



Deliverable 6.14 Activity 6.06

Climate-related prioritization of the aquatic NSC and taxa/specimens selection for the “extended digital specimen” descriptors. Digitization of selected NSC and return of the digital dataset and metadata. Networking of digitized (meta)data



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1. INTRODUCTION

Natural Science Collections (NSCs) hold a wealth of knowledge, and museums and academic institutions serve as the primary custodians of this heritage. These collections reflect the diversity of life (biodiversity) and the environment, encompassing rocks, sediments, and soils (geodiversity).

[Armeli Minicante et al. \(2024a\)](#) retrace the scientific path that from the origins of natural history museums leads to the RI DiSSCo, underlining the importance of NSCs in biodiversity and geodiversity studies. Natural history museums, originating during the Enlightenment, preserve artefacts and reconstructions spanning 250 years. The 1752 Encyclopedia by Diderot introduced the “Natural History Cabinet” classifying fossils, plants, and animals - a system later refined by Linnaeus through binomial nomenclature. In 1859, Darwin’s theory of evolution and Wallace’s biogeography established foundational principles, linking biodiversity to systematics, ecology, and geology.

The 20th century integrated studies of species behaviour and environment, such as [Elton’s \(1927\)](#) trophic niche, [Raunkiaer’s \(1934\)](#) plant morphology adaptation to climate, and [Hutchinson’s \(1957\)](#) niche tolerance to abiotic factors. These laid the groundwork for extensive ecological research.

ICT and biodiversity informatics, supported by databases such as GenBank, BOLDSystems, TRY, and OBIS, enable advanced analyses. Today’s biodiversity crisis is termed the “sixth mass extinction” or the “Anthropocene extinction”, driven by human activities like habitat destruction, pollution, and climate change ([Kolbert 2014](#); [Cowie et al. 2022](#)). Large monitoring programmes all over the world, such as those related to the [European Water Framework Directive \(2000/60/EC\)](#) and the [European Marine Strategy Framework Directive \(2008/56/EC\)](#) for the quality assessment of water systems, are a more recent source of biodiversity samples and data.

NSCs serve as an essential foundation for systematics, natural history, ecology, and numerous other specialized fields. The case history is vast. Microplastics, pervasive in marine environments, have been traced through museum collections, documenting their exponential rise since 1950 ([Haram et al. 2020](#); [Ilechukwu et al. 2023](#)). Herbarium studies have revealed the influence of temperature on plant phenology, with flowering anticipation in response to rising temperatures ([Vellend et al. 2013](#)). Genetic analysis of historical DNA (hDNA) from museum specimens have uncovered genetic erosion, species extinction, and disease origins ([Raxworthy & Smith 2021](#)). In epidemiology, NSCs helped uncover species jumps of pathogens, such as in the context of studies on COVID-19 in bats ([Thompson et al. 2021](#)).

The Distributed System of Scientific Collections (DiSSCo, <https://www.dissco.eu/>) Research Infrastructure unifies European NSC data, adhering to the FAIR principles (Findable, Accessible, Interoperable, Reusable). It fosters a pan-European knowledge base, enabling real-time access to metadata for diverse research fields. DiSSCo connects biodiversity data with taxonomic, biogeographical, and genetic information, supporting the UN Sustainable Development Goals (SDGs 4, 13, 14, and 15).

Activity 6.06 of ITINERIS enhances access to biodiversity (meta)data through digital specimens. Furthermore, it contributes to the OBJ3 of WP6, which aims to build a service to support RIs data used in ecological responses to changes and their implications for functional biodiversity organisation and conservation. In this context, aquatic NSCs preserved in the Institute of Marine Science (CNR-ISMAR) and the Water Research Institute (CNR-IRSA) of the National Research Council were selected to verify this objective.

The following aspects are considered:

- 1) Italian aquatic environments as hotspots of biodiversity and introduced alien species, important for ecological studies aiming to understand the long-term effects of environmental and/or climate change.
- 2) Collections from community ecology studies, as they provide data as potential benchmarks for models of community change over time. Selected taxa e.g. endemic, rare or otherwise relevant species are scrutinized in more detail.

2. CONCEPTS AND DEFINITIONS

Natural Science Collections (NSCs) are archives storing physical objects with a large amount of related data, resulting from studies in different scientific fields (i.e. zoology, botany, ecology, biogeography, physiology, geology, paleontology, etc.).

This section describes the key concepts and criteria adopted within Activity 6.06.

Physical specimen (henceforth specimen): it represents the basic unit of sampling or investigation; it is relative to a unit of time and space; it is identifiable, can be stored separately and catalogued; it can include one or more specimens or portions thereof (fragments, tissues, sections, DNA, etc.). Depending on the nature of the samples, preservation methods can vary between dry preservation on a stable support (adhered on a slide, sheet, etc.), or immersed in a preservation medium.

Digital specimen: a ‘digital specimen’ acts as a surrogate in digital environment for a specific physical specimen, identifying its actual location and authoritatively providing information on its collection event (who, when, where) and taxonomy (what), as well as links to high-resolution images. A digital specimen may expose supplementary information about related literature, traits, tissue samples and DNA sequences, chemical analyses, environmental information, and much more, stored elsewhere than in the NSC itself.

Metadata: “data about data”. This means that metadata are descriptions or information about an object, an entity, a variable or a datapoint. The primary purpose of metadata is to describe or annotate the data it accompanies in a machine-readable way.

Minimum Information about a Digital Specimen (MIDS): the minimum information elements expected to be present when publishing digitised specimen information. This information is categorised in four levels of digitisation (0-3) according to its type and complexity.

Voucher specimen (or voucher): a specimen archived in a permanent collection which serves as physical evidence of its occurrence (time and place) and of any identifications and descriptions based on it. In this context, the voucher is an individual monospecific sample and the physical reference for digitalization purposes and selected based on explicit criteria.

In the context of this work, the following catalogable objects are proposed:

A) *sample*: sample conservation can follow more or less complex levels of organization. We define the following levels here:

- individual monospecific sample: a single specimen of a given taxa, that may be selected, based on specific criteria, as a voucher.

- multiple monospecific samples: multiple specimens belonging to the same species and sampling event, arranged on the same herbarium sheet, container or slide box.
- multispecific sample: multiple specimens of different species arranged in the same containers (e.g., herbarium sheet, jars, tubes, slides, etc.).
- complex matrix: e.g., sediment sample, wood colonized by woodborers, etc.

B) *series*: set of organized samples grouped according to specific criteria (e.g., years or sampling area).

2.1 Samples prioritization and MIDS levels

Bakker et al. (2018) provided an inventory of criteria for prioritisation of the digitisation of NSCs. The digitisation of a NSC aim to the transition from Physical Specimens to Digital Specimens, providing findable, accessible, interoperable and reusable data, according to the FAIR principles¹. To specify the information elements expected to be present when providing access to specimens within a digital framework, the *Minimum Information about a Digital Specimen*² (MIDS) was developed.

MIDS is divided into several levels that represent a progression through the stages of digitisation by heterogeneous approaches. The MIDS standard is evolving, and, in this document, we will refer to what was reported by Haston et al. (2023; Table 1).

Table 1- Minimal information about the list of the Natural Science Collections involved in the ITINERIS Project.

Record extent	Purpose	Label	Definition
0 - Bare	A bare or skeletal record making the association between an identifier of a physical specimen and its digital representation, allowing for unambiguous attachment of all other information.	Physical Specimen ID	A unique identity for the specimen within the curating institution. Whatever the institution uses to uniquely identify the item. For example: DOI, stable identifier, catalogue number, barcode, etc.
		Organization	A term to indicate in which institution the specimen is held. This may include an institution code and an institution identifier.
1 - Basic	A basic record of specimen information.	Name	A name given to the object. Any string of characters and/or numbers by which the object is referenced within a collection. This name is not necessarily its name according to an accepted scientific classification, identification, or taxonomic determination.
		Specimen Type	High-level term to delimit and define specimens. For example: preserved specimen, fossil specimen, as opposed to observation.
		Object Type	General term to describe the kind of specimen. In combination with SpecimenType - hierarchical; a more specific classification than described by SpecimenType.
		License	License under which the specimen data are published
		Modified	UTC date/time of date/time of first creation or subsequent modification, if any

¹ <https://www.go-fair.org/>

² <https://github.com/tdwg/mids/blob/working-draft/current-draft%20MIDS-definition-v0.17-13Jul2023.md>

Record extent	Purpose	Label	Definition
2 - Regular	Key information fields that have been agreed over time as essential for most scientific purposes.	Qualitative Location	A term to describe the where the specimen was collected. In combination with quantitativeLocation; should capture textual geographic information.
		Quantitative Location	A term to describe where the specimen was collected. A quantitative measure that would include coordinate or shape data, an identifier, or data that can be easily converted into a quantitative measure. In combination with the qualitative term, qualitativeLocality.
		Collecting Agent	A list (concatenated and separated) of names of people, groups, or organizations responsible for recording the original Occurrence.
		Date Collected	The date/time at which a gathering event occurred. For specimen gathering, this is the date/time when the event was recorded.
		Collecting Number	An identifier given to the specimen at the time it was recorded. Often serves as a link between field notes and a specimen record.
		Media	A list (concatenated and separated) of media associated with the specimen.
		Geological Age	Refers to the geological age of an Earth Science specimen (i.e. Fossil, Rock, Mineral or Meteorite) and can be any kind of stratigraphic age, isotopically determined age or structural age.
		Type Status	An indication of the nomenclatural type status of the specimen, where a null value is taken to mean "Assumed not to be a type".
3 - Extended	Other data present or information known about the specimen, including links to third-party sources.	Institution ID	An identifier for the institution having custody of the object(s)
		Collector ID	A list (concatenated and separated) of the identifier(s) for the person, people, groups, or expeditions responsible for collecting the specimen.
		Scientific Name ID	An identifier for the nomenclatural (not taxonomic) details of a scientific name.
		Geographical Locality ID	An identifier for the geographical locality where the specimen was collected.
		Identified By ID	A list (concatenated and separated) of the identifier(s) for the person, people, groups, or organizations responsible for assigning the scientific name to the subject.

As a general principle, institutions should aim to publish the fullest available data about their collections and individual specimens at the earliest opportunity. The minimum amount of information to be made available (published) must be the expected information elements at any chosen level of digitization. As best practice, level 2 Regular should be the minimum standard to aim for. However, publishing information in accordance with levels 1 Basic and/or 0 Catalogue and enriching it over time is acceptable.

3. METHODOLOGY

This guideline describes the steps of a methodological path leading from the study of the samples to the digitisation, and highlighting the needs and kind of work to be undertaken. To organize and make scientific collections available for researchers and stakeholders, two intervention categories have been identified:

- Curatorship and laboratory work for Physical Specimens
- Information technology for Digital Specimens

3.1 Curatorship and laboratory work for Physical Specimens

Most laboratory work is divided into four phases common to the different collections:

- Curatorship: includes preservation and maintenance, ensuring that physical specimens are properly stored and preserved to prevent degradation. For example, topping up or replacement of the preservatives, environmental control of the specimens preserved/stored in the slides, control and/or treatment of the herbarium *exsiccata*, checking and/or replacing labels and descriptive sheets, re-organization of the samples in containers, slides, trays, boxes and cabinets, identification of air-conditioned and ventilated rooms to store and/or display the collections.
- Taxonomic determination, revision and nomenclatural updating: taxonomic determination of samples in NSCs is sometimes uncertain or provisional, and the achieved taxonomic resolution may be at a higher level than species. The uncertainty or provisional status can be expressed by a set of terms and abbreviations, known as Open Nomenclature (ON) qualifiers. The use of ON qualifiers will be based on [Sigovini et al. \(2016\)](#), providing a summary and guide to current practice in zoology. Nomenclature follows the International Code of Nomenclature for algae, fungi and plants ([McNeill et al. 2012](#)) and The International Code of Zoological Nomenclature ([ICZN 1999](#)). Nomenclature will be updated based on the World Register of Marine Species ([WoRMS Editorial Board 2023](#)) and AlgaeBase ([Guiry & Guiry 2025](#)). Different criteria for used nomenclature can be specified, depending on the aims according to which the data was collected.
- Cataloging: the attribution of the catalog number and barcode to each physical object. The catalog number (DwC: catalogNumber) must include the collection code (maximum 6 alphabetical characters) followed by a serial number (maximum of 9 alphanumerical characters).
- Selection of vouchers: a selection of the most significant and best-preserved specimens as voucher samples. This phase is mandatory for multiple samples.
- Storage and sharing solutions: developing and maintaining appropriate storage facilities that ensure safe and easy access to physical collections for researchers, either on-site or through lending protocols.

3.2 Information Technology for Digital Specimens

This phase includes:

- Digital catalog creation: compilation of a template with metadata identified according to MIDS levels and international standards. This ensures that digital records are accompanied by standardized metadata, facilitating interoperability between research platforms. As of today, we are referencing the MIDS version from July 2024.
- Metadating: transcription of all available information relating to the physical object into digital format (e.g., excel sheet).
- Digitisation: image acquisition of specimens and documents to create the digital object of the physical collections.

- Data Storage and Management Systems: physical and virtual IT structure hosted at ISMAR-VE to store, organise, and retrieve digital objects.
- Online Access: publication, through the IPT, on the Global Biodiversity Repository (GBIF) of the collection datasets, to be integrated and interconnected with the ITINERIS Hub and the WP6 Coordination Hub. Furthermore, a further access point could be guaranteed through a local repository of the OUs involved in DiSSCo IR.

The workflow for the study and data management of the aquatic collections developed within Activity 6.06 is summarised in Fig.1.

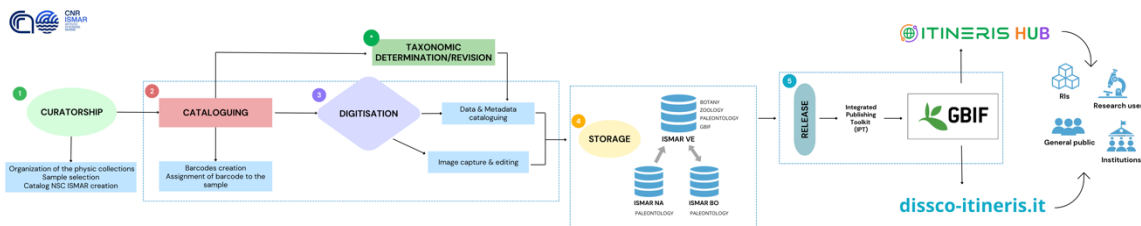


Figure 1: Workflow showing the methodological path implemented to make the scientific collections available in digital format.

4. RESULTS

4.1 Curatorship and laboratory work for Physical Specimens

At the planning stage, a prioritization of the collections was already carried out according to the objective of the project and to Bakker et al. (2018). The most important criteria include contribution to partnerships within broader scientific community efforts, support for research infrastructure, facilitation of multidisciplinary research or analyses, relevance to ecological and geographical imperatives, importance for improving knowledge on presence and distribution of invasive alien species and endemisms, relevance for the discovery and access to primary biodiversity data and addressing the most urgent biodiversity and environmental challenges of our time.

In detail, the selected collections can be traced back to:

- aquatic herbaria. Acquisition and digitization of *exsiccata* and label data mobilization might be used to assess changes in biogeographic distributions comparing either modern and historical herbaria or herbaria of other institutions available online;
- collections generated by Long Term Monitoring (LTM). Data on alien (invasive) species produced by LTM, focused on general aspect of biodiversity, could be used to develop specific LTM plans of invasive species;
- collections from community ecology studies.

Within Activity 6.06, seventeen collections were selected (Table 2; Figure 2) as representatives of three scientific fields - botanical, paleontological and zoological – and of different types of studies. Specifically, the collections consisted of three herbaria preserved on paper sheets (*exsiccata*) and

fourteen animal collections preserved on different supports as slides (five collections) and vials (nine collections). A detailed description of each collection can be found in Annexe 1. Figure 2 shows the distribution of the hosting Institutions and Fig. 3 shows main geographic origin of the collection specimens considered in this project.

