NATURAL SCIENCE COLLECTIONS PRODUCED BY MARINE ENVIRONMENTAL RESEARCH: FROM SAMPLE TO THE WEB

F. MAGGIORE[1], S. DONNICI[1,2], A. DE LAZZARI[1], S. ARMELI MINICANTE[1]*

[1] CNR - National Research Council of Italy, ISMAR - Marine Sciences Institute in Venice, Castello 2737/f, 30122 Venice, Italy

[2] CNR - National Research Council of Italy, IGG - Institute of Geosciences and Earth Resources in Padua, Via G. Gradenigo 6, 35131 Padua, Italy

** Corresponding author: sandra.donnici@cnr.it*

NATURAL SCIENCE COLLECTIONS
ANCILLARY COLLECTIONS
MARINE HABITAT
ESTUARINE HABITAT
TAXONOMY
SPECIES INVENTORY
FUNCTIONAL TRAITS
BIODIVERSITY INFORMATICS

ABSTRACT. – Collections of marine organisms were gathered during environmental research projects carried out by the National Research Council of Italy-Marine Sciences Institute (CNR-ISMAR) in Venice, in marine and estuarine habitats of the North Adriatic Sea. Sediment cores were extracted to investigate the Venice Lagoon subsidence. The need to organize and make accessible natural science collections led to the drawing up of a practice guideline to conserve and digitize them. The practice guideline describes the steps of a "multidisciplinary" methodological path from the study of the samples to their networking on the ISMAR repository "Archivio di Studi Adriatici" (ASA). The path includes: laboratory activities (maintenance and setting up of collections, taxonomic study), organization of ancillary collections, analysis of functional traits through bibliographic research, data organization through biodiversity informatics. Following this path, the collection is organized as a valuable tool for research, knowledge, training, education and conservation of biodiversity and is also a bridge between scientific community and citizens.

INTRODUCTION

Conservation and management of natural science collections (NSC) have been historically the prerogative of natural history museums and botanical gardens; they have been collected during expeditions and field work aimed at discovering the natural heritage of a geographical area. The environmental scientific research, carried out in research institutions and universities, aims at assessing the impacts on biotic and abiotic components, which have been sampled and preserved and, in some cases, made available in NSC (Chambers 2001, Scripps Institute of Oceanography https://scripps.ucsd.edu/collections/bi/research/san-diego-shelf-collection). As a result, the specimens originated through research activities, planned campaigns or fortuitous discoveries are generally conserved, catalogued and managed by museums and scientific organizations.

Among these NSC, the collections of animal and plant species provide information on the biodiversity of a habitat at a given time and place and evidence on the natural conditions of a habitat, essential to understand the causes of species decline and biodiversity loss (Suarez & Tsutsui 2004, Johnson *et al*. 2011, Robbirt *et al*. 2011, van Andel *et al*. 2012, Meineke *et al*. 2018). Pyke & Ehlrich (2010) highlighted the importance of biological collections as a reservoir of information that cannot be deduced from simple raw data; being able to study organisms, even if preserved, provides knowledge on spatial and temporal models of a species population size, morphological attributes (length of the body or stem), reproductive traits (fruit and seed size, number of seeds per fruit, number of eggs, size of the reproductive organs, number of juveniles per female), genetic attributes, growth measures and resistance forms. These phenotypic data can help to comprehend the processes of species decline, the influence of climate changes on seasonal patterns of species reproduction and growth and to contribute to the control, conservation and sustainable use of biodiversity.

The Earth Sciences collections, made up of minerals, fossils and samples of rocks and sediments, describe and characterize the natural environment from which they come, also providing environmental data from the time of their formation or deposition. Paleontological collections provide information on composition of the biosphere in the different phases of the Earth history, helping us to study biological evolution, from the earliest evidence of life until the present. Even the collections of sediment cores, sediment samples tens or hundreds of meters long taken mainly on the sea floor are useful to study the composition of the oceanic crust and for research on global change, global warming and marine pollution. Sediment cores are invaluable to investigate the evolution of climate in the past, as they represent a time interval in the history of the Earth (Cotterill 2016).

