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A scoping study of specimen archiving activity in the UK and the potential for a UK Environmental Specimen Bank

J.S. Chaplow, L.A. Walker, C. J. MacKechnie and R.F. Shore

May, 2010



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UK Environmental Observation Framework

A scoping study of specimen archiving activity in the UK and the potential for a UK Environmental Specimen Bank¹

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May, 2010

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Executive Summary

There are numerous monitoring and experimental research studies in the UK that involve collection and archiving of environmental specimens. As part of the current project, we have estimated the cost of these activities to be approximately £16 million per year. However, there is no current UK-wide strategic coordination of this investment. Although the United Kingdom Environmental Observation Framework (UK-EOF) catalogues environmental observations made for and by the UK, it does not currently catalogue specimen collection.

This report describes a short study to: (i) gather information on current specimen collection and archiving in the UK; (ii) determine what information on this activity can be incorporated into the UK-EOF Environmental Observation Activity Catalogue (UK-EOF Catalogue), (iii) investigate the potential for a UK Environmental Specimen Bank (UK-ESB) that would provide links and strategic coordination between different collections. This study focused on environmental specimens, largely biological and geological samples, but excluding medical specimens.

The current study provides what, as far as we are aware, is the first collated information on current UK collection and archiving of environmental specimens. We surveyed 42 organisations that, from their UK-EOF Catalogue entries, appeared to collect/archive environmental samples. We subsequently identified 28 archives or distinct groups that archive one or more type of specimen. The size and breadth of archives range from specimens kept by individuals at home to large museum collections. Many types of specimens are archived and include terrestrial, freshwater and marine biota (including DNA extracts), soils/sediments and geological samples. Collecting schemes usually archive their own samples and sometimes those collected by others, and use facilities that range from stand-alone domestic freezers to purpose built complexes. Sample preservation techniques are similarly diverse and include fresh, frozen, dried and fixed (in preservative) storage; methods are dictated by the purpose of the archive and the nature of the samples. Collections have been stored for between 5 and 200 years and, typically, plan to retain samples indefinitely or have ‘no time limit’ for retention. Most collections do not have spare capacity to accommodate other samples; those that do tend to be existing specimen banks and museums. Archives have electronic and paper catalogues of some sort and often have both as they retain historic (pre-electronic) records.

A UK-ESB would be a national partnership between holders of UK environmental specimens. It would be designed to promote knowledge, and subsequent scientific use, of archived specimens of national importance. A UK-ESB would facilitate delivery of world-class environmental science, particularly the detection and characterisation of patterns and rate of environmental change and the emergence and progression of environmental hazards and risks. A UK-ESB would link nationally valuable specimen holdings, encourage the sharing of data, samples and facilities and promote best practice. It could also facilitate strategic links with other types of specimen banks (human, DNA banks etc) and associated data. Overall, it would help maximise the benefits gained from the current disparate UK investment in archiving environmental specimens.

The outputs from the workshop conducted as part of the current project were:

- **metadata fields** describing archiving activities that could be incorporated or linked to the EOAC

- **a synthesis of the benefits of a UK-ESB.** Overall, the workshop considered that a UK-ESB would deliver benefits both scientifically and to policymakers/regulators by improving current capability to monitor the health of the natural environment
- **“buy-in” to the concept of a UK-ESB.** Thus, the workshop has developed a consortium of stakeholders upon which to base development of the UK-ESB
- **recommendations** on the models by which a UK-ESB could be developed and operate, and **the next steps** needed to achieve this

Recommendations:

1. *In the short term*, develop a “virtual UK-ESB” that includes a dedicated website to link different archives, and develop a database of standardised metadata describing UK archive holdings. This database would promote better knowledge of specimen archives that can be used to address pressing environmental issues. A virtual-ESB would not require changes to current archive or access practices. It would yield significant benefits rapidly and require only modest resources.
2. *In the medium term*, develop a “federated UK-ESB” that would build on and incorporate the benefits and attributes of the virtual model. It would have a steering group to oversee the development of strategic management and sustainable business plans. Such plans are likely to include: establishment of global links with other national ESBs; development of best practice (potentially accredited to international quality standards); agreed principles of access to and use of samples by the wider research community; avoidance of duplication of collection; identification of strategically important gaps in archive holdings; support for/rescue of valuable “at risk” specimens; securing long-term funding, defining and developing metrics to measure value and impact.

Next steps:

1. Establish a “champion” to develop next steps
2. Obtain funding/resources to develop a metadata catalogue, a virtual “UK-ESB” and business and strategy plans to move to a “federated” model
3. Develop and populate a metadata catalogue for national specimen collections that links or is incorporated into the UK-EOF Catalogue
4. Construct and populate a UK-ESB website
5. Manage and maintain the website/catalogue
6. Develop funding model for a “federated UK-ESB”
7. Develop a “federated UK-ESB”

A “Virtual” UK-ESB would require relatively modest investment but achieve rapid gains, including an on-line searchable database of metadata for UK archives. It would also provide a springboard to the more pro-active “Federated” UK-ESB model. Such a federated model would be strategic in outlook and provide the impetus for wider ranging initiatives, such as collaborations with human specimen archives (to link environment with human health) and with cryo-bank initiatives that address biodiversity loss. A federated UK-ESB would provide significant National Capability to underpin key UK science areas.

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1. Introduction

The United Kingdom Environmental Observation Framework (UK-EOF) is a 5 year programme established to identify and address the issues surrounding environmental observations made for and by the UK. The framework seeks to provide a cost effective mechanism to work in partnership across government, the devolved administrations, agencies and the voluntary sector to make best use of expertise and resources in support of national and international goals.

The UK-EOF has the overall aim of shaping the UK's capability to 'facilitate the ongoing environmental evidence required to understand the changing natural environment, thus guiding current and future environmental management, policy, science and innovation priorities for economic benefit and quality of life'.

