A Biobanking platform for fish-borne zoonotic parasites: a traceable system to preserve samples, data and money

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ABSTRACT

A biobank is a non-profit service that hosts a collection of biological samples organized as a technical unit with defined quality criteria, order and destination, to ensure full traceability of the sample, and above all, is a valuable underpinning for medical and biological research. We present the first Biobank on Marine Biological Samples, stemming mainly from the activity developed on zoonotic parasites. The creation of the biobank had three objectives: a) Improve the quality and traceability of the collection of zoonotic parasite samples; b) Serve as a supplier of marine field samples for scientific, industrial and clinical studies, and c) The creation of a solution with high added value of marine samples derived from monitoring, both in its self-studies and derivatives. Web-based technology allows for an easier, faster and less disruptive implementation. Data from 15855 fish specimens, which included morphometric and meristic data, as well as the description, quantification and location of the zoonotic parasites found on any single host, genetic and antigen and protein data, were introduced in the database of the biobank. These metadata were introduced into the Biobank software, which only requirement is an Internet connection, and are now stored under a traceable basis and regulations herein described. The software has a restricted accession by codes and passwords. Our biobank stores more than 278000 zoonotic anisakids, as well as their associated information from 19 fish species and 13 fishing areas.. These samples include whole animals, DNA and proteins. Furthermore, we estimated the income for the basic functioning of the Technical Unit of Biobank to maintain its infrastructure. The constitution of this biobank and the development of the programmed action will yield several global benefits that otherwise would not be achievable in a local/regional framework in three ways: economic, ecologic and transference to stakeholders.

1. Introduction

Curators of natural history museums have been responsible for the collection, storage and exploitation of ecosystem samples during the last century. The usual purpose of such collections, oriented to a wide audience as well as to provide reference material for taxonomic classification and cataloguing of biodiversity, limited the potential use of this material for scientific purposes. This valuable work on natural history was the origin of sampling programs carried out for many decades, from early 20th century until the 1960's, when the industrial perspective gained more relevance and the need to explore, assess and monitor the use of marine ecosystems was wider developed. Nowadays, biological samples collected from the marine environment are valuable for a wide variety of purposes such as long-term studies of climate change or the supply of compounds of pharmaceutical and cosmetic interest (Christiansen et al., 2014; Galli et al., 2014)

During the last decades, research projects and networks for managing marine samples and sampling programs have been diverse and sometimes controversial. Efforts have been directed towards collecting components of the marine ecosystems during field sampling programs with no general attempts to implement internal management platforms or self-monitoring analysis and reporting technology for samples and associated information. Despite of the limitations associated with sample processing, researchers made efforts towards improving the processing and use of the samples. Thus, there are some examples, such as the BIOTA cluster (<https://wiki.ceh.ac.uk>) and CORONA network (<http://sites.biology.duke.edu>) that fostered this search for excellence using links between researchers to optimize the use of samples under a multidisciplinary approach. More recently, MarBEF, an EU-funded project (<http://www.marbef.org>), was a platform to integrate and disseminate knowledge and expertise on marine biodiversity, with links to researchers, industry, stakeholders and the general public, undertaking a socio-economic approach in the field of marine biodiversity under a relatively fragmented nature. Other networks, as Marnet (<http://whitakerinstitute.ie/project/marnet/>), an EU funded transnational cooperation project aimed at creating a marine socio economic network to develop a methodology to create, collate and use comparable marine socio-economic data across the Atlantic regions. The baseline of these networks is set from the utilization of "marine repositories". It is important to remark that processing of repositories does not imply a complete traceability, in the way that, for instance, it is being applied in the clinical protocols for "biobanking". Therefore, banking and repositories are two terms that have to be understood in a different way. The main differences rely on the control

process: while repositories could have a relative uniformity in the way they are stored and in its linked information, in sample banking, software guarantees the complete traceability and quality of the entire process, its linked information and the donor-session system. Therefore, sample banks provide a complete traceability in the exploitation of these resources, improving the scientific excellence and also adding value to the outcomes of the present and future research projects. The session-donation scheme of marine samples banks, the monitoring of traceable samples and interoperability of the data, will optimize the trans-disciplinary studies to be undertaken in the future.