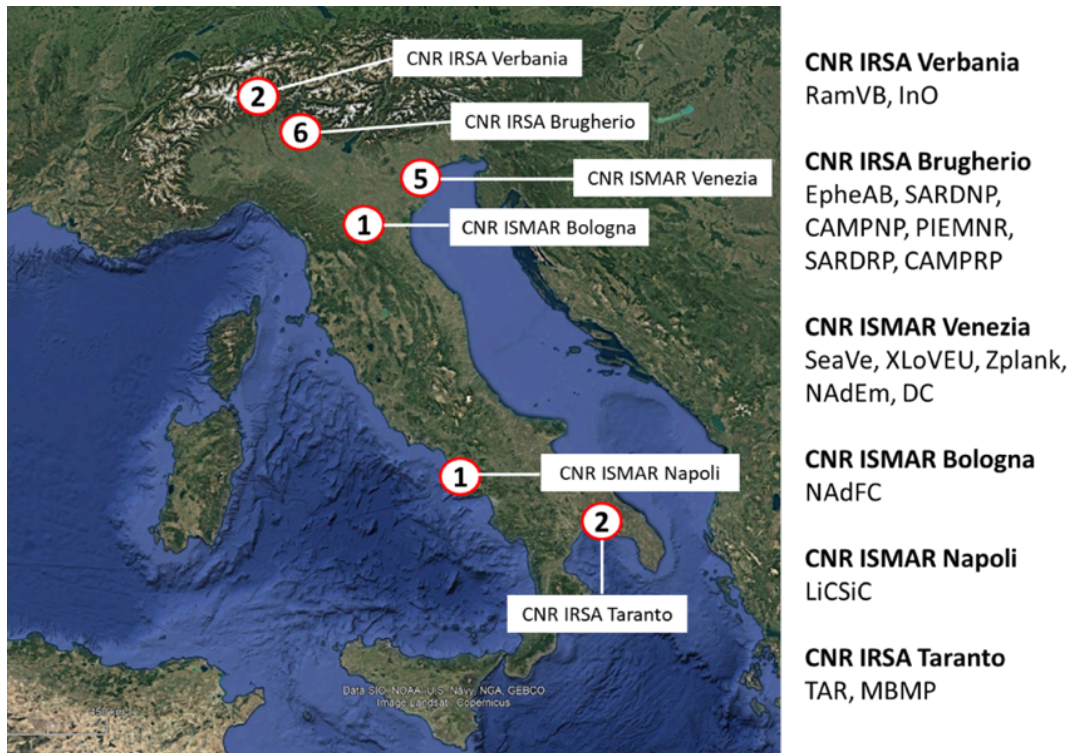


Figure 2: Institutions and their hosted collections considered in this Activity.

Most aquatic natural collections (13) contained samples collected from the 2000s to the present time, 2 were born in the 1980s, and 2 collections can be considered “historical”. These are represented by the collections: “MBMP” (herbarium) and “RamVB” (tardigrade), which included samples collected from 1921 to 1967 and from 1938 to 1964, respectively.

Table 2 - List of the aquatic Natural Science Collections involved in the ITINERIS Project.

Collection type	Collection name	Collection code	Institution	Institution code	Main taxa	Nr. of physical specimens	Environment	DOI
Herbarium	Herbarium Istituto Sperimentale Talassografico A. Cerruti	TAR	CNR IRSA Talassografico "A. Cerruti"	CNR-IRSA-TA	Chlorophyta, Rhodophyta, Ochrophyta Angiosperms	201-1000	marine	https://doi.org/10.15468/dnqmqe
Herbarium	Erbario Pierpaoli	MBMP	Museo di Biologia Marina di Porto Cesareo - Disteba - Università del Salento	MBMP	Chlorophyta, Rhodophyta, Ochrophyta	201-1000	marine	https://doi.org/10.15468/9z98fh
Herbarium	Seaweeds of Venice Lagoon	SeaVe	Istituto di Scienze Marine di Venezia	CNR-ISMAR-VE	Chlorophyta, Rhodophyta, Phaeophyceae	~ 500	marine, transitional water	https://doi.org/10.15468/ksjwmn
Slides	Linosa Sicily Channel Collection	LiCSiC	Istituto di Scienze Marine di Napoli	CNR-ISMAR-NA	Foraminifera	~ 2755	marine	https://doi.org/10.15468/gv8k7a
Slides	North Adriatic Foraminifera Collection	NAdFC	Istituto di Scienze Marine di Bologna	CNR-ISMAR-BO	Foraminifera	~ 6000	marine	https://doi.org/10.15468/2b5bha
Slides	Ephemeroptera BUFFAGNI-	EpheAB	Istituto di Ricerca Sulle Acque	CNR-IRSA-MI	Ephemeroptera	>200	freshwater	https://doi.org/10.15468/ctauz3
Slides	Tardigrada Ramazzotti collection	RamVB	Istituto di Ricerca sulle Acque di Verbania	CNR-IRSA-VB	Tardigrada	4200	terrestrial, freshwater	https://doi.org/10.15468/wngz4x
Preserved	Northern Adriatic Epimegabenthos	NAdEM	Istituto di Scienze Marine di Venezia	CNR-ISMAR-VE	Annelida Polychaeta, Crustacea Decapoda, Echinodermata, Mollusca, Tunicata, Ascidiacea	1001-10000	marine	https://doi.org/10.15468/r8f2c2

Preserved	Dese Crustaceans	DC	Istituto di Scienze Marine di Venezia	CNR-ISMAR-VE	Crustacea: Peracarida, Decapoda	23-300	marine	https://doi.org/10.15468/5hgi7b
Preserved	Xilofagi della Laguna di Venezia ed Europei	XLoVEU	Istituto di Scienze Marine di Venezia	CNR-ISMAR-VE	Mollusca, Crustacea Peracarida	201-1000	marine	https://doi.org/10.15468/rfthq6
Preserved	Marine zooplankton collection	ZPlank	Istituto di Scienze Marine di Venezia	CNR-ISMAR-VE	Copepoda, Cladocera, Bivalvia larve, Chaetognatha, Decapoda larve, Echinodermata larvae, Gastropoda larve, Ostracoda	20-200	marine, transitional water	https://doi.org/10.15468/8scg2m
Preserved	Sardinia river invertebrates – slightly altered sites	SARDNP	Istituto di Ricerca Sulle Acque	CNR-IRSA-MI	Ephemeroptera, Odonata, Plecoptera, Hemiptera, Coleoptera, Trichoptera, Diptera.	>1000	freshwater	https://doi.org/10.15468/uta29e
Preserved	Campania River invertebrates - slightly altered sites	CAMPNP	Istituto di Ricerca Sulle Acque	CNR-IRSA-MI	Ephemeroptera, Odonata, Plecoptera, Hemiptera, Coleoptera, Trichoptera, Diptera.	>2000	freshwater	https://doi.org/10.15468/nnrbqm
Preserved	Piedmont River Invertebrates - slightly altered sites	PIEMNR	Istituto di Ricerca Sulle Acque	CNR-IRSA-MI	Ephemeroptera, Odonata, Plecoptera, Hemiptera, Coleoptera, Trichoptera, Diptera.	>2000	freshwater	https://doi.org/10.15468/dtu2jv
Preserved	Sardinia river invertebrates –	SARDRP	Istituto di Ricerca Sulle Acque	CNR-IRSA-MI	Ephemeroptera, Odonata, Plecoptera,	>2000	freshwater	https://doi.org/10.15468/32ra6q

	nearly pristine sites				Hemiptera, Coleoptera, Trichoptera, Diptera.			
Preserved	Campania river invertebrates - nearly pristine sites	CAMPRP	Istituto di Ricerca Sulle Acque	CNR-IRSA-MI	Ephemeroptera, Odonata, Plecoptera, Hemiptera, Coleoptera, Trichoptera, Diptera.	>1500	freshwater	https://doi.org/10.15468/v5c55v



Figure 3: A) Geographical origin of the collections; B) Detail of the Italian sites and the environment of origin.

Overall, a total of 5592 physical specimens were catalogued. In most collections, the classification level achieved included the species or genus. In some cases, updating the nomenclature after reviewing the available databases was necessary before starting the digitisation process. As a result of this activity, a total of 84 nomenclatural updates were carried out. Moreover, 15 taxonomic revisions were necessary, while three are in progress. The pie chart (Fig. 4) illustrates the percentage representation of various taxonomic groups in the studied collections. Arthropoda accounts for the largest portion, comprising 22% of the specimens. Other prominent groups include Mollusca (12%) and Annelida (10%). Smaller groups such as Foraminifera and Porifera contribute 2% each. The

chart highlights the taxonomic diversity within the collections, showcasing a wide range of marine and terrestrial taxa. A significant aspect is the presence of 25 alien species in the marine collections (Tab. 3), two of which (*Amphistegina lobifera* and *Teredo bartschi*) are reported in the literature as invasive.

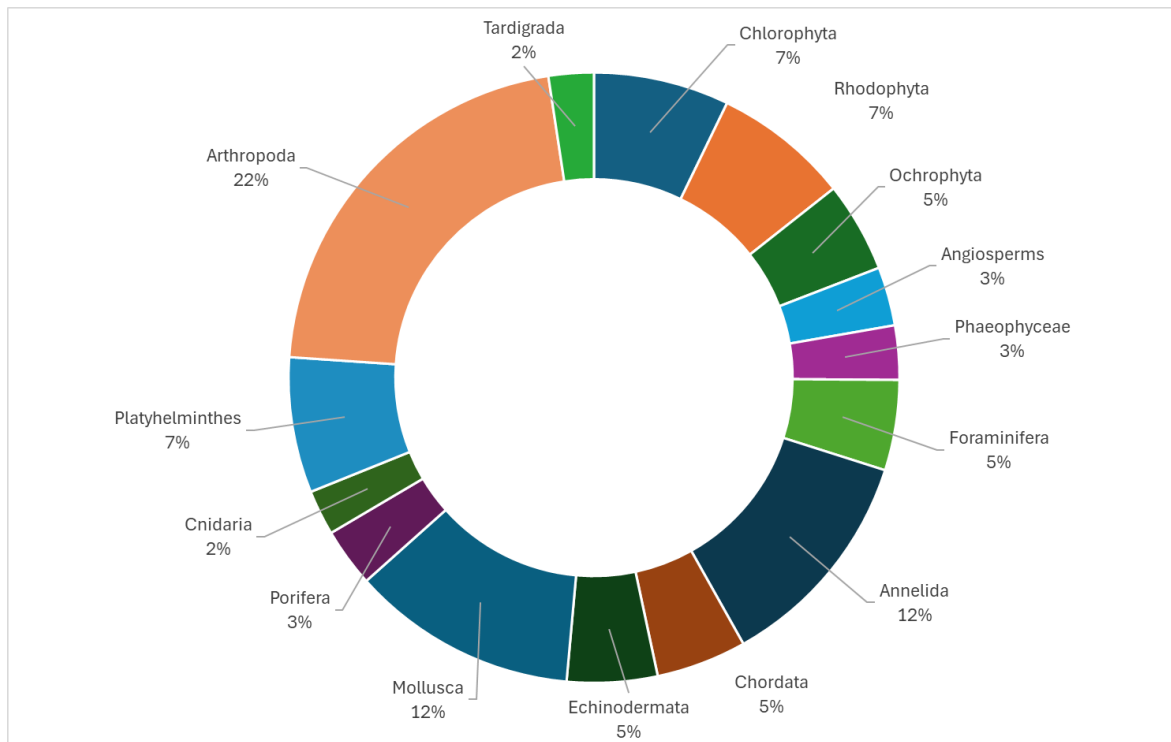


Figure 4: Percentage representation of taxonomic groups in the collections involved in ITINERIS.

Table 3 - Alien species present in marine collection.

Collection	Species	Higher -taxa	Climate areas				
			tropical	subtropical	temperate	cold temperate	wide geographic range
TAR	<i>Agardhiella subulata</i> (C. Agardh) Kraft et M.J. Wynne	Rhodophyta				✓	✓
	<i>Caulacanthus okamurae</i> Y. Yamada	Rhodophyta				✓	
	<i>Codium fragile</i> (Suringar) Hariot	Chlorophyta				✓	✓
	<i>Colpomenia peregrina</i> Sauvageau	Ochrophyta				✓	✓
	<i>Grateloupia minima</i> P. Crouan & H. Crouan	Rhodophyta				✓	
	<i>Grateloupia turuturu</i> Y. Yamada	Rhodophyta				✓	✓
	<i>Osmundea oederi</i> (Gunnerus) G. Furnari	Rhodophyta				✓	
	<i>Polysiphonia morrowii</i> Harvey	Rhodophyta				✓	✓
	<i>Solieria filiformis</i> (Kützting) Gabrielson	Rhodophyta				✓	✓
MBMP	<i>Solieria filiformis</i> (Kützting) Gabrielson	Rhodophyta				✓	✓
ZPlank	<i>Pseudodiaptomus marinus</i> Sato, 1913	Crustacea			✓	✓	
TAR	<i>Cutleria multifida</i> (Turner) Greville	Ochrophyta			✓		
ZPlank	<i>Dyspanopeus sayi</i> (Smith, 1869)	Crustacea			✓		✓
	<i>Acartia</i> (Acanthacartia) <i>tonsa</i> Dana, 1849-1852	Crustacea		✓	✓		
TAR	<i>Caulerpa cylindracea</i> Sonder	Chlorophyta		✓			✓
	<i>Hypnea corona</i> Huisman & Petrocelli	Rhodophyta	✓	✓			
	<i>Asparagopsis</i> cf. <i>taxiformis</i> (Delile) Trevisan	Rhodophyta	✓	✓			✓
DC	<i>Caprella scaura</i> Templeton, 1836	Crustacea	✓	✓			✓
LiCSiC	<i>Amphistegina lessonii</i> d'Orbigny in Guérin-Méneville, 1832	Foraminifera	✓	✓			
	<i>Amphistegina lobifera</i> Larsen, 1976	Foraminifera	✓	✓			
	<i>Amphisorus hemprichii</i> Ehrenberg, 1839	Foraminifera	✓	✓			
	<i>Sorites orbicularis</i> (Forskal, 1775)	Foraminifera	✓	✓			
XLoVEU	<i>Teredo bartschi</i> Clapp, 1923	Mollusca	✓				
SeaVe	<i>Ulva australis</i> Areschoug	Chlorophyta					✓
	<i>Ulva californica</i> Wille	Chlorophyta					✓

In the oldest collection, the MBMP a herbarium of algae collected in the Mar Piccolo of Taranto from 1921 to 1962, only one alien species of cold temperate climate was found. From 1982 to 2024 algae collected in the same environment are preserved in the TAR herbarium which contains 12 alien species mostly temperate/cold temperate and 3 species of subtropical/tropical origin two of which have achieved a wide geographical distribution. None are invasive although only *Hypnea corona* has settled and reproduces without competing with the native ones.

The presence of alien species from subtropical/tropical waters is observed for the other collections. Among them two are invasive: the mollusc wood-borer mollusc *Teredo bartschi* and the foraminifer *Amphistegina lobifera*. It must be noted that most alien species from subtropical/tropical waters have also spread to low latitudes and currently have a wide geographic distribution.

4.2 Information Technology for Digital Specimens

For each digital specimen a *specimen ID* was assigned. Specimen ID, consisting of the Collection Code and a maximum of 9 characters (including letters and/or numbers) (see the Annexe 1). Metadata is mainly done using the reference standards of DarwinCore and DublinCore. 106 terms - grouped into five categories: Basic, Taxonomy, Morphology, Genetic, and Sampling - have been identified for the metadating of the biological aquatic natural collections of CNR-ISMAR and CNR-IRSA. The descriptions of the related terms and the reference ontologies are reported in [Armeli Minicante et al. \(2024b\)](#).