In a nutshell, NSC are archives containing a large amount of data originated from various scientific studies such as zoology, botany, ecology, biogeography, physiology, geology, paleontology; therefore, if organized, they become vital tools with multiple functions:

– irreplaceable proof of long-term ecological trends. Hoeksema *et al.* (2011), comparing corals and sponges sample collected in the Netherlands Antilles with collection samples taken in the same place 30 years earlier, reveal the depletion of coral reef fauna, probably due to the stress caused by the anchoring of large ships. Lister (2011) underlines the importance of the "Discover" and "Challenger" marine expeditions during which hundreds of marine stations were sampled at the turn of 20th century; nowadays these data sets provide an exceptional (and largely unused) resource for a reconstruction of past communities and for comparison with recent data;

– taxonomic revision. New tools, such as molecular techniques, can be used of the revision of the scientific collections, supporting a correct taxonomic identification and providing new data (France & Kocher 1996, Chase *et al.* 1998, Hingston *et al.* 2007, Abdou *et al.* 2017, Le Gall *et al.* 2017). Examination of old collections stored in a permanent way, including type material, is the basis of systematic biology; the taxonomic revisions are also needed because new collection materials had changed our views about the diversity of a taxon or there is a different species' concept. Considering how provisional nomenclature and taxonomy are, the study of the vouchers and related scientific publications reveals how the knowledge in the naturalistic field evolves;

– cultural and educational value. NSC are a primary source either for the study of the evolution of natural science disciplines or as educational and exhibition function (Nudds & Pettit 1997, Stanley 2004, Winston 2007, Lacey *et al.* 2017). Geological collections also have other values: in addition to aesthetic and economic values, some fossils may have great historical value and they also may be crucial for primary research. The fossil record covers plants, invertebrate and vertebrate fossils, as well as trace fossils; it is the only evidence that life on Earth has existed for more than 3.4 billion years. Fossils are nonrenewable scientific resources.

NSC storage is essential to biological and paleontological research and requires qualified personnel, basic technical tasks for management and educational activities and serious preservation planning. Therefore, economic resources are a global issue to avoid the loss of the world scientific heritage (Andreone *et al.* 2014). To make the NSC accessible, first of all a taxonomic accuracy is required for biological and paleontological samples; a traditional approach for species identification is based on morphological characters; the phenotypic taxonomy integrates the *DNA barcoding* method (Hebert *et al.* 2003, Boero & Bernardi 2014), based on the sequencing of specific genomic regions (*barcode*), as a discriminating character in the species identification. The taxonomic knowledge of the species present in a habitat is the starting point for good conservation of biodiversity, but the second fundamental requirement is the in-depth knowledge of their ecology, physiology and biogeography (Pyke & Ehlrich 2010, Boero & Bernardi 2014).

The NSC are often strengthened by the available information and material making up ancillary collections. Winston (2007) and Holmes *et al.* (2016) strengthen the importance of the ancillary collections (geo-references, collectors' field journals, letters, field notes, photographs, sketches and maps, descriptors of the biotic and abiotic environment) useful repeated surveys in a specific area, for the ecological interpretation and in historical studies.

In order to meet the needs of science and society, the natural science and ancillary collections must be organized in a form of efficient recovery; this task is well done by biodiversity informatics, discipline integrating biological research, computational science and software engineering to face memorization, integration and retrieval of biotic data. It is a synthetic tool for biodiversity investigations and for environmental planning analysis that allow preservation of these unique data for the future and to demonstrate either the power of the existing collections or the geographical, ecological and taxonomic gaps that must be filled by surveys and additional collections (Krishtalka & Humphrey 2000, Rainbow 2009, Pyke & Ehrlich 2010, Johnson *et al.* 2011, Ellwood *et al.* 2015, Page *et al.* 2015).

The Marine Science Institute (ISMAR) of the National Research Council of Italy (CNR) has a long tradition focused on the study of the biological communities and geological research in the Venice Lagoon and Adriatic Sea. The research activities, although not aimed at the creation of NSC, inevitably generated collections of organisms and sediment samples.