A decade ago, the cover of Time magazine also addressed that Biobanks were one of the ten ideas changing the world. They may constitute one of the next years' research infrastructures, which facilitates the samples and information exchanges under a best-value for money approach. A biobank is a product that collects, stores and distributes biological material and their data associated. The OCDE in 2001 defined biobanks as Biological Resource Centers (BRCs). They are an essential part of the infrastructures that sustain the life sciences and biotechnology. They consist of service providers and depots of living cells, genomes of different organisms and information concerning the inheritance and functionality of biological systems. Biorepositors must meet the highest standards of quality and experience required by the international scientific community as well as the industry for the distribution of biological material and information. They must therefore provide access to biological sources on which they depend on research and development in life sciences and the advancement of biotechnology. By biological material is meant: living organisms, cells, genes and relative information.

Currently, a major trend in environmental research consists in addressing global phenomena around the study of large series of samples organized with well-defined and detailed criteria, with the specific information required in each case. The availability of traceable samples and associated information of high quality has been a plea that has been at the root of many of the most important advances in marine science. Typically, the collection of significant numbers of marine samples and quality information involves a major effort in planning, construction, and finally operation; it is very time and resource consuming constraining the accurate development of the marine research. Therefore, the promotion and implementation of biobanks facilitate the access to quality samples (and associated data) by researchers who present a project with the appropriate scientific organization and with the proper ethical and legal safeguards. This represents an essential milestone in shortening the time that

normally elapses between research and the application of its results, improving also the effectiveness of research. To enhance this effort and the desired impact, constant coordination and collaboration between biobanks and conceptually related initiatives is required, and within each of them among the different professionals involved in processing the samples and their associated information: identification of the extractions (samples), sampling itself, processing, storage, distribution, transfer, use of samples and associated information, and overall management of these proceedings. The main distinguishing feature of biobanks, as currently understood, with respect to the classical concept of a collection of samples and associated data (collection of a research group, institutional collection, or private collection), is its commitment to transferring samples and associated information to research groups in an open, transparent, and partnering way for the benefit and improvement of high-quality science. This distinguishing feature is unambiguously reflected in the current definition of a biobank drawn up by the OECD as a Biological Resource Centre.

The pressure to know what resources are being used and what results in products or services are obtained from them is becoming increasingly important in the field of public institutions. In this situation, the legislators issue rules that regulate the information of costs that the organisms must elaborate. At the same time, among the managers of public institutions, there is growing awareness of the importance of this type of information in order to make decisions (Pérez Morote, 2000; Robleda, 2010).

One of the main objectives of the PARASITE project was the creation of the first Biobank on Marine Biological Samples, stemming mainly from the activity developed on zoonotic parasites. We understand the Biobank as a non-profit service that will host a collection of biological samples resulting from this project and organized as a technical unit with defined quality criteria, order and destination, to ensure full traceability of the sample. Specific software operated remotely served as the base for the functioning of the Biobank platform. The creation of the Biobank had three objectives: a) Improve the quality and traceability of the collection of zoonotic parasite samples obtained during the study of the main commercialised fresh fish species; b) Serve as a supplier of marine field samples for scientific, industrial and clinical studies, thus establishing bonds of connection between the marina and biomedical research in the European R+D space; c) The creation of a solution with high added value of marine samples derived from monitoring, both in its self-studies and derivatives. The main idea is that the Biobank serves to control and regulate the storage of biological samples and associated data, meaning any biological sample or biological material capable of conservation and that can hold information about the project objectives.

This will allow us to ensure the availability of biological material quality, well sorted, processed and preserved to meet the demands of research. Given the boom that is taking the research in the field covered by this tool and the consequent need for biological samples within the scope of the biological material stored in the Biobank will be available to the scientific community. Thus, the Biobank work as a promoter of scientific research as researchers upon request, obtain such biological material for use in research, present and future, whose purpose here is the diagnosis of marine zoonotic parasites in fishery products. Derived from the main objective, we aimed also to present a model of cost analysis applicable to the Technical Unit of Biobank, held at IIM-CSIC, in order to provide a tool to obtain information on the costs incurred to meet the demand for samples.