The UK-EOF, as part of its ongoing programme, has developed an Environmental Observation Activity Catalogue (UK-EOF Catalogue). This catalogue was designed to provide a strong basis for strategic planning by giving a holistic overview of activities and a place to:

- discover who is doing what, where, why and when
- make contact with observation managers
- find out where the data is held and if it is available for reuse
- search online.

Specimens

The catalogue was not initially designed to collect significant information regarding specimen archiving. However, it was evident from the UK-EOF Catalogue that significant resources are committed to specimen archiving within the UK. The archiving activities appeared to be being conducted independently and usually in isolation of each other.

A specimen is a portion or quantity of material for use in study, testing or examination. This study focused on environmental specimens and includes biological samples (individual animal, part of an animal, plant, part of a plant, microorganism) and geological specimens (piece of a type of rock, gem, or mineral taken from the earth and ice cores). It did not include medical specimens (samples taken from a patient, most frequently blood, urine, or semen).

This report describes a scoping study, conducted by the Centre for Ecology & Hydrology (CEH) on behalf of the UK-EOF², which focuses on specimen archiving activities in the UK. The study was designed with three main aims:

- to gather information on current specimen archiving undertaken in the UK
- to suggest how this information could be incorporated into the existing UK-EOF Catalogue
- to investigate the potential for a UK Environmental Specimen Bank (UK-ESB) that would provide strategic development and links between current disparate archiving activities

² We would like to acknowledge the support of the Environmental Research Funders' Forum in funding this project

The plan of work consisted first of harvesting information held in UK-EOF Catalogue to identify and then survey (by e-mail and telephone) organisations that, from their data entries, appeared likely to be collecting and/or archiving samples. The second stage was to develop and host a workshop with representatives of key organisations involved in archiving samples. The principle aims of the workshop were to discuss and gather the collected views as to (i) how collection activities could be described adequately using metadata fields and so linked in to the existing catalogue; (ii) the potential for developing a UK-ESB and what this might look like.

2. Survey of current collecting/archiving activities in the UK

2.1. Interrogation of the UK-EOF Catalogue

Organisations involved in collecting and potentially archiving specimens were identified when their entries in the ‘Description’ or ‘Objective’ fields of the UK-EOF Catalogue mentioned that samples were collected as part of the project activities. Thirty-four contributors were identified from the catalogue as potentially collecting samples. In addition, there were other organisations known to CEH that were thought to be collecting and/or archiving samples.

In total, 42 organisations, some of which held more than one collection, were identified (Table 1), and were selected both for survey (see Section 2.2) and as invitees to a workshop. The information gathered by this exercise will be used to update the EOAC (including contact details) where necessary.

Table 1. UK organisations identified as potentially collecting and archiving samples

AEA	Institute of Zoology (IoZ)
Agri-Food and Biosciences Institute Northern Ireland (AFBINI)	Lancaster University Centre for Chemicals Management
British Antarctic Survey (BAS)	Macaulay Land Use Research Institute (MLURI)
Bat Conservation Trust	Mammal Society/ Aberdeen University
Biotechnology and Biological Sciences Research Council (BBSRC)	MBA/DASSH
British Geological Survey (BGS)	MEDIN
British Trust for Ornithology (BTO)	National Museum Scotland
Bureau Veritas UK & Ireland	National Museum Wales
Cardiff University	Natural History Museum
Centre for Ecology and Hydrology (CEH)	Royal Botanic Garden Edinburgh (RGBE)
Countryside Council for Wales (CCW)	River Conservation Trusts
Cranfield University NSRI	Rothamsted Research
Culture Collection of Algae and Protozoa (CCAP)	Sir Alister Hardy Foundation for Ocean Science (SAHFOS)
Department of Environment Northern Ireland (DOENI)	Science and Advice for Scottish Agriculture (SASA)
Environment Agency (EA)	Scottish Agricultural College
Freshwater Biological Association (FBA)	Scottish Association for Marine Science (SAMS)
The Food and Environment Research Agency (Fera)	Scottish Environment Protection Agency (SEPA)
Fisheries Research Services (FRS)	Stoke on Trent Museums (Natural History Collections officer)
Forestry Commission (Forest Research)	United Kingdom Acid Waters Monitoring Network (UKAWMN)
Geological Survey of Northern Ireland	Veterinary Laboratories Agency (VLA)
Herefordshire Heritage Services	Welsh Assembly Government (WAG)

2.2. Survey questions and responses

The 42 organisations that had been identified were contacted by e-mail and then by telephone. They were asked to complete a number of survey questions about their collecting and archiving activities and to indicate their interest in a UK-ESB and attendance of the workshop.

The survey questions were:

1. Do you collect samples of any kind as part of your scheme?
2. What kind of samples are they?
3. Do you currently store samples after analysis?
4. For how long?
5. How are they stored?
6. Do you have a specimen archive facility?
7. Does it have a catalogue? Is it paper or electronic?
8. Do you share samples with other organisations?
9. If you do not retain samples, why not?
10. Would you retain samples if you had access to facilities that specialise in long term storage?
11. Would you be interested in depositing samples into an ESB?
12. Would you be interested in accessing samples archived by other scientific organisations if they were stored following Standard Operating Procedures (SOP's)?
13. Are you interested in participating in an ESB?
14. Is there a representative of the group available for a workshop on 12th November?

A further group of organisations that were identified either by attendees at the workshop in November (Table A1 in the appendix of this report), or by initial survey responses. These organisations were then also contacted and surveyed using the same questions (except for question 14 when the survey was after the workshop had been held). In total, we surveyed 86 organisations and over 100 individuals.

Forty-seven responses were received. Of those, 6 respondents did not collect samples and 14 stated that they were not currently archiving samples. More than half of these organisations (Table 2) wanted to be kept informed of developments with regards a UK-ESB. In contrast, seven respondents did not want to participate in a UK ESB initiative at this time. It was apparent from survey comments regarding non-retention of samples that some collecting schemes already pass on their samples to national institutions, e.g. museums. Other schemes do not retain samples for one or more of a variety of reasons. These include lack of facilities or space, inherent instability of samples, legal reasons and because archiving was outside the requirements of the research being undertaken.

