LIFE Project Number

**LIFE08 ENV/IT/000413**

# FINAL Report (EXCERPT)

**Covering the project activities from 01/04/2010 to 31/10/2013**

Reporting Date

**13/1/2014**

LIFE+ PROJECT NAME or Acronym

# Local hydro-morphology, habitat and RBMPs: new measures to improve ecological quality in South European rivers and lakes - INHABIT

## Data Project

| | |
|---|---|
| **Project location** | Italy (Piedmont, Sardinia, Lombardy) |
| **Project start date:** | 01/04/2010 |
| **Project end date:** | 31/03/2013 |
| **Total budget** | € 2.264.341 |
| **EC contribution:** | € 1.118.493 |
| **(%) of eligible costs** | 49.4% |

## Data Beneficiary

| | |
|---|---|
| **Name Beneficiary** | Consiglio Nazionale delle Ricerche - Istituto di Ricerca Sulle Acque, CNR-IRSA |
| **Contact person** | Mr Andrea Buffagni |
| **Project Website** | www.life-inhabit.it |

# 1. List of content

# 2. Executive Summary (maximum 5 pages)

With the title 'Local hydro-morphology, habitat and RBMPs: new measures to improve ecological quality in South European rivers and lakes' INHABIT aimed at integrating information on local hydro-morphological and habitat features into practical measures to improve the reliability of implementation of WFD River Basin Management Plans (RBMPs) in South Europe. The focus was on rivers and lakes that were scrutinized in two areas in Italy, covering a wide range of environmental features and water body types. For habitat issues, the outcome of the project will complement the implementation of Water Framework Directive river basin management plans over larger areas in Italy and, possibly, other European regions, especially in the South. INHABIT is a common project of CNR-IRSA, CNR-ISE, ARPA Piemonte and Regione Autonoma della Sardegna and considered the enhancement of WFD measures proposed in river basin management plans in selected catchments of Piedmont and Sardinia, for both rivers and lakes, based on the study of habitat-biota association and nutrient retention potential.

The project had both demonstration and innovation character, because it considered the transfer of recently updated approaches and methods, not yet of common use in Italy, to environmental agencies and regulatory institutions and provided evidence to put into practice new concepts, derived by recent research activity. Dissemination, demonstration of WFD-compliant methods and knowledge transfer were highly relevant for the project and have been realized via reports, articles, web site, courses, seminars and workshops, all along the life-time of the project. A number of publications on technical and scientific journals, as well as further transfer of final results, are still being performed after the formal end of the project, so that its outcomes get further circulation and impact. Close to the end of the project, three different international workshops dedicated to transfer INHABIT results and approaches and to verify their applicability outside Italy were organized, in Spain (Barcelona), Austria (Vienna) and Cyprus (Nicosia). Moreover two national workshops were organized in Italy to demonstrate projects results applicability in the national context (Cagliari and Rome), with detailed examples provided to the audience and extensive discussions. INHABIT project has now reached its conclusion and even if the technical activities suffered some delay, all the expected results and Milestones have been achieved and all Deliverables completed, according to the proposal. Organized in Milan on October 2013, the final conference showed all major results gained and saw the participation of more than 130 people, from different organizations (Environment Agencies, Regions, JRC, Ministry of the Environment, Research Institutes, Universities, SMEs, associations and private companies).

As far as technical aspects are concerned, INHABIT applied an innovative approach based on the employment of habitat information to support the assessment of ecological quality and status in rivers and lakes. The record, storing and analysis of habitat features were key elements in the project to: assess precision and accuracy in defining reference condition for WFD water bodies; verify nutrient retention capacity in rivers; explain the response of biological communities to environmental gradients; evaluate potential consequences of habitat-related measures to restore ecological quality and thus their effectiveness.

On habitat-related issues - and not only -, INHABIT stated for a 4-years period an appropriate pathway to promote and distribute knowledge on the WFD implementation and most updated methods in Italy. During the project, many technical aspects that still needed to be demonstrated and/or finely adjusted to better fit South European requirements, as far as habitat influence on ecological status is concerned, were approached and circulated. As a consequence of INHABIT activities, a new awareness arose in Environment Agencies and

among water managers in Italy about the need for including habitat information when describing, assessing and managing rivers and lakes. A step further will be to put into practice on the large scale information gained from habitat analysis, in a way that financial limitations are no more seen as prevailing over ecosystems needs, at least when clear evidence is provided of habitat influence on ecological status.

## 2.1 Objectives

The main objectives of the project were:

- to quantify in a standard way the natural variability in undisturbed conditions of selected hydro-morphological, habitat and physio-chemical features, which are known to be highly influent on biological communities i.e. WFD Biological Quality Elements (BQEs). Successively, biological attributes for selected BQEs were assessed accordingly.
- To quantify such habitat-related features, that can therefore noticeably affect ecological status classification, in degraded water bodies as well.
- In general terms, to focus on highlights that emerged from ongoing issues of WFD implementation in South Europe e.g. robustness and weakness of WFD typologies, setting reference conditions in harsh environments, water quantity-quality concern and water scarcity. Such aspects were considered early in the project, so that test areas and sites were selected accordingly, in the meantime covering as much as possible habitat gradients in the selected areas.
- To put into practice the most updated approaches and methods for the collection of WFD-compliant data, classification of ecological status, selection and description of habitat survey protocols for rivers and lakes and transfer such issues to local and national Authorities, on a larger scale.
- To evaluate which habitat aspects can mostly influence, and how, ecological status attribution and the overall uncertainty in classification i.e. as deriving from natural variability, errors in measurements, failure in methodological approach, direct influence of hydro-morphology and habitat.
- Finally, we aimed at considering the above mentioned information to describe and propose integrations, which are explicitly related to habitat conditions, to existing restoration measures of RBMPs so that good or high ecological status can be achieved in the studied water bodies and catchments.

## 2.2 Key deliverables and outputs

INHABIT reached results dealing mainly with the Water Framework Directive (WFD) effective implementation. In detail INHABIT allowed:

- To consolidate methods used to assess habitats in rivers and lakes. On this concern, the Lake Habitat Survey method has been validated in the Italian context and INHABIT contributed to the activities carried out within the CEN standard Committee. On the river side, the CARAVAGGIO method, used to assess river habitats in South Europe, was upgraded together with the associated software for habitat data storing and elaboration and the application manual completed. These results are part of Deliverables Pd3, I3d2 and D1d5.
- To validate a range of reference sites based on habitat information and to confirm methods used to assess reference conditions. Relevant results are included in I1d1 and I1d4 (rivers) and D1d4 and D1d5 (lakes). As an outcome of INHABIT, some river stretches were proposed as Italian official reference sites.

- To verify if and where different biological groups are distinguishable for official WFD river types (Deliverable I1d4). INHABIT results confirmed the general validity of regionalization (basis for typology in Italy) and approach, while emphasizing the need for refinements in river types definition in the Mediterranean area, especially for intermittent rivers.
- To derive metrics and habitat features linked to river nutrient retention capacity in order to gain useful elements to guide river basin management measures (Deliverables Pd4, I2d2, I2d3 and I3d3).
- To define models relating biological metrics and habitat features. For rivers, these models were proposed to be used to better estimate biological reference conditions (thus implementing the accuracy in reference values definition), to propose possible measures based on habitat features to restore ecological quality and, finally, to assess the efficacy of restoration measures. Emphasis has been placed on the importance of the lentic-lotic characters in rivers. Most results on accuracy of ecological assessment methods are included in I3d1 deliverable. Here, for lakes, the response of BQEs to hydromorphological parameters is also quantified. Other important deliverables related to habitat/biota relationship are I3d2 and D1d5.
- Two software supporting WFD implementation in rivers were improved during the project, based on INHABIT results: MacrOper.ICM, to facilitate ecological status classification based on aquatic invertebrates in rivers, and CARAVAGGIOsoft, to store and analyse habitat data. Both are now distributed by the INHABIT web site, to aid a more comprehensive application of INHABIT outcomes.
- To propose possible measures based on habitat features to restore ecological quality (Deliverable I3d2, I3d4), for rivers and lakes.
- A set of guidelines on how to use habitat information to enhance biological field data interpretation and to achieve a better ecological status in rivers and lakes has been provided (I3d4).
- A range of national and international workshops (6) have been organized on INHABIT issues, that were attended by about 400 people overall.
- More than 15.000 overall downloads were recorded for project Deliverables and other INHABIT documents from project web site.

# 3. Introduction (1 page)

The WFD (Water Framework Directive, 2000/60/EC) is a key environmental European Directive aiming at preventing deterioration of the status of surface water bodies and protecting, enhancing or restoring surface water bodies. The WFD brings Biological Quality Elements (BQEs) to the core of ecological status evaluation. This is quite an innovative approach but leads into additional problems to be managed for effective monitoring and classification. In fact, biological communities show an intrinsic variability, which can affect quality evaluations, whose effects the WFD attempts to limit by introducing a type- or site-specific approach. Such approaches aim at creating groups of water bodies, showing no (or little) variability within the groups, when no or little anthropogenic impact is present. Groups – or 'types' according to the WFD approach - must be defined in the best possible way and with adequate detail. This will ensure that impact on biological communities is precisely assessed and catchment management can be cost-effective. Unfortunately, the definition of water bodies types is not always sufficient to reduce natural biological variability. This

variability, that is mostly related to habitat patchiness and unevenness, remains potentially high, affecting any quality estimations and evaluation of efficiency of measures in River Basin Management Plans (RBMPs).

An important aspect dealing with WFD and RBMPs implementation is therefore linked to habitat. Once we exclude the potentially high influence of water pollution, for which management actions are comparatively well known and implemented, physical habitat conditions are the most relevant aspect affecting aquatic taxa presence and distribution. The WFD refers to such habitat conditions under the term 'hydro-morphology'. In fact, local hydro-morphology e.g. presence, distribution and feature of micro- and meso-habitats, local flow conditions, substrate characteristics, is what defines directly or indirectly overall habitat conditions. Hydraulic and morphological i.e. hydro-morphological features are crucial in structuring the habitats of aquatic organisms in rivers and lakes. The importance of hydraulic conditions at the site scale in influencing freshwater biotic communities is historically recognized by the scientific community. Not only such habitat aspects will determine presence and distribution of species, but will also finely tune abundance of most taxa, aspect that has to be statutorily considered for WFD monitoring and assessment. Therefore, it is clear how 'local hydro-morphology' i.e. habitat should always be considered in the key steps of water body characterization, classification and setting of measures, due to its unquestionable relevancy for BQEs. This will support a reliable interpretation of biotic response to pressures and, therefore, of ecological status classification, simultaneously providing evidence on sources for what is often generically called 'uncertainty' in biological results. Such uncertainty can be, to a relevant degree, related to habitat conditions, which can be quantified and taken into account for classification issues and while setting measures to restore/maintain water bodies in a good or high ecological status. Local hydro-morphology and habitat structure will affect not only BQEs but also nutrients dynamics. In summary, habitat conditions and local hydro-morphology in rivers and lakes have impressive concern for aquatic ecosystems functioning and, therefore, will affect any methods applied for monitoring and classification, unless their influence on biota and processes is explicitly addressed and quantified. In the overall context presented above, INHABIT evaluated all such aspects and quantified their impact on assessing ecological status, in both rivers and lakes. Hence, aim of the INHABIT project was to bring into real world some WFD key concepts (i.e. habitat-related information in RBMPs scenarios), so that biological uncertainty in classification can be assessed, efficiency of existing measures checked and innovative restoration measures proposed for application. In synthesis, the most relevant and durable effects linked with results gained in INHABIT are: practical elements and methods for optimizing monitoring activities and protocols in lakes and rivers; conceptualization and introduction of simultaneous collection of habitat and biota information for WFD monitoring; manual of the CARAVAGGIO method: survey and description of river habitats; tools and approaches to improve accuracy when defining reference conditions and quantifying the effects of habitat degradation on biota; new elements and support for measuring the efficacy of restoration measures; guidelines for habitat-oriented activities in future WFD management plans; better comprehension of habitat issues and overall improved ecological status in rivers and lakes.

# 4. Technical part (maximum 50 pages)

## 4.1. Task by task - description

The INHABIT project is structured in different groups of actions. Figure below illustrates the original timetable for the different groups of Actions. The project experienced some delay in the execution of the technical part, mainly linked with financial problems. INHABIT activities continued throughout the whole 2013 and all project objectives were reached. Finally, the delay allowed an overall improvement of the quality of Deliverables, because project beneficiaries went on working on project issues well after the originally set date for conclusion. Also, the extra-time available endorsed even more effective dissemination activities.

| Group of actions | 2010 | | | | 2011 | | | | 2012 | | | | 2013 | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | I | II | III | IV | I | II | III | IV | I | II | III | IV | I | II | III | IV |
| Management | | | | | | | | | | | | | | | | |
| Preparation | | | | | | | | | | | | | | | | |
| Innovation_1 | | | | | | | | | | | | | | | | |
| Innovation_2 | | | | | | | | | | | | | | | | |
| Innovation_3 | | | | | | | | | | | | | | | | |
| Demonstration_1 | | | | | | | | | | | | | | | | |
| Demonstration_2 | | | | | | | | | | | | | | | | |
| Dissemination | | | | | | | | | | | | | | | | … |

Original project ending date

To each of the groups of actions a paragraph in this chapter is dedicated, with the exclusion of Management and Dissemination (partly) that is reported in Chapter 4.