2. Material and Methods

2.1. Biobank implementation

The functioning of the biobank is based on the traceability of the samples and their associated data. For this purpose, it was used a computer system based on BioeBank (Navarro-Mateu et al., 2013; Torres-Pérez et al., 2015), a complete biobank information management system (BIMS), the market leader and system most used by clinical biobanks across Spain. Registration, classification and automatic labelling of samples ensures traceability of samples from the moment of reception in the biobank. Web-based technology allows for an easier, faster and less disruptive implementation. The principle of this biobank we implemented was that all the samples and the associated information of the project run through a protocol designed for the Parasite biobank (Fig. 1). For this purpose, we create a complete questionnaire to be filled by the registers of the biobank, entering all data agreed for this particular research field. The flux of the samples can be summarised as follows:

1. All partners are registers and have a personal password for entering the software. They are able to create a code (2D barcode) for any sampled fish. The code is automatically assigned by the software and allows the register to introduce the associated data (fish species, fishing ground and coordinates, size, weight, presence of parasites, location in the fish, etc). This information is automatically uploaded to the PARASITE BIOBANK server, which is prepared with the same level of security than the clinical biobanks.
2. The automatically generated code assigned by the system allows partners from different entries (surveys, laboratories or countries) to introduce data at once. The only requirement to introduce the data is an Internet connection. All successive

subsamples of each fish (whole parasite, DNA, proteins, etc.) are automatically linked to the original code. The biobank will locate any particular sample in a system-defined site (freezer, racks, boxes, etc.), which on the other hand is controlled by the software.

3. All parasite samples are circulated from registers to the biobank node/subnodes following the structure detailed in Fig 2.
4. All the information can be processed, filtered and transformed into XL files to be analysed.

2.2 Cost benefit scenario

There are numerous systems that can be applied to calculate the costs of a biobank. The choice among models depends on the productive process to be applied and on the objectives to be achieved with this calculation (AECA, 2001). For the calculation of costs of the Parasite Biobank we have followed a complete cost system based on the activities. With this system, all the entity's costs are applied to the final cost, either directly or indirectly, thus obtaining the total cost of a product or service by adding up the costs of each phase of its elaboration to which are compounded by the costs of raw materials (AECA, 1999). Direct costs are allocated immediately to the corresponding cost objective, whereas for indirect costs it will be necessary to establish an allocation criterion.

3. Results

3.1. Biobank architecture

The architecture of the parasite biobank (Technical Unit of Biobank, TUB) is shown in Fig. 2. A central Biobank (central node) is hosted in Vigo (IIM-CSIC) and it manage sample and data (Fig 1). This repository collects not only a back up of 30% of the samples of the sub-Biobanks we created, but also the information linked to the samples (i.e., the additional information regarding to the traceability) which is contained in the sample code (2 dimensions) as an excel file. The first sub-Biobank include whole parasites and is established by NIFES (Norway). A sub-Biobank containing the DNA samples of all anisakid nematodes of zoonotic importance, collected from different hosts and geographical areas, is organized by the University of Tuscia (Italia), which also already possesses a large collection of anisakids and DNA stored that can be used in comparison with those from the present project. A third sub-Biobank is organized at the laboratory of SERMAS for the characterized antigens specific for different species of anisakid parasites of zoonotic importance, proteins and

positive sera gathered from animal models after experimental infections and exposure to parasite antigens.

For storage, all the samples are codified in tubes using 2D codification. This encryption ensures full traceability of the sample over time, while not creating extra work for the laboratory staff. This storage system is associated with reading by a scanner and software decoding to identify specific samples and export information to any ODBC database. The samples are stored at low temperature to ensure their conservation and integrity over time (Low Temperature: refrigerators, freezers and ultra low freezers). All these systems will include Backup and Alarm Security Systems.

3.2. Biobank database

In PARASITE project, we undertook an intensive sampling of the main fish species caught in European fishing grounds and commercialised in fresh markets. These studies were extended also to some other imported species with importance in the European markets such as the yellowfin tuna *Thunnus albacares* or the Japanese squid *Todarodes sagittatus*. Overall, we analysed 15855 fish specimens, which were dissected following the protocol established for PARASITE. That included morphometric and meristic data, as well as the description, quantification and location of the zoonotic parasites found on any single host, genetic, antigen and protein data. These metadata were introduced into the Biobank software and are now stored under traceable and regulations herein described.