The main goal of this paper is to describe a multidisciplinary approach to make accessible the NSC generated by ISMAR's environmental scientific research via the following steps: i) to identify a general path for the study of biodiversity and taxonomy of CNR ISMAR's natural science collections; ii) to check the scientific collections of CNR ISMAR Venice; iii) to identify specific management and research activities to be carried out for the different collection types.

Our aim is the building of a virtual museum easily accessible not only to the scientific community, but also to citizens and local management authorities, to contribute to the dissemination of knowledge. Therefore, a reorganization of scientific samples and related data will be useful to future conservation and biodiversity studies.

THE ISMAR RESEARCH AND NSC

Biologists and geologists of the CNR-ISMAR in Venice carried out scientific surveys in coastal and marine environment that generated NSC.

Among 1941 and 1952 research activities on seaweeds of Venice Lagoon were undertaken by the Istituto di Studi

Adriatici as part of a research project funded by the Central Laboratory of Hydrobiology of Rome and with the aim of starting the *agar-agar* production. During this period several phenological and reproductive studies on *Gracilaria* and *Ulva* species were carried out. From these research activities a macroalgae herbarium collection currently conserved at the ISMAR headquarters in Venice was realized.

In the 1970s, deep boreholes were drilled to study the subsidence of Venice. Through the analyses of the core samples, the geologists characterized the sediment record through a thickness of 1000 meters and provided valuable information on the hydrogeological structure of the subsoil.

Since the 1980s, research has been developed on the benthic foraminifera communities of the coastal and estuarine ecosystems of the Northern Adriatic in relation to environmental variables, climate change and the impact of human activities. The study of the foraminifera biotopes of the Venice Lagoon continued in the 1990s as part of different research projects on the Lagoon and the Adriatic Sea.

In the 1990s, research was carried out on the particulate flux in the water column, both in the southern Adriatic and the Ionian sea. This research was conducted through sediment traps, making observation of particulate material changes possible and to control the variations in short and long time scale; living organisms fall by chance in sediment traps and a photographic selection was conserved.

From the late 90s, the benthic invertebrate collections were gathered during community analysis studies for the biological characterization of estuarine and coastal habitats. The first study focused on hydrodynamic, physicochemical and biological analysis of the Piave River estuary. Afterwards, research progressed to the Lagoon of Venice in the context of two projects; the first was focused on biological diversity either as basic knowledge or as a contribution to understand the mechanisms regulating the lagoon ecosystem, the second established a methodology for the determination/identification of ecological quality indices, based on the integration of biological, ecotoxicological and chemical data.

In Northern Adriatic sea the project "Sea Experimental Field", was aimed at creating an equipped area in the sea for environmental experiments, in particular techniques and methodologies for coastal protection, fish re-stocking and mollusc farming, environmental monitoring by means of bioindicators and study of colonization processes.

Presently, a collection aimed at a molecular survey of macroalgae from the Venice Lagoon is in progress, as well as the update of the benthic foraminifera collection.

WORKING METHOD

The actions needed to organize and make the scientific collections available for research are as follows: 1) laboratory work; 2) collection of ancillary material; 3) analysis of functional traits through bibliographic research; 4) uses of Information Technology tools. A preliminary phase includes the inventory of the scientific research collections of ISMAR Institute in order to have a complete overview on their type, consistency, organization level and, in particular, on the needs and kind of work to be undertaken.

Laboratory work

The first phase includes:

– ***maintenance***: assessment of the conservation status of the collections, topping up or replacement of the preservatives for the wet specimens, environmental control of the foraminifera in the cells, control of the state of preservation of the cores and sediment samples, control and/or treatment of the *herbarium exsiccata*, checking and/or replacing labels and any descriptive sheets;

– ***preparation***: re-organization of the samples in containers, trays, boxes and cabinets; identification of air-conditioned and ventilated rooms to store and/or display the collections.