### 4.1.1 Group of actions P

The 'Preparation' group of actions was already described in the Inception report and successfully concluded (see the Commission letter sent on 24 March 2011 – ref. Ares (2011) 326316). The present paragraph reports what already reported in the Inception Report, in order to provide a complete overview – within this final report – of all actions carried out within the project.

- **All the Milestones** expected have been achieved.
- **All the Deliverables** planned for the first 9 months of the project have been completed.

Relevant deliverables attached (all Deliverables authored to present): Pd1, Pd2, Pd3 and Pd4 (on CD only).
More in detail:

- Approaches and methods used in the preparation of river basin plans in the study areas were reviewed in close collaboration between all the partners. Results of this action are included in **Deliverable Pd1** "River basin management plans for the WFD in selected Italian catchments: approaches, methods, scale factors and setting of measures", delivered on 30/9/2010. Pd1 deliverable was produced in Italian with an extended summary in English. This Deliverable focuses on the

collection of information potentially useful for project activities in the areas that will be investigated for I1 and I2 groups of actions, thus being preparatory for the respective actions by each beneficiary.

- Methods and field protocols for deriving nutrient-related information were reviewed and results are included in **Deliverable Pd4** "Guideline and field protocols for deriving nutrient-related information". The deliverable Pd4 was uploaded on the INHABIT web site on the 30/9/2010. Pd4 deliverable was produced in Italian with an extended summary in English. The Deliverable focuses on the methodologies able to measure the nutrient retention in rivers particularly by means of nutrient addition experiments.
- CNR-IRSA selected river sampling areas in close collaboration with ARPA Piemonte and Regione Sardegna and the same did CNR-ISE for lakes. For the selection of river sites some field inspections were organized: one major inspection trip was performed in Sardinia to get an overview of water bodies for investigation and potential sampling sites; one-day inspection trips were performed for selecting sampling sites in Piedmont. CNR-ISE performed a field inspection (summer 2010) in Sardinia for suitable lakes pre-selection. Results of sites selection are described in **Deliverable Pd2** "Typology and reference condition criteria in selected Italian catchments: approaches, methods and selection of investigation sites", including typology and reference condition criteria applied in selected Italian catchments.
- **Deliverable Pd3** "Guidelines and field protocols to be applied in the project for deriving hydro-morphological and habitat information" has been compiled, for both lake and river methodologies. The focus for lakes, for which methods are at an earlier stage, has been put in particular on a general description of the selected method (Lake Habitat Survey). For rivers, where the methodological scenario in Italy is more advanced, emphasis has been placed on the use of the habitat information, both in terms of rationale behind and practical calculation.
- A **kick off meeting** was organized and held in Sardinia (in Cagliari, 22-24 November 2010). During the meeting, hosted by RAS, administrative and management aspects were jointly discussed, to fix residual ambiguities on procedures and support the preparation of the Inception report. As well, emphasis was given to the technical aspects of the project, with special focus on various topics linked with Preparation actions. In particular, the contents of the Pd2 and Pd3 deliverables were discussed, together with the approaches for selecting sampling areas and investigation sites. Additionally to INHABIT partners, ARPA Sardegna (ARPAS, the Regional Environment Agency) has been invited to the meeting and was formally present. The project has thus been presented and possible collaboration and joint activities have been proposed and discussed, from both sides.

***Problems*** – In the execution of the Group of Actions P we did not encounter significant problems. All expected Actions were carried out on time allowing I1 and I2 Groups of Actions to start according to the proposed programme.

### 4.1.2 Group of actions I1

This group of actions was dedicated to the collection of data on biological communities (benthic invertebrates and diatoms), water quality and hydromorphology (habitat) in rivers and biological communities (phytoplankton, macrophytes, macroinvertebrates and fishes in

different combinations), water quality and hydro-morphology in lakes. Within this group of actions, subcontracting was activated. Information on databases containing biological, physio-chemical and hydro-morphological information for rivers and lakes produced in the INHABIT project is present in Deliverables I1d2 and I1d3 (attached to the present report). A selection of raw data and databases are available for download on the INHABIT web site and a part of them have been distributed on cd at INHABIT workshops.

***Overall Results (rivers and lakes)*** - Expected Deliverables (attached to the present Report) and Milestone for this group of action were all completed. In conjunction with the production of data (see below) to be elaborated in the other Groups of Actions, the most important results of this group of Actions, were:

- The quantification of natural and anthropogenic variability for rivers (I1d4): the consistency of river types definition was assessed demonstrating the general validity of regionalization but emphasising the need for refinements in river types definition in the Mediterranean area.
- The quantification of natural and anthropogenic variability in lakes (I1d5); the reliability of collected samples for classification of ecological status was evaluated suggesting possible amendments to sampling efforts (e.g. reduction of phytoplankton samples, increase of macroinvertebrate samples in the littoral area in natural lakes).

**Rivers**

***Problems experienced*** **-** Bad weather conditions in 2011, determining a delay in the planned sampling campaign, forced us to plan intensive sampling period in Sardinia in different years, one in May 2011 and the other in March 2013. Some weather problems were also experienced when sampling rivers in Piedmont, which resulted in an extended period of sampling. Despite these problems, sample collection and data analysis were successfully completed, covering the expected environmental gradient.

***Results*** **-** Taxonomic identification of river invertebrates and diatoms (subcontracting, for Sardinia samples) has been completed according to project requirements. All expected data have been collected, with the last field activities performed in March 2013. CNR-IRSA, RAS and ARPA Piemonte all contributed to this group of actions. In detail, CNR-IRSA had the responsibility of sampling activities and data processing in Sardinia and received support from RAS in data storing and gathering information on sampling areas. In Piedmont, ARPA Piemonte performed biological sampling and samples identification; CNR-IRSA provided support for habitat data collection, storing and interpretation. Moreover, ARPA Piemonte supported this action by providing extra data in order to improve available information for the analyses performed within this and in other action groups (I3 and D1). As part of this activity, many meetings were organized in order to coordinate the different sampling actions and to plan the analyses. In particular 2 dedicated meetings were organized between ARPA Piemonte and CNR-IRSA to coordinate and check macroinvertebrate taxa identification (2/08/2012 and 18/12/2012). Although produced in this group of actions, Diatoms data are presented in Deliverable D1d1, with corresponding elaborations. For main results of this group of actions, please see all relevant Deliverables.

As far as the study areas are concerned, investigated river stretches/water bodies have been selected according to following criteria:

- To select river reaches representing ‘reference sites’ (i.e. showing predominantly natural conditions).

- To select river reaches presenting different habitat conditions or peculiar morphological alterations.
- To cover a wide gradient of morphological alterations, ranging from slightly to severely altered water bodies.
- Lastly, where possible, contiguous sampling stations showing obvious differences in habitat features but located on the same river reach were selected, so that water quality was the same for both sites and habitat effect can be better discriminated.

In general, the adopted experimental approach considered the so-called 'space for time substitution', for which a wide environmental gradient and a high number of river sites (space) included in the analysis account for the possible variability related to annual or seasonal differences (time). In Sardinia, this strategy led to the selection of river sections showing evident differences also in terms of local hydraulic features, specifically considering the relative presence of lentic and lotic areas, in accordance with the importance of the lentic-lotic character in defining the structure of aquatic biocoenoses in Mediterranean river systems. In this area, a first field campaign was performed in May 2011 and a second one in March 2013, when some of the additional sites were selected in order to increase the number of sampling sites with truly lotic conditions. In Piedmont, where the overall habitat diversification is lower, fewer sampling sites were selected, and data were been collected in the same sites in two different seasons.
In all investigated water bodies, different spatial scales were considered: basin, sub-basin, water body or river stretch, sampling site, mesohabitat and microhabitat. The biological elements investigated are macroinvertebrates and diatoms. The analyses dedicated to habitat/biota relationships and their connection with ecological status evaluation have been based on benthic macroinvertebrates, considered the leading biological element, for which more data is comprehensively available. On some of the inspected river stretches in Sardinia and Piedmont, the experiment of nutrient addition has also been performed, in order to evaluate self-depuration capacity (see I2 action group). In addition to data specifically collected for INHABIT, a set of data from areas not considered in INHABIT (accounting for some extra 400 samples), have been included in the analyses for biological validation of river types and assessment of classification uncertainty.

Figures 1-8 give an idea of the experimental context for rivers in Sardinia (fig 1-4) and Piedmont (fig. 5-8). In both regions, the environmental gradient explored goes from unaltered rivers (reference sites) to rivers with strong habitat alteration (usually, water quality not impacted).

Figure 1. Flumineddu reference. (Sardinia, OT)

Figure 3. Corr'e Pruna (Sardinia, CA)

Figure 5. Sizzone Reference (Piedmont, HER 06, NO)

Figure 7. Guarabione (Piedmont, HER 06, VC)

Figure 1. Tirso reference. (Sardinia, NU)

Figure 4. Foddeddu (Sardinia, OG)

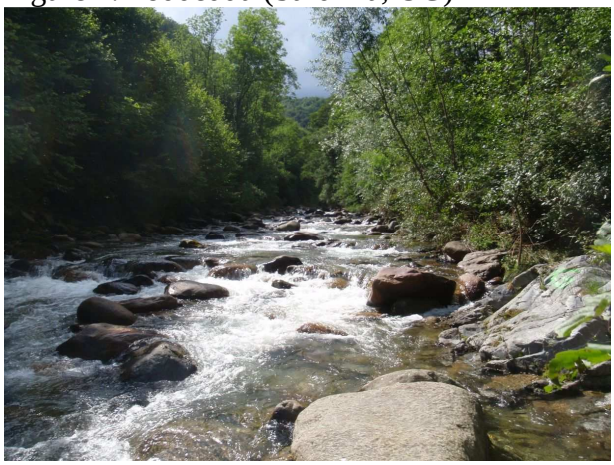

Figure 6. Savenca Reference (Piedmont, HER 01, TO)

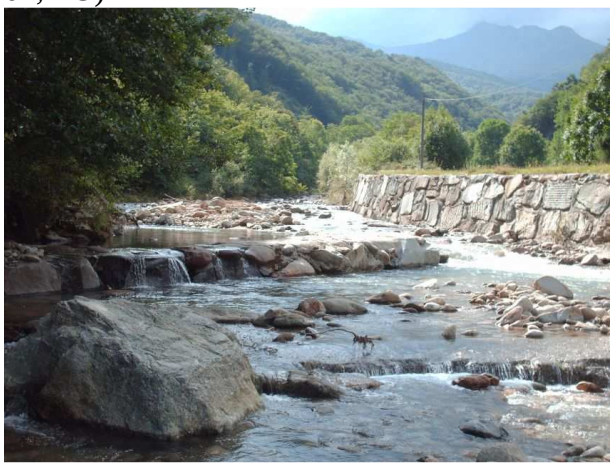

Figure 8. Savenca (Piedmont, HER 01, TO)

Table 1 reports a synthesis of the number of collected data for rivers (including the samples considered for I2 action group).

Table 1. Amount of data collected and used for rivers analyses. NP= Not Planned in the proposal; NA= Not Available; HER: Hydro-Ecoregion.

| | | HER | Italian official WFD river type | River stretches investigated | # HABITAT characteristics (transects) | # benthic samples (used for WFD classification) | # benthic samples ( from individual micro-habitat ) | # samples for water quality analyses | # river stretches for nutrients experiment addition | # nutrients addition samples |
|---|---|---|---|---|---|---|---|---|---|---|
| INHABIT (newly collected data) | Sardinia | 21 | IN, EF, SS, SR | 48 | 480 | 88 | 880 | 48 | 23 | 621 |
| | Piedmont | 1 | SS2 | 9 | 160 | 30 | 300 | 18 | NP | NP |
| | Piedmont | 6 | SS2 | 8 | 150 | 24 | 240 | 16 | 6 | 390 |
| | Lombardy | 6 | SS2 | 1 | 20 | 4 | 40 | 1 | 2 | 93 |
| | **Tot INHABIT** | | | **66** | **810** | **146** | **1460** | **83** | **31** | **1104** |
| Extra data (from existing datasets)* | Sardinia | 21 | IN, EF e SS | 30 | 370 | 72 | 720 | 36 | NA | NA |
| | Piedmont | 1 | SS2 | 33 | NA | 137 | NA | 137 | NA | NA |
| | Piedmont | 6 | SS2 | 17 | NA | 59 | NA | 59 | NA | NA |
| | Piedmont | 4 | SS1, SS2, SS3 | 5 | NA | 28 | NA | 28 | NA | NA |
| | Piedmont | 5 | SS2, SS3 | 2 | NA | 5 | NA | 5 | NA | NA |
| | Piedmont | 8 | SS1, SS2, SS3, SS4 | 8 | NA | 46 | NA | 46 | NA | NA |
| | Piedmont | 10 | SS1, SS2, SS3 | 7 | NA | 29 | NA | 29 | NA | NA |
| | Alto Adige | 3 | 03SS2 | 21 | 100 | 40 | NA | 40 | NA | NA |
| | **Tot extra** | | | **123** | **470** | **416** | **720** | **380** | **0** | **0** |
| **GRAND TOT** | | | | **189** | **1280** | **562** | **2180** | **463** | **31** | **1104** |

*data used for accuracy testing, river types validation, analysis of the relationships between biological metrics and environmental gradients.