The software has a restricted accession by codes and passwords (Fig. 3). Actually, the resume of the metadata we compiled is presented in Table 1. The participants of the Parasite project registered more than 278000 zoonotic anisakids from 19 fish species and 13 fishing areas. In total, about 150000 parasite samples as well as the information of the total number of parasites found are available in the biobank. These samples include whole animals, DNA and proteins.

The main characteristics of the biobank we created can be summarized as follows:

- Registration, classification and automatic labelling of samples ensures traceability of samples from the moment of reception in the biobank. Combination with labelling systems allows the marking of each and every sample with its own unique barcode.
- Workflow tracking allows to follow each sample individually and check for any processes pending.

- Connectivity between nodes reduces task and data duplication and, thus, errors and omissions in data.
- A simple yet powerful requests module and search engine helps to get the most out of our biological resources. It makes a greater, safer and quicker exchange of samples possible – allowing making the jump from sample repository to true biobank. Search results also can be exported into i.e. XL files for further data drilling and research. The system permits the storage of any data, photo, DNA sequence, etc. associated to the fish sample.
- Configurable sample storage allows the application to replicate physical storage layout. Each sample is labelled before storage, improving its traceability.
- The improvements in data security, traceability and process integrity that Bio-o-Bank provides facilitate the compliance with data protection in at the same level of biomedical research laws.
- Web-based technology allows for an easier, faster and less disruptive implementation. Does it require less intervention and maintenance by any IT department, and always make accessible the latest version.

3.2. ISO 9001 certification

Since January 2016, the central node of the biobank was certified with the ISO 9001 (Fig. 4). This certification specifies requirements for a quality management system where an organization needs to demonstrate its ability to consistently provide product that meets customer and applicable statutory and regulatory requirements, and aims to enhance customer satisfaction through the effective application of the system, including processes for continual improvement of the system and the assurance of conformity to customer and applicable statutory and regulatory requirements.

All requirements of ISO 9001 are generic and are intended to be applicable to all organizations, regardless of type, size and product provided. Where any requirement(s) of ISO 9001 cannot be applied due to the nature of an organization and its product, this can be considered for exclusion.

General requirements requires an organization to “establish, document, implement, and maintain a quality management system and continually improve its effectiveness in accordance with the requirements of this International Standard”

278 The Biobank implemented guarantees that the quality management system
279 documentation include:

- 280 a) Documented statements of a quality policy and quality objectives.
- 281 b) A quality manual.
- 282 c) Documented procedures required by this International Standard.
- 283 d) Documents needed by the organization to ensure the effective planning, operation
284 and control of its processes, and;
- 285 e) Records required by this International Standard.

286

287 The Biobank couples with the ISO 9001 making clear that where the standard
288 specifically requires a “documented procedure”, the procedure is established,
289 documented, implemented and maintained (Davis et al., 2012; Cortés et al., 2014). It
290 also emphasizes that the extent of the QMS documentation may differ from one
291 organization to another due to:

- 292 – The size of organization and type of activities;
- 293 – The complexity of processes and their interactions, and
- 294 – The competence of personnel.

295

296 3.3. *Biobank Cost-Benefit model*

297 The biobank cost calculations defined a cost scenario based on the implementation of
298 the results of the PARASITE Project (GA312068), evaluating the sum of the
299 implementation costs of a biobank platform in each elaboration phase along the value
300 chain, according to Table 2.

301 Overall, the calculations made for the basic functioning of the Technical Unit of
302 Biobank showed that it is necessary an income of about 50,000€ per year to maintain
303 the biobank infrastructure, which means a cost (excluding shipment) of 2,64€ per
304 macroparasite delivered. This unit rate per sample is adaptable to each macroparasite,
305 being necessary to re-calculate the cost system in function of the biological
306 peculiarities and storage. It will also be necessary to take into account that the
307 products maintained in the TUB can be held for a long time, even years stored, and its
308 value, however, does not increase. Finally, it is necessary to bear in mind that due to
309 the special characteristics of the activity carried out by the researchers there is no
310 guarantee that the stored material will be requested and, therefore, assigned for
311 research projects. Even reliable estimates of the samples to be sent are not possible,
312 since the uncertainty about the amount of cessions is rather high.

