ViBRANT e-Infrastructure

Work Package 8: Ecological and conservation data mobilisation

Milestone 8.20: Ecological and Conservation applications implemented as a service

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The Biological Index Calculation Tool (BICT) is an online tool available via OBOE (Oxford Batch Operation Engine, https://oboe.oerc.ox.ac.uk/). The BICT calculates up to eleven different biodiversity indices on data files submitted by the user and returns calculated data as well as a graphical report. The development of the BICT module was completed during the third year of the project.

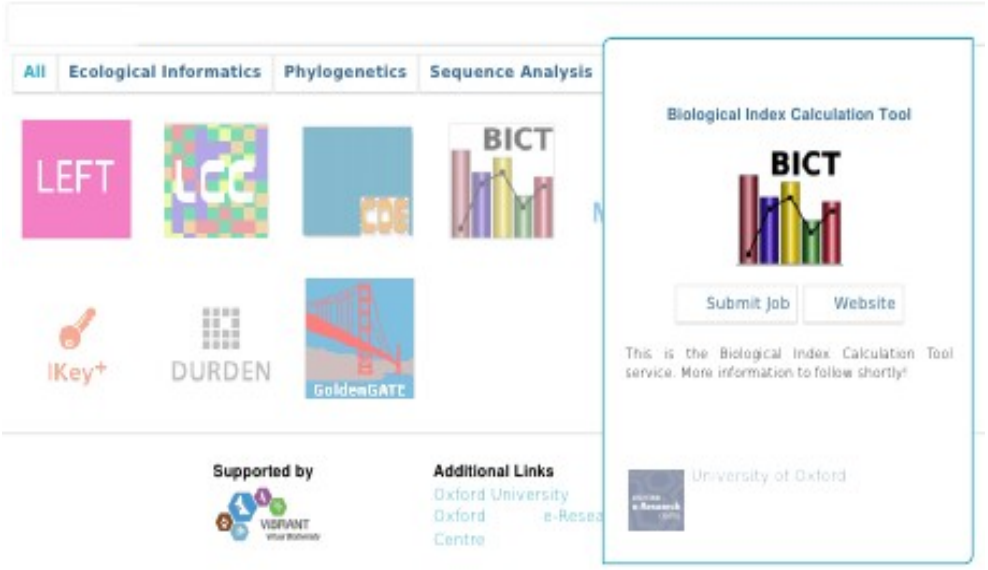


Figure 1. The BICT module as it appears on the OBOE web site.

The indices calculated by the module are those most frequently used in ecological, conservation and environmental health assessment studies. The three last indices (see below) are largely used during the implementation of the EU Water Framework Directive (WFD) and of the Marine Strategy Framework Directive (MSFD).

The following indices can be calculated:

1. Species Richness (S)

The total number of different species in the submitted file per station / sample.

2. Number of Individuals (N)

The total number of individuals in the submitted file per station / sample.

3. Shannon Index (H')

Shannon's diversity index is defined as: $H' = -\Sigma_i p_i (log\ p_i)$, where p_i is the proportion of the total count arising from the *i*-th species. Logs are calculated with all three possible bases.

4. Pielou's Index (J')

A species evenness index, indicating how close in numbers the species in an environment are distrubuted. It is calculated as: $J' = H'(observed) / H'_{max}$, where H'_{max} is the maximum possible diversity which would be achieved if all species were equally abundant.

5. Margalef's index (d)

This is a diversity index which makes use of both the species richness and species abundance values. It is defined as: $d = (S-1) / ln\ N$, where *S* is the number of species and *N* is the number of individuals. NB: this richness index standardizes the number of species encountered against the total number of individuals encountered.

6. Rarefaction

As a standard measure of the rerefaction curves, the *ES50*, the “expected number” of species from 50 individuals in a given sample, as developed by Hurlbert, is calculated.

The formula used in BICT is:

$$ES50 = 1 - \sum_{i=1}^{s} \frac{(N - N_i)!(N - 50)!}{(N - N_i - 50)!N!}$$

where *N* is the total number of individuals in a given sample and *Ni* is the number of individuals of the species *i-th* in the same sample, for all samples with more than 50 individuals.
Low *ES50* values are supposed to be calculated from samples where the mostly tolerant species are abundant and, therefore, from disturbed habitats. High values of *ES50* come from samples with sensitive species and indicate a healthy environment.

7. Average Taxonomic Distinctness

The Average Taxonomic Distinctness (Δ^+) describes the average distance between species, taking into account their higher classification / phylogeny). The calculation follows the formula proposed by Clarke & Warwick (1998) and is based on presence/absence data.
The formula used is:

$$\Delta^+ = [\Sigma\Sigma_{i<j}\, \omega_{ij}] / [s(s-1) / 2]$$

where ω_{ij} is the phylogenetic/taxonomic path length between species *i* and *j*, *s* is the number of species.