To settle the quality of the metadata process, we adopted the Minimum Information about a Digital Specimen (MIDS levels). The standard achieved was: 50% of the collections have reached a MIDS-2 level, while the remaining 50% have almost completed the MIDS-3 level. We obtained data and metadata for 7032 digital specimens.

The minimum number of obtained digital specimens was 20 for LiCSiC collection, while the maximum was 3328 for RamVB ones. To date, 11 collections have been fully digitized, while for the other collections, the percentages of transformation of physical objects into digital samples ranged from a minimum of 50 to 60% approximatively. For the “InO” collection, the digitization process has not yet begun as the activities planned for the project are still in a preliminary stage.

For image acquisition, a resolution of no less than 400 dpi is recommended, and in any case between 400 and 600 dpi. Given its information preservation characteristics, the format chosen for file storage is TIFF, .tif extension, uncompressed and in color (RGB). According to [Nieva de la Hidalga et al. \(2020\)](#) and reference therein, “images must include a set of visual elements that appear next to the specimen and are intended to help in the identification, processing and quality control.” These elements include color checker (A), scale bar (B), labels (C), QRcode or barcode (D) and Institution name (E). 7300 images were acquired; the list of the equipment used for the image acquisition is reported in Table 4.

The IT structure for the storage of digital specimens and related data consists in a federation of systems that can interact and interoperate across ISMAR headquarters. The system is based on three NAS-QNAP (Network Attached Storage – Quality Network Appliance Provider) with QuTS hero (TS-h3087XU-RP). The NAS access is managed through myQNAPcloud, the mirroring of the archives through HBS 3 Hybrid Backup Sync.

Table 4 – Types of equipment for image acquisition

Equipment models	Type of collection in which it was used
Bookeye® 5 V2, Nikon Z7II, Digital Handled Microscope (Dino-Lyte)	Botany
Camera: Olympus® EP50, Leica K3C and K5C, TiEsseLab TrueChrome HD IIS; Digital microscopes: Keyence VHX-7000N; Leica DM6 B; Leica M205 FCA	Paleontology and zoology

Each headquarters (Venice, Bologna, and Naples) stores the data in his reference NAS. Each archive is mirrored in another NAS (Figure 5): ISMAR-VE contain the complete version of the archive, ISMAR-NA contain the data produced in Naples and copied in ISMAR-VE, ISMAR-BO store the data produced in Bologna that is also copied in Venice, and it hosts also the copy of ISMAR-VE. In this way, each local archive has a mirror delocalized copy.

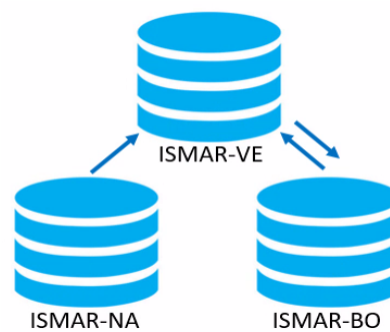


Figure 5: Federation of systems.

The archives have a consistent structure consisting in organized folder based on the NSC (botany, paleontology and zoology) and inside the specific collections. The QNAP supports authentication by credentials, and the authorization system is based on multiple access levels depending on the folder permissions and on the user privileges (administrator, read and write, read only). QNAP allows users to store the digital specimens and obtain a free or password-protected URL (Uniform Resource Locator) to be included in the metadata record (DwC, DC) useful to incorporate the picture into external platforms.

To publish the collection datasets - in accordance with FAIR principles - we utilized the Global Biodiversity Information Facility (GBIF, <https://www.gbif.org/>) and the GBIF Registry of Scientific Collections builds on the former Global Registry of Scientific Collections (GRSciColl, <https://scientificcollections.gbif.org/>).

Once the dataset catalog has been compiled by the researcher/curator of the collection as described above, it is reviewed by the GBIF technical point(s) of ISMAR/IRSA. If the dataset catalog is related to a naturalistic collection, the collection is first registered under the institution of affiliation on the GRSciColl platform by the GRSciColl Editor User. Following the registration, the obtained collection UUID (Universally Unique Identifier) will be inserted within the dataset catalog as the DwC:datasetID. Via access to the IPT (Integrated Publishing Toolkit), the GBIF technical point

uploads the dataset catalog, mapping the metadata and providing it with information requested by GBIF. Once published, the administrator will validate the dataset by registering it on GBIF and releasing the related DOI. As a result, each dataset published on GBIF will have a DOI and a reference citation; furthermore, containing the collection UUID in its metadata specimen records are automatically associated with the collection registered on GRSciColl and consequently with the relative branche. The procedure to publish the aquatic NSCs dataset on GBIF and GRSciColl is showed in Figure 6.

All collections were registered on GrSciColl, and 16 datasets were released on GBIF.

A further access point is the local repository (<https://www.dissco-itineris.it/>) which aggregates data from the OUs involved in DiSSCo IR.

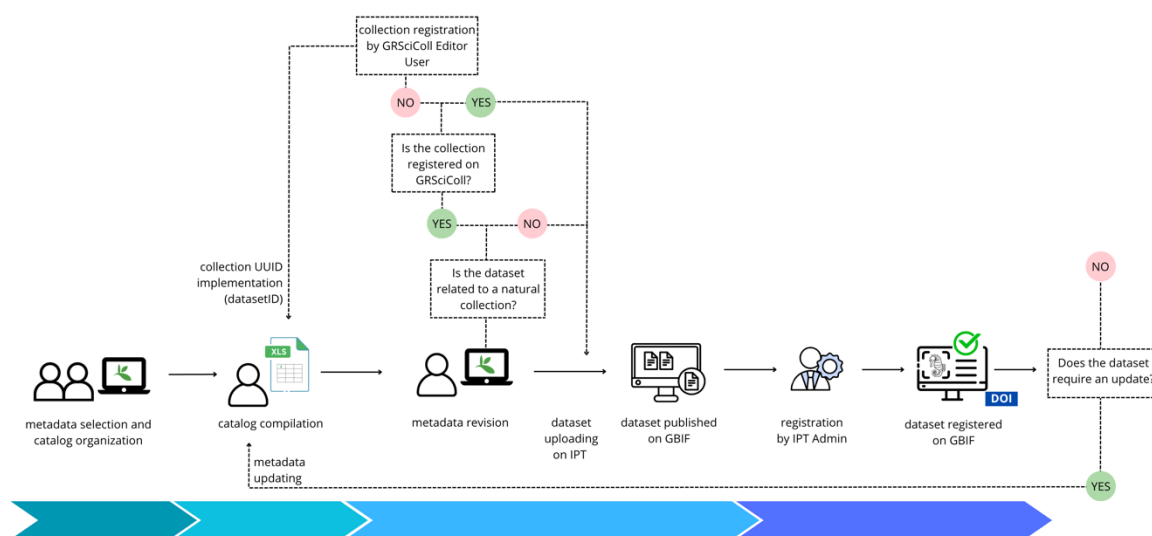


Fig. 6: Procedure to publish the Aquatic Natural Collections dataset on GBIF and GRSciColl (by Armeli Minicante et al. 2024, modified).

5. DISCUSSION

The results of this study provide insights on the biodiversity of the aquatic science collections (ASC). The key results include the composition of species, the conservation efforts, the digitization potential to improve accessibility.

The collection of organisms included in the naturalistic collections, and the choice of digitization itself, responded to partly different goals and objectives. This makes it difficult to draw an overall picture, but at the same time it highlights the wealth and diversity of the information available. The 17 collections for which the digitisation process has been initiated, and in some cases completed, include both plant organisms (3 collections, all from marine or brackish habitats) and, predominantly, aquatic invertebrates, brackish waters (2), marine (4) and freshwater (8). Most of the collections cover a wide range of organisms collected at a few stations, while some are focused on single groups – Bivalvia, Crustaceans, Foraminifera, Oligochaeta, Tardigrada and Ephemeroptera - with collections in the latter two cases covering larger geographical areas. The difference in focus is inevitably reflected in the level of identification achieved in the different collections. However, both approaches are extremely interesting for the study of biodiversity and provide an important starting

point - more or less detailed - for the assessment of current and future deviations from the observed situation. In addition to two historical collections, a marine Herbarium (1921-1962) and the Tardigrada collection (1938-1964), two collections (Herbarium and Ephemeroptera) contain specimens collected from the 1980s to the present. The other collections generally refer to specimens collected more recently, often with timelines within the duration of individual projects.

Given the different purposes of collecting and archiving, the ASC collections in question cannot approach the numbers of museum collections. Nevertheless, the numbers observed are considerable. The plant collections (all marine) contain on average a hundred species, totalling almost 10000 physical specimens (over 700 digital specimens). The animal collections each contain 13-80 taxa/species, totalling more than 58000 physical specimens (6600 digital specimens). The ASCs are small collections (less than 100,000 specimens). The small collections constitute the vast majority of natural science collections (NSCs), although they are not adequately recognized for their contribution to biodiversity research. [Monfils et al. 2020](#) propose the term “regional collection” as a more appropriate descriptor for “small” collections and emphasize their importance because they best represent local diversity and can provide unique occurrence records that can fill gaps in taxonomic, geographic, and temporal understanding of global biodiversity.

Marine and brackish water collections of the Mediterranean are characterized by the presence of alien species. Several papers elucidate how aquatic NSCs can be incisive in the global change biology. Among others, [Ewers-Saucedo et al. 2011](#) documented introduction, range expansion and decline of some epibenthic species in the Baltic and North Seas in a time lap of 200 years dating back to the nineteenth century, analysing German museum collections.

The spread of marine species occurs mainly through commercial shipping routes which, in the era of globalized markets, lead to the continuous spread of non-native species. The main vectors of spread are ballast water and ship fouling, in addition to driftwood. Entry into the Mediterranean occurs through the Strait of Gibraltar and the Suez Canal, but most of the alien species were found in the eastern Mediterranean basin, close to the Suez Canal where warm water species account for 88.4% ([Zenetos et al. 2012](#)).

Furthermore, since the early 2000s, the tropicalization of the Mediterranean has been the subject of studies based on the introduction/expansion of alien species from tropical seas ([Bianchi and Morri 2003](#), [Bianchi 2007](#)), even if this aspect has been gradually explored since the early 90s.

Most alien species of ASCs of tropical/subtropical origin, settled in new habitats without competing with existing species and some of them currently have a wide geographical distribution reaching temperate and cold temperate areas.

The warm tolerant species *Hypnea corona* and *Caulerpa cylindracea* (TAR collection) show a different population trend in the Mar Piccolo di Taranto where, since 2011, temperature has generally exceeded 27°C in the warmest week persisting, in recent years, for several weeks. *H. corona* is the most abundant alien species that behaves as an invasive species since 2000. *C. cylindracea*, considered the first among the ten most invasive alien seaweed species in the Mediterranean Sea, was found, with undetectable biomass, only in 2013. The cause could be the high sedimentation in Mar Piccolo di Taranto not tolerated by *C. cylindracea* whose survival is linked to low light conditions ([Petrocelli et al. 2024](#)).

The tropical species *Teredo bartschi* (XLoVEU collection) become invasive in Lagoon of Venice exceeding in density the more abundant local species being able to overwinter at temperatures a few

degrees above zero, to tolerate a wide range of salinity and to be resistant to hypo/anoxia (Tagliapietra et al. 2021).

The tropical-subtropical species *Amphistegina lobifera* (LiCSic) is a large symbiont-bearing foraminifera, originating from the Indo-Pacific region, thriving in shallow waters below 20 m depth and proliferating at temperatures above 14°C. *A. lobifera* is recognized as highly invasive in the Eastern and Central Mediterranean. Genetic studies suggest a shift away from sexual reproduction, enhancing its colonization success (Raposo et al. 2023). While *A. lobifera* arrival in the Mediterranean region was enabled by the opening of the Suez Canal (e.g., Mancin et al. 2023) its establishment and spreading in this basin was related to climate change (Guastella et al. 2021).

Based on current knowledge, it can be stated that the ability of a species to establish itself in a new habitat and become potentially invasive depends mainly on its adaptive strategy, with climate change acting as a catalyst.

All collections provide data as potential benchmarks for models of community change over time. They seem to provide important references for the assessment of possible variations induced by global changes. In the case of freshwater collections, where the presence of alien species is less represented, the presence of endemic species, some however also found in marine environments, is remarkable. For some species, samples have been collected in their type locality, greatly enhancing the value of the preserved sample. For freshwaters, there are some collections derived from sample sets collected about 20 years ago at so-called riverine reference sites (Sardinia and southern Italy), i.e. relatively pristine sites which, given the recent acceleration of climate change, may provide an important basis for quantifying any biodiversity loss. In some cases, such as the Ephemeroptera collection, the foundations have been laid for the creation of a comprehensive catalogue of Italian species, combining morphological and genetic information. This in itself will be a unique event in southern Europe and will make it possible to disseminate knowledge in Italy and abroad about many of the endemic species of the order found in our territory. This is the first step towards a better understanding of the biodiversity of freshwater ecosystems (Buffagni & Belfiore 2025) and the effective protection of species and their habitats. More in general, added values could be the phenological analysis and the knowledge of the biological traits of the species, which are important information for the study of functional biodiversity, aiming to assess over time the dynamics, functioning, and vulnerability to anthropogenic impacts including climate changes (i.a. Pyke & Ehrlich 2010; Filipe et al. 2013; Miatta et al. 2021). Given the timing of the project, it was not possible to examine these topics, but it is desirable that phenology and biological traits will be the focal point to explore in future projects.

An important added value of many of the collections is the extensive supporting data sets that can be obtained directly from the generated GBIF files (where possible) or requested from the collection managers. Often, especially in the case of collections built within projects of an ecological nature - and not explicitly aimed at taxonomic studies - a strong emphasis has been placed on the description of habitats (at different scales), pressures, impacts, and the chemical and physical characterisation of water. All of this information can be used both to study biodiversity and, more simply, to describe changes in the habitats themselves, extending the usefulness of the information collected beyond the limits of the organisms covered by the collections.

The process of digitising the collections has been accompanied and complemented by the acquisition of images of the organisms in the collection. This process, aimed in particular at integration into the DiSSCo context, at supporting remote viewing and consultation of the collections (where possible), and thus at widening the possibilities for studying the material in the collection by promoting international exchanges, represents a significant improvement over the past in the way the participating institutes enhance the collections.

The progress made by ISMAR-CNR and IRSA-CNR has been agreed with the DiSSCo project partners IBBR-CNR and the Natural History Museum of Florence and the final stage of the project is the creation of a page dedicated to the NSCs on GBIF. This will be the repository connecting to the central HUB of ITINERIS.

The process initiated will continue after the end of the ITINERIS project and will accompany, in some cases, the expansion and gradual digitisation of the collections.

6. CONCLUSION

The need to make collections available to a wider range of researchers and interested stakeholders or institutions has in many cases stimulated their rationalisation. This process has enabled a further step of sharing and synergy with, for example, ongoing activities within the National Biodiversity Future Centre (NBFC). The NBFC is implementing a Biodiversity Gateway, one of the objectives of which is to serve as a focal point for available information on a wide range of organisms found in Italy. Some of the collections presented (e.g. Ephemeroptera) will be linked to the repositories activated on the BOLD system and to the relevant sections of the NBFC Gateway, where available genetic information, starting with DNA barcoding, will be collated and coordinated.

In conclusion, the work of rationalising the collections, with a view to making them available to both the scientific community and the general public, has made it possible to bring to light a significant amount of information that was previously unavailable. The digitisation process provides an initial cognitive access to the physical collections, which can later be enhanced by physical access in the places where they are housed. The willingness to continue and expand the important work started in ITINERIS on naturalistic collections will be able to support targeted insights and thematic developments, based on feedback and suggestions received from interested colleagues and stakeholders. This will effectively support the study of current and future Italian biodiversity through comparison with the naturalistic heritage of the past.