4. Discussion

The field of biobanking as it has evolved from a simple collection of frozen specimens to the virtual biobank. Biorepository and biospecimen science has also evolved in response to the changing landscape of external regulatory pressures, the advances made in the biological sciences, and the advent of the computer chip. Biospecimen banking is a growing enterprise crucial to health science research and other biological sciences (De Souza and Greenspan, 2013).

The biobank we implemented, for the first time concerning oceanic samples (PARASITE BIOBANK), is expected to provide a number of outcomes that will boost the development of a network of biobanks in parasitology, which comprise the fishing sector related parasites and the recently created biobank of aquaculture parasites. Maybe the most valuable aspect of its focus is that the outcomes will facilitate the future development within the same specific research fields or in new and complementary ones. An additional direction for the future extensions is improving coverage of various aspects of the biobanks, such as availability of quality management systems, advertising additional services such as sample/data hosting (Holub et al., 2016).

The PARASITE Biobank is a technological solution for the preservation of zoonotic parasites affecting fish and fish products and parasite-related samples, together with their associated data. It was designed following the model adopted by clinical biobanks, which ensures the complete traceability and the availability of thorough and reliable information of each sample. It incorporates an adaptation of well-known commercially available software for medical biobanks (e-BANK). The importance of this special infrastructure as transversal tool was evidenced in the large amount of papers published in mainstream journals (i.e. Schiermeier and Abbot, 2016)

It is designed using client/server architecture, based on the Internet Information Server, with remote client access after identification and authentication, possible from anywhere through a standard Internet connection and a web browser. This application, named Bio-o-Bank, is a complete web solution for marine samples management specific for the PARASITE biobank network but that can be easily adapted to any other biological field. The server hosts the database, provides access to it and allows data processing and storage.

The pressure to know what resources are being used and what results in products or services are obtained from them is becoming increasingly important in the field of

public institutions. In this situation, the legislators issue rules that regulate the information of costs that the organisms must elaborate. At the same time, among the managers of public institutions, there is growing awareness of the importance of this type of information in order to make decisions (Pérez Morote, 2000; Robleda, 2010).

Another objective of this study was to present a model of cost analysis applicable to the TUB we implemented, in order to provide a tool to obtain information on the costs incurred to meet the demand for samples. It should be taken into account that, according to the Biomedical Research Law (Law 14/2007 of July 3), a biobank can be defined as a public or private, non-profit establishment that houses a collection of biological samples conceived with diagnostic or biomedical research purposes and organized as a technical unit with criteria of quality, order and destination. Regarding the cost analyses in clinical biobankings, the maintenance of these infrastructures are permanently analysed due to the complexity of the issues regarding human samples. Although infrastructures that collect, process, store, and distribute human biospecimens are working to improve access, no single accepted business model exists that enables long-term operation of biobanks (Clément et al., 2014). Therefore, biobanks are a non-profit research support platform and, in the case of TUB (IIM-CSIC), a cost model will provide key information for decision-making, fostering commitment to efficiency, continuous improvement and self-sustainability.

In relation with the calculation of the biological samples cost, it is worth mentioning: 1) The absence of previous work on the calculation of costs of tangible goods in the public sector in general and concerning biobanking in particular; 2) Limited economic orientation and little tradition in the calculation of managers' costs; 3) Short period of validity of the regulation on the calculation of tariffs. In the Biomedical Research (Law 14/2007) only give brushstrokes and the Royal Decree that develops it (R.D. 1716/2011) is very recent publication (December 2, 2011), and 4) Heterogeneous production processes and a great diversity of final products that hinder the development of a common model applied to the entire TUB. The types of samples stored in the TUB can be very varied and each collection of samples has an individualized performance protocol. However, the basic questions about organization and production process are common. While it is clear that resource consumption and intensity will vary according to the type of sample in question, since each has an individualized protocol of action, the basic issues of organization, legislation and production process are common.

Facing this situation, it has been necessary to provide content with all the preliminary steps, to specify the TUB, the types of products it stores, the applicable legislation, and other questions necessary to know, ultimately, what resource consumption is necessary to supply the requested samples to a particular researcher.