Table 2. Organisations not currently archiving but that wish to be kept informed of UK-ESB developments

ADAS	Environment Agency
AEA	Marine Environment Data and Information Network
British Trust for Ornithology	Museums Libraries and Archives Council
Cardiff University	Scottish Environment Protection Agency
Countryside Council for Wales	Welsh Assembly Government
Department of Environment N. Ireland	

Of the 28 groups that were found to be collecting specimens (Table 3), a good proportion was able to attend the workshop in November 2009. In all, there were 28 attendees and they are listed in Table A2 in the Appendix.

Table 3. UK archived specimens or groups that archive \geq one type of specimen

Collection	Sample type	Archive Duration
British Antarctic Survey	Geological and environmental samples and biota	Indefinitely
British Geological Survey	Geological samples	10+ years
CABI	Fungi	Indefinitely
CCAP (Culture Collection of Algae and Protozoa)	Prokaryotic cyanobacteria, algae and free-living protozoa	Indefinitely
Centre for Environment, Fisheries and Aquaculture Science (CEFAS)	Fish tissues	Unrecorded
Centre for Ecology and Hydrology (CEH) - Countryside Survey	Soils and soil invertebrates	Soils since 1978, fauna since 2000
CEH Bangor - Beddgelert forest catchment study	Soils and vegetation	Indefinitely
CEH Bangor	Soil & vegetation	10+ years
CEH Lancaster	Phytoplankton	Indefinitely
CEH Lancaster - Environmental Change Network	Soils and invertebrate fauna	15+ years
CEH Lancaster – Predatory Bird Monitoring Scheme	Predatory bird tissues and egg contents	since 1967
CEH Oxford	Butterflies and moths, and pathogens	Indefinitely
CEH Wallingford (Fish Archive)	Fresh water fish	Since 2009
Cranfield	Soil	Indefinitely
NCIMB Ltd.	Bacterial isolates	Since 1950's
UCL Environmental Change Research Centre (ECRC)	Aquatic plant and diatom samples and sediment samples	Indefinitely
Forestry Commission	Foliage and other tree	Since 2000
Geological Survey of Northern Ireland	Soils, sediments & stream waters	5 years
Geological Survey of Northern Ireland	Rock core samples	Indefinitely
Lancaster Environment Centre (LEC)	Air samples & extracts, soil, vegetation and biological samples	Unrecorded
Institute of Research in the Applied Natural Sciences (LIRANS), University of Bedfordshire	Fish tissues	Since 2002
Macaulay Land Use Research Institute (MLURI)	Bulk soil samples & DNA extracts	Indefinitely
Marine Biological Association/ Data Archive for Seabed Species and Habitats (MBA/DASSH)	Marine biota and DNA extracts	Indefinitely
Royal Botanic Garden Edinburgh (RGBE)	Various botanical samples	Indefinitely
Sir Alistair Hardy Foundation for Ocean Science (SAHFOS)	Plankton	Since 1958
Scottish Association for Marine Science (SAMS)	Zoological specimens	Indefinitely
Stoke on Trent Museums	Animals, plants and geological specimens	200 years+
United Kingdom Acid Waters Monitoring Network (UKAWMN)	Various samples	Since 1988

3. Consideration of metadata fields to describe archiving activity in the UK

As part of the workshop, attendees were asked to consider and rate the importance of 14 metadata fields in terms of providing information about their archived specimens. Workshop participants were also asked to recommend any fields that they felt would be appropriate and were additional to the 14 fields already suggested. The suggested metadata fields and their priority order, as rated by workshop attendees, is shown in Table 4.

Table 4. Potential metadata fields relating to archived specimens

Priority	Metadata field
1	Geographical provenance (need options on degree of spatial resolution)
2	Sample type (e.g. liver, whole plant, rock, soil, etc—drop down box categories)
3	Sample description
4	Name, address and contact details of collecting organisation
5	Physical state (e.g. slide, preserved, whole, homogenised, air dried, freeze dried)
6	Limitations on access to the samples (e.g. freq. of use, destructive sampling)
7	Link to existing catalogue and format
8	Storage requirements (choose one of offered categories)
9	Number of samples held (provide broad band number categories)
10	Contact person who has added the record
11	Title of collection
12	Size and type of container (e.g. glass jar, plastic bags)
13	H & S issues
14	Free text field for additional information

Some of the fields overlap with the existing UK-EOF Catalogue and some would be additional. The most obvious, and perhaps most useful, single field that could be added would be a tick box field to record which catalogue records actually have archived specimens associated with them. If further fields can be added, the three most important fields, as scored by the workshop attendees from the list provided, were:

1. Geographical provenance -this could be broad areas but an indication of spatial resolution of samples would be advantageous.
2. Sample type – selected from a list of categories, e.g. liver, plant, rock, soil core etc.
3. Sample description – possibly a free text field, to give a more holistic view of what specimens are archived and how they can be accessed.

Fields such as ‘Geographical Provenance’ and ‘Sample Type’ could be populated from drop down menus or tick boxes to ensure standardised data entry. Tick boxes would be preferable as they would allow organisations that archive more than one type of specimen, or specimens from multiple geographical regions, to record the breadth of their collections. It was felt that free text fields (e.g. sample description), although difficult to interrogate and summarise, can be useful for contextual information, could include keywords, and would be helpful for identifying potential collaborators and experts.

Attendees identified a further 19 metadata fields that could be useful (Table 5). The three that were mentioned most often were:

1. Temporal extent – the time period over which samples are collected and an indication of sampling frequency
2. Existing data or studies – details of what type of data associated with samples already exist
3. Sampling techniques and reference to Standard Operating Procedure (SOPs) –details to what standards (if any) the samples were handled under.