The second phase, related to biological and paleontological collections, requires taxonomic accuracy. Species may be identified on the basis of morphological and genetic characters, integrating both methods into a form of cooperation (Boero & Bernardi 2014). Morphology is one aspect of the phenotype (sensu Mahner & Kary 1997) assumed as all observable properties (traits) of an organism (morphological, reproductive, growth, behavioral) needed to comprehend broader ecological phenomena (Pyke & Ehlrich 2010).

It is also necessary to allow time for the conclusion of the activities and the formation of an organized collection. Based on the above, the study includes the following steps:

1) ***taxa identification***: specimens will be identified by the use of different tools such as taxonomic dichotomous keys, descriptive taxonomic papers and books, drawings, photos. Sometimes identification is restricted to the taxonomic rank above the species (bad state of preservation, variability of diagnostic characters, unknown species as non-indigenous species or new to science, etc.), terms and their abbreviation qualifiers, expressing different degrees of uncertainty, will be defined according the "Open Nomenclature" procedure harmonized by Sigovini *et al*. (2016);

2) ***taxa validation***: revision of dubious species in the light of the progress in taxonomy and the spread of non-indigenous species and updating nomenclature based on the World Register of Marine Species (WoRMS Editorial Board 2018) and AlgaeBase (Guiry & Guiry 2018);

3) ***analysis of phenotypic traits***: population size, growth measures, reproductive traits (propagules, spores, number of eggs, size of the reproductive organs, number of young per female, forms of resistance);

4) ***selection of reference specimens*** for each species, the best preserved specimens will be stored, photographed and digitized;

5) ***DNA barcoding***: when possible, the samples will be identified and/or revised by integrating to the morpho-anatomical taxonomic methods the molecular technique of DNA barcoding (Hebert *et al*. 2003);

6) ***labeling and coding*** of samples, securely ***storing*** to allow tracking and future checks.

Ancillary collections

All data on a single species or collection will be assembled and organized in ancillary collections which will include:

– ***field notes***: they may include locality information, date, reference points, description of the field activity, depth and every qualitative information regarding habitat type including underwater photographs;

– ***geographic coordinates***: if not georeferenced, sampling stations will be recorded according to the methods proposed by Armeli Minicante *et al*. 2017b, which takes into account all reference point as annotations, maps and associated notes;

– ***environmental information***: associated with each collected specimen, there may be concurrent and/or historical information about biotic and abiotic descriptors of the species original habitat;

– ***documentary material***: texts for taxonomic determination, scientific articles, grey literature, diaries, memoirs, collection logs, expedition itineraries which could be available in the historical library of ISMAR, but also coming from external sources such as the Natural History Museum of Venice;

– ***sediment samples***: in addition to the sample description, the data obtained from the analyses on sediment samples are also archived: particle size analysis; macro and micro-paleontological analyses; petrographic, mineralogical and geochemical analyses; dating; etc.

Functional traits

All data following on from taxonomic activity leads to the establishment of a "catalogue of species", each playing a functional role in the ecosystem on the basis of its ecological and biological characteristics (functional traits).

Functional traits may be useful to ecology scientists and university students, but it may also be of concern to a wider public interested in biodiversity and natural sciences.

Databases on functional traits exist for many marine species, the main ones are: BIOTIC (http://www.marlin.ac.uk/biotic/) and POLYTRAITS (http://polytraits.lifewatchgreece.eu/), databases on the functional traits respectively of invertebrates and benthic plants of the English and Irish coasts, and of Polychaetes of the world. They are main reference points but not exhaustive for the ISMAR collections for geographical and taxonomic issues.

For the species not been quoted in the aforementioned databases, the "catalogue of species" will be complemented by a biographical profile for each species containing systematics and taxonomy, ecological and biological information (functional traits) taken from bibliography. The traits categories quoted in BIOTIC will be applied (Marlin 2006).

Biodiversity Informatics

The procedure is reported in Armeli Minicante *et al*. (2017a, b) and was primarily designed for biological collections, but also adapted to geological ones, which will be treated similarly.

All data relating to each voucher (e.g., scientific name of the species, systematic position, sampling date and locality, authors of the collection, sample code, etc.) will be recorded on a spreadsheet together with the data from ancillary material and information concerning functional features.