## Lakes

***Problems experienced*** - In Lake Baratz, Sardinia, unexploded bombs dating to World War II were present on the bottom, so it was not possible to sample all biological elements (sampling was restricted to phytoplankton and macrophytes); therefore, it was necessary to add another lake that could replace Lake Baratz adequately, for all biological elements and hydomorphological features to be properly assessed. Bad weather was also an important factor for lake sampling, but all the expected sampling activities were carried out.

***Results*** - Biological, and hydro-morphological data on lakes were collected mainly by CNR-ISE through dedicated field sampling from autumn-winter 2011 until autumn 2012 (mainly), in different periods, depending on biological community. With regard to chemical sampling and some biological sampling (phytoplankton in lakes of Sardinia) subcontracting was assigned to University of Sassari to provide support to CNR-ISE in data analysis for the assessment of natural and anthropogenic variability. University of Sassari carried out phytoplankton sampling into euphotic zone and analysis 6 times every year, for a total of 36

samples and 3 chemical samples, collected in the metalimnion and ipolimnion, for 6 times every year. In situ, contextually to sampling, additional physio-chemical variables have been measured e.g. transparency with Secchi disk, water temperature, oxygen dissolved, pH and conductivity, with multiparametric probe. Biological analyses have been performed through total count of phytoplankton organisms at the species level; chemical analyses for determination of total alkalinity, ammonium, nitrate, total nitrogen, reactive phosphorus, total phosphorus, and reactive silica. All these activities have been made according to the National official guidelines "Protocollo per il campionamento del fitoplancton in ambiente lacustre" available on ISPRA Web site. In Piedmont, phytoplankton and chemical analysis were partly carried out by CNR ISE and partly by ARPA Piemonte. Logistic support was offered by authorities and companies managing reservoirs, such as ENAS in Sardinia and ENEL in Piedmont. All sampling data have been used for elaboration of water and biological quality for each water body, as reported in deliverables I1d1, I1d2 and I1d3.

Data collection (activities carried out by CNR-ISE) was concluded in 2013. A large effort was done to ensure field work for all biological quality elements. In the case of macroinvertebrates, data collection has been done on all lakes and reservoirs together with sediment sampling and granulometric analyses. The criteria used to select study lakes are:

- at least one reference site within the two regions of the project. In the Piedmont Region the only lake that seemed to meet the requirements to be a reference site, at least for eutrophication and phytoplankton, is Lake Mergozzo. In Sardinia, there is only one natural lake, while all other lentic waterbodies are reservoirs, which cannot be considered in reference conditions from hydromorphological point of view, but they can be in trophic conditions close to reference status, such as Sos Canales and Torrei reservoirs.
- At least two lakes in the same catchment area of selected rivers, in order to concentrate the activities in the same areas and to interact in the definition of the suggestions of measures for the improvement of RBMPs. In Piedmont selected lakes were Morasco, in the basin of the River Toce, and Serrù, in the basin of river Orco. In Sardinia they were Liscia, in Liscia River basin , Posada, in Posada River basin and Torrei, Tirso river basin.
- Lakes belonging to different types and reservoirs with different use (e.g., hydropower, drinking water, agriculture), and a balance between natural lakes and reservoirs. As there is only one natural lake in Sardinia, we focus on natural lakes in Piedmont.
- Natural lakes in different climatic and altitudinal zones.
- Presence of previous data, in particular for reservoirs in Sardinia where the large year-to-year variability in precipitation that can affect phytoplankton composition and biomass.
- Special regional interests.

In light of the above criteria, the lakes investigated were 13: 12 lakes for all biological quality elements (phytoplankton, macrophytes, macroinvertebrates and fish) and only 1 for phytoplankton and macrophytes, namely Lake Baratz, for which a full sampling was not possible because of the presence of unexploded ordnance on the bottom. Selected lakes are in the following types: AL-2 (shallow, Alpine), AL-9 (deep, Alpine), AL-5 (shallow, low altitude) and AL-6 (deep, low altitude) in Piedmont and ME-2 and ME-3 (shallow Mediterranean), ME-4 and ME-5 (deep Mediterranean) and S (brackish, not connected with the sea) in Sardinia.

Figures 9-12 give an idea of the experimental context for lakes in Sardinia (figg. 9-10) and Piedmont (figg. 11-12).

Figure 9. Liscia lake (Sardinia, OT)

Figure 10. Bidighinzu (Sardinia, SS)

Figure 11. Avigliana Piccolo (Piedmont, TO)

Figure 12. Viverone (Piedmont, BI)

Table 2 reports a synthesis of the number of collected data for lakes.

Table 2. Amount of data collected and used for lakes analyses.

| | | | Tipo | # Lakes | # HABITAT characteristics (transects) | # samples for water quality analyses | # samples for sediments quality analyses | #samples for granulometry | # fitoplancton samples | # macrophytes samples | # benthos samples | # fish samples (nets) | # fish samples (eletctrofishing) |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| INHABIT | Sardinia | S | | 1 | 0 | 6 | | | 6 | 1 | 0 | 0 | 0 |
| | Sardinia | ME-2 | | 1 | 10 | 6 | 10 | 2 | 6 | 0 | 10 | 64 | 130 |
| | Sardinia | ME-3 | | 2 | 10 | 12 | 15 | 4 | 12 | 0 | 15 | 8 | 52 |
| | Sardinia | ME-4 | | 1 | 10 | 5 | 15 | 3 | 5 | 1 | 15 | 22 | 0 |
| | Sardinia | ME-5 | | 1 | 10 | 5 | 12 | 2 | 5 | 2 | 12 | 33 | 36 |
| | Piedmont | AL-2 | | 1 | 10 | 3 | 4 | 1 | 3 | 0 | 4 | 26 | 0 |
| | Piedmont | AL-5 | | 2 | 20 | 12 | 30 | 9 | 12 | 18 | 30 | 10 | 56 |
| | Piedmont | AL-6 | | 3 | 30 | 18 | 62 | 31 | 18 | 46 | 62 | 84 | 307 |
| | Piedmont | AL-9 | | 1 | 10 | 3 | 12 | 2 | 3 | 0 | 12 | 22 | 0 |
| | **tot** | | | **13** | **110** | **70** | **160** | **54** | **70** | **68** | **160** | **269** | **581** |
| Extra data* | Piedmont | AL-3 | | 2 | 60 | | | | | | | | |
| | **GRAND TOT** | | | **15** | **170** | **70** | **160** | **54** | **70** | **68** | **160** | **269** | **581** |

* used to test Lake Habitat Survey method

### 4.1.3 Group of actions I2

This group of actions was dedicated to the evaluation of nutrient retention efficiency by means of short-term nutrient addition experiments in the studied river reaches (I2_IRSA). For lakes, the activities were based on the analysis of long term data series (I2_ISE).

***Rivers***

***Problems*** - In a few Piedmont rivers, the second field campaign, planned for October 2011, was not fully performed, because hydrological conditions were not suitable (i.e. high flow) to carry out the addition experiments. In one of these water bodies, the addition was postponed to May 2012, while two other sites were abandoned, as they exhibited a hydrological variability not consistent with the experimental protocol. To face this problem, an additional site on the Curone stream, in Lombardy, was selected, where a sampling campaign was carried out in October 2011.

***Results*** – (I2_IRSA; I2_PI). The field campaigns as well as the chemical analysis of the collected samples have been successfully completed. Data elaboration for the physio-chemical and hydrological characterisation of the study sites and for the computation of the uptake length and the other associated metrics were also completed. The obtained results are included in the Deliverables I2d1, I2d2, I2d3 and I2d4 available on INHABIT web site and attached to the present report. The analyses carried out within this group of action (Deliverable I2d3 and I2d4) revealed complex interactions between nutrient retention metrics, hydro-morphology, habitat and ecological indicators. One of the most interesting results is the observed

relationship between the nutrient retention efficiency, expressed as "uptake length", and the "transient storage" zones (i.e. local lentic conditions, spots of stagnant water that is not subjected to downstream transport). Uptake length of both ammonia and ortophosphate decreases at the increasing of the transient storage area normalized for the river section (As/A) (Fig. 13). The nutrient retention processes are enhanced at locations where the reduced current velocity allows a longer contact between water and active biological surfaces (e.g. sediments).

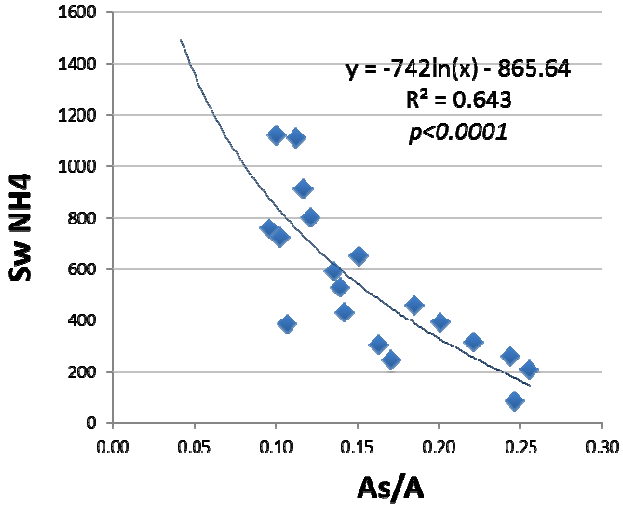


Fig. 13. Relationship between transient storage area (As/A) and the uptake length of $NH_4$ for the Sardinian river stretches examined.

We observed highly significant and distinct relationships between the size of storage areas (As) and the ratio between wet channel width and channel depth (w/d), for unmodified river stretches and re-sectioned ones. This finding has important implications on the upscaling of results and for river management.


Fig. 14. Rio Baldu upstream (left) and downstream (right) a specific alteration (culvert).

We detected the effects of hydro-morphological alterations in selected sites downstream specific artificial structures (e.g. culverts, fords, embankments), that showed lower or no retention and reduced transient storage areas (Fig. 14).
Lastly, we found a significant and indeed interesting relationship between the $NH_4$ uptake velocity (Vf) and the STAR_ICM index, suggesting a link between the retention efficiency and the biological quality, as expressed by the macroinvertebrate community. In addition, the

analysis of the trophic roles of aquatic invertebrates permitted to further investigate these interactions, highlighting the importance of grazers taxa and, apparently, of periphyton.

***Lakes***
***Problems***– No problems related to the implementation of this action group.
***Results –*** (I2_ISE; I2_PI). CNR-ISE prepared four deliverables related to action I2_ISE: a database of long temporal series of nitrogen concentration in atmospheric deposition and lake and river water (I2d5), a report on modelling nitrogen behaviour in selected catchments (I2d6), a report on statistical analysis of the relation between nitrogen concentration and species composition (I2d7) and a report summarizing the effects of nitrogen pollution on lakes and rivers and containing suggestions for improvement of RBMPs (I2d8). From the data collected in deliverable I2d5 it appears that in part of both Piedmont and Sardinia regions, the atmospheric deposition of nitrogen compounds exceeds the critical load for forest soils. As a consequence, rivers and streams in pristine area carry nitrate to the lakes. For each lake considered in the INHABIT project, we estimated the amount of nitrogen reaching the lake and coming from atmospheric deposition and we compared those values to the amounts due to human activities in the catchment (deliverable I2d6). The statistical analysis of the relation between nitrogen concentration and species composition (deliverable I2d7) showed that phytoplankton is the biological quality element more sensitive to nitrogen concentration. High levels of nitrogen may cause high biomass and/or blooms of some species of cyanobacteria. Because of the atmospheric deposition of nitrogen compounds, phytoplankton is also affected in lakes considered as “reference sites” on the basis of the analysis of the human pressure in the catchment. The modifications of the phytoplankton biomass and composition in “reference” sites was evaluated in deliverable I2d8, considering the effect on lake classification. Results showed that relatively oligotrophic lakes are dominated by different algal classes in relation to atmospheric nitrogen inputs.
Expected Deliverables (attached to the present Report) and Milestone for this group of action were all reached.

### 4.1.4 Group of Actions I3

This group of actions was dedicated to devising how habitat data and information can be included in innovative restoration measures and/or contribute to enhance the efficacy of existing ones, for improving RBMPs. The activities in this action group have been largely based on the results of previous actions and are strictly connected to D1 and D2 action groups. Inputs from D2 action group (related to regions not directly covered by the project) were included in I3 results and results of I3 action group were included in D1 and D2 action groups. All partners contributed to this group of actions, in particular CNR-IRSA led the analyses linked with rivers and CNR-ISE led the lake part. Within this group of actions, subcontracting was activated, in relation to habitat characterization and large scale analysis. The results of such subcontracting activities are included mainly in Deliverable I3d2.

***Problems*** – This group of actions experienced some delay, but all the expected results have been obtained.
***Results*** – The planned Milestones and Deliverables (attached to the present Report) for this group of actions have been all achieved and completed. Main results dealing with this group of actions are summarized hereafter. Some of the contributions presented in the various project deliverables will be considered for inclusion in a dedicated issue of the ‘Notiziario dei Metodi Analitici’, an ISSN journal published by CNR-IRSA, after a review process. Publication is expected by the first half of 2014.