Table 5. Suggested additional metadata fields to describe archived samples

Suggested extra fields	Count¹
Temporal extent (time span, sampling frequency)	10
Existing data/studies	7
References to Standard Operating Procedures (SOP)s	6
Storage methods	5
Access restrictions	5
Lineage (why was sample collected)	4
Any history of sample in/out of storage or change in location	3
Loan information (is sample available or being used by someone else)	3
Intellectual Property Rights (IPR) and confidentiality	2
Citations	2
Is sample at risk?	2
Keywords from controlled vocabulary	2
Operated under what Quality Control (QC) /Quality Assurance (QA)	1
Archive location	1
Images	1
References to analytical standards	1
Time to remove from store	1
Link to EU collections	1
ISO standards	1

¹Counts indicate the number of workshop attendees who rated these fields as amongst the most important

Discussions on these additional fields included the following points:

- it might be necessary to include additional ‘Temporal Extent’ fields to the existing UK-EOF Catalogue since sample archiving may not be carried out over the same period as observation activities, and detail may be required regarding sampling frequency
- a field summarising ‘Existing Data/Studies’ would be useful when searching the catalogue for potential collaborators, publications, information etc, but it is unclear what format this field would be other than free text
- a field detailing the standards under which the samples were collected, processed and stored in collections would be useful to assess the degree of curation in specimen archives, and help identify areas that could benefit from improvement.

An exemplar (using information for CEH's Predatory Bird Monitoring Scheme- www.ceh.ac.uk/sections/er/PredatoryBirdMonitoringScheme.htm) of what an archiving metadata entry in the UK-EOF Catalogue might look like is given in Table 6. This uses an initial field to indicate whether specimens are collected, and then the top three suggested metadata fields from each of Tables 4 and 5.

Table 6. Exemplar entry for archiving activities of CEH's Predatory Bird Monitoring Scheme (PBMS) using the priority metadata fields identified during the workshop

Field	PBMS entry:
Specimens archived	Yes
Geographical provenance	United Kingdom
Geographical Resolution	10km square
Sample Type	Organs - Whole
Sample Description	A range of tissues, including liver, kidneys, muscle, brain, fat, feather and bone, and homogenised egg contents from a range of diurnal and nocturnal predatory birds. All kept frozen at -20C.
Temporal start (Year)	1967
Temporal finish (Year) or ongoing	Ongoing
Existing Data	Organics and metal contaminant concentrations in predatory bird livers and eggs. Also biometric data for bird carcasses and eggs.
Sampling Techniques and SOPs	Scheme operates under Joint Code Of Practice (JCOP)

In conclusion, the workshop outputs on metadata fields to describe archiving activities highlighted 33 potential relevant fields. These have, to some extent, been ranked in order of importance. Some of the recommended fields may seem to be repetitions of those already present in the UK-EOF Catalogue but archive holding may not mirror the data holdings.

While it is impractical to include all fields in the current UK-EOF Catalogue, it may be possible to include one or more of the priority fields identified. It should be possible to develop a separate metadata database for UK archiving activities containing all the fields listed in Tables 4 and 5 which is linked to the UK-EOF Catalogue. Such a database should be possible to establish relatively rapidly as it would require only metadata entries, not detail on hundreds of thousands of individual samples. It could be available via the web, and potentially be designed so organisations could edit/update their own entries on-line, thereby reducing the resources needed to manage the database. The database could be maintained through UK-EOF, through a NERC designated data-centre or by the coordinators of the ESB.

One aspect of database fields that was not discussed at the workshop was that of quality standards. As far as we are aware, there do not appear to be a specific metadata standard for environmental specimens, although this warrants further investigation. Collaboration with established international ESBs would help ensure adoption of internationally acceptable best practice and standards.

4. The potential for developing a UK Environmental Specimen bank (UK-ESB)

4.1. Introduction

This study has identified diverse environmental monitoring and other projects in the UK that, as part of their activities, archive samples. However, there is no national metadata holding that describes what samples (and associated data) are held and by whom, the preservation status of archived samples or their potential availability for use by the wider research community. The risk status of specimen archives is also uncertain, largely in terms both of back-up storage facilities (e.g. if power fails for samples held in cryogenic facilities) and the availability of long-term resources to maintain archived material.

The development of a UK-ESB could address and overcome the strategic shortcomings of current archives in the UK. A UK-ESB could work under one or more of various operational models but, whatever the model, it would link nationally valuable specimen holdings, encourage the sharing of data, samples and facilities and promote best practice. It could also facilitate strategic collection and use of specimens and associated data. It is anticipated that this would lead to improvements in the quality of specimen archiving at a national scale, and an ESB would help maximise the benefits that can be gained from the UK science investment in archiving activities.

The concept of a UK-ESB closely fits the work conducted by UK-EOF to coordinate observation activities and particularly the UK-EOF Catalogue. Future developments of the UK-EOF Catalogue are likely to incorporate links to the datasets themselves as well as informing users of data availability, access and suitability for reuse. The catalogue will be a federated system in that it will hold metadata and the data providers will continue to hold the actual data. The development of a UK-ESB metadata catalogue for specimens would provide equivalent functions for physical environmental specimens.

Consideration of the benefits of a UK-ESB is discussed in section 4.2 and possible operational models for a UK-ESB are considered in section 4.3.

4.2. The scientific and regulatory benefits of a UK-ESB

There are some immediately obvious potential benefits from having a UK-ESB.

These include:

- better knowledge and subsequent exploitation of archived specimens to address environmental issues, particularly with regards tracking environmental change and quantifying emerging risks
- more cost-efficient, effective and collaborative maintenance/development of specimen archives
- avoidance of unnecessary duplication of collection
- identification of strategically important gaps/areas in archives (such as the development of cryo-banks for both tissue samples and viable lines established from

tissue extracts; the cell lines could provide a continuing supply of material for other cellular and molecular studies – in effect a genome and proteome bank)

- support for, or rescue of, valuable “at risk” specimens
- strategic linkage of environmental archives with archived human samples, thereby strengthening ability to detect impacts of the environment on human health

As part of the workshop hosted by CEH, participants were divided into breakout groups and were asked to outline their views of the likely benefits that a UK-ESB would deliver.