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Deliverable 6.14 Activity 6.06

Climate-related prioritization of the aquatic NSC and taxa/specimens selection for the “extended digital specimen” descriptors. Digitization of selected NSC and return of the digital dataset and metadata. Networking of digitized (meta)data

ANNEXE 1



Collection name: Herbarium Istituto Sperimentale Talassografico A. Cerruti

Collection code: TAR

Institution code: CNR-IRSA-TA

Referent Name(s): Loredana Papa, Lucia Spada, Ester Cecere, Antonella Petrocelli

Curator(s): Ester Cecere, Antonella Petrocelli

Numerical consistency: 507 *exsiccata*

Description: The herbarium of the CNR-IRSA of Taranto, named TAR in the “Index Herbariorum”, was founded in 1987 and is made up of 155 species organized in 394 physical specimens including 3 Angiosperms, 29 Chlorophyta, 47 Ochrophyta, 76 Rhodophyta. The collection includes 113 herbarium sheets which haven't the minimum information according to MIDS criteria. Therefore, they were excluded from the digitization process. Samples were mainly collected in the Taranto Seas (Mar Piccolo and Mar Grande), however several specimens coming from Svalbard Islands, western Canada and New Zealand are also present. The physical specimens of the herbarium occurred in dried and pressed form (*exsiccata*), mounted on a paper sheet and preserved in a protective cover. All sheets are stored into 4 drawers according to the belonging phylum.

Sampling methods and geographical provenience: The TAR samples were collected manually or by scuba divers according to the depth of sampled area.

Number of Physical Specimens catalogued: 394

Number of images acquired: 353

Number of Digital Specimens published: 17

Link of the dataset on GBIF: <https://www.gbif.org/dataset/e6ed1fee-829b-4ecb-91a3-de4074472cb1>



Fig. 1 - Map of the Taranto Seas: Mar Piccolo with the two basins and Mar Grande.

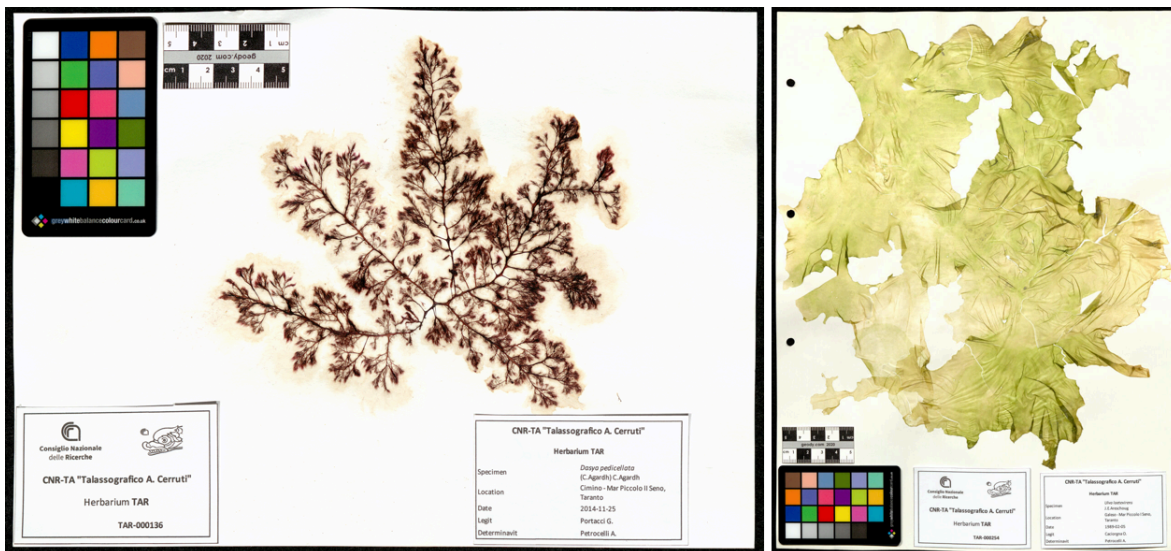


Fig. 2 - The image indicates two digitalized sheets of the TAR herbarium.

Collection name: Erbario Irma Pierpaoli

Collection code: MBMP

Institution code: CNR-IRSA-TA

Referent Name(s): Loredana Papa, Lucia Spada, Ester Cecere, Antonella Petrocelli

Curator(s): Ester Cecere, Anna Maria Miglietta

Numerical consistency: about 600 *exsiccata*

Description: The herbarium is entitled to Irma Pierpaoli, the botanist who collected the specimens. It was recently coded as MBMP in the Hindex Herbariorum and it counts 424 sheets and about 600 specimens collected in the Taranto Seas and in the middle Adriatic (coastal area of Marche region). The physical specimens of the herbarium occurred in dried and pressed form, mounted on a paper sheet (*exsiccata*) and preserved in a protective cover. All herbarium sheets are stored into 3 drawers according to the belonging phylum: 195 Rodophyta, 120 Ochrophyta and 105 Chlorophyta.

Sampling methods and geographical provenience: The MBMP samples were collected manually along the coastal areas of Mar Piccolo and Mar Grande of Taranto and along the Adriatic coasts.

Number of Physical Specimens catalogued: currently 584

Number of images acquired: currently 240

Number of Digital Specimens published: 54

Link of the dataset on GBIF: <https://www.gbif.org/dataset/7d3cd3c0-e761-42d0-8f93-3085edf29ddd>



Fig. 3 - The image indicates the two main areas in which Irma Pierpaoli collected specimens for realizing the MBMP herbarium.



Fig. 4 - The image indicates 3 digitalized sheets of the MBMP herbarium.

Collection name: Seaweeds of Venice Lagoon

Collection code: SeaVe

Institution code: CNR-ISMAR-VE

Referent Name: Simona Armeli Minicante

Curator(s): Simona Armeli Minicante, Edoardo Di Russo

Numerical consistency: 616 *exsiccata*

Description: The SeaVe collection of the Herbarium ISMAR is a contemporary collection of over 600 algal specimens from the Venice Lagoon and the North Adriatic and belonging to different taxa (Chlorophyta, Rhodophyta and Phaeophyceae). This collection includes a section dedicated to alien species. Within the SeaVe collection, The SeaVe_Ulva series, including over 300 specimens, was chosen within the ITINERIS project as part of Activity 6.6.

Sampling methods and geographical provenience: All samples of *Ulva* were manually collected using a rake in different seasons from 24 sampling sites of the Venice Lagoon, including LTER-Italy stations. In the laboratory, the samples were cleaned and preserved in herbarium sheets. For each sample, the collection includes also a subsample preserved in silica gel for molecular analyses through DNA barcoding. The *Ulva* series of the SeaVe collection constitutes the most consistent and often controversial section in correct taxonomic identification. This series constitutes a point of reference for the knowledge of the *Ulva* species present in the Venice lagoon, including the Non-Indigenous Species.

Number of Physical Specimens catalogued: 305

Number of images acquired: 28

Number of Digital Specimens published: 28

Link of the dataset on GBIF: <https://www.gbif.org/dataset/270c9b3e-63e3-4eb1-a7dc-89331c9db608>

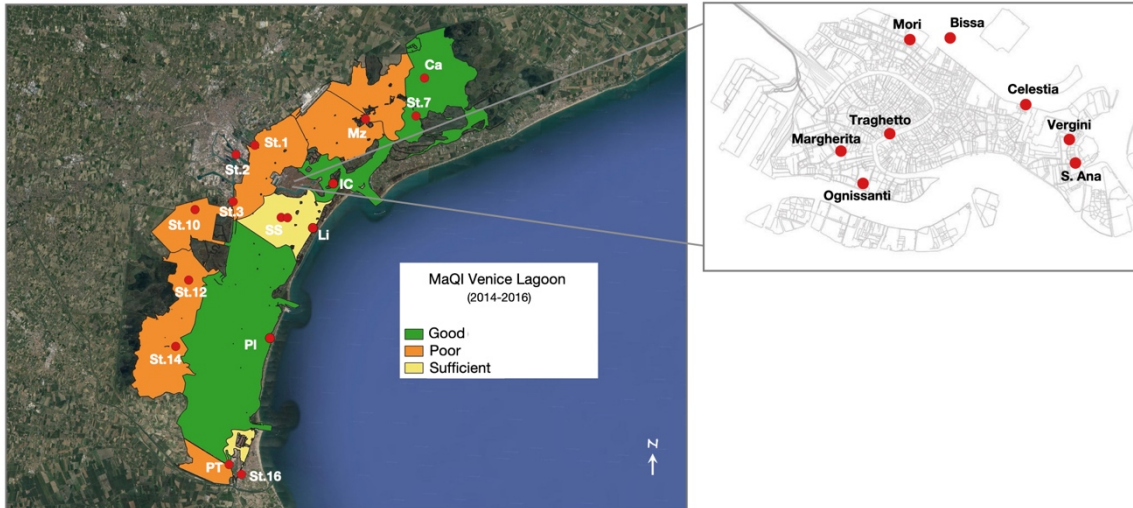


Fig 5 – *Ulva* sampling sites from the Venice Lagoon, from Armeli Minicante et al., 2024c.



Fig. 6 – *Exsiccata* of the SeaVe_ *Ulva* series (Herbarium ISMAR).

Collection name: Linosa Sicily Channel Collection

Collection code: LiCSiC

Institution code: CNR-ISMAR-NA

Referent Name: Luciana Ferraro

Curator(s): Luciana Ferraro – Laura Giordano

Numerical consistency: 2755 specimens

Description: LiCSiC collection is composed of 13 micropaleontological slides collecting benthic foraminifera specimens from Linosa Island seafloor (depth ranging between 50 and 400 m). A total of 140 taxa were identified from the 13 sediment samples. LiCSiC collection is generated by counting, classifying and selecting benthic foraminiferal specimens. The collection is physically stored in the CNR ISMAR buildings of Naples (Italy) and derives from a compilation of physical samples consist of a multi-level material:

- a complex matrix: the dry washed residue stored into a plastic container.
- a multispecific sample: labelled microslide containing the whole foraminiferal assemblages from a specific complex matrix used for classification and relative/absolute counts of foraminiferal taxa.
- a multiple monospecific sample: a numbered cell/s of multispecific microslide containing multiple specimens of a specific taxon.
- a monospecific and individual voucher: labelled microslide containing the most significant and best-preserved specimen of a selected taxon.

Sampling methods and geographical provenience: The LiCSiC samples were collected on board of research vessel Minerva UNO during research cruise BioGeoLin 2017. The sediment sample collection was performed by adopting different tools such as Reineck box-corer and Van Veen grab.

Number of Physical Specimens catalogued: 2755

Number of images acquired: 20

Number of Digital Specimens published: 505

Link of the dataset on GBIF: <https://www.gbif.org/dataset/b41c9cca-a21c-44d3-b293-4441cd31c007>

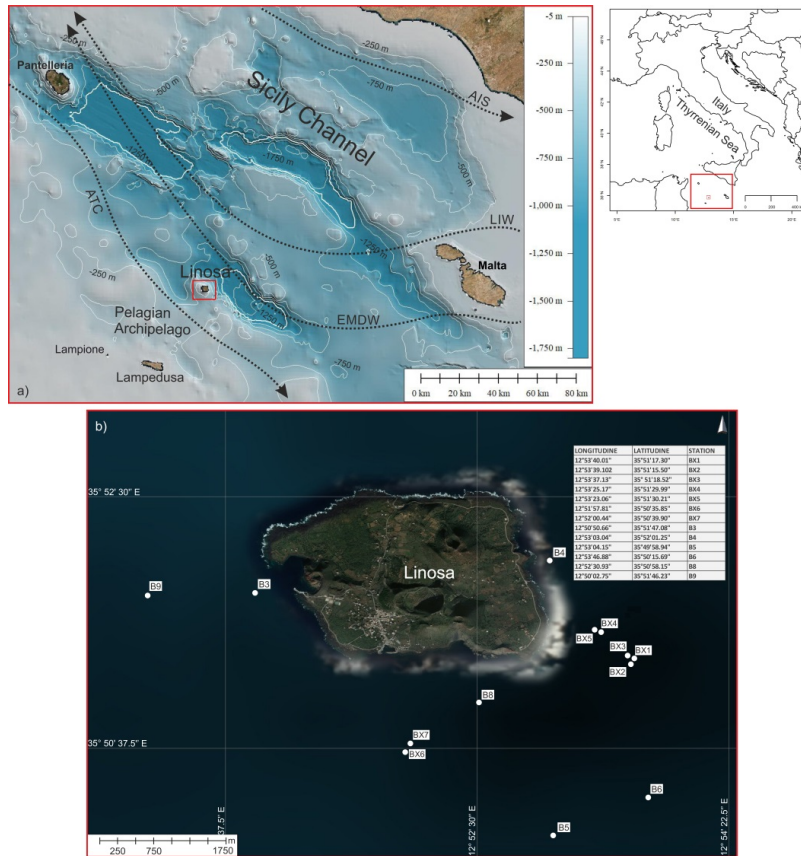


Fig 7- A) Map of Linosa Island with the four principal currents of the Sicily Channel: Atlantic Ionian Stream (AIS), Atlantic Tunisia Current (ATC), Levantine Intermediate Water (LIW) and Eastern Mediterranean Deep Water (EMDW). B) Location of LiCSiC sediment samples; from Ferraro et al., 2020.

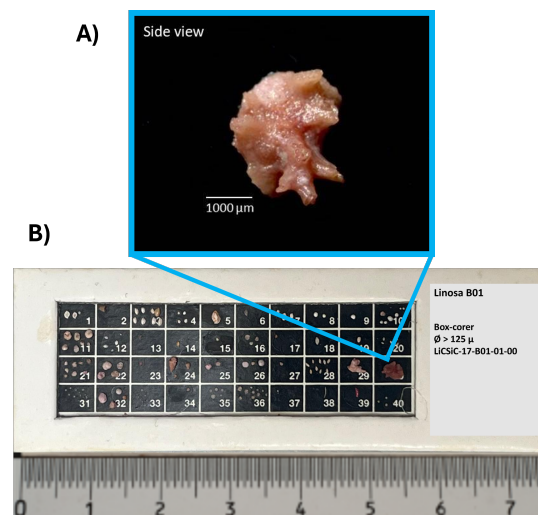


Fig. 8 - A) Digital image of *Miniacina miniacea* from the LiCSiC sample B01 collected at -96 m water depth (catalog number LiCSiC-17-B01-01-29). B) Digital image of LiCSiC multispecimen slide (catalog number LiCSiC-17-B01-01-00).

Collection name: North Adriatic Foraminifera Collection

Collection code: NAdFC

Institution code: CNR-ISMAR-BO

Referent Name: Lucilla Capotondi

Curator(s): Lucilla Capotondi – Roberta D’Onofrio

Numerical consistency: 6000 specimens

Description: NAdFC is composed of 17 micropaleontological slides containing benthic foraminifera specimens from 15 sediment samples collected at the sea-bottom of two key Northern Adriatic stations, S1-GB (South-Est of the Po Delta River) and E1 (Rimini offshore), part of the Italian Long-Term Ecological Research network (LTER-Italy) Site "Delta del Po and Costa Romagnola". A total of 100 taxa and ca 6000 specimens were identified from the 15 NAdFC sediment samples. NAdFC collection is generated by counting, classifying and selecting benthic foraminiferal specimens. The collection is physically stored in the CNR ISMAR buildings of Bologna (Italy) and derives from a compilation of physical samples consisting of a multi-level material:

- a complex matrix: the dry washed residue stored into a vial or a laboratory bag.
- a multispecific sample: labelled microslide containing the whole foraminiferal assemblages from a specific complex matrix used for classification and relative/absolute counts of foraminiferal taxa.
- a multiple monospecific sample: a numbered cell/s of multispecific microslide containing multiple specimens of a specific taxon.
- a monospecific and individual voucher: labelled microslide containing the most significant and best-preserved specimen of a selected taxon.