About ecological status evaluation in **lakes** and hydro-morphological and habitat variability, it has to be emphasized that:

- there are correlations between the macroinvertebrate-based BQIES index and hydromorphological variables;
- estimated fish abundance is correlated to the morphological characteristics of the littoral zone. However, the composition of the fish fauna as a whole is more sensitive to the chemical, physical and trophic variables than to hydromorphology;
- macrophytes composition is related to the nature of the shore substrate and the land use of both the bank and surrounding area, particularly in presence of trees or structures shadowing lake surface;
- phytoplankton, strictly pelagic, is not particularly influenced by the morphological quality of the shore, but its biomass reacts significantly to the year-to-year hydrological variability;
- in small lakes, measures aimed to the reduction of diffuse nutrient load derived from agriculture are important for the improvement of the ecological quality of the lakes and are necessary to improve the adaptation of the lakes to climate change. In fact, a marked relationship between year-to-year meteorological variability and lake ecological quality can be ascribed to climate-related differences in nutrient wash out from arable land.

As far as ecological status evaluation and hydro-morphological/habitat variability in **rivers** are concerned**,** the following points summarize the main results obtained.

- INHABIT assessed the precision of the invertebrate method used to derive ecological status (in relation to e.g. sampling, identification, sorting), for a wide range of river types. This was done by quantifying both the variance associated to variability of reference conditions and 'sampling' variability observed along the whole degradation gradients.
- All Italian IC-macrotypes i.e. those officially intercalibrated during the CIS intercalibration process, have been analyzed, and precision coefficients provided. The coefficients obtained for 'sampling' variability are comparable to those found in the literature, with smallest ones observed for Alpine rivers, where the degradation gradient is shorter than elsewhere. For reference conditions, the greatest variability has been observed in the Mediterranean area, where the high variability of habitat conditions can lead to greater uncertainty.
- The probability of attribution (percentage) to each Ecological Status class was calculated for a range of sample datasets (from Piedmont, Sardinia and Alto-Adige), according to the STARBUGS approach.
- The analyses run in INHABIT nonetheless support the conclusion that the abovementioned portion of uncertainty (i.e. precision of methods), in the peculiar Mediterranean environment, at times accounts for a minor part of the overall uncertainty (read variability) associated to ecological status attribution in river systems. In fact, if compared to the part of variability in biological metrics related to the diverse habitat conditions that can be found at a river stretch e.g. in different seasons and years, the 'precision' component is less significant.
- This conclusion is particularly evident when we consider the proportion of lentic and lotic areas (LRD, Lentic-Lotic character) found in the water body. In absence of hydrological alterations, the effects of natural LRD variations can lead to a misinterpretation of community structure and ecological status. On the other side, similar effects on the aquatic community are observed when the LRD varies in relation

to anthropogenic alteration (see Figure 15). Higher values of STAR_ICMi - optimal conditions for the invertebrate community - are observed at intermediate values of LRD (i.e. not extremely lentic nor lotic rivers), around '0' or slightly higher. Moving toward more lotic conditions (negative LRD values) or more lentic (positive), values observed for the biological metrics usually decrease and points are distributed along an approximately 'bell-shaped' curve. These effects are particularly evident in the Mediterranean area, but can be manifest also outside this area. Accordingly, INHABIT proposed a model, in the details dedicated to Sardinia, to better estimate the expected reference conditions for biological metrics in relation to LRD, in order to have more accurate classification systems (**Deliverable I3d1**): a site-specific approach is added to the type-specific one.

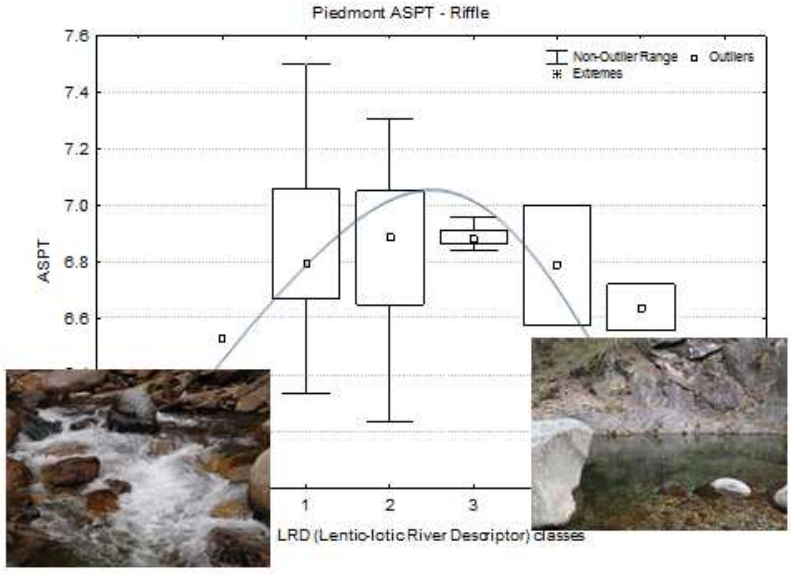


Figure 15. Variability of the ASPT metric in Piedmont riffle samples. In blue the 'Arch effect' linked with relative presence of lentic and lotic areas. Left side: very lotic river stretches; Right side: river stretches with higher proportion of lentic areas.

- As an additional, highly relevant result, the approach proposed by INHABIT can be managed to assess the impact due to water abstraction, by quantifying the deviation of observed biological metrics value from expected values in relation to observed/expected LRD values. Mostly, this deviation is linked with the aptitude of biological communities to adapt to different lentic-lotic conditions. Normally, in the Mediterranean area, when water is diverted from river channels the lentic-lotic character goes from neutral/slightly positive to highly positive (i.e. reproducing the same effect of 'natural' low flow conditions). This has the evident effect of lowering most biological metrics.
- INHABIT has also demonstrated that in the Alpine area water abstraction can determine an apparent improvement of ecological quality (see Fig. 15), in fact corresponding to an important alteration of biological communities, that can be clearly detected if the lentic-lotic character is evaluated. In such circumstances, assessing ecological status in an unbiased way will need to quantify the 'distance' from reference conditions in absolute terms i.e. through an increase or decrease of

biological metrics, and not simply by looking at the decrease in their value: when water abstraction is present, this last situation would lead to a remarkable overestimation of river quality.

- INHABIT provided elements for interpreting the effect of interactions between different habitat elements on aquatic communities (see Figure 16). For instance, evidence was found proving how the quantity and quality of riparian and aquatic habitats directly influence the capacity of biological communities in tolerating water pollution, water abstraction and morphological alteration. In particular, it was demonstrated that the simultaneous presence of optimal conditions for different habitat features - e.g. habitat diversification and lentic-lotic character (LRD) - can limit the negative effects of other perturbation factors (e.g. pollution, morphological alteration). As for points above, when assessing ecological status in presence of any major alteration, the potential mitigation or amplification of its effects due to the relevant habitat aspects should be considered, especially while setting restoration measures.

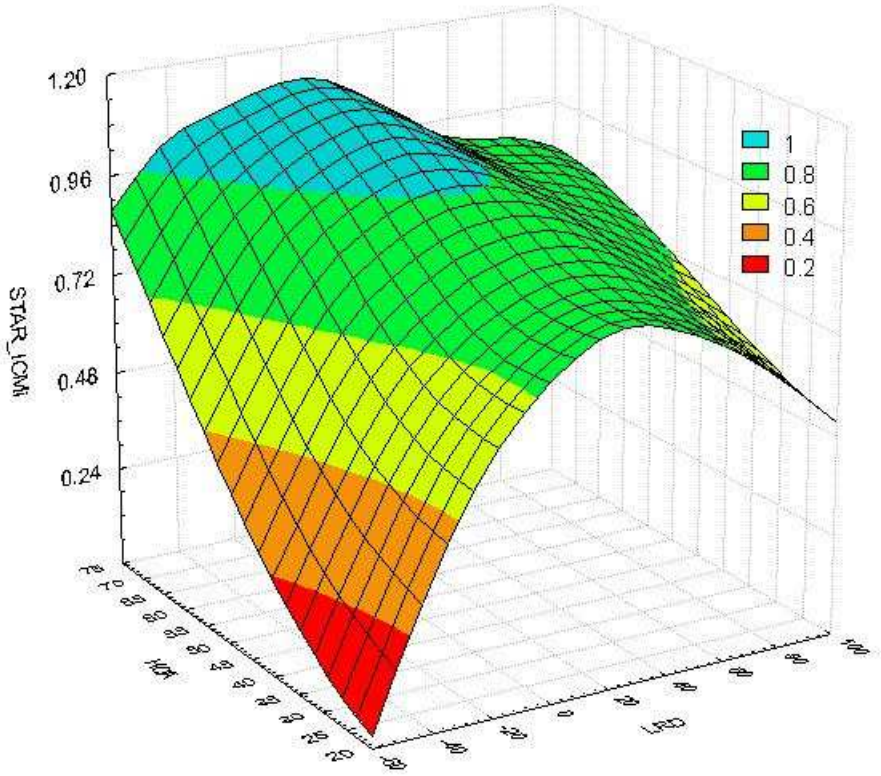


Figure 16. Example of biological response (river invertebrates) in not or only slightly altered river stretches to difference levels of habitat quality, in terms of ecological status (STAR_ICMi in pool mesohabitat, Sardinia). High habitat diversification (HQA, y axis) mitigates the effects of extreme lentic-lotic conditions (LRD, x axis) on the STAR_ICM index. Classes and colors in figure approximately correspond to ecological status classes.

- A list of possible actions addressed at improving habitat quality was delineated. The potential effects of such actions were quantified in **Deliverable I3d2**.

- **Annexed to Deliverable I3d2** (attached to the present report) the 'Guida al rilevamento e alla descrizione degli habitat fluviali - Manuale di applicazione del metodo CARAVAGGIO / Survey and description of river habitats - Manual of the CARAVAGGIO method'. Monografie dell'Istituto di Ricerca Sulle Acque del CNR, Roma, 1/i' was compiled and printed. This manual, produced in relation to habitat characterization activity, has been partly supported by subcontracting.
- As well, as part of the activity linked with habitat characterization, the **CARAVAGGIOsoft** has been upgraded and finalized. This product is a MS Access-based software dedicated to managing the data collected with the CARAVAGGIO method and includes calculation routines for the quantification of a series of river habitat descriptors (HQA, HMS, LUI, LRD). The software is included as attachment to the present Report.
- **Habitat at a large spatial scale** was characterized in this group of actions (subcontracting activity). Results of such analysis are included in **I3d2** report (rivers). In particular, main processes related to bank erosion and depositional/erosional zones at the catchment scale in Sardinian INHABIT study areas were assessed (by GIS). Moreover, land erosion trends, sediment transport balance, artificial structures and river longitudinal continuity in the same areas were evaluated (Figure 17), again by using GIS tools. Results showed that, in all catchments, the presence of dams highly influences longitudinal connectivity and sediment transport. The more affected catchments are Flumendosa and Cedrino. The condition of buffer strips was evaluated by combing data from GIS and CARAVAGGIO. Mixed woodland is the primary vegetation structure more suitable to maintain banks stability. In general, wide catchment portions are characterized by some criticisms on this aspect i.e. riparian forests scarce, and we observe a diffuse bank instability. However, the 'Macchia Mediterranea' has probably to be re-considered as primary vegetation structure (i.e. when running analysis, it should not be pondered as equivalent to degraded vegetation), and the presence of bank instability has not to be considered *per se* a degraded or unnatural condition.

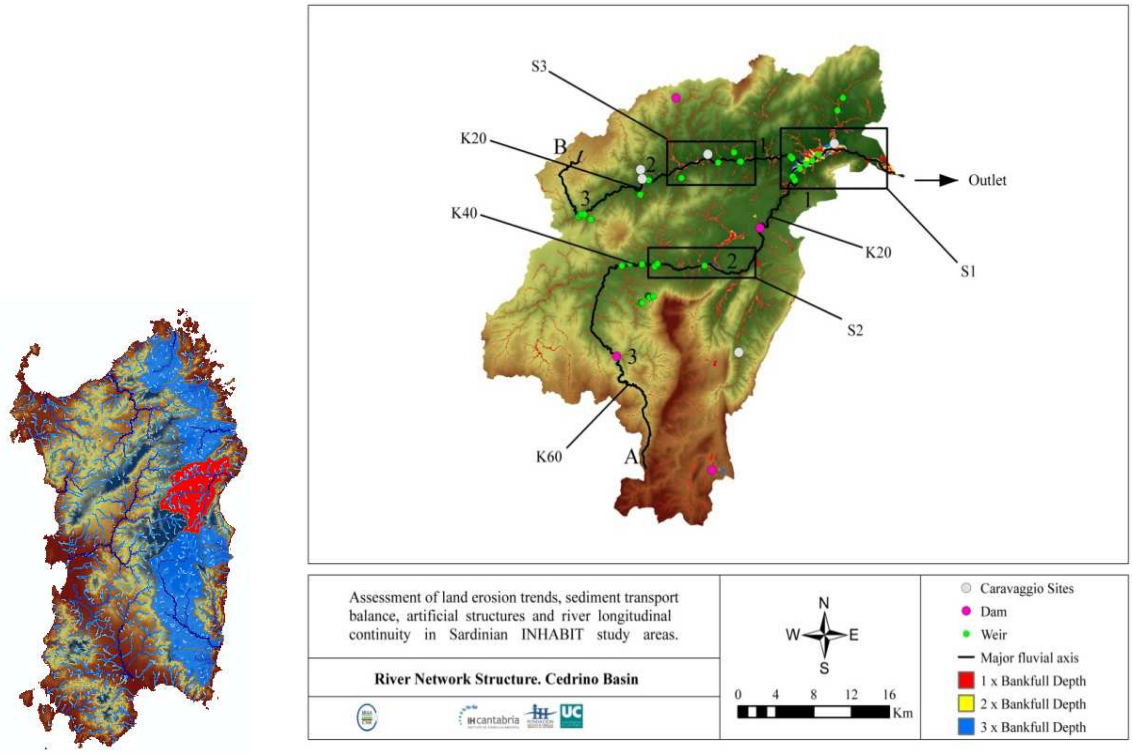


Figure 17. Summary of River Network analysis in the Cedrino catchment to predict sediment loads.