Key benefits to the science community were seen to be:

- improved knowledge about specimen holdings and archive facilities
- increased access to time series specimens and data at a national level
- increased use/sharing of samples and information collected (data, publications, collaborations)
- access to samples that are collected, processed, catalogued and archived following Standard Operating Procedures (SOP’s)
- ability to identify environmental change, gaps in current science
- raise science profile, inform public and regulatory bodies, increase knowledge transfer
- reduce lead in time for science projects as have access to a wealth of background information (results, key experts, citations, issues)
- security over funding a national resource rather than many small facilities
- allows a holistic approach
- identification of ‘at risk’ archives, facilities

The regulatory benefits that were identified were:

- reduced costs –single portal, one stop shop, less overlap in science
- demonstration of the value of archive facilities to the public and policy makers
- information feeds global change biology and adds to the international picture
- provides evidence based legislation for policy and public end users

Overall, a UK-ESB could be expected to improve current ability to monitor the health of the natural environment within the UK. It would do this by increasing the access to a wide range of samples that can be analysed to identify trends and effects across species, environmental matrices (e.g., air, water, soil, and biota), regions and scientific fields. This is not currently possible because there is a lack of information as to what samples have been collected and are available. Sample availability (through the UK-ESB) may also facilitate development of new research approaches and collaborations to address environmental questions. Such multidisciplinary approaches are increasingly needed to address the problems of how economic development and environmental change can be reconciled with protection of natural resources, habitats and ecosystem services.

Examination of the websites of established environmental specimen banks in other countries (Japan, US, Germany, Sweden (and hence Nordic)) together with some peer-reviewed journals, has also helped identify the potential benefits that are derived from national specimen banks. These are well articulated in several documents – particularly in ‘German Environmental Specimen Bank Concept (Oct 2008)’³, a special issue of the ‘Journal of Environmental Monitoring’⁴ and ‘Design and Applications of the National Institute of Standards and Technology’s (NIST) Environmental Specimen Banking Programs’⁵.

The key benefits that are described and extrapolate to the UK context are that a national ESB would:

- allow determination of temporal trends of newly recognised contaminants and understand how these differ between environmental matrices. This could be achieved through retrospective analysis of both archived historic samples and current samples.
- provide storage of material that can be subsequently analysed to identify changes in ecosystem services (for example, how the organic (carbon) content of different soils may change over time and with land management).
- provide material that can be analysed retrospectively to verify scale and rate of change in different environmental matrices following mitigation actions
- standardisation of collection and storage procedures, thereby facilitating inter-comparison between different monitoring schemes

It is more difficult to assess the commercial benefits, or so called “Return on Investment”, of a UK-ESB. There will most likely be opportunistic cost savings in terms of not having to invest resources towards particular problems or mitigation measures because of either evidence or samples from a UK-ESB. Such savings are difficult to predict or estimate, partly because it often unclear exactly what costs would have been incurred. However the concept of a UK-ESB clearly fits a National Good case. According to the NERC definition, National Good ‘refers to activities where the primary customer is society rather than the research base, and which cannot be measured by scientific metrics’.

4.3. Challenges in developing a UK-ESB

A number of challenges and opportunities would need to be addressed to establish a UK-ESB. These challenges include:

- defining the scope and remit of the ESB
- development of rules governing the availability of specimens to the research community (if this does not remain the sole preserve of the sample holders)
- establishment of best working practices (for example ‘chain of custody’ records, storage)

³ http://anubis.uba.de/wwwupb/servlet/upb?action=change_lang&language=0

⁴ Journal of Environmental Monitoring, 2006, 8.

http://www.rsc.org/Publishing/Journals/em/Specimen_Banking_SI.asp

⁵ Cell Preservation Technology. Spring 2008, 6(1): 59-72.

- standard and published procedures for collection and archiving that conform to best practice
- addressing possible concerns about the retrospective use of specimens and data (trustworthy, catalogued, SOP's, storage, stability, destructive sampling)
- development of international co-operation with other ESBs
- agreeing the scope, development and maintenance of a meta-data catalogue or database of holdings
- formulation and implementation of strategic developments and initiatives (sharing of resources, reducing duplication where appropriate, collection of new material that are strategically important, rescue of abandoned or at risk archives of value, future developments etc)
- potential IPR, commercialisation and access issues

It was considered that a steering group, or a number of specialist groups based loosely on science areas (such as the current Geological Curators Group), may be required to meet such challenges. However, the exact nature of what would be needed and the relative importance of different challenges would depend upon the type of operational model adopted by a UK-ESB.

4.4. Possible operational models for a UK-ESB

A UK-ESB could be based on various different models. Four possible models were presented to workshop participants. These ranged across what can be considered the total spectrum of possibilities from maintaining the “Status Quo” (i.e. do nothing), through to centralising all archived specimens in one national, dedicated facility.

No additional distinct operational models were volunteered by the workshop participants for consideration.

The four models that were considered were:

1. Status Quo - *individual schemes/archives remain distinct and operate independently*

- No change in current practice
- Limited linkage (apart from brief UK-EOF Catalogue entry)

2. Virtual - *operationally as Status Quo except for:*

- Dedicated website that would provide a single point of initial information and links to different archives
- Standardised metadata catalogue of holdings which would be more detailed than could be incorporated directly into the UK-EOF Catalogue
- No change in current archive or access practices

- No coordinating or steering group to actively promote collaboration and address challenges (as identified in section 4.3)
- Some (but relatively low) resource requirement for catalogue development and hosting/ maintaining the website

It was recognised that the above option was at most a catalogue and not, in effect, a UK-ESB. However, it was important that the extent, if any, of “buy-in” by workshop participants to changing current practice (moving on from the Status Quo) was gauged.