8. Variation in Taxonomic Distinctness

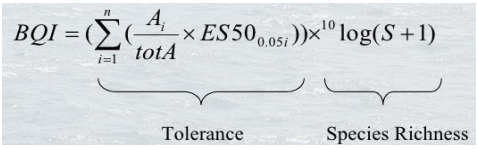
The Variation in Taxonomic Distinctness (Λ^+) describes the "evenness" or "variation" in taxonomic distances between each pair of species, across their taxonomic / phylogenetic tree. The calculation is performed as described in Clarke & Warwick (1998) and is based on presence/absence data.
The formula used is:

$$\Lambda^+ = [\{\Sigma\Sigma_{i\neq j}\, \omega_{ij}^2\} / [s(s-1) / 2]] - (\Delta^+)^2$$

10. Biological Quality Index (BQI and BQI_{fam})

An Index of biological quality, developed for the EU Water Framework Directive by Rosenberg et al. (2004). Here, it is used in its modified form as described by Leonardsson et al. (2009). The species' sensitivity values are taken from the publication by Dimitriou et al. (2012).

The formula used is:



where,

Ai is the abundance of the *i-th* species at the considered station; a mininmum requirement for species to be taken into account in the calculation of the index is that the species occurs in at least 5 samples or its total abundance in all samples in the matrix is more than 30 individuals,

totA is the total abundance of the individuals belonging to the species for which $ES50_{0.05}$ can be computed,

$ES50_{0.05i}$ is the $ES50_{0.05}$ of the *i-th* species, by accepting that in a given species the most tolerant individuals (defined at the levels of 5% ($ES50_{0.05}$) show the lowest *ES50* values,

S is the total number of species at the considered station.

BQI_{fam} is calculated the same way after the species matrix is aggregated to the family level.

10. AMBI (BI)

This index has been proposed by Borja et al. (2000) and it is based on the Biotic Index launched by Glemarec & Hilly (1981) and Hilly (1984). It uses five groups of species sensitivitiy to environmental pollution. Subsequently, the species are assigned to this five groups with the most sensitive ones to GI and the most tolerant to GV. The calculation of the (AMBI) Biotic Coefficient follows as:

BI = {(0 x %GI) + (1.5 x %GII) + (3 x %GIII) + (4.5 x %GIV) + (6 x %GV)} / 100

AMBI has been tested on benthic community datasets all over the world. This version, however, uses the species sensitivity groups appeared in itas original publication (Borja et al., 2000).

11. BENTIX index

An Index of biological quality, developed for the assessment of the ecological and trophic status of water bodies according to EU Water Framework Directive (Simboura & Zenetos, 2002; http://www.hcmr.gr/gr/listview3.php?id=1195). The BENTIX makes use of the same concept of the Biotic Index but uses only three species sensitivity groups.

BENTIX = {6 x %GI + 2 x (%GII + %GIII)} / 100

It has been thoroughly tested in the Mediterranean benthic communities.

Different input matrices (in *.csv format) are required for the calculation of the indices made available by the BICT module:

(a) species richness, number of individuals, Shannon's, Pielou's and Margalef's, as well as Rarefaction and BQI, they all need a stadnard species-by-samples matrix with abudance values in the cells;

(b) Average Taxonomic Distinctnes, Variation in Taxonomic Distinctness and BQI_{fam} need an extra matrix which provides information on the phylogenetic/taxonomic classification of the species into higher categories. The Taxonomic Distinctness indices require classification matrices with a much larger species pool than the one included in the species-by-samples one.

(c) Both AMBI and BENTIX indices require a fixed species sensitivity matrix in which the species are classified into five categories of sensitivity for the former index and just into three for the latter. It should be noted that only the species sensitivity matrices published by the relevant literature (see references above) are provided by BICT. In these matricess, the species names have been updated according to the PESI (/WoRMS) TaxonMatch tool. Therefore, the users are adviced to perfom the same operation for their own matrices prior to using the BICT module.

The module has a user-friendly interface which allows the calculation of the above indices within a few clicks, after the registration of the user:

Figure 2. The BICT registration web page (https://oboe.oerc.ox.ac.uk/jobs/new/bict).

A message is occurring on the web site when the job is finished, which normally takes a few seconds, so he/she can collect the results.

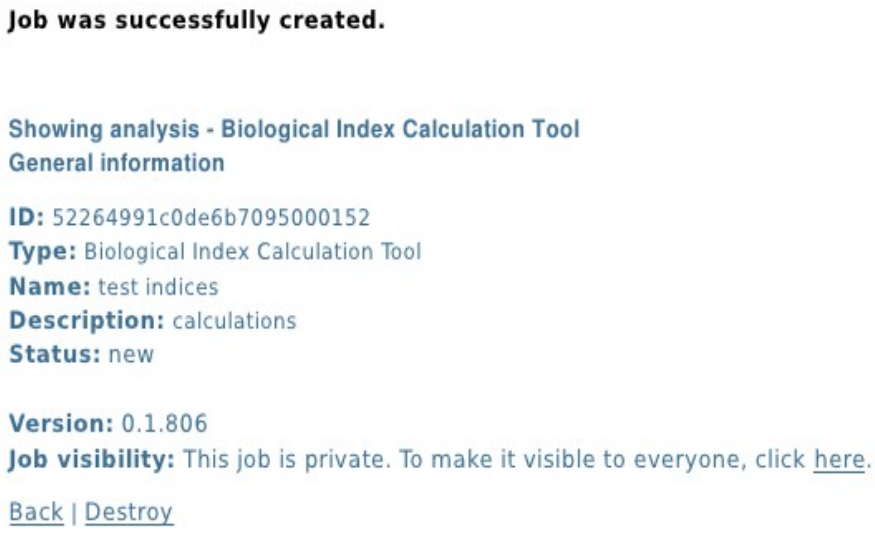


Figure 3. Screenshot of the delivery of job message.