- The observed relationships between the nutrient retention metrics and the transient storage areas demonstrated that habitat features profoundly affect not only the biological communities but also the dynamics of nutrients and in particular the retention efficiency of $NH_4$ and $PO_4$. In highly diversified river stretches with high habitat richness the chance to find locations of comparatively stagnant waters (e.g. As) is increased, if compared to altered river stretches. This seemingly supports a higher retention efficiency. In terms of potential management practices and/or river restoration works, the efficiency of nutrient retention might be increased through interventions on the river channel, aimed at increasing local topographic complexity, the surface/volume ratio and hydraulic retention, so as to allow greater contact between water, sediment and benthic communities. INHABIT results on this regard are outlined in **Deliverable I3d3** (in Italian and in English).

**Both rivers and lakes**

**Deliverable I3d4** is a summary of most relevant results gained in INHABIT for both rivers and lakes, also including nutrient related aspects. The document is presented as a **guideline** to support the achievement of good ecological status **by considering habitat issues**, at all the scales and with all the approaches developed within INHABIT. These guidelines are in English and in Italian.

### 4.1.5 Group of Actions D1

This group of actions deals with the practical application in the studied area of the most updated WFD-compliant methods, in relation to both biological elements and habitat.

***Problems*** – This group of actions experienced some delay, but all the expected results were completed.
***Results*** – The planned Milestones and Deliverables (attached to the present Report) for this group of actions have been all achieved and completed. Main results dealing with this group of actions are summarized hereafter. Some of the contributions presented in the various project deliverables will be considered for inclusion in a dedicated issue of the 'Notiziario dei Metodi Analitici', an ISSN journal published by CNR-IRSA, after a review process. Publication is expected by the first half of 2014.

**Rivers –** The classification according to the most up to date WFD classification tools was completed for both water bodies investigated during the INHABIT project (D1) and those not directly investigated in the field by the project (D2). Most results are jointly included in **Deliverable D1d1**. An updated version of this deliverable (attached) was produced in order to include field data collected in March 2013 for rivers and classification based on Diatoms community, for Piedmont water bodies; for practical reasons, equivalent results for Sardinia are included in Deliverable I3d1.
All main results and approaches have been summarized in **Deliverable D1d5** (both in Italian and in English). More in detail, the most important results obtained within this group of actions are linked to the **selection of biological metrics** able to detect definite anthropogenic stressors or to react to a specific environmental gradient. An example synthesis of these results is reported in Table 3.

Table 3. List of biological metrics (invertebrates, rivers) usable to detect specific anthropogenic stress or environmental factors. RQ= Quantile Regression analysis, RDA= Redundancy analysis.

| | Pool | Riffle | Analysis |
|---|---|---|---|
| General degradation (water quality, habitat, morphological alteration and land use) | STAR_ICMi | STAR_ICMi | RQ |
| | ASPT | ASPT | RQ |
| | nEPT | nEPT | RQ |
| | Shannon Diversity | -- | RQ |
| | LEPab (Abundance of Leptophlebidae) | -- | RQ |
| | DIPab (Abundance of Diptera) | -- | RQ |
| | -- | NFAM | RQ |
| | SelTRI_GN (Abundance of Odontoceridae, Limnephilidae, Polycentropodidae) | SelTRI_GN (Abundance of Odontoceridae, Limnephilidae, Polycentropodidae) | RDA |
| | | Sel Ple (Abundance of Nemouridae, *Leuctra*, Perlidae) | RDA |
| Habitat (HQA) & morphological alteration (HMS) | nFAM | -- | RQ |
| | log(SelEPTD) | -- | RQ |
| | DIPB (Abundance of Ceratopoginidae, Culicidae e Syrphidae) | -- | RQ |
| | % shredders | % shredders | RQ |

| | | | |
|---|---|---|---|
| | -- | MTS (Mayfly Total Score) | RQ |
| Morphological alteration (HMS) | 1-GOLD | 1-GOLD | RQ |
| | -- | log(SelEPTD) | RQ |
| | *Dugesia&Lymnaea* | *Dugesia&Lymnaea* | RDA |
| Water Quality (LIMeco) | SelOLIGHI_SA (Abundance of Naididae, Tubificidae, Chironomidae) | -- | RQ |
| | MTS (Mayfly Total Score) | -- | RQ |
| | TRIab (Abundance of Trichoptera) | TRIab (Abundance of Tricotteri) | RDA |
| | SelTri_SA (Abundance of Leptocaeridae, Rhyacophilidae, Glossosomatidae) | SelTri_SA (Abundance of Leptocaeridae, Rhyacophilidae, Glossosomatidae) | RDA |
| | *Leuctra&Calopteryx* | *Leuctra&Calopteryx* | RDA |
| | SelEpheGN (Abundance of *Procloeon, Centroptilum, Ecdyonurus*) | SelEpheGN (Abundance of *Procloeon, Centroptilum, Ecdyonurus*) | RDA |
| Lentic-lotic character (LRD) | nOCH (number of taxa of Odonata, Coleoptera, Hemiptera) | nOCH (number of taxa of Odonata, Coleoptera, Hemiptera) | RQ |
| | *Baetis*/BAETIDAE | *Baetis*/BAETIDAE | RQ |
| | SelEpheM (Abundance of *Baetis cfr. rhodani, Ecdyonurus, Habrophlebia*) | | RDA |

The selection of such metrics is particularly useful to assess the efficacy of restoration measures and to set out and/or **interpret surveillance and investigative monitoring** (*sensu* WFD). Moreover, Deliverable D1d5 includes a description of **aquatic state** and its importance in ecological status evaluation, jointly with a contribution on managing possible **conflicts among end-users**, which is dedicated to the Mulargia river basin (Sardinia). This work wants to highlight the possible conflicts arising when different users are interested to the same resource (water), also in relation to the adoption of different environmental regulation and criteria.

**Lakes -** A database of monitoring data for lakes was compiled and delivered (**D1d2)**. The reports for modelling reference conditions for lakes and on temporal and spatial variability of reference conditions, BQEs and EQRs were also completed (**D1d3 and D1d4**).
The modeling exercise carried out during the INHABIT project showed that:

- in the case of phytoplankton, the spatial approach used to define the class boundaries in the Italian rules can be considered reliable for most Italian lakes. Our results also suggest that $PTI_{ot}$ index may be used for all Italian lakes, and the use of a specific index ($PTI_{species}$) for the deepest lakes is not necessary;
- for shallow Mediterranean lakes (types ME-1 and ME-2) it seems to be necessary to verify reference conditions case by case, using more complex models or palaeolimnological approaches, to avoid to set too strict quality targets;
- the lack of a simple and direct relationship between reference total phosphorus concentration and quality indices based on the other BQEs does not allow to extend this exercise to all the quality indices.

### 4.1.6 Group of Actions D2

This action group deals with pilot applications of approaches developed within the project to other sample river stretches/basins, in regions not directly covered by project field activities. The core of this action group is linked to the organization of workshops and meetings dedicated to the transmission, application and discussion of results gained in the other action groups. To prepare the workshops, data from institutions not present in the project partnership have been considered and analysed (see also I3 and D1). The outcomes of the workshops were jointly analysed by project beneficiaries and were used to refine the work in I3 action group. All partners participated to the national workshops, while international workshops were a CNR-IRSA activity.

***Problems*** – We experienced some problems in the organization of the first workshop, related to the delay in receiving feedback from the Commission on the Mid-term report, that led us to reschedule the dates for workshops organization. In general, this group of actions experienced some delay, but all the expected activities were finally completed and results obtained.

***Results*** – The two national workshops planned in the proposal, dedicated to apply results in areas not covered from the project were held since December 2012. In addition, three international workshops were organized, in Vienna (A), Barcelona (ES) and Nicosia (CY), the last two with emphasis on the Mediterranean environment and its open WFD issues. The main objective of the international workshops was to exchange information on approaches related to the evaluation of habitat/biota relationships and to disseminate INHABIT results and approaches. This was done in order to assess comparability of INHABIT methodologies and outcomes with analogous activities and results in other EU countries and to promote the application of INHABIT approaches in such countries. At National level, we concentrated on disseminating INHABIT approaches and consolidated results, with examples from various geographic areas. The organization of such workshops gave the opportunity of producing two deliverables: D2d1 dedicated to the outcomes of national workshops, including some results obtained as complementary activities demonstrating the applicability of the INHABIT approach elsewhere, and D2d2, in English, dedicated to international activities (here, as well, demonstration of INHABIT approach in other European region). Papers included in these Deliverables deal with the following issues: general presentation of INHABIT actions, the adopted experimental approach, the activity of reference sites validation and critical aspects of typology issues, results of classification of investigated river sites, results of nutrient addition in river stretches, the approach and possible proposal for Good Ecological Potential definition in an Italian case study, the habitat control on ecological status. A significant part of deliverable D2d2 is dedicated to illustrate topics parallel or complementary to those developed in INHABIT as perceived in other Mediterranean countries, Cyprus and Greece.

The first national workshop, organized by CNR-IRSA and RAS, was held in Cagliari on 11-12 December 2012; it has seen participation of about 60 people mainly form ARPAS (Environment Protection Agency of Sardinia) and from Regione Sardegna. Officers from the Italian Ministry of the Environment and Protection of Land and Sea (MATTM), ENEA and local organizations were also present (see the Annex 'list of participants to 1$^{st}$ national workshop' attached to Deliverable D2d1). This first workshop also gave the chance to celebrate the 20$^{th}$ anniversary of the LIFE Program. The second national workshop was held in Rome, on 27 March 2013, and was organized by CNR-IRSA with the collaboration of 'Università la Sapienza'. About 75 people, coming from different contexts (e.g. Universities,

National and Regional Environment Agencies, private companies, catchment authorities) participated to the workshop (see the list attached to Deliverable D2d1).
The first International workshop was held in Barcelona, hosted by Universitat de Barcelona on October 2012, and involved the participation of the University of Barcelona, University of Cantabria, Catalan Water agency, Centro de Estudios Avanzados de Blanes – CEAB (see the list of participants attached to Deliverable D2d2). The workshop was addressed to a relatively small number of participants (15-20 people) including mainly scientists, water managers and representatives from Environmental Agencies. The idea was to discuss topics related to habitat and hydro-morphological assessment under the focus of habitat-biota relationships (INHABIT approach) and potential nutrient retention. The second International workshop, hosted by Lebensministerium, was held in Vienna on February 2013 and involved the participation of Lebensministerium, Wasser Cluster Lunz and BOKU (see the list of participants attached to Deliverable D2d2). Finally a third workshop was organized in Cyprus (Nicosia), hosted by WDD - Water Development Department in Cyprus. The workshop has been addressed to representatives from the Water Development Department, the Fisheries and Marine Research Department and other Cyprus Governmental Departments, to environmental NGOs and consultancies as well as to water managers and scientists. Similarly to the other occasions, topics related to habitat and hydro-morphological assessment under the focus of habitat-biota relationships (INHABIT approach) were discussed. Here, additionally, focus was placed on presenting the results of applied research programs performed in Cyprus to support the WFD implementation, covering three Biological Quality Elements used in river monitoring: fish, macrophytes and benthic invertebrates. The workshop, organized with the support of Prothea s.r.l. and HCMR - Institute of Marine Biological Resources & Inland Waters (Greece), saw the participation of more than 50 people, coming from different Institutions (see the list of participants attached to D2d2 Deliverable).

For information on the final project conference, please see DI section.

## 4.2 Evaluation

We trust the project successfully completed the planned actions and reached the expected objectives, despite some delay in completing a few activities, in relation to the original time schedule. The INHABIT approach, as defined in the project proposal, was actively put into practice, through the collection of those additional elements necessary to implement and complement with habitat information the assessment systems in use for rivers and lakes. During workshops and dissemination events, people working in the fields of aquatic resources management and freshwater environment demonstrated keen interest in project results and showed availability in putting into practice INHABIT approaches, accordingly with resources and time available. INHABIT provided criteria and tools able to support an enhanced management of river and lake ecosystems by the quantification of uncertainty linked with assessment methods, by increasing accuracy in classification of ecological status and, lastly, providing means to prove reliability of restoration measures. Project results were obtained mainly through the analysis of data from a few geographic areas, in Mediterranean environment, in the Alps and in the Po valley. However, INHABIT approaches seem to be directly applicable in the whole of Italy and, at least, in the South of Europe. Globally, INHABIT actions seem then cost-efficient.

