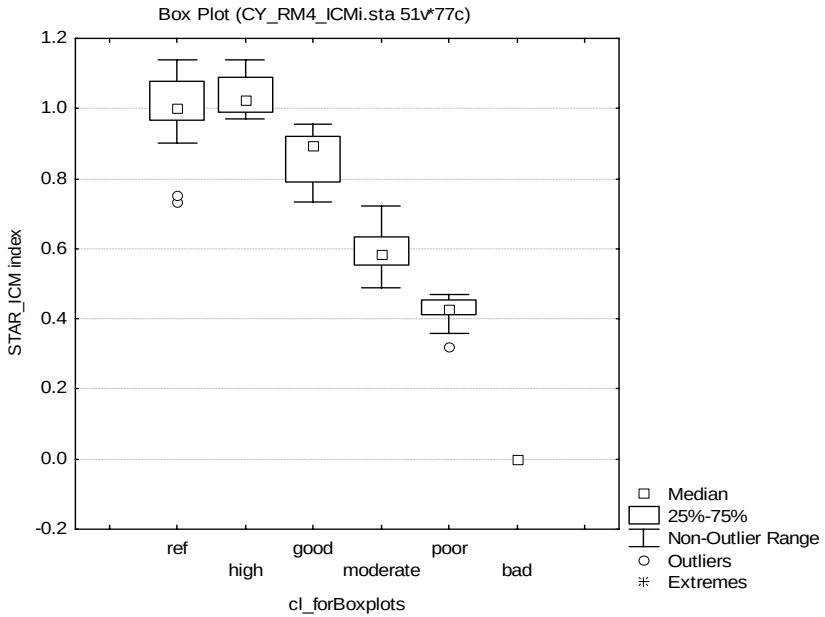
Level of diversity

The level of diversity of invertebrate taxa is accounted by the Shannon-Wiener diversity index (see graph below). The variation of this metric in Good status samples shows only slight signs of alteration from reference sites levels (Median of REF: ca 2.05; Median of Good status: ca 1.9, with a full range reaching values lower than 0.6).



Richness of the community is presented in 'Taxonomic composition and abundance' (Total Number of Families) and in 'Ratio of disturbance sensitive to insensitive taxa' (Number of EPT Families.

Overall trend of STAR_ICMi



The distribution of the values of the STAR_ICMi in the proposed Ecological Status classes shows how High status samples are distributed similarly to REF samples.