Sampling methods and geographical provenience: The NAdFC sediment samples were collected on board of the research vessel G. Dallaporta during the research cruise InterNos 2019 (21-28 February 2019, Bastianini et al, 2019) and during the ordinary maintenance activities of S1-GB and E1 autonomous meteo-oceanographic systems conducted since 2016 and includes a depth transect centered on S1-GB (depth ranging between 10,5 and 30 m). Foraminifera and sediment samples as well as sedimentological, hydrological, chemical and biological data acquired at the sea-bottom and along the water column were collected and stored by the National Research Council, Institute of Marine Sciences (CNR-ISMAR). The sediment sample collection was performed by adopting the Reineck box-corer. About 30 cm³ of sediments samples of the box corer were collected with a tube of 8 cm in diameter from the interval 0-1 cm of the seafloor for the foraminiferal analyses, and treated following the FOBIMO protocol (Schönfeld et al., 2012), to facilitate distinguishing living from dead foraminiferal tests.

Number of Physical Specimens catalogued: 6000

Number of images acquired: 75

Number of Digital Specimens published: 519

Link of the dataset on GBIF: https://cloud.gbif.org/eca/resource?r=nadfc_foraminifera&v=1.2

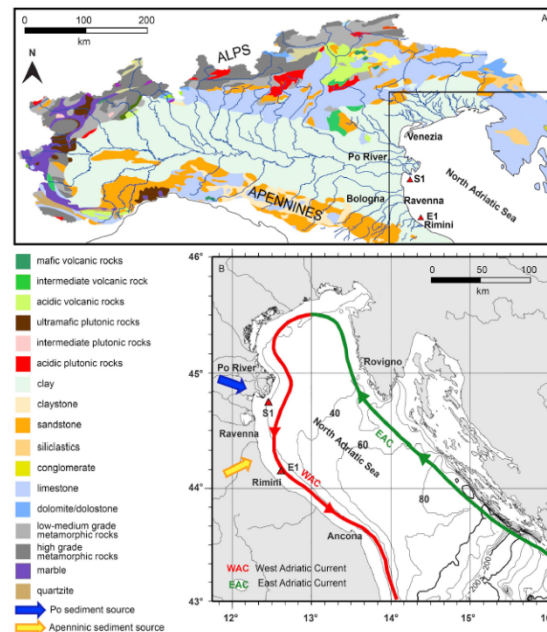


Fig. 9 - A) Map of the Po River drainage basin with lithological units and location of the NAdFC sites S1 and E1. B) the North Adriatic circulation pattern. From Capotondi et al., (2019).

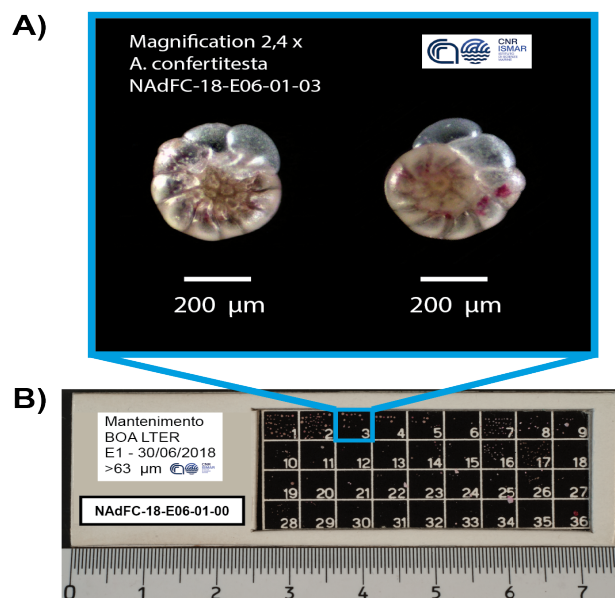


Fig.10 - A) Digital image of *Ammonia confertitesta* on ventral (left) and spiral (right) sides from the NAdFC sample collected at the E1 buoy (catalog number NAdFC-18-E06-01-03). B) Digital image of NAdFC multispecimen slide (catalog number NAdFC-18-E06-01-00).

Collection name: Ephemeroptera BUFFAGNI

Collection code: EphemAB

Institution code: CNR-IRSA-MI

Referent Name(s): Andrea Buffagni

Curator(s): Andrea Buffagni, Simona Cislaghi

Numerical consistency: >200 (whole collection)

Description: dedicated to Ephemeroptera taxonomy and faunistic. Body and mouth parts of Ephemeroptera species are mounted on Microscope slides in Hoyer's medium. Drawings, preserved specimens and photographs of living specimens can be added to the collection.

Sampling methods and geographical provenience: This collection refers to qualitative sampling, with general habitat characterisation at the site level, with some exceptions providing information at the microhabitat scale. The main habitats present in the freshwater ecosystem were sampled with the aim of maximising the detection of mayfly species. In some cases, adults were sampled during flight or with light traps. Samples have been collected intermittently from 1989 to the present. The collection includes specimens from the following river types/regions: mountain rivers in the central and western Alps, lowland rivers in northern Italy, spring-fed small streams in northern Italy (Lombardy), large rivers (e.g. Po river), streams in Sardinia and some other European areas (Switzerland, France and UK). The collection contains specimens representing endemic species and a few specimens collected from type localities.

Number of Physical Specimens catalogued: 58

Number of images acquired: in progress

Number of Digital Specimens published: 58

Link of the dataset on GBIF: <https://www.gbif.org/dataset/1c016e80-a3dc-47d5-b49b-cd89885992d0>

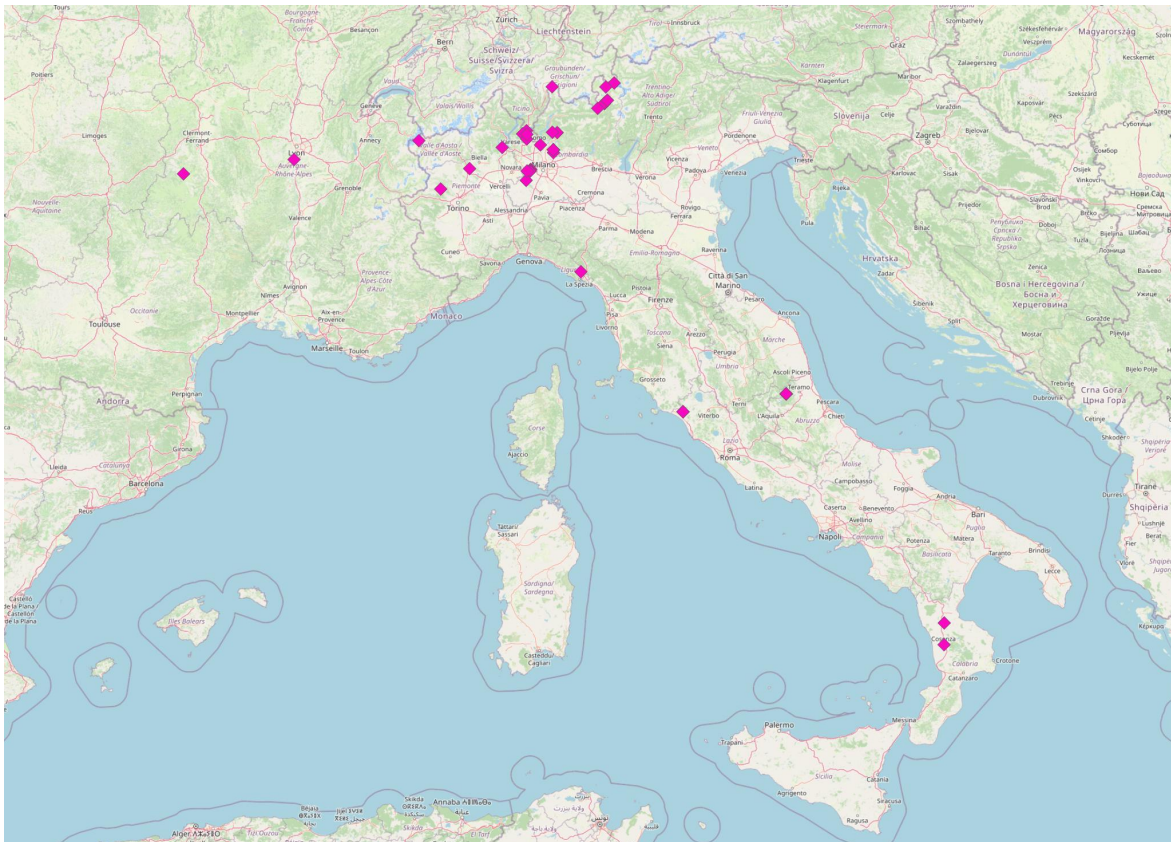


Fig. 11 – Location of freshwater sampling sites from which specimens currently in the Ephemeroptera (EpheAB) collection were collected.

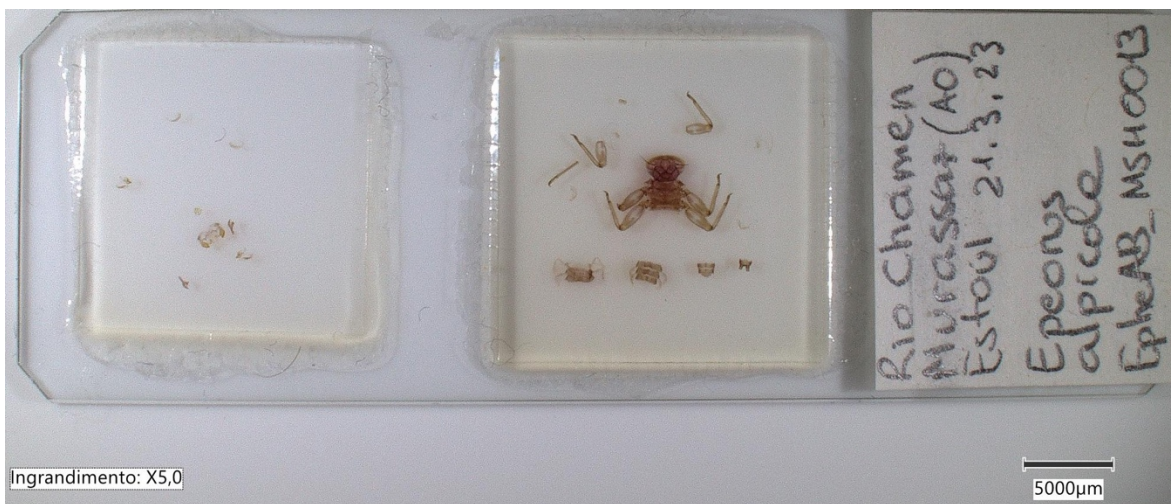


Fig.12 - Slide of *Epeorus alpicola* (catalog number EpheAB_MSH001).

Collection name: Tardigrade Collection of Ramazzotti

Collection code: RamVB

Institution code: CNR-IRSA-VB

Referent Name: Diego Fontaneto

Curator(s): Monica Beltrami, Roberta Piscia, Silvia Zaupa

Numerical consistency: Slides with 3328 specimens

Description: The Ramazzotti collection, preserved at the Water Research Institute, is composed of numerous slides and microscopic preparations of tardigrades, including animals and their eggs (which are useful for taxonomic identification). The collection is composed of ten boxes, numbered in progressive order with Roman numerals, containing a variable number of slides. There are a total of 856 slides divided as follows: box I contains 100 slides, II 98, III 98, IV 100, V 99, VI 93, VII 85, IX 83, X 82 and XI 17. This collection is physically stored in the CNR IRSA building of Verbania (Italy).

Sampling methods and geographical provenience: The samples were collected using pumps in an aquatic environment, scraping the surfaces of stones, rocks, wood, and aquatic plants in a terrestrial environment. Collected organisms were preserved by preparing slides using mainly Faure or Polyvinyl as mounting medium. Most of the samples were taken in Europe, in particular from Italy, Germany, France, Finland, Norway, Poland, Austria, Switzerland, Sweden, the Netherlands and the United Kingdom. Other samples come from Africa (Uganda and Congo), North America (United States) and South America (Chile and Mexico)

Number of Physical Specimens catalogued: 3328

Number of images acquired: 4183

Number of Digital Specimens published: 4183

Link of the dataset on GBIF: <https://www.gbif.org/dataset/e9aeced17-b33f-4af2-8471-9be87633d7e1>



Fig. 13 - Ramazzotti Collection: Example of box with slides.

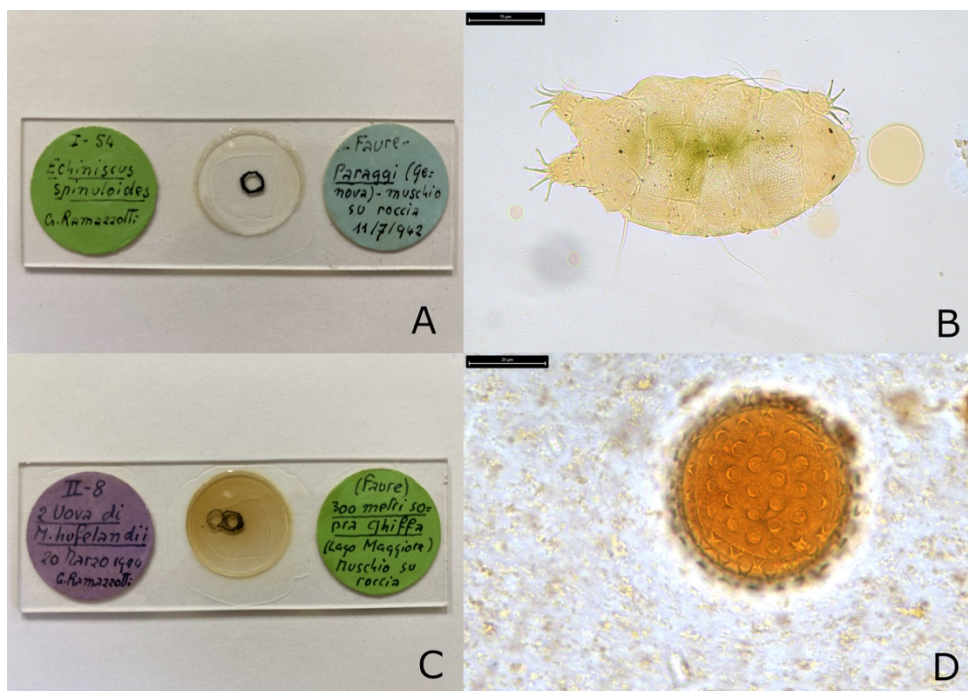


Fig. 14 - Ramazzotti Collection: A) slide 54 Box I; B) specimen *Echiniscus spinuloides* (RamVB-I-54); C) slide 8 Box II; D) specimen (egg) n° 2 *Macrobiotus hufelandii* (RamVB-II-8_2).

Collection name: Northern Adriatic Epimegabenthos

Collection code: NAdEm

Institution code: CNR-ISMAR-VE

Referent Name: Marco Sigovini

Curator(s): Marco Sigovini, Irene Guarneri, Davide Tagliapietra, Andrea Sabino, Edoardo Di Russo

Numerical consistency:

Description: The collection includes organisms belonging to the Northern Adriatic epimegabenthic fauna. Epimegabenthos is conventionally defined as the zoobenthos living at the top of the substrate and larger than 1 cm. This compartment includes most macroinvertebrate phyla, such as Annelida, Arthropoda, Bryozoa, Cnidaria, Echinodermata, Mollusca, Porifera. Samples belong to coastal benthic habitats ranging in depth from intertidal to 30 m, either manually or by means of dredges or trawl nets. Samples are generally preserved in ethyl alcohol 70% or dry.

Sampling methods and geographical provenience: Most samples have been collected along the Veneto coastline during 2016-2019 monitoring activities in the framework of the Marine Strategy Directive 2008/56/EC. Annual monitoring campaigns were performed in the period 2016-2019 over four 25 km² areas characterized by muddy sand bottom, located between 3 and 6 nautical miles from the Veneto coastline, on bathymetries between 15 and 20 m. Samplings were carried on a fishing vessel, by means of “rapido” trawling. A quantitative sub-sample of the collected material, mostly by-catch, was collected for analysis, maintained at low temperatures, sorted and stored within 48 hours. Other samples were collected in the Northern Adriatic Area, most of them along the Veneto coastline, by means of diverse approaches, including manual harvesting or by gear such as nets, samplers and traps. All the organisms were quantified and determined to the lowest achievable taxonomic rank, based on up-to-date taxonomic keys and scientific literature.