DELIVERABLE PRODUCTS OF THE PROJECT

| Deliverable | | Code of the associated action | Expected deadline (month) | Actual deadline (month) | Evaluation |
|---|---|---|---|---|---|
| Pd1 | River basin management plans for the WFD in selected Italian catchments: approaches, methods, scale factors and setting of measures | P_IRSA<br>P_ISE | 6 | 6 | Achieved as planned |
| Pd4 | Guideline and field protocols for deriving nutrient-related information | P_IRSA | 6 | 6 | Achieved as planned. |
| Pd2 | Typology and reference condition criteria in selected Italian catchments: approaches, methods and selection of investigation sites | P_IRSA | 9 | 9 | Achieved as planned, after solving some problems. Some problems in selecting WBs with important habitat alterations in the alpine area in Piedmont. Some problems in finding reference stretches in the Po plain (Piedmont), thus a river was added in Lombardy. Some problems with lakes selection, successfully solved. |
| Pd3 | Guideline and field protocols for deriving hydro-morphological and habitat information | P_ISE | 9 | 9 | Achieved as planned. |
| I2d5 | Database of long temporal series of nitrogen concentration in atmospheric deposition and lake and river water | I2_ISE | 18 | 18 | Achieved as planned. |
| I1d1 | Compilation of a summary report on study areas, field sites, sampling strategy, overall difficulties and outline of main results | I1_IRSA<br>I1_ISE<br>I1_PI<br>I1_SA | 18 | 18 | Achieved as planned. |
| I1d2 | Compilation of a database containing biological and water quality data | I1_IRSA<br>I1_ISE<br>I1_PI<br>I1_SA | 22 | 22 | Achieved as planned. |
| I1d3 | Compilation of a database containing hydro-morphological data | I1_IRSA<br>I1_ISE<br>I1_PI<br>I1_SA | 22 | 22 | Achieved as planned. |
| I2d1 | Report on physico-chemical and hydrological characterisation of the study sites | I2_IRSA | 24 | 24 | Achieved as planned. |
| I2d6 | Report on modelling of nitrogen | I2_ISE | 24 | 24 | Achieved as planned. |

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| | behaviour in selected catchments | | | | |
| I2d7 | Report on statistical analysis of the relation between nitrogen concentration and species composition | I2_ISE | 24 | 24 | Achieved as planned. |
| D1d1 | Report on classification results in the study areas | D1_IRSA | 24 | 24 | Achieved as planned. |
| D1d2 | Compilation of a database of monitoring data, for lakes | D1_ISE | 24 | 24 | Achieved as planned. |
| D1d3 | Report on modelling reference conditions | D1_ISE | 24 | 24 | Achieved as planned. |
| I1d4 | Natural and anthropogenic variability at river sampling sites | I1_IRSA | 26 | 26 | Achieved as planned. |
| I1d5 | Natural and anthropogenic variability at lake sampling sites | I1_ISE | 26 | 26 | Achieved as planned. |
| I3d1 | Ecological status classification and local hydro-morphological/habitat variability: potential effects on effectiveness of restoration measures and criteria to overpass inconsistencies | I3_IRSA<br>I3_ISE<br>I3_PI<br>I3_SA | 27 | 27 (Lakes) 32 (Rivers) | Some delay in the analysis of river data, but results successfully got. Important elements provided for refinements of sampling strategy in lakes and for refinement of reference values in rivers, jointly to some indication on assessing the impact of water abstraction. |
| I2d2 | Report on uptake length measurement and related parameters in river study sites | I2_IRSA | 28 | 27 | Achieved as planned. |
| D2d1 | Proceeding of the 1st workshop published on-line (Report also provided individually) | D2_IRSA<br>D2_ISE<br>D2_PI<br>D2_SA | 30 | 44 | Some delay experienced in relation to the late organization of the 1st national workshop. This product was integrated to 'Italian INHABIT proceedings' collecting 15 contributions presented in the national context and related to INHABIT |
| D2d2 | Proceeding of the 2nd workshop published on-line (Report also provided individually) | D2_IRSA<br>D2_ISE<br>D2_PI<br>D2_SA | 32 | 44 | Some delay experienced in relation to the late organization of the 1st workshop. This product was integrated to 'International INHABIT proceedings' collecting contributions presented in the international context and related to INHABIT |
| I2d3 | Report on comparison of the nutrient retention with the habitat and hydro-morphological indices | I2_IRSA | 30 | 30 | Achieved as planned. |
| I2d4 | Report on the relationship between nutrient retention and aquatic invertebrates distribution and abundance, feeding categories and ecological status classification in the study areas | I2_IRSA | 30 | 45 | Some delay experienced in relation to the field campaign done in March 2013, whose data were included in this report in order to provide a more complete scenario. Results gained are considered complete and satisfactory. |
| I3d2 | Ecological status classification and local hydro-morphological/habitat | I3_ISE | 30 | 45 | Some delay experienced also in relation to the field campaign done in March 2013, whose data were included in this |

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| | variability: proposal of new measures to restore ecological quality | | | | report in order to provide a more complete scenario. Moreover, this product was delayed to way for the analysis at large spatial scale. Results achieved are considered satisfactory. |
| I3d4 | Guidelines on how and where the new set of measures should be adopted to aid the achievement of good ecological status by 2015 | I3_IRSA | 32 | 45 | Some delay experienced in order to wait for the project final results, here summarized in terms of guidelines. |
| I3d3 | Nutrient cycling and good ecological status: proposal of new measures based on local hydro-morphological/habitat features of aquatic environments and large scale concern | I3_IRSA | 33 | 45 | Some delay experienced in relation to the field campaign done in March 2013, whose data were included in this report in order to provide a more complete scenario. Results gained are considered complete and satisfactory. |
| I2d8 | Final report on the effects of nitrogen pollution on lakes and rivers and suggestions for improvement of RBMPs | I2_ISE | 36 | 42 | Some delay experienced, but all results achieved. |
| D1d4 | Report on temporal and spatial variability of reference conditions, BQEs and EQRs | D1_ISE | 36 | 45 | Some delay experienced in relation to new data collected which have improved results reliability. |
| D1d5 | Final report on classification uncertainty and correlated suggestions to improve RBMPs | D1_IRSA | 36 | 45 | Some delay experienced in order to include data collected during March 2013 |
| DId1 | Layman's report | DI_IRSA | 36 | 45 | Completed |
| DId2 | After LIFE communication plan | DI_IRSA | 39 | 45 | Completed |

MILESTONES OF THE PROJECT

| Milestone | Code of the associated action | Expected deadline (month) | Actual deadline (month) | Evaluation |
|---|---|---|---|---|
| Review of approaches and methods used in the preparation of RBMPs | P_IRSA,<br>P_ISE,<br>P_PI,<br>P_SA | 6 | 6 | Achieved as planned. |
| Review of methods and field protocols for deriving nutrient-related information | P_IRSA,<br>P_ISE,<br>P_PI | 6 | 6 | Achieved as planned |
| Selection of water bodies and sites for field investigation and selection of methods to be applied in the field | P_IRSA,<br>P_ISE,<br>P_PI,<br>P_SA | 9 | 9 | Achieved as planned |
| Workshop for harmonizing approaches and field activity between partners | I1_IRSA,<br>I1_ISE,<br>I1_PI,<br>I1_SA | 9 | 9 | Achieved as planned |
| Activation of the web-site | DI_IRSA | 9 | 9 | Achieved as planned. |
| Collation of long temporal series of nitrogen concentration in atmospheric deposition, lake and river water. | I2_ISE | 18 | 18 | Achieved as planned |
| Conclusion of field data collection to assess hydro-morphological, chimico-physical and biological variability - reference conditions and degraded sites - in different water body types. | I1 _IRSA<br>I1_ISE<br>I1_PI<br>I1_SA | 20 | 36 | Some delay experienced firstly linked to weather constraints secondly to the delay in receiving the second pre-financing. All planned data collected: Milestone achieved. |
| Workshop for data analysis planning | I1&D1_IRSA<br>I1&D1_ISE<br>I1&D1_PI<br>I1&D1_SA | 21 | 23 | Achieved as planned |
| Selection of the model and statistical analysis for studying nitrogen behaviour in study catchments under different deposition and climate change scenarios | I2_ISE | 24 | 24 | Achieved as planned |
| Demonstration of innovative approaches to relate habitat/local hydro-morphological information to quality classification | I1 _IRSA<br>I1_ISE<br>I1_PI<br>I1_SA | 26 | 36 | Some delay in relation to the late sampling (see above). Milestone achieved. |
| Classification of ecological status in the study areas according to | D1 _IRSA<br>D1_ISE | 26 | 36 | Some delay in order to include the late collected data. A first |

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| the most updated WFD methods available – Biological and hydro-morphological classification | D1_PI<br>D1_SA | | | classification scheme was provided and secondly updated. Milestone achieved. |
| 1st Workshop on ecological status classification | D2 _IRSA<br>D2_ISE<br>D2_PI<br>D2_SA | 28 | 33 | Postponement in relation to the delay of the second pre-financing. Objectives reached (≈60 people participating) |
| Application of project approaches to classification and measure proposal to a sample area not directly covered by partners | D2 _IRSA<br>D2_ISE | 30 | 36 | Activity largely based on the organization of dedicated workshops. Objectives reached (e.g. more than 150 people participating globally) |
| 2nd Workshop on ecological status classification | D2 _IRSA<br>D2_ISE<br>D2_PI<br>D2_SA | 30 | 36 | Postponement in relation to delay of the second pre-financing. Objectives reached, with more than 70 people participating. |
| Suggestions for improvement of RBMPs and Programmes of Measures as far as uncertainty in classification issues is concerned provided | D1&I3 _IRSA<br>D1&I3_ISE<br>D1&I3_PI<br>D1&I3_SA | 32 | 45 | Delayed to fit with other activities. Milestone achieved. |
| Proposal of measures to achieve good ecological status based on innovative approaches focused on the interaction between hydro-morphology, habitat structure, physio-chemical conditions and biological response, for the RBMPs under examination | I3 _IRSA<br>I3_ISE<br>I3_PI<br>I3_SA | 32 | 45 | Delayed to fit with other activities. Milestone achieved. |
| Proposal of measures to support mitigation of nitrogen contamination at the local scale based on innovative approaches focused on the interaction between hydro-morphology, habitat structure and overall physio-chemical conditions, for the RBMPs under examination. | I3 _IRSA<br>I3_ISE<br>I3_PI<br>I3_SA | 32 | 45 | Delayed to fit with other activities. Milestone achieved. |
| Final conference presenting project results | DI_IRSA<br>DI_ISE<br>DI_PI<br>DI_SA | 36 | 43 | Delayed to fit with other activities. The final conference reached the target and more than 130 people participated from different contexts. Milestone achieved. |

## 4.3 Analysis of long-term benefits

1. *Environmental benefits*

*1a Direct / quantitative environmental benefits*

The foreseen environmental benefits linked with INHABIT are mainly related to the enrichment of management options of inland water bodies, enhanced on the basis of habitat-derived evidence. A range of tools and options to achieve more efficiently the WFD

environmental objectives is provided by the project. An important aspect, often overlooked or not adequately addressed within the River Basin Management Plans, is the relationship between habitat/hydro-morphological aspects and biological quality elements. In Plans where hydro-morphological aspects are evaluated, a single parameters or impact is usually considered, and its effect on ecological quality is rarely weighed. The evaluation of correspondent measures effectiveness is even more infrequent. Anyhow, when ecological quality of water bodies is evaluated, and restoration measures are planned, it becomes crucial to know, assess and quantify the response of the Biological Quality Elements (BQEs) at local and habitat scale. As well, before setting measures in River Basin Management Plans, it appears necessary to fill major cognitive gaps on the pertinent hydro-morphological/habitat aspects and their influence on biocoenoses and ecological quality. The activities carried out within the INHABIT project allow the analysis of both hydro-morphological and habitat features, with special emphasis on highlighting the relationships among these features and biological quality elements. If INHABIT outcomes will be picked up, fine-tuned to regional experience and applied, a far more efficient evaluation of ecological status, and subsequent planning and validation of measures, can be performed in large European areas: this can lead to notable resources savings.
To provide a concrete example, appliance of INHABIT approaches in rivers would strongly limit the occurrence of ‘false positives’ (Mediterranean context) or ‘false negatives’ (Alpine context) when assessing ecological status. More in detail, these two circumstances can be reduced respectively in absence and presence of water abstraction when verifying if any observed distance from reference conditions (and Good or High status) is significant for a test water body. In the first case (Med), this would result in preventing overspending when no restoration is needed according to the WFD (i.e. long-term cost savings obtained); in the second (mountain areas), it will unveil hidden impacts due to anthropogenic flow reduction and therefore be used to direct management practices (i.e. to obtain quantitative environmental benefits).
As an example on the lake side, INHABIT highlighted that pressures on the littoral zone can affect most biocoenoses, decreasing lake ecological quality. As a consequence, adopting measures aimed at preserving this habitat and its biological diversity is fundamental for maintaining ecosystem services, supporting a high biodiversity and a better ecological quality.
In short, as far as project themes are concerned, appliance of INHABIT approaches can lead to an improved environmental protection and/or to cost-effective management of aquatic ecosystems.

In summary, some of the most relevant long term environmental benefits expected are:

- Optimization of monitoring activities for rivers and lakes.
- Activation and /or integration of a simultaneous collection of habitat and biological data.
- Optimization of restoration measures in relation to the tools provided for the evaluation of measures efficacy.
- Optimization of cost effectiveness of restoration practices, in terms of ecological status.
- Identification of innovative measures to restore river and lake habitats.
- Support to quantifying river ecological flow (e-flows) to obtain Good/High Ecological Status, using habitat descriptors e.g. the lentic-lotic character of rivers, and their relation to biological communities.