The images relating to the selected voucher will be acquired using different instrumentation: Bookeye® 3 digital planetary scanner (herbarium sheets, photographs, books, etc.), SEM microscope (foraminifera, etc.), digital camera (macrozoobenthos, geological samples, etc.).

Each image will be associated with a set of metadata obtained from the previous spreadsheet and selected according both to the Dublin Core and the Simple Darwin Core standards (Biodiversity Information Standards). The digitized samples from the respective collections and their associated metadata will be organized in the "Archive of Adriatic Studies" (ASA, www.archiviostudiadriatici.it) repository, developed in collaboration with the Research Institute on Sustainable Economic Growth CNR (IRCrES) (Ceregato *et al*. 2016, Armeli Minicante *et al*.

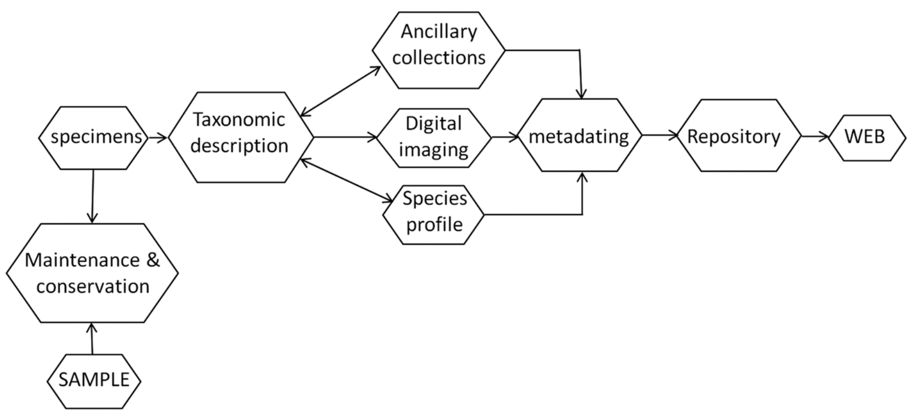

Fig. 1. – Workflow showing the methodological path.

2017a, b, Perin *et al*. 2017). To facilitate full access and reuse of the contents of the repository and the virtual museum to be implemented, standard open licenses (CC-BY) will be adopted according to the Creative Commons standard (https://creativecommons.org). The work-flow for the study of the NSC is shown in Fig. 1.

APPLICATION OF THE METHODS TO THE NSC OF ISMAR-VENEZIA: FIRST RESULTS

An initial census of the collections present in the Institute was realized and the results are shown in Table I. Moreover, a search for information on the consistency, the level of organization and the geographical location of each collection was carried out. The information obtained for each collection is described below.

Macroalgae

Macroalgal samples are hosted in the *Algarium Veneticum,* the institutional herbarium of ISMAR-Venice established in 2015 and registered with Index Herbariorum <ISMAR> (http://sweetgum.nybg.org/science/ih/). The *Algarium Veneticum* consists of:

– **the Thuret collection**: includes a sample of *Corallina mediterranea* Areschoug, of the historical Herbarium Thuret, collected in 1870 at Biarritz (France); its presence is probably due to an interchange among researchers. This specimen represents the oldest sample of the *Algarium Veneticum*;

– **the Minio and Spada collection**: includes 1169 herbarium sheets (*exsiccata*). The main section comprises 19 folders with 884 *exsiccata* identified as *Gracilaria confervoides* (L.) Greville, collected from 1941 to 1950 in 107 sampling sites, around the historical centre of Venice and the islands of Chioggia, Lido and Murano. The collection includes also a miscellanea section, composed of 9 folders with 285 *exsiccata*, belonging to different taxa of red, brown and green algae. The results of this research was published in Minio (1949), Minio & Spada (1950, 1952);

– **the SeaVe collection**: contains 197 *exsiccata* of Rhodophyta, 34 Phaeophyceae and 164 Chlorophyta, sampled from 2014 to 2016 in several sampling sites of Minio and Spada around the historical centre of Venice to make a comparison almost 60 years later and updating information on the macroalgal species.

Table I. – The biological collections of the Institute of Marine Sciences (CNR-ISMAR) in Venice.