3. Federated - *same attributes as Virtual model but ADDITIONALLY:*

- Some standard operating procedures—possibly accredited to ISO standards
- Likely to need agreed principles of access and use of samples for the wider research community
- Steering group whose functions would include governance of the UK-ESB, strategic development, joint initiatives, developing shared resource where possible, promoting and developing best practice, active building of collaboration, strategic rescue of “at risk” archives
- training, resource and some changes to current practice may be needed

4. Centralised - *national facilities.*

- Samples collected through individual schemes are deposited and curated in a central facility or groups of facilities, each perhaps with a common theme such as storage method or type of sample.
- Centralised facilities would have to establish governance procedures that covered strategic development, joint initiatives, shared resource where possible, promoting and developing best practice, active building of collaboration, strategic rescue of “at risk” archives, training
- Centralised facilities would require staffing, associated management and infrastructure resources, a dedicated funding stream

It was suggested that, given the diverse nature of specimen archiving in the UK, a mixed model (some combination of the above models) may be the best approach. However for the purposes of the workshop, each of the suggested models was discussed individually.

4.5. SWOT analysis of four possible operational models for a UK-ESB

Four breakout groups in the workshop discussed the strengths, weaknesses, opportunities and threats (SWOT) posed by one model; each group considered a different model. Their discussions were recorded, collated and presented to the group as a whole. In addition, attendees were asked to think about next steps and possible timeframes for developing the model.

At the end of the workshop, attendees were canvassed for their preferred model option. All attendees preferred the Virtual model as a short term measure that was readily achievable. All but one attendee considered a move towards a Federated model was the preferred longer term option that could be logically developed from the Virtual model. The SWOT analyses from

the workshop for the Virtual and Federated models are summarised in Tables 7 and 8 respectively. The SWOT analyses for the Status Quo and Centralised models that were not preferred by the workshop participants are in the appendix in Tables A3 and A4 respectively.

Table 7. SWOT analysis for the Virtual ESB model

Strengths <ol style="list-style-type: none"> 1. 1st step in the right direction 2. Cheaper than Federated and Centralised models 3. Quicker to establish 4. Faster return of benefits 5. Organisations more likely to sign up to low level of commitment 6. Preserves individual approach 7. Flexible system i.e. methodologies 8. Save samples/data if organisational funds are cut 9. Increased knowledge of existence of other organisations that hold/store specimens 10. Good community work 11. Opposite to cost share 	Weaknesses <ol style="list-style-type: none"> 1. Lack of coordinated methods 2. Lack of money 3. Who will manage and host website? 4. Lacks organisation 5. Lack of buy in/engagement by scientists 6. Who will coordinate and how? 7. Difficult to communicate between many organisations for coordination of research 8. Informal, leading to lack of official buy-in 9. No QC/best practice
Opportunities <ol style="list-style-type: none"> 1. Web presence will promote science and research 2. Involves the public 3. Community sell to funder 4. Advert of quality 	Threats <ol style="list-style-type: none"> 1. Archives or organisations under risk from funding cuts 2. Risk loss of specialisation 3. Risk loss of control of samples 4. Risk of loss of data
Next steps <ol style="list-style-type: none"> 1. Establish how to fund & who will champion this initiative 2. Get funding/resource 3. Develop and populate a metadata catalogue that links to UKEOF 4. Construct website 5. Manage and maintain the Website/catalogue 6. Manage expectations 	

Table 8. SWOT analysis for the Federated ESB model

<p>Strengths</p> <ol style="list-style-type: none"> 1. Value for money if successful 2. Promotion of Standard Operating procedures (SOPs) and best practice 3. Improved Quality Control (QC) 4. Would provide a focal point for end user input (this is also a need for a successful initiative) 5. Shared SOPs and improved QC leads to greater consistency and comparability between schemes 6. Linkages 7. Relatively cheap to implement compared to Centralised (uses existing infrastructure) 8. Good practice- buy in 9. Improved individual and collective presence of schemes 10. Steering group to drive implementation and coordination 11. Would still allow flexibility for individual archives 12. Could encompass a broad range of archiving activities 	<p>Weaknesses</p> <ol style="list-style-type: none"> 1. Costs of administrative support 2. Relative differences across archives may cause difficulties in implementing the model 3. Core funding needed to pump prime 4. Longer term funding required 5. Requires long-term buy-in of funding bodies 6. Need to generate buy-in from potential participants who may perceive threats 7. Would the 'Added value' above the Virtual model justify the added costs involved?
<p>Opportunities</p> <ol style="list-style-type: none"> 1. Increased research opportunities 2. Improved international networking 3. Natural progression from Status Quo - gradually build up profile, interest and funding 4. Build on positive outcomes 5. Gaps in archives and in best practice become known; shared learning 6. Quick win 7. 'Added value' may lead to survival of individual archives 	<p>Threats</p> <ol style="list-style-type: none"> 1. Some archiving activities may occur without explicit funding, which may become 'above the radar' and threatened 2. Need for longevity of funding 3. Publicising PR 4. Subject to political whim 5. Who makes the decisions, agendas? 6. Is it too all encompassing? 7. Might be superseded by other initiatives e.g. EU or global? 8. Loss of independence of collections
<p>Next steps</p> <ol style="list-style-type: none"> 1. This is a stepped process moving from Status Quo through Virtual to Federated, so establishment of a Virtual ESB (Table 7) is the first step. 2. Develop funding stream to resource move from Virtual to Federated 3. Develop governance framework for federated UK-ESB. This could be done through a steering committee and/or broad topic groupings (based on specimen type or end user themes -such as climate change) that would enable cross-discipline approach and promote added value, increased opportunities and public awareness). 4. Develop and implement strategic plan for developing the coverage, scope and operation of the UK-ESB to meet stakeholder needs in the future 5. Develop sustainable business model for long-term future funding 	

5. A survey of estimated current archiving costs for the UK

After the workshop, a follow-up survey was conducted and was sent to all relevant UK organisations. This consisted of two questions:

1. What are the annual archiving costs (costs of preparing the samples for storage and actual archiving costs) for the scheme you are involved in (nearest £5-10K if possible)?
2. What are the annual collection costs of the samples you archive (nearest £5-10K if possible)?