*1b Relevance for environmentally significant issues or policy areas*

- The project gives practical answers to some points arisen from the EC in the examination of Italian River Basins plans, such as: methods to quantify anthropogenic pressures, methods to assess measures efficacy, methods to validate typological systems in use, methods to assess reference conditions and biological values at reference sites, approaches to improve reliability of ecological assessment methods (see above).
- In small rivers and lakes, measures aimed at reducing diffuse nutrient load derived from agriculture are important for the improvement of ecological quality.
- For lakes, this reduction is necessary to increase the potential adaptation to climate change. In fact, a marked relationship between year-to-year meteorological variability and lake ecological quality can be ascribed to climate-related differences in nutrient wash out from arable land.
- Improvement of the ease of application of WFD-related methods, also in relation to the softwares developed and finalized within the project (CARAVAGGIOsoft and MacrOper.ICM). More in general, the tools developed within INHABIT can be used outside Italy (Europe and outside).
- The project outlined the need for integrating the WFD and the Habitat Directive (92/43/CEE).
- INHABIT outcomes and guidelines can support the ongoing work on ecological flows (as a component of 'e-flows') criteria.

INHABIT clearly demonstrated how habitat information should be directly used when dealing with the assessment of ecological status in inland water bodies. Such information is crucial for, at least, four definite steps:

1) setting biological reference conditions and limiting their apparent variability;
2) interpreting biological response to pressures and unveiling hidden impacts;
3) support to setting adequate restoration measures and
4) make the assessment of measures effectiveness possible, by disclosing and eliminating major confounding effects due to the variation of habitat features.

We think the use of habitat information in such context should find explicit room in normative regulations.

*2. Long-term sustainability*

a. *Long-term / qualitative environmental benefits*

- INHABIT outcomes support sustainability in water resources management.
- INHABIT improves the knowledge related to effective WFD implementation.
- INHABIT improves knowledge on cost/benefits related to measures efficacy evaluation.
- Significant potential on e-flows setting and criteria selection to support WFD objectives (see above).
- Potential of INHABIT approaches for managing habitat information.

b. *Long-term / qualitative economic benefits (e.g. long-term cost savings and/or business opportunities with new technology etc., regional development, cost reductions or revenues in other sectors)*

- INHABIT provided tools to significantly improve accuracy of assessment systems, thus supporting a better evaluation of ecological status and measures setting (i.e. cost savings).
- INHABIT provided an innovative approach and tools to quantify the effects of water abstraction in rivers, in direct relation to assessing ecological status. This can support a better management and improvement of RBMPs, with enhanced potential for efficient resources allocation.
- Especially in the Mediterranean context, INHABIT approaches in rivers have the potential to strongly limit the occurrence of 'false positives' when investigating to discover impacted WBs (i.e. lower than High or Good ecological status) and thus determine long-term cost savings (see also point 1a above).

c. *Long-term / qualitative social benefits (e.g. positive effects on employment, health, ethnic integration, equality and other socio-economic impact etc.)*

- INHABIT results may determine a change in the way the WFD implementation is approached from the BQEs side, because of the new viewpoint focusing on habitat proposed, which is now recognised as a key aspect in structuring and interpreting biological communities. If this new viewpoint will be agreed on the large scale and will find a collocation in European guidelines and/or normative regulations, a whole process can be delineated, including education, training and potentially new job positions.

d. *Continuation of the project actions by the beneficiary or by other stakeholders*

- There is a strong need to perform and extend studies similar to those developed within the INHABIT Project, on further water body types. This will support understanding the complex - and frequently non-linear - relationships among hydrological, morpohological and trophic pressures and biological metrics, helping to identify and calibrate restoration measures. INHABIT beneficiaries will look for other funding sources to go on implementing and developing project guidelines.

*3. Replicability, demonstration, transferability, cooperation*

- The approach applied in INHABIT is strongly transferable to other geographic contexts. For example, the INHABIT approach has been successfully and fully applied in Cyprus rivers jointly with the Water Development Department (WDD) of Cyprus, to aid a sounder assessment of ecological status in intermittent rivers.
- During the execution of the project, INHABIT beneficiaries were careful in considering findings and approaches used in the European contexts (e.g. contacting constantly other Institutes and organizations operating in the field of WFD implementation). The same was done at the National level, and results successively arranged to guaranteeing project demonstrability and applicability.
- The transferability of Project results is ongoing and some more details can be found in the after life communication plan.

*4. Best Practice lessons: briefly describe the best practice measures used and if any changes in the followed strategy could lead to possible adjustment of the best practices*

The background strategy of INHABT was linked to simultaneous collection of biological, chemical and hydro-morphological / habitat data, to understand more about their relationships and thus correcting monitoring actions and measures accordingly. A huge number of recommendations to improve monitoring activities, defining reference conditions, set and validate measures has been proposed during the project (in various Deliverables); the easiest way to pick them up is to refer to INHABIT Guidelines (Deliverable I3d4): 'Guidelines on how and where the new set of measures should be adopted to aid the achievement of good ecological status by 2015'.

*5. Innovation and demonstration value*

Lakes - Innovative technologies developed during the project cover two main topics (1) development of paelolimnological techniques to validate reference conditions for two biological quality elements and (2) tools to assess the influence of local habitat into the quality classification of waterbodies. Demonstration value was mainly based on the verification of the possibility to apply the National standards for lake monitoring and quality assessment in the Mediterranean ecoregion and in reservoirs, and the development of modifications to the National standards in order to keep with the peculiarity of that ecoregion and those waterbodies.

Rivers – The innovation of project results lies in the overall approach applied, which combines directly habitat information and biological elements. In this light, habitat is finally proposed as a crucial tool to set up more accurate classification systems and interpret soundly biological response to pressures and to restoration measures. The highest demonstration value is linked with the full application of INHABIT results and approaches to a range of environmental situations, which may lead in the next future to a possible integration of INHABIT viewpoints in the systems officially in use for WFD compliance in Italy.

*6. Long term indicators of the project success*

The results of the INHABIT project mainly deal with a sound assessment of ecological status, with the governance of waterbodies and with potential improvements to River Basin Management Plans. Long term indicators of the project success can include the following:

- Number of new or updated quality classification methods or elements included in the National legislation refined using results from the project.
- Number of WFD implementation decrees and guidelines including directly or indirectly elements derived from INHABIT outcomes.
- Number of river management plans including measures and/or criteria suggested by the project, such as improvement of habitat quality or control of nutrient release from arable land.
- Number of river basin management plans explicitly including habitat and hydro-morphological quality assessment in areas where INHABIT dissemination has been/will be performed.
- Number of downloads of project Deliverables (in general).
- Number of downloads of project Guidelines (Deliverable I3d4).
- Number of downloads of the Manual: 'Guida al rilevamento e alla descrizione degli habitat fluviali - Manuale di applicazione del metodo CARAVAGGIO / Survey and description of river habitats - Manual of the CARAVAGGIO method' (Annex to Deliverable I3d2).

- Number of downloads of software upgraded during the project (MacrOper.ICM, CARAVAGGIOsoft, APPs).
- Number of people globally visiting the INHABIT web site.
- Number of new visitors of the INHABIT web site (first visit).
- Number of new documents related to project themes uploaded by INHABIT consortium after the end of the project.
- Number of technical, scientific and policy-oriented papers produced mainly based on INHABIT outcomes.
- Number of courses where INHABIT results, approaches, criteria and tools will be the basis for training.
- Number of dissemination events where INHABIT results, approaches, criteria and tools will be presented and/or distributed.

## 4.4 Dissemination issues - Group of Actions DI

INHABIT project dedicated a specific group of actions to the Dissemination activities. This group of actions was addressed to the diffusion of the results, approaches and methods of the INHABIT project.

*Problems* – No specific problems related to this activity, apart some delay linked with the overall delay in project activities (see above).

In the following table, we report the list of national and international dissemination meetings each partner participated/organized. Main presentations produced are uploaded on the web site and are attached to the present report.

This list does not include the five workshops described in D2 activity, but lists the final project conference held in Milan on the 29-30 October 2013. The conference was focused on explaining how the obtained results can have an influence on the assessment of ecological status, with regard, among others, to the following themes:

- INHABIT methods and approaches for aquatic habitat characterization;
- evaluation of the variability associated to the classification and to the accuracy of the applied methods;
- habitat aspects, also associated to the relation between water quality and water quantity;
- biological response to habitat alterations and verification of effectiveness of measures.

Main results presented are also referred to the possible contribution of INHABIT project to some of the key remarks highlighted by European Commission on the analysis of Italian RBMPs, among these:

- characterization of reference conditions;
- HMWBs and GEP: proposals for HMWBs classification;
- programs of measures: verification of biological metrics sensitivity to different causes of anthropic pressures;
- evaluation of specific anthropic impacts.

The event has been dedicated to provide useful information not only to technical water resources operators but also to land management officers, people involved in RBMPs formulation or operating on the field for monitoring activities.
This two-days conference was successful, with more than 130 people participating, including MATTM (Italian Ministry of the Environment and Protection of Land and Sea), JRC, Po catchment authority, Environment Protection Agencies, etc. (see the list of participants attached to Deliverable D2d1).

| **Date** | **Place** | **Dissemination meetings** | **teams involved** |
|---|---|---|---|
| 24-25/03/2010 | Milan (IT) | CISBA meeting 'Evaluation of lacustrine environments. State of the art after 10yrs of WFD' | CNR-ISE |
| 26-30/09/2010 | Rome (IT) | XX SITE Congress. Presentation on relevance of hyporheic and hydromorphology in nutrient retention, part of INHABIT activities | CNR-IRSA |
| 03/11/2010 | Como (IT) | Phd thesis presentation on INHABIT Project (1st year) – University of Insubria | CNR-ISE |
| 1-2/12/2010 | Castiglione del Lago (IT) | Congress "For the future of Lake Trasimeno" Presentation on ecological status and reference conditions in Italian lakes, includes references to INHABIT results for lakes – ARPA Umbria | CNR-ISE |
| 26-27/01/2011 | Mainz (DE) | First LHS results on Italian lakes. The contribution of the INHABIT project to CEN commitee | CNR-ISE |
| 14/02/2011 | Sassari (IT) | Seminar "Sampling activity on macroinvertebrate of some Sardinian artificial lakes: organization, needs and critical aspects", includes the experience of INHABIT project – Sassari University | CNR-ISE |
| 30/03/2011 | Bari (IT) | Presentation of the LIFE+ INHABIT project to ARPA Puglia | CNR-IRSA |
| 3-6/10/2011 | Palermo (IT) | XXI SITE Congress. Presentation of Life-INHABIT Project: first results on lake macroinvertebrates during SITE Congress | CNR-ISE |
| 09/06/2011 | Rome (IT) | Presentation of the contribution of the LIFE+ INHABIT project to the Italian assessment system on macroinvertebrates | ARPA Piemonte |
| 31/08/2011 | Tovel (IT) | Presentation of INHABIT project to university students in a Summer school on macroinvertebrates | CNR-IRSA |
| 9/11/2011 | Como(IT) | Phd thesis presentation on INHABIT Project (2nd year) – University of Insubria | CNR-ISE |
| 27-29/02/2011 | Peterborough (UK) | The contribution of the INHABIT project to CEN commitee | CNR-ISE |
| 19/03/2012 | Viterbo (IT) | Phd thesis presentation on INHABIT Project (1st year) – University of Tuscia | CNR-IRSA – UniTuscia |
| 25/05/2012 | Brescia (IT) | Presentation of INHABIT project at 20th anniversary of LIFE Programme celebration at University of Brescia | CNR-IRSA |
| 05/06/2012 | Milan (IT) | Presentation of INHABIT project at Open day LIFE-Lombardia at Municipality of Milan | CNR-IRSA |
| 12-14/09/2012 | Evora (PT) | Presentation of the importance of habitat features in ecological status assessment in the Mediterranean area including reference to INHABIT project | CNR-IRSA, Prothea |
| 2-3/10/2012 | Milan (IT) | Presentation of INHABIT results and concepts in a course for University students dedicated to acquire the key aspects of hydro-morphology and habitat evaluation in relation to the | CNR-IRSA, Prothea |

| | | | |
|---|---|---|---|
| | | WFD. Title of the Event 'Introduzione al metodo CARAVAGGIO' | |
| 15-16/11/2012 | Peterborough (UK) | The contribution of the INHABIT project to CEN committee | CNR-ISE |
| 09/11/2012 | Rimini (IT) | Presentation of INHABIT results to ECOMONDO 2012 - XVI International Trade Fair of Material & Energy Recovery and Sustainable Development | CNR-IRSA |
| 10/12/2012 | Sassari (IT) | WFD seminar – Sassari University | CNR-ISE |
| 27/02/2013 | Viterbo (IT) | Presentazione tesi di dottorato sul progetto INHABIT (II anno) – Università della Tuscia | CNR-IRSA – UniTuscia |
| 31/03/2013 | Bologna (IT) | Workshop for presentation results and methods INHABIT Project to Italian Agencies for Environment Protection | CNR-ISE |
| 21/05/2013 | Alessandria (IT) | DISIT - University of Eastern Piedmont - The classification of the ecological status of the lake environments. The project INHABIT | CNR-ISE |
| 16-18/09/2013 | Ancona | XXIII Congresso SItE – Presentation of the poster "Uso del suolo e comunità macrobentonica in fiumi mediterranei: un semplice approccio per monitoraggi a scala di tratto" | CNR-IRSA, Prothea |
| 29-30/10/2013 | Milan (IT) | Final project Conference | All |
| 14/11/2013 | Mestre (IT) | Presentation of the INHABIT approach in relation to the classification of HMWB | CNR-IRSA |

### 4.4.1 Dissemination: overview per activity

**DI_IRSA 1, DI_IRSA2 and DI_IRSA3**

In addition to the participation/organization of the dissemination events above listed, the dissemination activity specifically done by the project coordinator includes the following.