As with the other OBOE modules, BICT provides the user with multiple types of results files. Results can be found on the web site and have the form of the following screenshot.

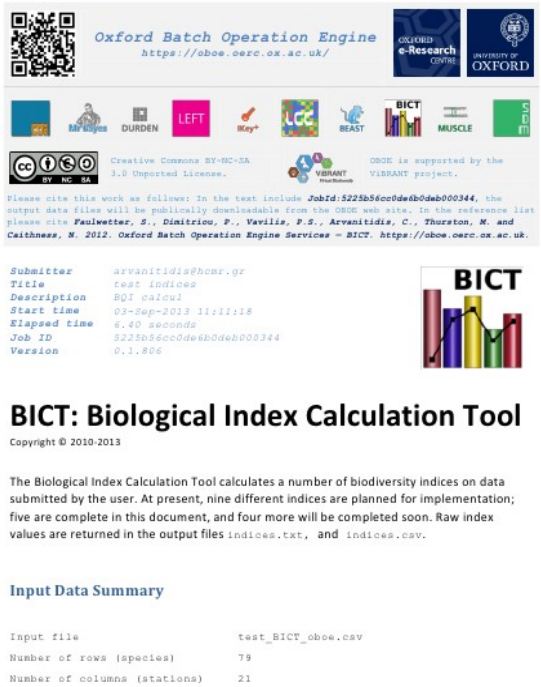


Figure 4. Screenshot of the BICT results page.

The results may also be provided in the form of frequency graphs, as the following one:

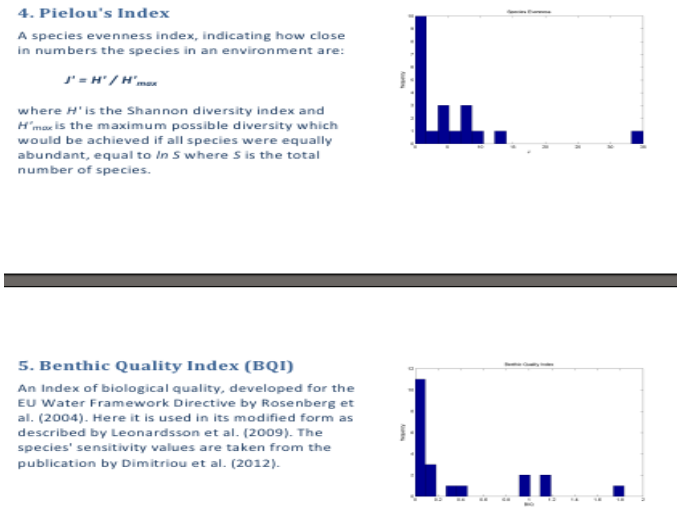


Figure 5. Example on the frequency of values of the calculated indices on the web page.

Additionally, the results can be provided in the form of standard files (e.g. *.pdf, *.doc), where the calculated indices values appear as normal text tables. The user can take these values from the resulting files and use them for any additional analysis if he/she wishes so.

References:

Borja A, Franco J, Perez V (2000) A marine biotic index to establish the ecological quality of soft-bottom benthos within European estuarine and coastal environments. *Marine Pollution Bulletin* 40: 1100–1114

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Dimitriou PD, Apostolaki, ET, Papageorgiou N, Reizopoulou, S, Simboura N, Arvanitidis C, Karakassis I (2012) Meta-analysis of a large data set with Water Framework Directive indicators and calibration of a Benthic Quality Index at the family level. *Ecological Indicators* 20: 101–107

Glemarec M, Hilly C (1981) Pertubartions apportees a la macrofaune benthique de la baie de Concarneau par les effluents urbains et portuaires. *Acta Oecologica Oecologica Applicata* 2: 139-150.

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Hurlbert S (1971) The Nonconcept of Species Diversity: A Critique and Alternate Paradigms. *Ecology* 52: 577–586

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Rosenberg R, Blomqvist M, Nilsson H, Dimming A (2004) Marine quality assessment by use of benthic species-abundance distributions: a proposed new protocol within the European Union Water Framework Directive. *Marine Pollution Bulletin* 49: 728–739

Simboura N, Zenetos A (2002) Benthic indicators to use in Ecological Quality classification of Mediterranean soft bottom marine ecosystems, including
a new biotic index. *Mediterranean Marine Science* 3: 77–111