We do not present costs for individual schemes but give a summary of responses to give an indication of the overall costs associated with archiving, as far as we can estimate them. To date we have received 20 survey responses that provided information on costs; the schemes/groups that provided information are listed in Table A5 in the Appendix.

The estimated summed cost of archiving activities of those organisations that provided information is £7.96 million and the estimated collection cost is £1.93 million. Notably, the ratio between archiving costs and collection costs varied markedly between museum collections, where most resources are used to maintain collections that are donated, and non-museum collections that undertake collection and monitoring (Table 9).

The figures in Table 9 are likely to be an underestimate of the total archiving costs within the UK for environmental samples, because information was not provided by some groups. However, a crude indication of the likely cost of archiving in the UK can be calculated from these figures by extrapolating the average collection and archiving costs to all the collections identified in this report as probable participants in a UK-ESB. This results in an estimate of £16.3 million per annum. These estimated figures, however crude, emphasise that significant resource is currently invested annually in collecting and archiving environmental specimens, but that there is no coordination or even collated knowledge of what this investment is delivering.

Table 9. Summary of total collection and archiving costs per year for 20 organisations in the UK

Type of collection	Archiving costs £k	Collection costs £k	Total cost £k	Average cost per scheme £k
Museum	6,647	300	6,947 (n = 4)	1,737
Non-museum	1,312	1,628	2,940 (n = 16)	184
Total	7,959	1,928	9,887 (n = 20)	494

Costs are units of £1000 (k).

6. Conclusions

This three month project has identified a wide range of collection and archiving of environmental samples across the UK. Some 40 groups are known to be involved in making significant collections of environmental samples and 28 of these archive samples. Although it seems likely that the majority of the major specimen archives within the UK have been identified, some collections have probably been missed, as at least a third of organisations failed to reply to our survey.

The purpose of specimen archiving in the UK falls into two main categories: (i) reference and non-destructive observation (mainly museums); (ii) use (possibly destructive) for future research (mainly monitoring programs). The degree of detailed cataloguing varies between archives, although the majority have an associated paper and/or electronic catalogue.

We have crudely estimated that specimen collection and archiving activities in the UK costs some £16 million per year. Despite this significant national investment, there is no centralised catalogue that lists what samples are collected, and which are archived and potentially available for use in other research. Such knowledge is currently obtained through informal and opportunistic contacts. This most probably results in duplication of collecting and archiving effort, and failure to fully exploit and utilise the national resource of archived specimens. The feasibility [and likely content] of a metadata catalogue or database for archived environmental specimens has been outlined in this report. It can be seen from the responses to our survey that this concept has “buy-in” from the research community that would populate the catalogue.

The current project has also been able to gather collective views on the potential for developing a UK-ESB. Likely benefits from a UK-ESB have been described and include better knowledge of specimen archives that can be used to address pressing environmental issues, avoidance of duplication of collection, identification of strategically important gaps in archive holdings, support for or rescue of valuable “at risk” specimens, and more cost-efficient, effective and collaborative maintenance/development of specimen archives.

Of the potential operational models for a UK-ESB that were scoped in the workshop held by CEH, a progressive development from a “Virtual” to a “Federated” UK-ESB was favoured. A start with a “Virtual” operational model would achieve rapid significant gains (metadata catalogue of specimen archives and associated awareness of available archives) for relatively modest investment. A “Virtual” UK-ESB would also be likely to provide the springboard for developing a “Federated” UK-ESB which would allow more strategic development and use of archives. A “federated model” would also provide the impetus for much wider ranging initiatives. These could include collaborations with human specimen archives, such as the UK biobank initiative (www.ukbiobank.ac.uk/) in order to address issues of how the environment impacts on human health, and with cryo-bank initiatives such as Frozen Ark (www.frozenark.org/index.html) and the Genome 10K project (www.genome10k.org/) that address biodiversity loss. A UK-ESB could therefore comprise be a significant component of UK National Capability for NERC that would stimulate and underpin work in some of NERCs main science themes.

7. Appendix

Table A1. Additional organisations highlighted by workshop attendees to be surveyed about their sample archiving activities. All were subsequently contacted by CEH.

Association of River trusts	Museums Libraries and Archives (MLA)
British Waterways	Natural Sciences Curators Association (NatSCA)
Cambridge University	North Wyke Research
CEFAS	Scottish Agricultural College
Defence Science and Technology Laboratory	Scottish Crops Research Institute
Geological Curators Group (GCG)	Scottish Fisheries Co-ordination Centre
Health and safety laboratory Buxton	Society of Environmental Toxicology and Chemistry
Health Protection Agency	The Agri-Food and Biosciences Institute
LIFEWATCH	N. Ireland
Linnean Society	UK Water Industry Research
Liverpool Museum	Welsh Environmental Research Hub
Local Authority Research Council Initiative	Wildlife trusts

Table A2. Attendees of a workshop held November 12th 2009 at CEH Lancaster

Name	Organisation
Alex Tomlinson	Fera
Amber Vater	UK-EOF
Andrew Johnson	CEH
Andrew Kitchener	National Museums Scotland
Ben Smith Haddon	CEH
Beth Greenaway	UK-EOF
Daniel Merckel	Environment Agency
Dr Richard Harrington	Rothamsted Research
Dr Rob Huxley	Natural History Museum
Elaine Potter	CEH
Elizabeth Sharp	SASA
Gemma Truelove	UK-EOF
Heinz Ruedel	Fraunhofer IME
Helaina Black	Macaulay Land Use Research Institute
Hilary Blagbrough	British Antarctic Survey
Jacky Chaplow	CEH
Jan Koschorreck	Federal Environment Agency
Kate Harrison	CEH
Kevin C Jones	Lancaster Environment Centre
Lee Walker	CEH
Liz Chadwick	Cardiff University Otter Project
Marianne Wootton	Sir Alister Hardy Foundation for Ocean Science
Martin Rose	Fera
Mike Howe	British Geological Survey
Richard Shore	CEH
Rob Rose	CEH
Stephen Axford	Environment Agency
Susan Foord	British Antarctic Survey