- The definition (and continuous upgrading) of a mailing lists of relevant organisations to whom communicate project results (see annex of relevant stakeholders).
- The construction of the project web site (www.life-inhabit.it) which was constantly updated and used to disseminate project outputs, which has also been used for real-time communication of public **offers for collaboration** (scholarship and research grant) for providing support to INHABIT activities.
- CNR-IRSA activated a PhD position in collaboration with Università della Tuscia with the title "Variabilità degli habitat e comunità macrobentoniche in sistemi fluviali della Sardegna. (*Habitat variability and macroinvertebrate community in Sardinian rivers*)". Dottorato in ecologia e gestione delle risorse biologiche - XXVI Ciclo.
- Four different **degree theses** were carried out at CNR-IRSA in relation to INHABIT activities. i) 'Ritenzione di nutrienti in corsi d'acqua di Piemonte e Sardegna lungo un gradiente di alterazione morfologica'(Nutrient retention in streams of Sardinia and Piedmont along a gradient of hydro-morphological alteration". Laurea Magistrale in Biodiversità ed Evoluzione Biologica. AA 2010-2011. ii) 'Risposta delle comunità di macroinvertebrati bentonici alle alterazioni di habitat indotte dalla presenza di manufatti nei fiumi della Sardegna (Response of aquatic invertebrates to habitat alteration due to the presence of artificial structures in Sardinian rivers). Laurea Magistrale in Biodiversità ed Evoluzione Biologica'. AA 2011-2012. iii) 'Implementazione della direttiva 2000/60/EC: validazione dei siti di riferimento in diverse regioni italiane e

problematiche legate alla tipizzazione di corpi idrici in area mediterranea'(WFD implementation: reference sites validation in different Italian regions and typological problems for rivers in the Mediterranean area). Laurea Magistrale in Biodiversità ed Evoluzione Biologica. AA 2011-2012. iv) 'Analisi delle caratteristiche ambientali e delle pressioni che influenzano le comunità macrobentoniche nei fiumi della Sardegna' (Analysis of environmental features and pressures acting on benthic communities in Sardinian rivers). Università degli Studi di Milano. Laurea Magistrale in Scienze della Natura. AA 2011-2012.

- The dissemination of the web site address by e-mail to a large number of Italian institutions working for the WFD implementation (e-mail sent on May 2011, see the Annex 'Relevant stakeholders', and other successive e-mails).
- The dissemination of the web site address by e-mail at an international level. In addition, up to now, the project web address has been divulgated by direct communication (e.g. at courses, training and meetings).
- International dissemination, mainly by informal contacts with some non-Italian institutions (e.g. UK EA, CEMAGREF, Ministry of the Environment of a few European MS), for information exchange on selected project issues.
- The preparation of **dissemination material** distributed during public events (mouse-pad with INHABIT subjects, pencils and pens with LIFE and INHABIT logos, paper notebooks with INHABIT subjects). Some examples of this material are included for the Commission.
- The preparation of a project **roll-up** (here attached in pdf) that was exposed to all public INHABIT events.
- The preparation of a **Notice board**, regularly exposed outside project coordinator's institute. An additional notice board was prepared and exposed inside the institute.
- The preparation of some **scientific publications**, involving project partners, presently sent and subjected to acceptance/review process.

**Action DI_ISE; DI_PI and DI_SA**

As far as Dissemination activities expected from all partners, the following are listed:

- The preparation **of Notice boards** describing the project – with the LIFE logo included – have regarded all beneficiaries and these have been erected at the location of the Institutes, at strategic places accessible and visible to the public. All partners have contributed with documents they want to share in the web site.
- All partners gave their contribution in highlighting people to whom address mails concerning project results.
- All partners actively divulgated projects results, within their lists of contacts and internally within their Institutes, according to various themes and circumstances.
- CNR-ISE activated a PhD position with the title "Utilizzo dei macroinvertebrati come indicatori di qualità ecologica ai sensi della Direttiva Comunitaria 2000/60/CE" ("Macroinvertebrates as indicators of ecological quality according to WFD 2000/60/EC"), Dottorato di Ricerca in Scienze Ambientali - XXV Ciclo.
- CNR-ISE prepared and exposed a notice board in each of the studied lakes, summarizing the activities carried out within INHABIT for that lake (annexed).

**Assessing the effectiveness of dissemination related to web site**

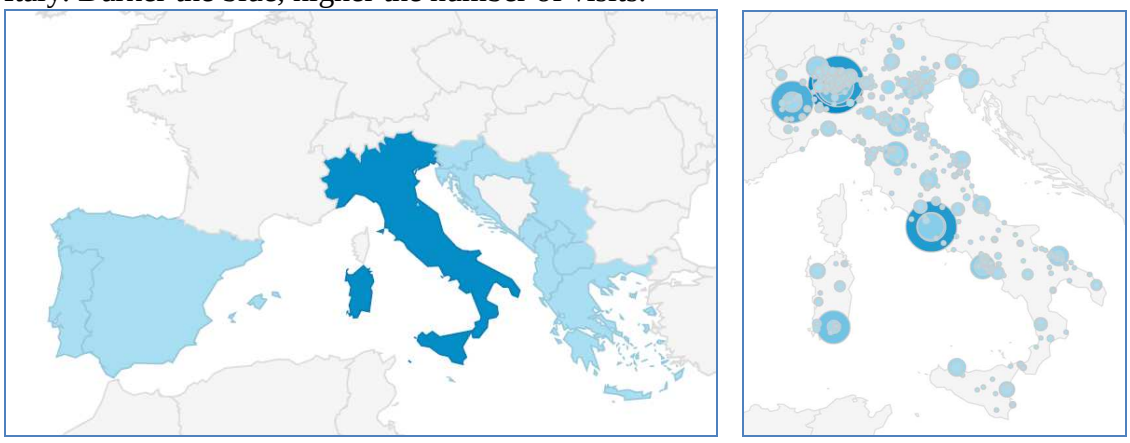
To assess the effectiveness of the dissemination related to the web site, as stated in the proposal (M IRSA_1), we evaluated:

- the number of people visiting the web site;
- number of downloads related to Deliverables uploaded;
- number of downloads related to presentations from the list of dissemination meetings.

Results of this checking are reported hereafter, with statistics updated to the 8th (downloads) and 12th (visits) of January 2014.

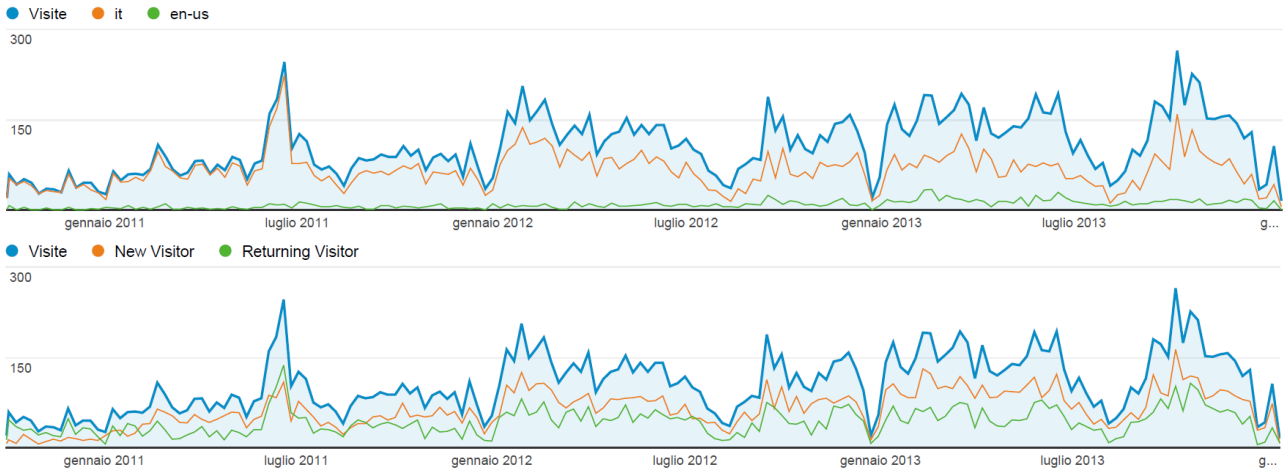
The INHABIT web site consists of more than 300 (x2, English and Italian) pages. The total number of visitors to the web site recorded (Google Analytics and URLmetriche - urlm.it) since 30/09/2010, date of activation, to 12/01/2014 is 18.409. 11.039 are new visitors, and the remaining are returning visitors, with a total number of pages visited amounted to 72.883, with an average from 4 (whole period) to 7 (last 3 months) pages per visitor. There is a consistent base of returning visitors, who enter the site periodically, presumably to check for updates. On the base of geographical area, the countries most interested in the project are those of southern Europe (16.465 visits); Italy is obviously (most documents for download in Italian) the largest user base with 15.969 visits (86.7%).

Figure 18. Graphic rendering of geographical distribution of visitors in southern Europe and Italy. Darker the blue, higher the number of visits.



In Italy, the regions where the institutions involved in the project are based (Lombardy 25%, Piedmont 7% and Sardinia 4%), or with the greatest presence of environment and government agencies, research institutes and universities (e.g. Rome 13%), constitute the most involved user bases. However, it is worth noting how people from all Italian regions, from the Alps to Sicily, visited the web site, covering in a quite homogeneous way the whole territory. The number of visits has increased after the initial months, reaching a weekly average that exceeds 100 visits excepting for the Italian holiday periods (summer and year-end). The peaks of visits correspond to significant INHABIT events; for example, the MacrOper.ICM software release in June 2011 (peak of 246 visits) and INHABIT national workshops (in particular, the final conference in October 2013, with a peak of 265 visits).

Figure 19. Number of visitors on week base; they are distinguished between italian or english language and between new or returning visitors.




Altogether, INHABIT documents uploaded on the website counted more than 33.000 downloads during INHABIT lifespan i.e. single visitors usually download more than one document. The most downloaded category is that of project Deliverables, with > 15.000 downloads. Out of these, about 4.000 were for three Deliverables: 'Guideline and field protocols for deriving hydro-morphological and habitat information', 'River basin management plans for the WFD in selected Italian catchments: approaches, methods, scale factors and setting of measures' and 'Guideline and field protocols for deriving nutrient-related information in rivers'. This emphasizes the importance of INHABIT in promoting the distribution of most updated methods and techniques for the implementation of the WFD in rivers and lakes. Statistics on the latest Deliverables incorporating most project results and guidelines and finalized in 2013, will be evaluated in 2014. The interest for project results is also attested by the downloads of workshops ppt presentations, with nearly 6.000 downloads. Information on datasets built and used in INHABIT gained good attention, with > 2.500 downloads of related Deliverables. As a remarkable aspect, we must note that even the simple location of INHABIT sampling sites (even if posted on the website only in October 2013) got ≈ 300 downloads for the three kmz files, in a couple of months; this presumably attests a strong interest of local authorities and personnel working on freshwater ecosystems for integrating INHABIT results and data to already existing information.

In general all partners have:

- used the LIFE logo on documents and durable goods according to Common Provisions rules. Thus the LFE logo was used in Deliverables and associated products (e.g. CARAVAGGIO Manual), presentations related to INHABIT project, Software finalized and distributed within INHABIT, project web site, durable equipment acquired for INHABIT, project notice boards, project leaflets, project roll-up, project dissemination material (mousepad, pen, pencils etc. see below and see the attached material on DVD) project posters, project workshops and final conference program. In all public conference and workshop of the INHABIT project the LIFE flag was exposed.
- Audio-visual products (if relevant): videos were not considered relevant for project purposes.

- A lot of photographs were taken during project life duration. A subset of these photos is attached on DVD. If further images are needed we can provide according to Commission requirements.
- One hand book was prepared, printed and distributed as part of I3 activities;
- Press cuttings were not delivered, also because when a INHABIT event was organized we were able to reach (and in some cases even overpass) the capacity of the rooms selected for such public event. We will anyway prepare and distribute a press cutting with the CNR office preposed, when all the results will be given to the Commission.
- The following web pages make reference to INHABIT project and/or to workshops and public events organized from INHABIT project
  http://www.wise-rtd.info/en/info/local-hydro-morphology-habitat-and-rbmps-new-measures-improve-ecological-quality-south
  http://chidiacquaferisce.blogspot.it/2013/10/convegno-finale-di-presentazione-dei.html
  http://www.minambiente.it/sites/default/files/archivio/allegati/life/life_progetto_inhabit_convegno29102013_scheda_pre_registrazione.pdf
  www.cirf.org/

### 4.4.2 Layman's report

Done and attached to the present Report (in pdf and hard copy). In particular, as pdf file, 2 different version are provided one with high and one with low resolution.

### 4.4.3 After-LIFE Communication plan

Done and attached to the present Report