Number of Physical Specimens catalogued: 255 specimens

Number of images acquired: 350

Number of Digital Specimens published: 246

Link of the dataset on GBIF: <https://www.gbif.org/dataset/31a4262f-d109-4cb6-87dd-d9b5aff7108c>



Fig. 15 - Location of the samplings for the NAdEm Collection.

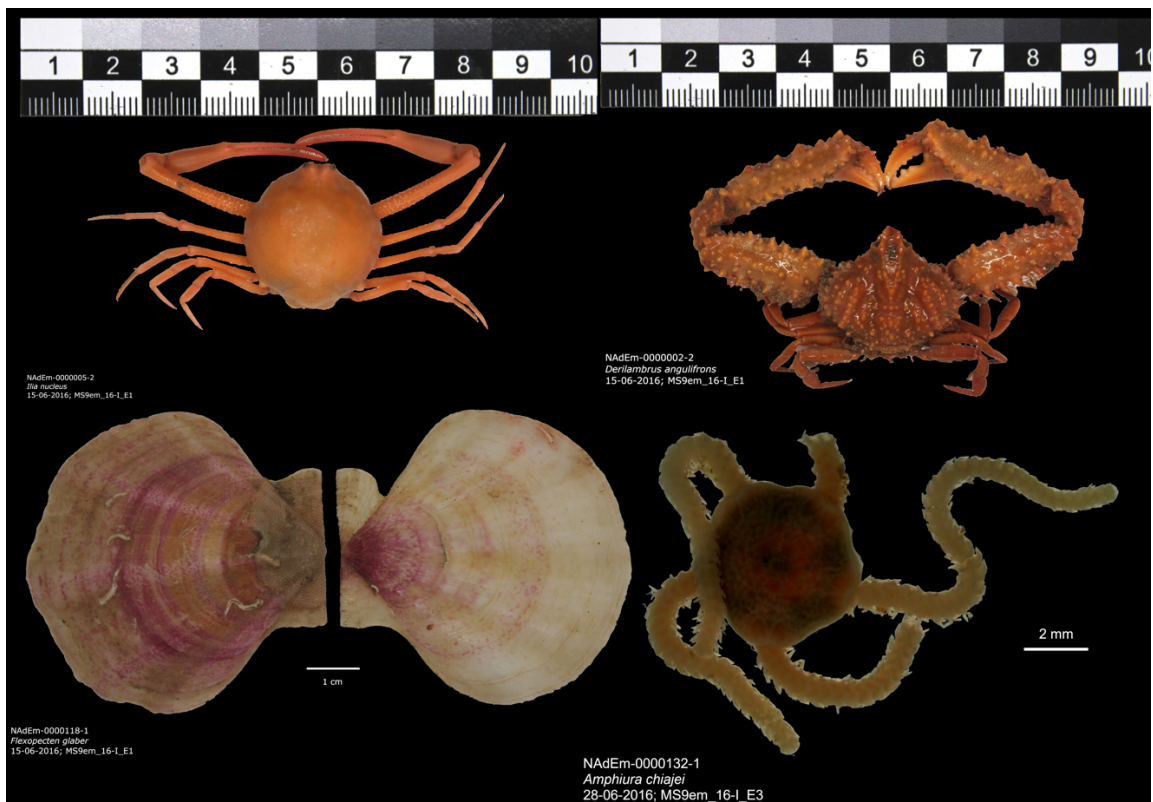


Fig. 16 - Vouchers as examples of the NAdEM Collection.

Collection name: Dese Crustacean Collection

Collection code: DC

Institution code: CNR-ISMAR-VE

Referent Name: Francesca Maggiore

Curator: Edoardo Di Russo

Numerical consistency: 599 physical specimens

Description: The collection contains crustaceans collected during studies on the biodiversity of the Venice Lagoon and is a subset of the larger DeseCo collection which also includes polychaetes, molluscs (both will be catalogued by the end of the project) and oligochaetes. In the framework of the RI-DiSSCo and project ITINERIS the crustacean samples underwent curation, cataloging and digitization in order to make virtually available the NSCs to any level of audience simplifying access and sharing information. The collection is supported by available bibliographic information on the life history of species.

The collection is physically stored in the CNR ISMAR headquarter Venice (Italy). It is made of:

- Monospecific vials with more individuals.
- Vouchers. It is a monospecific sample of a given taxa selected based on best-preserved specimens, to be tagged, photographed and digitized.

Sampling methods and geographical provenience: The study was focused on the Dese estuary, distinctive habitat inside the northern Venice lagoon area characterized not only by wide tidal amplitudes, but also by the Dese River flow. The estuary (about 14 km) extends from the Dese outflow in the lagoon to the Lido inlet, forming a narrow, meandering channel (Canale di Burano) between salt marshes and mud flats. The collection come from samplings carried out in nine stations located in the mud flats around the *Canale di Burano* from the Lido inlet to Dese river outflow in the lagoon. At each station geographical position was recorded by GPS. The samplings were carried out during May, August and October 2002 and March 2003. Quantitative samples were taken at an average depth of 0.5 m. At each station five samples of sediment were collected with an Ekman box corer (volume=13 cm³). The samples were randomly taken around the boat; the block of sediment provided by the tool was cutted in two pieces: the surface layer of 5 cm and the underlying layer of 12 cm. The material was washed through a 1.0 mm mesh screen, organisms retained were placed in plastic jars where a sufficient amount of 1% chloral hydrate solution in sea water was added. The organisms were fixed in 4% buffered formalin after 30 minutes. In the laboratory the specimens were sorted, identified to the lowest possible taxonomic level and enumerated. The specimens of each species were preserved in vials or jars with 70% ethanol.

Number of Physical Specimens catalogued: 599

Number of images acquired: 60

Number of Digital Specimens published: 599

Link of the dataset on GBIF: <https://www.gbif.org/dataset/57455ab8-2f56-4e27-ab32-67cf3c13692a>



Fig. 17- Dese estuary and location of sampling stations.

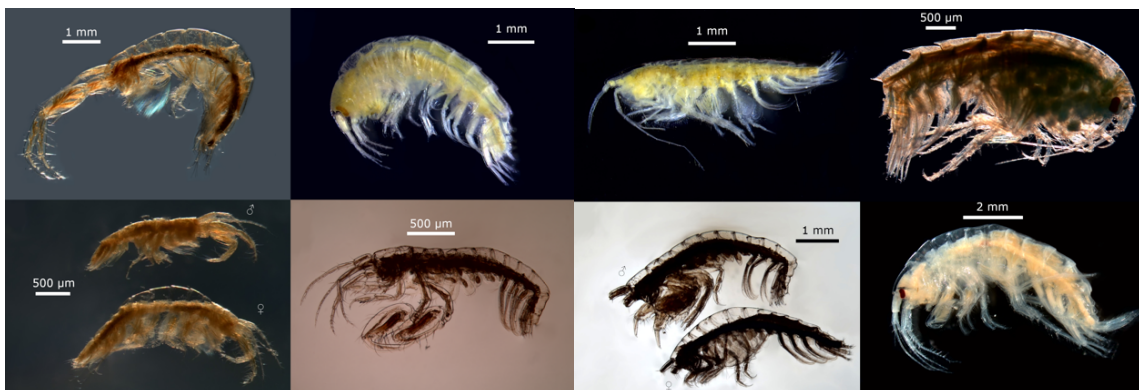


Fig. 18 - Vouchers as examples of the DC Collection.

Collection name: Xylophagous from the Lagoon of Venice and EUrope

Collection code: XLoVEU

Institution code: CNR-ISMAR-VE

Referent Name(s): Irene Guarneri, Marco Sigovini

Curator: Edoardo Di Russo

Numerical consistency: 395 physical specimens for a total of 1200 individuals

Description: The collection is divided into two series: XILAG and LimNAr. The LimNAr series consists of specimens from different sites in the Northern Adriatic belonging to the families Limnoriidae and Cheluridae. The XILAG series is described below. Collection of bivalve and peracarid xylophagous organisms collected through wood collectors in the Venice lagoon and sites distributed in Europe. The samples of the collection do not only come from the various projects conducted in the Venice lagoon (Accoya, MAV1_5staz, MAV3_SS, Doge palace water door), or from the Italian seas (Deep mooring, RItMARE), in 2016 a synchronous observation was conducted in 15 European countries, with a total of 25 participants (Xilag project). The test started at the beginning of the warm season and after three months the materials were recovered and sent back to the CNR-ISMAR in Venice. Here radiographs were performed and the organisms present were collected, identifying them at species level.

The collection is physically stored in the CNR ISMAR headquarter Venice (Italy). It is made of :

- Monospecific vials with more individuals;
- Vouchers. It is monospecific sample of a given taxa selected on the basis of best-preserved specimens, to be tagged, photographed and digitized.

Sampling methods and geographical provenience: Xilag: The specimens were extracted from wood samples that were kept immersed in sea water for 5 months and then collected. Samples were collected in November 2016 in 14 different sites by as many collaborators (see location map). The EN275 procedure has been followed but the duration of rack stasis was 5 months. Wood collectors consist of a plastic rack containing 3 blocks of pine wood (*Pinus sylvestris*). The dimensions of the single block are 20 cm x 7.5 cm, and all come from a single wooden board. Collectors were kept immersed for 5 months at a depth of 1 meter. Once extracted from the sea water the samples were collected and shipped to CNR ISMAR in Venice. Once they arrived in Venice the specimens were extracted and subsequently identified on classical taxonomy (morphological) basis. LimNAr: The samples were collected during sporadic sampling and not strictly linked to monitoring projects.

Number of Physical Specimens catalogued: 395

Number of images acquired: 778

Number of Digital Specimens published: 55

Link of the dataset on GBIF: <https://www.gbif.org/dataset/2efb7735-2564-4b7b-ae6e-477578ee72ef>

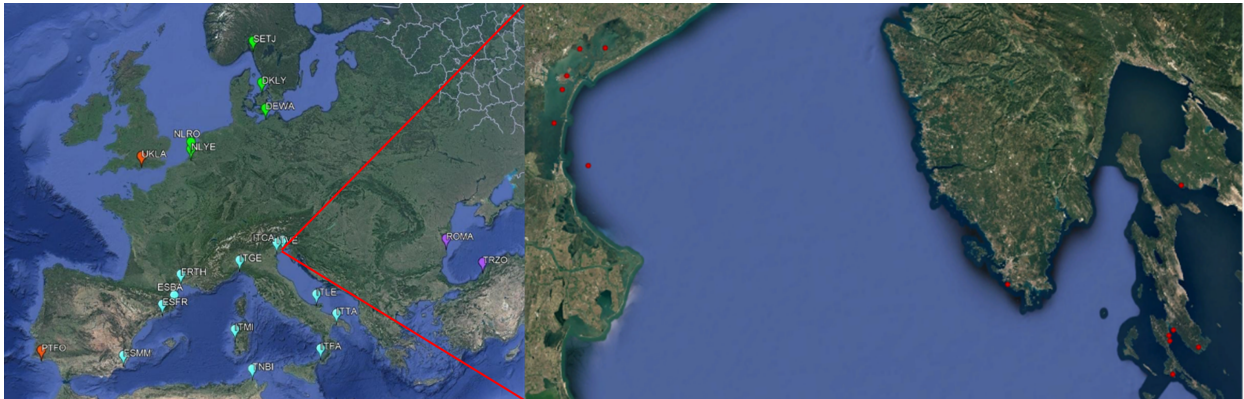


Fig. 19 - Location of sampling stations for the XILAG series (left) and LimNAr series (right).

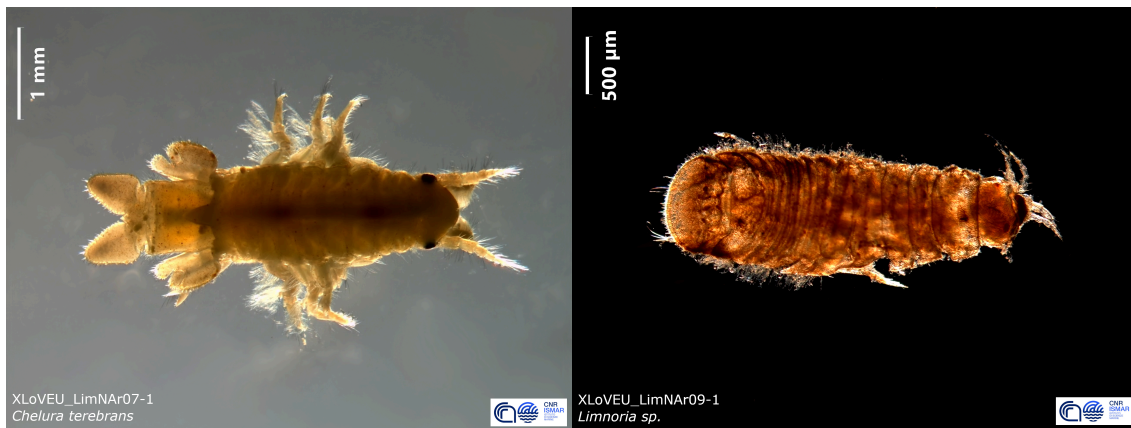


Fig. 20 - Two vouchers as example of the XLoVEU Collection.

Collection name: Marine zooplankton collection

Collection code: ZPlank

Institution code: CNR-ISMAR-VE

Referent Name: Elisa Camatti

Curator(s): Elisa Camatti, Edoardo di Russo, Nicola Nurra

Numerical consistency: 62 physical specimens for a total of 300 individuals

Description: The Marine zooplankton collections (ZPlank) comprise collections generated by counting, classifying, and selecting zooplankton organisms from samples collected as part of the long-term LTER series of ISMAR Venice. These samples are derived from the Venice Lagoon and Northern Adriatic LTER sites, as well as from oceanographic cruises in various Mediterranean regions, including the Ionian Basin and the Tyrrhenian Sea.

The collections are categorized into two types: the Long-Term Zooplankton Collection (LTZC) and the Mediterranean Zooplankton Collection (MedZC). Both collections are physically stored at the CNR ISMAR facilities in Venice, Italy.

The ISMAR ZC is based on physical samples collected during monthly long-term research cruises (for LTZC) or various research projects, well defined and limited over time (for MedZC). These samples are multispecific, labeled with microslides, and contain comprehensive zooplankton assemblages from specific matrices used for classification and relative/absolute counts of zooplankton taxa.

The samples include crustacean species from the subclasses Copepods and Cladocera, as well as various meroplanktonic forms, with a particular focus on alien species.

Sampling methods and geographical provenience: The LTZC samples were collected from the five LTER stations (www.lteritalia.it) located in the Venice Lagoon and from the one in the Acqua Alta Oceanographic Tower (North Adriatic Sea). The MedZC includes samples from different oceanographic cruises across the Adriatic, Ionian, and Tyrrhenian seas. For these collections, taxa representative from different geographical areas will be selected.

The NAdFC samples were collected aboard CNR research vessels using standard plankton nets with a mesh size of 200 microns (WP2 models, Indian Ocean or Apstein), through surface, horizontal, or vertical hauls, depending on the study area, water column depth, and scientific objectives. Collected organisms are stored in 250 ml plastic jars and preserved with borax-buffered formaldehyde. From these, individual taxa or groups will be selected for the collections.

Taxonomic and quantitative determinations of zooplankton were performed using a Zeiss stereomicroscope at the lowest possible taxonomic level (species for copepods and cladocerans) on either the entire sample for the rare species or a representative sub-sample.

Number of Physical Specimens catalogued: 62

Number of images acquired: 20

Number of Digital Specimens published: 62

Link of the dataset on GBIF: <https://www.gbif.org/dataset/3127c600-5a8b-4184-ad09-1cbbf291cc72>



Fig. 21 - Sampling on the LTER “Acqua Alta” site and preserved samples and microscope analyses.