Table A3. SWOT analysis of the Status Quo ESB model

<p>Strengths</p> <ol style="list-style-type: none"> 1. Expertise- samples are more likely to be held by collector compared to a Centralised model 2. Already happening 3. No increased costs 4. Freedom to develop wide range of collections 5. Recognition- centres of excellence where collections are held 6. Continuity of practices (this could be negative aspects) 7. Adaptability- less time taken to change archiving due to less degree of review. [This may be attractive to individual researchers but not to policy makers] 8. Smaller but more archive facilities may be associated with low transport costs but higher storage costs 9. Not got all eggs in one basket 	<p>Weaknesses</p> <ol style="list-style-type: none"> 1. Missed opportunities for collaborations, particularly across disciplines 2. Collections may become redundant 3. Lack of standardisation 4. Possible duplication- cost implications 5. No central one-stop shop for e.g. policy makers 6. Different standards make it difficult to link collections 7. Lack of awareness and knowledge of UK collections which leads to under-use 8. Hard to assess geographical, temporal and taxonomic gaps 9. Can't demonstrate cost effectiveness- hard to evaluate archiving and it's impact 10. No strategic direction- can miss trends 11. Not represented at EU/global level-poor relation- lack of International impact 12. Weaker risk control
<p>Opportunities</p> <ol style="list-style-type: none"> 1. Flexibility- individual schemes can change rapidly and independently if required 2. The UK-EOF Catalogue could provide a summary of and links to environmental sample archiving in the UK 	<p>Threats</p> <ol style="list-style-type: none"> 1. Individual archives may be more at risk due to technical failure or end of research projects 2. Hard to evaluate need for archiving if not seen in context of national archiving strategy
<p>Next Steps</p> <p>No next steps are required to maintain the Status Quo. However, the group agreed that there are advantages in developing a catalogue of current archiving activities to give an overview of the national effort in this field.</p>	

Table A4. SWOT analysis: Centralised Facility (2 options identified – single central or multiple themed archiving facilities).

<p>Strengths</p> <p>Central:</p> <ol style="list-style-type: none"> 1. Cost management benefits 2. 1 stop shop for potential users 3. All info in one place 4. All expertise together forming a critical mass 5. Easy to exchange/implement best practice 6. Consistent quality management 7. More profile 8. Reduced risk due to better investment 9. Longer term commitment 10. Fair access for all users <p>Themed</p> <ol style="list-style-type: none"> 1. Multiple site/theme spreads risk 2. 1 stop shop per theme 3. More expertise across themes 4. Themes develop specialised best practice 	<p>Weaknesses</p> <ol style="list-style-type: none"> 1. Less overall storage capacity 2. More susceptible to one massive disaster 3. Ownership of samples would be lost 4. IPR issues would need to be resolved 5. Very large set up costs would require up-front funding 6. Curation/management control 7. Loss of ‘understanding’ about sample (fragility, reason for collection, etc) 8. Big overheads, bureaucratic 9. Loss of immediacy of access to samples/data 10. Loss of funding could lead to catastrophic loss of archives 11. Less sample available per user 12. Loss of access to ‘own’ samples 13. Less flexibility in sample acquisition and storage
<p>Opportunities</p> <ol style="list-style-type: none"> 1. Global impact 2. Could contribute to EU/global ESB 3. ERFF provide opportunities to link with end user community 4. Extend global themed collections 5. New collaborations and science 6. Rescue ‘threatened’ but valuable samples 7. Data rescue with the specimen 8. ‘Controlled’ data and archiving standards 9. Strategic duties easier 10. Easier to recognise demand 11. Samples used for other projects 	<p>Threats</p> <ol style="list-style-type: none"> 1. Collectors feel disenfranchised 2. Undue burden to collectors 3. An international specimen bank could mean that a UK-ESB would not be required 4. Nobody deposits 5. Devolved government may push for an English, Scottish, Welsh and Irish specimen bank 6. Less subject specific innovation 7. Prevents innovation? 8. Samples may rarely meet user requirements
<p>Next steps</p> <ul style="list-style-type: none"> • Crude catalogue lead to detailed catalogue [funds] • ‘Depositors’ - who would do this? • Identify stakeholders and potential funders • Link with human ‘biobank’? • Who would develop initiative? • Business case including operation/cost benefits • Could go directly to this model more easily than the themed model • Unclear over what time-scale this could be achieved. 	

Table A5. Organisations whose estimated costs were used to calculate overall UK costs of specimen collection and archiving activity

Agri-Food and Biosciences Institute
Biotechnology and Biological Sciences Research Council (including Rothamsted Research)
British Geological Survey
CABI
Centre for Ecology and Hydrology (partial)
Countryside Council for Wales
Culture Collection of Algae and Protozoa
Freshwater Biological Association
Geological Survey of Northern Ireland
Herefordshire Heritage Services
The Macaulay Land Use Research Institute
National Museums of Scotland
Natural History Museum
NCIMB
Science and Advice for Scottish Agriculture
Sir Alister Hardy Foundation for Ocean Science
Stoke on Trent Museums
The Food and Environment Research Agency
University of Cardiff (including Otter Project)
Veterinary Laboratories Agency

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Crowmarsh Gifford, Wallingford	Oxford	Library Avenue, Bailrigg
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	(*CEH's Oxford site is due to close on 30 June 2010)	
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