It is clear that the analysis of economic profitability is not something that can be considered indispensable since a biobank is not a profitable entity because is based on a cession-donation scheme. This confers very peculiar characteristics to the analysis of costs in this sector, because the cost devoted to be more competitive or to obtain better results is not taken into account and the fundamental issue is the availability of quality biological material for investigation. However, it is foreseeable that this situation changes and that in the not too distant future the information of costs thus determined can allow:

- Provide an assessment of all the material stored, which provides useful information for the management of the biobank.
- Analyse the efficiency of the processes carried out.
- Evaluate the feasibility of some collections, which are more a personal interest of a researcher than the general interest of the scientific community.
- Carry out a cost benchmarking that would allow researchers to request samples from those banks that are most economical, as long as the quality assurance of the sample was the same. This would, therefore, introduce criteria of competition between biobanks.
- Encourage cooperation and mutual learning between biobanks since this cost information could allow them to assess the appropriateness of the stages of the production process, the techniques employed and even the possibilities of subcontracting some stages of the process.
- Manage biobanks more professionally. Increasing the standards that biobanks must comply with guarantees a higher quality in the samples transferred, which in the long term results in an increase in the number of assignments and better results of the investigations carried out.

Some of these improvements have been coupled yet with the implementation of the ISO 9001 for the Technical Unit of Biobank.

The proposed costing model can be configured as a tool to support the improvement of the management of biobanks, as it would cooperate in the application of criteria of efficiency in decisions, not only in the economic ones.

It is necessary to underline that the TUB has up-to-date information on all the stored material and all the samples that are transferred. The implementation of the cost model described above provides information on the costs per unit of stored product. With this information as a baseline it might be possible to create a system to allocate those costs to the stocks that are kept stored, that is, to complete the information about the material stored currently exists. The best option would be to do it through a computer program that, while calculating the costs of the different stages, will assign the value to the stocks stored according to the valuation method chosen by the TUB.

5. Conclusions

The constitution of this biobank and the development of the programmed action will yield several global benefits that otherwise would not be achievable in a local/regional framework:

1. Economic: PARASITE BIOBANK will target the optimization of the management of parasite samples collected in fish specimens. The visualization of this issue would probably be more effective by using an example. There are many samples (parasites, DNA, etc.) that could be stored with the associated data in a completely traceable way. That is possible by the application of software that is able to incorporate any single step in the pathway from the vessel to the storage. If anyone outside the banking tool want to use in the future some of these samples should not have to design and undertake a survey to collect a particular sample. Only by contacting the network responsible of any of the biobanks created, he is able to obtain the samples. The economic benefit will be immediate because, if anyone is able to obtain a parasite sample, DNA, etc. do not have to spend several thousands of euro organizing the sampling protocol. Only applying for that sample could get it much cheaper (the tool operates a non profit way). It is clear that the banking will provide the complete security that the samples have been processed, stored and delivered under the assumptions of quality provided by the outputs get in PARASITE BIOBANK.
2. Ecological: continuing with the above exposed and also related with the international cooperation, it is very important to create a long term network to establish protocols to store samples in a global level and thus will improve the key studies such as long term global change. Therefore, it is indispensable to incorporate a panel of multinational experts for solving the common matters to assure the traceability of parasites from fishing samples, bearing in mind that this

common objective could be afforded under the same approach since it does not matter if we want to create a bank to improve the resource efficiency and climate change or to target the seafood security and safety. According to this scheme, the global change studies will be easier to make since it will be possible to maintain a completely traceable repositories under the measures of accuracy for undertaking comparable studies in the future.

3. Transference to stakeholders. The information provided by PARASITE BIOBANK will favour also the transference of data and samples, not only for basic or applied public research, but also to supply of material collected at sea to be used by private enterprises, such as nano biotech, pharmaceuticals or seafood safety, and even policymakers. That will enhance the societal applications to improve the knowledge in a multi-scaled scheme, using several dissemination tools. The multidisciplinary of the tool tackled will also allow sharing data by the different nodes designed.

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References

- Asociación Española de Contabilidad y Administración de Empresa, (1999). La Contabilidad de Gestión en los centros sanitarios. Madrid. 128 pp.
- Asociación Española de Contabilidad y Administración de Empresa, (01). La Contabilidad de Gestión en las Entidades sin Fines de Lucro. Madrid. 130 pp.
- Christiansen, J.S., Mecklenburg, C.W., Karamushko, O.V., 2014. Arctic marine fishes and their fisheries in light of global change. *Global Change Biology* 20, 352–359.