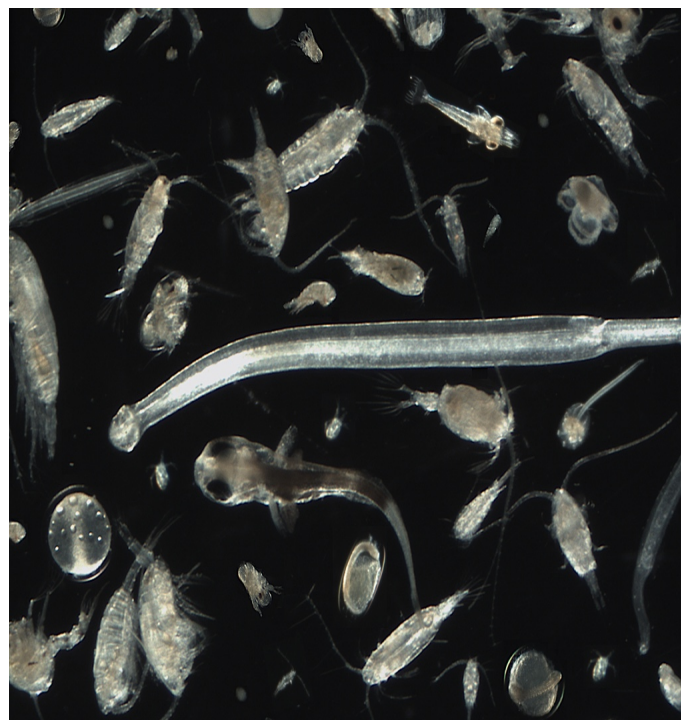


Fig. 22 - Zooplanktonic organisms photographed to stereomicroscope.

Collection name: Sardinia river invertebrates – slightly altered sites

Collection code: SARDNP

Institution code: CNR-IRSA-MI

Referent Name: Andrea Buffagni

Curator(s): Andrea Buffagni, Marcello Cazzola, Stefania Erba

Numerical consistency: > 1000 physical specimens

Description: This collection is composed of river invertebrate samples collected in pool mesohabitat. Invertebrate specimens are preserved in 70% denaturated ethanol and stored in vials. Each vial contains specimens of a single taxon collected at a sampling site and date in a specific microhabitat. Vials are labelled manually and contain at least information on date, site, habitat/microhabitat and taxon name. A new sampling code is assigned for digitized samples and its corresponding label inserted in the original vial. Different vials from the same sampling site are stored in boxes labelled by projects and/or geographical area. Boxes contains different river sites, from the same project and geographical area.

The most represented taxonomic group within this collection is the Arthropoda phylum and particularly the Insecta class. Most records refer to family level identification and comprise the occurrences of >90 macro-invertebrate families. Information on Ephemeroptera taxa and a few other groups is provided at genus level. In order to guarantee coherence with the aim of data collection, the nomenclature used in this dataset followed the one present in the MacrOper list (Buffagni & Erba, 2014), used to assess the ecological status of Italian water bodies according to the WFD.

Sampling methods and geographical provenience: invertebrates are collected at river located in the eastern part of Sardinia (South-western Italy). Considered rivers have a prevalent temporary character and are characterized by a gradient of alteration of water quality also including hydromorphological modification with artificial structures affecting banks and channel habitats. Samples have been collected within two different research projects, Micari (strumenti e procedure per il Miglioramento della CAPacità RICettiva di corpi idrici superficiali e proposta di stream standard specifici per corsi d'acqua a regime torrentizio) and INHABIT (LIFE08 ENV/IT/000413 INHABIT). Invertebrate samples are collected with a multihabitat proportional sampling technique. 20 sampling units are collected according to the proportional presence of organic biotic type and mineral substrate size. Sampling units are identified at a riffle-pool sequence within the reach (mesohabitat level). The 20 sampling units are quantitatively collected with a Surber net (area 0.05m²; mesh size 0.5mm). Each sampling unit is characterized by a specific substrate type, flow type, depth, and flow velocity (microhabitat level). A physicochemical characterization of the river site is usually available. River stretches are also characterized for their habitat features and modifications including bank and channel features (e.g., bank material, bank modification, width of the bank-top vegetation strip, channel width, substrate type, flow-type, channel modification). Map-based geographical data are also usually collected for each site and include distance from source, slope of the thalweg, altitude, latitude and longitude, land use percentages estimated from CORINE land cover maps. Water discharge, in a representative cross-section, is also usually measured while collecting river macroinvertebrates. For ITINERIS project only a selection of slightly altered sites is provided. The provided collection refers only to pool mesohabitat (10 sampling units per site).

Number of Physical Specimens catalogued: 277

Number of images acquired: *about 160*

Number of Digital Specimens published: 277

Link of the dataset on GBIF: <https://www.gbif.org/dataset/69f08226-8eba-4740-8acc-809290bb2c67>

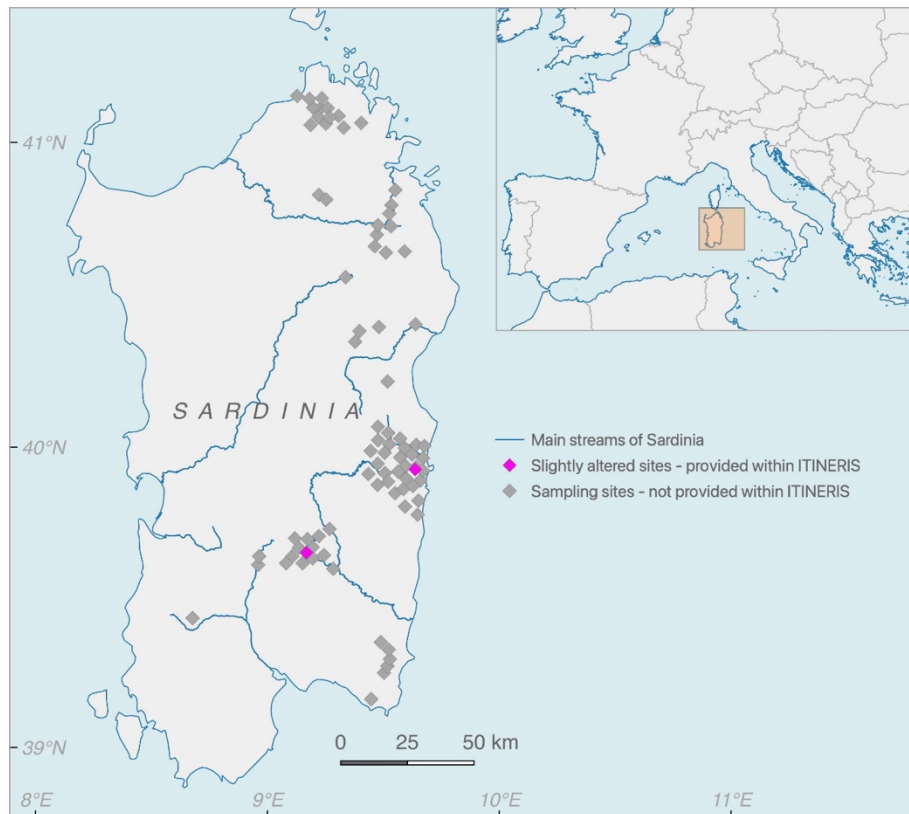


Fig. 23 - Map of investigated area related to the presented collection including the location of sampling sites provided for ITINERIS. Slightly altered sites.



Fig. 24 – Simuliidae images (Catalogue number SARDNP_00011A). Images acquired with Stereomicroscope (25X left; 40X center and right).

Collection name: Campania river invertebrates – slightly altered sites

Collection code: CAMPNP

Institution code: CNR-IRSA-MI

Referent Name: Stefania Erba

Curator(s): Stefania Erba, Marcello Cazzola, Andrea Buffagni

Numerical consistency: > 2000 physical specimens (>10000 individuals) - whole collection

Description: This collection is composed of river invertebrate samples collected in pool mesohabitat. Invertebrate specimens are preserved in 70% denaturated ethanol and stored in vials. Each vial contains specimens of a single taxon collected at a sampling site and date in a specific microhabitat. Vials are labelled manually and contain at least information on date, site, habitat/microhabitat and taxon name. A new sampling code is assigned for digitized samples and its corresponding label inserted in the original vial. Different vials from the same sampling site are stored in boxes labelled by projects and/or geographical area. Boxes contain different river sites, from the same project and geographical area.

The most represented taxonomic group within this collection is the Arthropoda phylum and particularly the Insecta class. Most records refer to family level identification and comprise the occurrences of 93 macro-invertebrate families (28 insects families provided to ITINERIS). Information on Ephemeroptera taxa and a few other groups is provided at genus level. In order to guarantee coherence with the aim of data collection, the nomenclature used in this dataset followed the one present in the MacrOper list (Buffagni & Erba, 2014), used to assess the ecological status of Italian water bodies according to the WFD.

Sampling methods and geographical provenience: invertebrates are collected at river located in the Campania (South-western Italy), Salerno Province. Rivers included in the original sampling design cover a wide alteration gradient, both in terms of water quality degradation and hydromorphological alteration. This collection refers to the EU funded project AQEM (EVK1-CT1999-00027), which objective was the development of an assessment system compliant with WFD (EC/2000/60) requirements. Samples were collected in different sampling seasons³. Invertebrate samples are collected with a multihabitat proportional sampling technique. 20 sampling units are collected according to the proportional presence of organic biotic type and mineral substrate size. Sampling units are identified at a riffle-pool sequence within the reach (mesohabitat level). The 20 sampling units are quantitatively collected with a Surber net (area 0.05m²; mesh size 0.5mm). Each sampling unit is characterized by a specific substrate type, flow type, depth, and flow velocity (microhabitat level). A physicochemical characterization of the river site is usually available. River stretches are also characterized for their habitat features and modifications including bank and channel features (e.g., bank material, bank modification, width of the bank-top vegetation strip, channel width, substrate type, flow-type, channel modification). Map-based geographical data are also usually collected for each site and include distance from source, slope of the thalweg, altitude, latitude and longitude, land use percentages. Water discharge, in a representative cross-section, is also usually measured while collecting river macroinvertebrates. For ITINERIS project only a selection of slightly altered sites is provided. The provided collection refers only to pool mesohabitat (10 sampling units per site) during spring season. Presently only a part of Insects was digitized.

Number of Physical Specimens catalogued: 236

Number of images acquired: *in progress*

Number of Digital Specimens published: 236

Link of the dataset on GBIF: <https://www.gbif.org/dataset/b0da61f6-a9db-4bec-9785-859393feb03b>

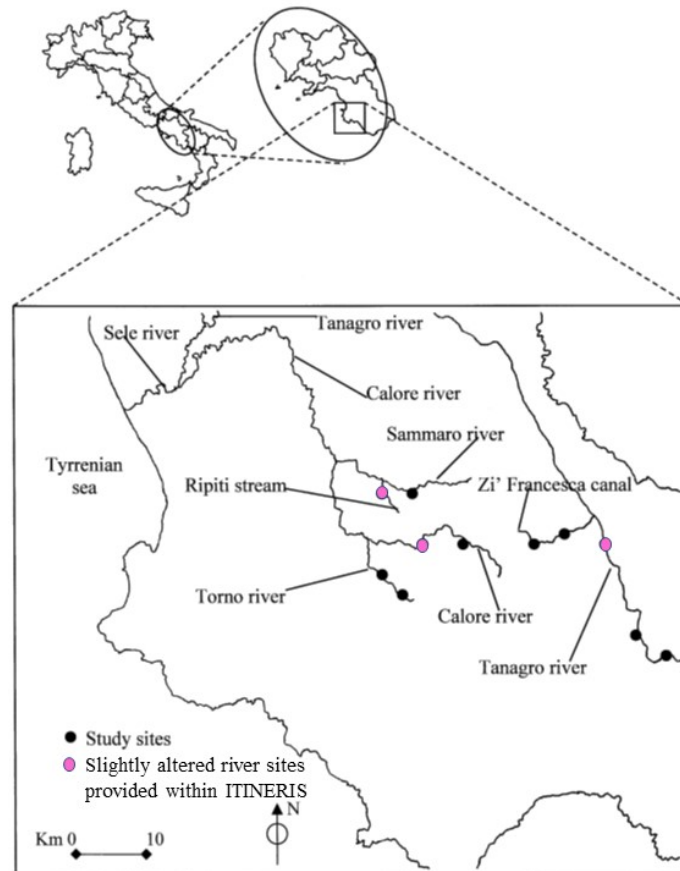


Fig. 25- Map of investigated area related to the presented collection including the location of sampling sites provided for ITINERIS. Modified from Buffagni et al., 2004.



Fig. 26 – *Isoperla* images (6.3X; Catalogue number CAMPNP_00022X). Images acquired with Stereomicroscope.

Collection name: Piedmont river invertebrates – slightly altered sites

Collection code: PIEMNR

Institution code: CNR-IRSA-MI

Referent Name: Marcello Cazzola

Curator(s): Andrea Buffagni, Marcello Cazzola, Stefania Erba

Numerical consistency: > 2000 physical specimens (>15000 individuals) - whole collection

Description: This collection is composed of river invertebrate samples collected in riffle mesohabitat. Invertebrate specimens are preserved in 70% denaturated ethanol and stored in vials. Each vial contains specimens of a single taxon collected at a sampling site and date in a specific microhabitat. Vials are labelled manually and contain at least information on date, site, habitat/microhabitat and taxon name. A new sampling code is assigned for digitized samples and its corresponding label inserted in the original vial. Different vials from the same sampling site are stored in boxes labelled by projects and/or geographical area. Boxes contain different river sites, from the same project and geographical area. The most represented taxonomic group within this collection is the Arthropoda phylum and particularly the Insecta class. Most records refer to family level identification and comprise the occurrences of > 70 macro-invertebrate taxa. Information on Ephemeroptera taxa and a few other groups is provided at genus level. In order to guarantee coherence with the aim of data collection, the nomenclature used in this dataset followed the one present in the MacrOper list (Buffagni & Erba, 2014), used to assess the ecological status of Italian water bodies according to the WFD.

Sampling methods and geographical provenience: invertebrates are collected at river located in the North Western Italian Alps, in the Piedmont Region. This collection refers to the EUROLIMPACS GOCE-CT-2003-505540 EU project and the catchments of the Orco and Chiusella rivers, with their varying land use and hydromorphological characteristics, were selected for the study. Considered rivers are typical alpine rivers, with pebble-cobble riverbeds and are characterized by a slight degree of alteration in hydromorphology and riverine habitats. Invertebrate samples are collected with a multihabitat proportional sampling technique. 20 sampling units are collected according to the proportional presence of organic substrate type and mineral substrate size. Sampling units are identified at a riffle-pool sequence within the reach (mesohabitat level). The 20 sampling units are quantitatively collected with a Surber net (area 0.05m²; mesh size 0.5mm). Each sampling unit is characterized by a specific substrate type, flow type, depth, and flow velocity (microhabitat level). A physicochemical characterization of the river site is usually available. River stretches are also characterized for their habitat features and modifications including bank and channel features (e.g., bank material, bank modification, width of the bank-top vegetation strip, channel width, substrate type, flow-type, channel modification). Map-based geographical data are also usually collected for each site and include distance from source, slope of the thalweg, altitude, latitude and longitude, land use percentages estimated from CORINE land cover maps. Water discharge, in a representative cross-section, is also usually measured while collecting river macroinvertebrates. A selection of samples from slightly altered sites is provided for ITINERIS project. The provided collection refers only to riffle mesohabitat (10 sampling units per site).