				Geographic location				
			Storage	Lagoon of Venice	Piave River estuary	North Adriatic Sea	South Adriatic Sea	Ionian Sea
Benthos	PHYLUM	TAXA						
	Annelida	Polychaeta	in liquid	X	X	X		
		Oligochaeta	id	X	X			
	Arthropoda	Crustacea Peracarida	id	X	X			
		Crustacea Malacostraca	id	X				
		Crustacea Cirripedia	id			X		
		Insecta Chronomidae	id		X			
	Bryozoa		id			X		
	Cnidaria	Hydrozoa	id			X		
	Echinodermata		id	X				
	Mollusca	Gastropoda	id	X				
		Bivalvia	id	X	X	X		
		Opistobranchia	id	X				
	Sipuncula		id	X				
	Vagile fauna		id			X		
	Foraminifera		dry	X		X		
	Ochrophyta	Phaeophyceae	*exsiccata*	X				
	Chlorophyta		*exsiccata*	X				
	Rhodophyta		*exsiccata*	X				
Plancton			image			X	X	X

Benthic invertebrates

Benthic invertebrates are split in three collections, which composition is explained in Table I.

– **Piave collection**: 2000 specimens were collected in 1997 along the Piave River estuary (north-eastern Italy) on soft bottom in shallow waters. Results are explained in Maggiore *et al*. (2001);

– **Dese collection**: 60,000 specimens were collected along the Dese River estuary (northern basin of the Venice Lagoon); sampling were carried out seasonally in 2002 and 2003 on soft bottom in the mud flat along the estuary (Maggiore & Keppel 2007); Dese collection will be strengthened by an ancillary collection, still to be organized (field notes, geographic coordinates, environmental information);

– **Artificial reef** in North Adriatic Sea: 10,000 specimens of sessile invertebrates were scraped from the surface of the Artificial reef; bimonthly sampling was carried out in 2004 and 2005 at 14 m depth (Maggiore & Keppel 2006); an ancillary collection of comprehensive field notes is still to be organized (geographic coordinates, environmental information, underwater photographs). The vagile fauna was unprocessed and needs to be sorted, counted and determined.

The three collections include about 170 species to which the taxa not yet identified must be added.

Benthic foraminifera

The main Foraminifera Collections (FC) came from the high density sampling in the Venice Lagoon and the upper Adriatic carried out since the 1970s. The FC of the Lagoon and Gulf of Venice contains over 100 species of benthic foraminifera, organized in taxonomic order (Albani & Serandrei-Barbero 1982, 1990, Serandrei-Barbero *et al*. 2008). FC from the Adriatic Sea (Donnici & Serandrei-Barbero 2002), from some bays of Australia, Brazil (Donnici *et al*. 2012) and China were set up during other research projects.

The foraminifera specimens, isolated from the sediment washing residue, once determined, are glued onto plastic cells or photographic paper and dry stored in dedicated trays in a special cabinet. An information paper sheet summarizes taxonomic information, description, distribution and any other observations for each catalogued species.

Sediment core samples

Sediment cores were taken by drilling boreholes at different depths in the subsoil. The sediment samples, stored in the Institute, come from several boreholes drilled in the historical centre of Venice and in the littoral zone.

The borehole "VENEZIA 1-CNR", near the historic centre of Venice, reached 950 meters of depth and cores were continuously recovered up to −920 m (Fontes & Bortolami 1973, Favero & Passega 1980, Mullenders *et al*. 1996); the VENEZIA 2-CNR, located at the Venice "Arsenale", reached −400 m (Serandrei-Barbero 1975, Mullenders *et al*. 1996); the LITO cores come from 18 drillings at an average depth of 25 meters and distributed along the Venice littoral zone (Tosi 1994, Bonardi & Tosi 1995).

Sediment samples collected within other projects (i.e., Albani *et al*. 2010) and rock samples taken as part of the geological study of the "Tegnùe di Chioggia" (Tosi *et al*. 2017, Franchi *et al*. 2018) are also stored in the archives.