481 Clément, B., Yuille, M., Zaltoukal, K., Wichmann, H.E., Anton, G., Parodi, B., Kozera, L.,
482 Bréchet, C., Hofman, P., Dagher, G., 2014. Public Biobanks: Calculation and Recovery
483 of Costs. *Science Translational Medicine* 6 (261) DOI: 10.1126/scitranslmed.3010444.

484 Cortés MA, Irrazábal E, García-Jerez A, Bohórquez-Magro L, Luengo A, Ortiz-Arduán A,
485 Calleros L, Rodríguez-Puyol M. 2014. Impact of implementing ISO 9001:2008
486 standard on the Spanish Renal Research Network biobank sample transfer process.
487 *Nefrologia* 34, 552-560.

488 Davis E, Hampson K, Bray C, Dixon K, Ollier W, Yuille M. 2012. Selection and
489 Implementation of the ISO9001 Standard to Support Biobanking Research
490 Infrastructure Development. *Biopreserv. Biobank* 10, 162-167.

491 De Souza, Y.G., Greenspan, J.S., 2013. Biobanking Past, Present and Future:
492 responsibilities and Benefits. *AIDS* 27: 303-312.

493 Galli, J., Oelrich, J., Taussig, M.J., Andreásson, U., Ortega-Paino, E., Landegren, U., 2015.
494 The Biobanking Analysis Resource Catalogue (BARCDB): A new research tool for the
495 analysis of biobank samples. *Nucleic Acids research* 43, 1158-1162.

496 Holub, P., Swertz, M., Reihs, R., van Enckevort, D., Müller, H., Litton, J.E., 2016. 515
497 Biobanks with over 60 million biological samples. *Biopreservation and Biobanking* 14,
498 559-562.

499 Navarro-Mateu, F., Tormo, M.J., Vilagut, G., Alonso, J., Ruíz-Merino, G., Escámez, T.,
500 Salmerón, D., Júdez, J., Martínez, S., Navarro, C., 2013. Epidemiology and genetics
501 of common mental disorders in the general population: the PEGASUS-Murcia project.
502 *BMJ Open* 2013;3:e004035. doi:10.1136/bmjopen-2013- 004035.

503 Pérez-Morote, P., 2000. "Las nuevas técnicas de gestión y su aplicación en la
504 Administración pública municipal", I Encuentro Iberoamericano de Contabilidad de
505 Gestión. Valencia, noviembre.

506 Robleda, H., 2010. El Nuevo Plan de Contabilidad Pública: una herramienta oportuna
507 para mejorar la información contable sobre la gestión pública, *Auditoría Pública*, nº
508 51:87-89.

509 Schiermeier, Q., Abbott, A., 2016. Flagship brain project releases neuro-computing tools.
510 *Nature* 532, 18.

511 Torres-Perez E, Valero M, Garcia-Rodriguez B, Gonzalez-Irazabal Y, Calmarza P, Calvo-
512 Ruata L, Ortega C, Garcia-Sobreviela MP, Sanz-Paris A, Artigas JM Lagos J, Arbones-
513 Mainar JM. 2015. The FAT expandability (FATe) Project: Biomarkers to determine the
514 limit of expansion and the complications of obesity. *Cardiovasc. Diabetol.*14: 40 22.
515 doi: 10.1186/s12933-015-0203-6.

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Species		N
Herring <i>Cuplea harengus</i>		1991 (A)
Sea-bram <i>Dicentrarchus labrax</i>		36 (M)
Anchovy <i>Engraulis encrasicolus</i>		5006 (A, M)
Cod <i>Gadus morhua</i>		351 (A)
Silver scabbardfish <i>Lepidopus caudatus</i>		93 (M)
Four-spotted megrim <i>Lepidorhombus boscii</i>		287 (A)
Monkfish (<i>Lophius</i> spp.)	<i>Lophius budegassa</i>	236 (A, M)
	<i>Lophius piscatorius</i>	146 (A, M)
Haddock <i>Melanogrammus aeglefinus</i>		291 (A)
Whiting <i>Merlangius merlangus</i>		259 (A)
European hake <i>Merluccius merluccius</i>		1496 (A, M)
Blue Whiting <i>Micromesistius poutassou</i>		1309 (A, M)
European plaice <i>Pleuronectes platessa</i>		406 (A, M)
Sardine <i>Sardina pilchardus</i>		1218 (A, M)
Chub mackerel <i>Scomber japonicus</i> (= <i>Scomber colias</i>)		433 (A, M)
Atlantic mackerel <i>Scomber scombrus</i>		1898 (A, M)
Yellowfin tuna <i>Thunnus albacares</i>		10 (P)
Bluefin tuna <i>Thunnus thynnus</i>		8 (M)
Japanese flying squid <i>Todarodes pacificus</i>		600 (P)