Number of Physical Specimens catalogued: 611

Number of images acquired: *in progress*

Number of Digital Specimens published: 611

Link of the dataset on GBIF: <https://www.gbif.org/dataset/ef3717e9-f894-4363-921a-ce2f029decf2>

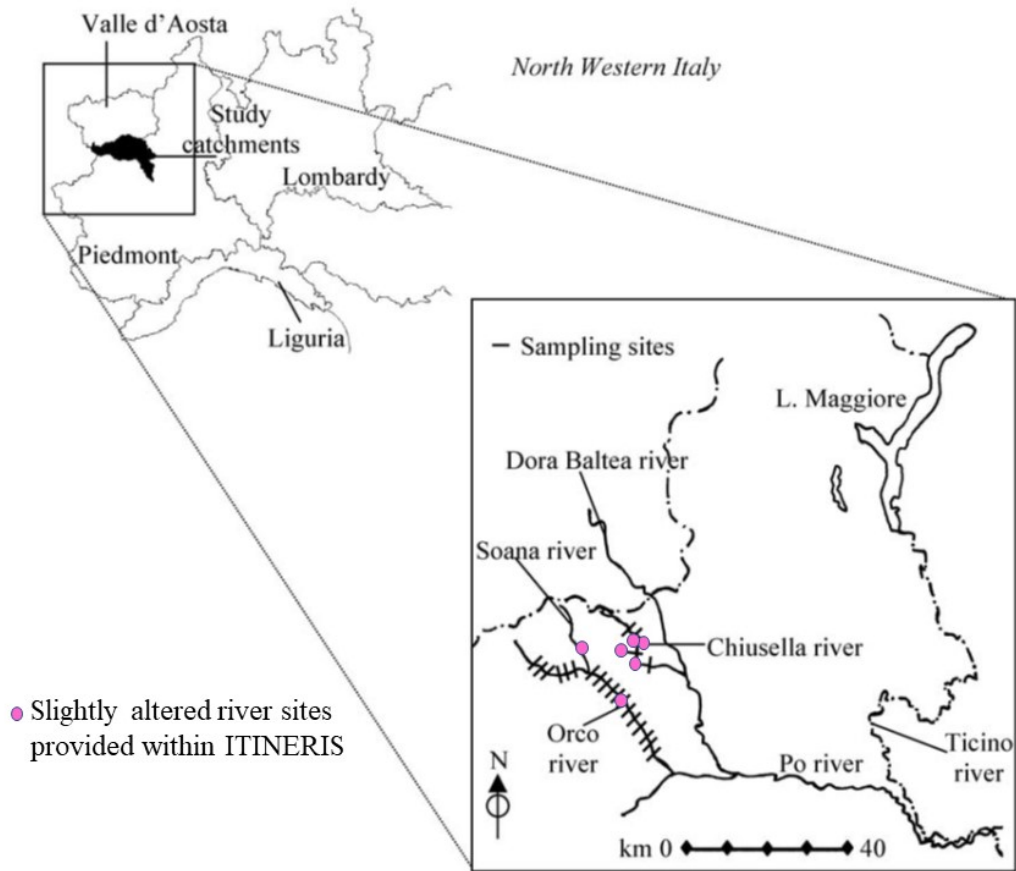


Fig. 27- Map of investigated area related to the presented collection including the location of sampling sites provided for ITINERIS. Short line segments represent the position of CARAVAGGIO survey. Modified from Buffagni et al., 2009.

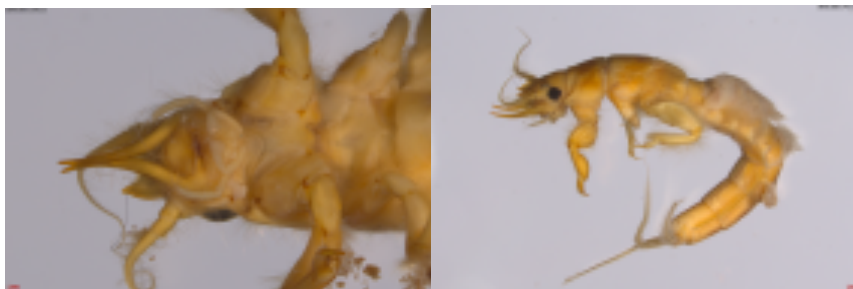


Fig. 28 – *Ephemera* images (Catalogue number PIEMNR_00425X) Images acquired with Stereomicroscope; magnification left 20X; right 8X.

Collection name: Sardinia river invertebrates – Nearly natural sites

Collection code: SARDRP

Institution code: CNR-IRSA-MI

Referent Name: Andrea Buffagni

Curator(s): Andrea Buffagni, Marcello Cazzola, Stefania Erba

Numerical consistency: > 2000 physical specimens (>20000 individuals)

Description: This collection is composed of river invertebrate samples collected in pool mesohabitat. Invertebrate specimens are preserved in 70% denaturated ethanol and stored in vials. Each vial contains specimens of a single taxon collected at a sampling site and date in a specific microhabitat. Vials are labelled manually and contain at least information on date, site, habitat/microhabitat and taxon name. A new sampling code is assigned for digitized samples and its corresponding label inserted in the original vial. Different vials from the same sampling site are stored in boxes labelled by projects and/or geographical area. Boxes contain different river sites, from the same project and geographical area. The most represented taxonomic group within this collection is the Arthropoda phylum and particularly the Insecta class. Most records refer to family level identification and comprise the occurrences of 80 macro-invertebrate taxa. Information on Ephemeroptera taxa and a few other groups is provided at genus level. In order to guarantee coherence with the aim of data collection, the nomenclature used in this dataset followed the one present in the MacOper list (Buffagni & Erba, 2014), used to assess the ecological status of Italian water bodies according to the WFD.

Sampling methods and geographical provenience: invertebrates are collected at river located in the eastern part of Sardinia (South-western Italy). Considered rivers have a prevalent temporary character and represent nearly pristine sites (reference sites) with no or not significant anthropogenic pressures. Samples have been collected within two different research projects, Micari and INHABIT (LIFE08 ENV/IT/000413 INHABIT). Invertebrate samples are collected with a multihabitat proportional sampling technique. 20 sampling units are collected according to the proportional presence of organic substrate type and mineral substrate size. Sampling units are identified at a riffle-pool sequence within the reach (mesohabitat level). The 20 sampling units are quantitatively collected with a Surber net (area 0.05m²; mesh size 0.5mm). Each sampling unit is characterized by a specific substrate type, flow type, depth, and flow velocity (microhabitat level). A physicochemical characterization of the river site is usually available. River stretches are also characterized for their habitat features and modifications including bank and channel features. Map-based geographical data are also usually collected for each site and include distance from source, slope of the thalweg, altitude, latitude and longitude, land use percentages estimated from CORINE land cover maps. Water discharge, in a representative cross-section, is also usually measured while collecting river macroinvertebrates.

Number of Physical Specimens catalogued: 642

Number of images acquired: about 140

Number of Digital Specimens published: 642

Link of the dataset on GBIF: <https://www.gbif.org/dataset/21505bf9-66bf-45ec-be66-6eec5e2da693>

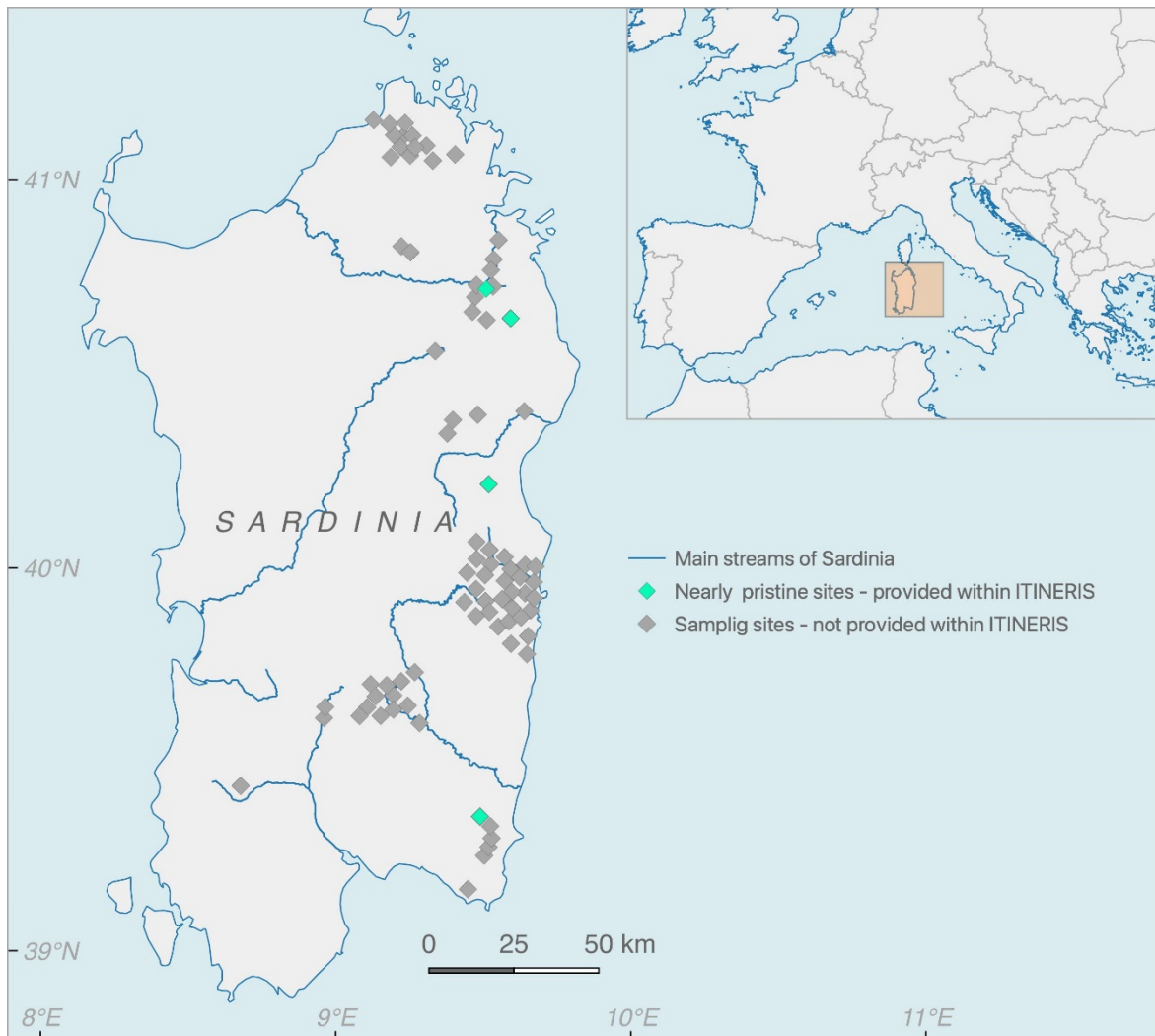


Fig. 29- Map of investigated area related to the presented collection including the location of sampling sites provided for ITINERIS. Nearly pristine sites.



Fig. 30 - Glossosomatidae images (catalog number SARDRP_00597A). Images acquired with stereomicroscope; magnification 20X.

Collection name: Campania river invertebrates – Nearly natural sites

Collection code: CAMPRP

Institution code: CNR-IRSA-MI

Referent Name: Stefania Erba

Curator(s): Andrea Buffagni, Marcello Cazzola, Stefania Erba

Numerical consistency: > 1500 physical specimens (>10000 individuals) - whole collection

Description: This collection is composed of river invertebrate samples collected in pool mesohabitat. Invertebrate specimens are preserved in 70% denaturated ethanol and stored in vials. Each vial contains specimens of a single taxon collected at a sampling site and date in a specific microhabitat. Vials are labelled manually and contain at least information on date, site, habitat/microhabitat and taxon name. A new sampling code is assigned for digitized samples and its corresponding label inserted in the original vial. Different vials from the same sampling site are stored in boxes labelled by projects and/or geographical area. Boxes contain different river sites, from the same project and geographical area. The most represented taxonomic group within this collection is the Arthropoda phylum and particularly the Insecta class. Most records refer to family level identification and comprise the occurrences of 95 macro-invertebrate taxa. Information on Ephemeroptera taxa and a few other groups is provided at genus level. In order to guarantee coherence with the aim of data collection, the nomenclature used in this dataset followed the one present in the MacOper list (Buffagni & Erba, 2014), used to assess the ecological status of Italian water bodies according to the WFD.

Sampling methods and geographical provenience: invertebrates are collected at river located in the Campania (South-western Italy), Salerno Province. Considered rivers sites do not present significant anthropogenic pressures and are considered nearly pristine (i.e. reference) sites. This collection refers to the EU funded project AQEM (EVK1-CT1999-00027). Samples were collected in spring and autumn 2000, winter 2001 and autumn 2003. Invertebrate samples are collected with a multihabitat proportional sampling technique. 20 sampling units are collected according to the proportional presence of organic substrate type and mineral substrate size. Sampling units are identified at a riffle-pool sequence within the reach (mesohabitat level). The 20 sampling units are quantitatively collected with a Surber net (area 0.05m²; mesh size 0.5mm). Each sampling unit is characterized by a specific substrate type, flow type, depth, and flow velocity (microhabitat level). A physicochemical characterization of the river site is usually available. River stretches are also characterized for their habitat features and modifications including bank and channel features (e.g., bank material, bank modification, width of the bank-top vegetation strip, channel width, substrate type, flow-type, channel modification). Map-based geographical data are also usually collected for each site and include distance from source, slope of the thalweg, altitude, latitude and longitude, land use percentages estimated from CORINE land cover maps. Water discharge, in a representative cross-section, is also usually measured while collecting river macroinvertebrates. For ITINERIS project only a selection of samples from reference sites is provided. The provided collection refers only to pool mesohabitat (10 sampling units per site) during spring season.

Number of Physical Specimens catalogued: 210

Number of images acquired: >50

Number of Digital Specimens published: 210

Link of the dataset on GBIF: <https://www.gbif.org/dataset/ac04038d-1e29-44d2-b80c-6bf2a8731351>

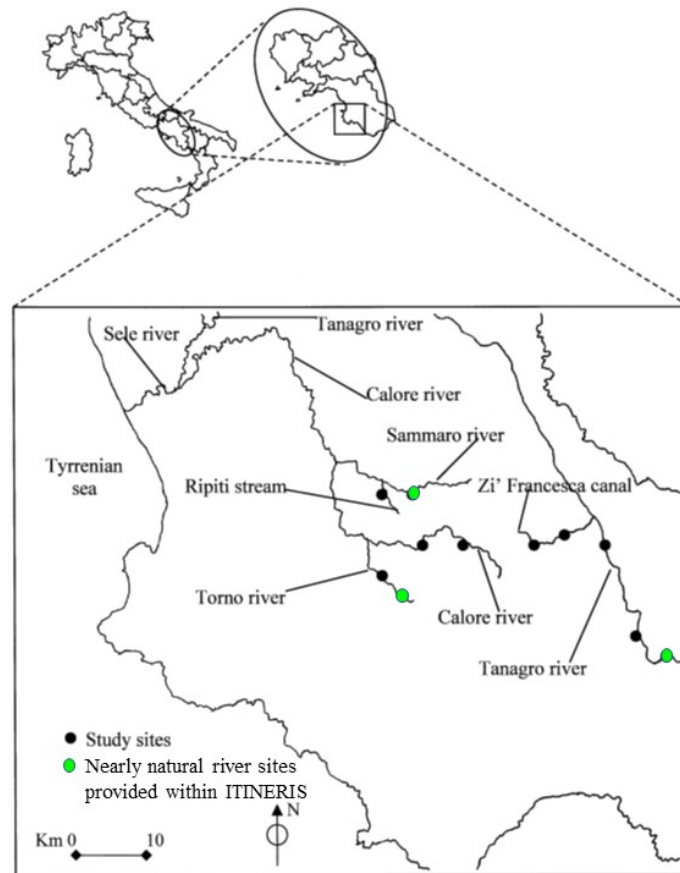


Fig. 31- Map of investigated area related to the presented collection including the location of sampling sites provided for ITINERIS. Modified from Buffagni et al., 2004.



Fig. 32 – *Dinocras* images (catalog number CAMPRP_00112A). Images acquired with Stereomicroscope; magnification 8X).