The archive contains the history of the last 2 million years of the Venetian area, cores should be re-arranged on shelving suitable for researchers and to allow control of the state of conservation. Furthermore, the collection must be digitized together with the associated metadata.

The photographic archive

The Digital Photos Archives allow the storage and organization of material collected in the various specific projects, material that can be reviewed and preserved over time, it also facilitates comparisons between old and new samples across various areas/parameters. The usefulness of a photograph collection of animal and plant species is its ability to improve the determination even in moments after the study.

A photographic selection of organisms, found in samples collected with sediment traps, is kept at the ISMAR headquarters in Venice. These samples come from different marine areas: North Adriatic, South Adriatic and Ionian Sea. The organisms belong to the phytoplankton, represented by diatoms, dinoflagellates, silicoflagellates and coccolithophores (the latter identified as cells whole or single limestone plaques, called coccoliths). Additionally, unicellular microzooplanktonic organisms, such as radiolarians and foraminifera and sometimes also specimens belonging to the mesozooplankton (the "swimmers"), that enter voluntarily or passively into the traps; the latter are represented by crustaceans, such as copepods, amphipods and euphausiaceans, which characterize the communities of an area.

Thanks to devices such as sediment traps, plant and animal organisms can be studied over time with complementary biogeochemical data, to control the variations and the short and long time-scale processes (De Lazzari *et al*. 1999, Socal *et al*. 1999, Boldrin *et al*. 2002). The photographic collection consists of a hundred digitized images, many of them, however, need a catalogue and determination of the unidentified taxa and dubious species.

These photos will also be accompanied by information sheets containing complementary data and information, so that they can constitute a structured, but continuously updated, data archive.

At present, all historical macroalgal *exsiccata* and a section of Chlorophyta were digitized and catalogued; images and metadata are available on the "Archive of Adriatic Studies" repository. A section of foraminifera has been implemented on the repository; the scanning electron microscope (SEM) images of the main foraminifera (Lagoon and Gulf of Venice) were digitized, while the digitization of the information sheets is underway.

CONCLUDING REMARKS AND FUTURE DIRECTIONS

The practice guideline proposed is an operational tool for the conservation and enhancement of the ISMAR's NSC; it could also be used by research institutions to manage their own NSC generated from scientific research.

The importance of a proper conservation of biological collections lies in the fact that they are a reservoir of genotypes and phenotypes. Several authors, analyzing samples from collections and related ancillary collections, documented how habitat modifications, exploitation of biological resources, pollution, introduction of alien species, climate change could act as specific selective forces on phenotypic traits among which population structure, growth, reproductive attributes are affected (Suarez & Tsutsui 2004, Holmes *et al*. 2016).

Proper conservation of NSC requires also the planning of sufficient resources and the presence of highly specialized figures, such as taxonomists working in classification and organization of vouchers. The taxonomy specialists play a key role, since taxonomy is crucial for understanding of planet's biodiversity.

The described path will allow the creation of a database of ISMAR collections containing also the phenotypic traits that, with the functional traits from literature and ancillary collections, will be a valid support to scientific research in the reference areas of the collections also and especially in relation to environmental changes; as an example, reference NSC offers the possibility of verifying how these impacts could have changed the ecosystem of the lagoon of Venice, subjected through time to natural and anthropogenic stressors as pollution, fishing and aquaculture activities, dredging of channels, land use, sediment erosion (Solidoro *et al*. 2010), and to engineering interventions that have been modifying its morphology (Cavallaro *et al*. 2017).

With regard to the geological collections, a lot of information on the geological evolution and on the environmental conditions of Venetian area in the past is obtained from the analysis of these samples, because core sediments are characterized by the different deposition environments when they were formed. The maintaining of this material is fundamental as it remains available to be investigated independently of the evolution of the analytical techniques, allowing researchers to obtain new information from the same samples and avoiding the running of new expensive drilling. The "VENEZIA 1-CNR" sediment cores, for example, were recently re-analysed, leading to update the scientific knowledge on sea level changes in the last 2 Ma (Kent *et al*. 2002, Massari *et al*. 2004); the samples of the other cores of the ISMAR collection