Table 1. Species and number of samples studied. A: Atlantic, M: Mediterranean, P: Pacific.

BIOBANK COSTS	VIGO
FIXED COSTS	VALUE
1. PERSONNEL	
DEDICATED HOURS/YEAR COORDINATION	40
COST/ PER HOUR COORDINATION (€)	60
DEDICATED HOURS/YEAR TECHNICIAN	600
COST/ PER HOUR TECHNICIAN (€)	15
TOTAL PERSONELL COST	11.400
2. EQUIPMENT/SOFTWARE COST	
2.1 FREEZER	
PURCHASE PRICE (€)	13.000
CO2 BOTTLES (€)/YEAR	200
LIFE TIME (YEARS)	8
DEDICATION (%)	100%
TOTAL COST	1.825
2.2 SOFTWARE BACKUP SERVER	
PURCHASE PRICE (€)	1500
LIFE TIME (YEARS)	4
DEDICATION (%)	100%
TOTAL COST	375
2.3 SOFTWARE	
ANNUAL LICENSE (€)	6.000
MAINTENANCE: DEDICATED HOURS/YEAR TECHNICIAN	40
MAINTENANCE: COST/ PER HOUR TECHNICIAN (€)	20
SOFTWARE COST	6.800
2.3 LABEL PRINTER	
PURCHASE PRICE (€)	200
LIFE TIME (YEARS)	4
DEDICATION (%)	25%
TOTAL COST	13
3. INSTALLATIONS	
M2 dedicated to Biobank	12
Cost per m2/year	144
DEDICATION (%)	50%
TOTAL COST	864
4. GOODS/FIXED ASSET (TABLES, CHAIRS, ETC.)	
PURCHASE PRICE (€)	3.000
LIFE TIME (YEARS)	5
DEDICATION (%)	100%
TOTAL COST	600
5. OTHER COSTS: ELECTRIC ENERGY	
COST per kWh (€)	0,16
KW/H CONSUMED BY EQUIPMENT/YEAR	6781
KW/H CONSUMED BY INSTALLATIONS/YEAR	38,4
DEDICATION (%)	100%
TOTAL COST	1.091
VARIABLE COSTS	VALUE
Nº OF PROCESSED SAMPLES OF ANISAKIDS	17.500
1. FISH PURCHASE	
PURCHASED FISH (KG)	350
COST PER KG (€)	7
TOTAL COST	2.450
2. SAMPLING CONSUMABLES	
FREEZER CONSERVATION UNITS (PACKAGING)	3.500
Nº OF ANISAKIS PER UNIT	5
COST PER CONSERVATION UNIT (€)	0,1
IDENTIFICATION LABEL COST (€)	0,02
TOTAL COST	84
3. SHIPMENT OF SAMPLES	
Nº OF SHIPPED SAMPLES OF ANISAKIDS	17.500
AVERAGE Nº SAMPLES OF ANISAKIS PER SHIPMENT	100
SHIPMENT PACKAGING COST (€)	2
AVERAGE TRANSPORTATION COST PER SHIPMENT (€)	20
Nº OF SHIPMENTS PER YEAR	175
TOTAL COST	3.850
	46.132
AVERAGE COST PER ANISAKIS	2,64
AVERAGE COST PER SHIPMENT	263,61

Table 2. Model cost analysis.

FIGURE LEGENDS

Figure 1. Biobank flux of traceable sample and associated data.

Figure 2. Architecture of biobank.

Figure 3. Software secure codification.

Figure 4. Technical Unit of Biobank Management System Certification 9001:2008.

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Figure 1

Figure 2

Figure 3

Figure 4