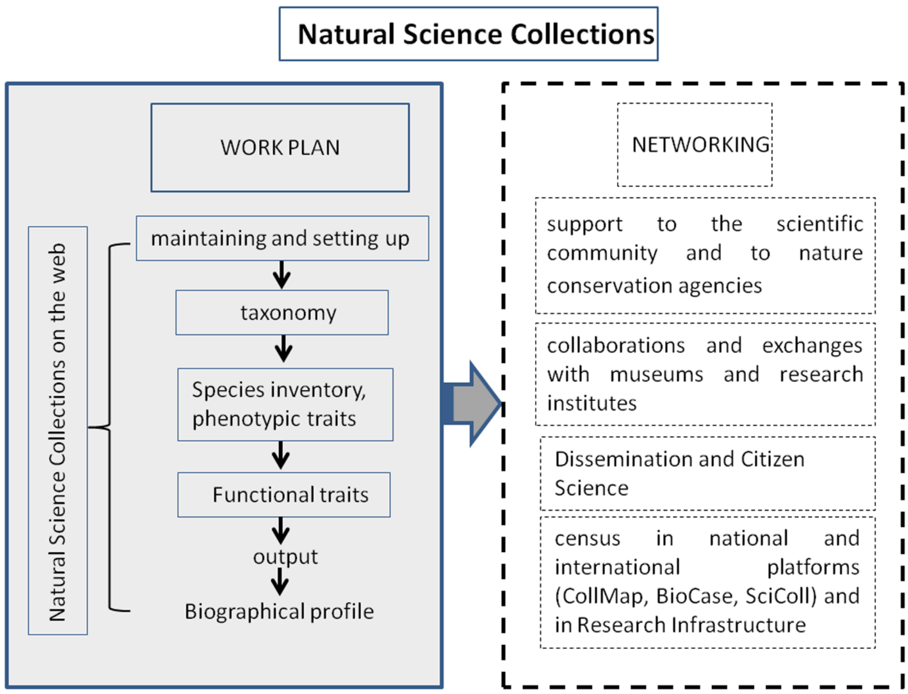

Fig. 2. – Working plan. On the left the activities to be carried out, on the right the networks.

were also used within the framework of the recent project of geological mapping of Italy (Tosi *et al*. 2007a, b).

The scientific heritage of the ISMAR NSC can be very useful:

– to the whole scientific community and university students for studies on biodiversity and long-term ecological trends;

– to establish forms of exchange and collaboration with national and foreign museums and research institutes;

– to public authorities that locally manage biodiversity data for nature conservation purposes;

– to be registered in biodiversity networks according to the different levels of taxonomic complexity as CollMap (http://www.anms.it/collmap/index.php?tipo=collmap), project of the Italian National Scientific Museums Association (ANMS) or BioCase (Biological Collection Access Service, www.biocase.org/) network collecting species inventories with geographical information (Berendsohn 2002, Vomero 2013);

– to disseminating and educational initiatives as:

a) design of a NSC virtual museum with the main purpose of outlining dissemination paths at various levels of complexity and related to the research themes of the Institute of Marine Sciences. In this way NSC will be available for research, education, decision making, academic and creative activities and for the public interest;

b) programmes of educational workshops for primary and secondary school using NSC as an outline for the path that leads to the collections;

c) programmes of *citizen science* involving non-specialized public in various activities, such as involvement in digitization activities as suggested by Ellwood *et al*. (2015), information exchange with citizen well-curated collections (Holmes *et al*. 2016), involvement of citizens, fans of natural sciences, in the study of a scientific collection and in field monitoring.

Fig. 2 summarizes the possible developments of the NSC organizing work and the end users.

In conclusion, besides having the function of data organization, the repository will be useful in terms of dissemination of information, exchange of knowledge, educational promotion and encouragement to collaboration, as well as being a very important source for biodiversity research.

Acknowledgments. – Authors thank the scientific editor, C Battisti, and the anonymous referees for their efforts in reviewing the paper.

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Received on January 24, 2019
Accepted on April 1, 2019
Associate editor: C Battisti