



THE NERC MARINE CENTRES' STRATEGIC RESEARCH PROGRAMME 2007-2012

National Facility 3: Culture Collection of Algae and Protozoa (CCAP)

Photosynthetic microbes (cyanobacteria and micro-algae), protozoa and macro-algae all play a major role in biogeochemical cycles and have considerable biotechnological potential. CCAP currently maintains ~2400 marine and freshwater strains in public collections; this will be expanded, using molecular approaches and cryopreservation to advance the taxonomy of these groups and to promote their wider exploitation.

CCAP is hosted by the Scottish Association for Marine Sciences and led by Frithjof Küpper, frithjof.kuepper@sams.ac.uk

- Main activities:
- Enhancement of strain quality
 - Molecular information and bioinformatics
 - Cryopreservation and strain stability
 - Taxonomic revision
 - New strain accessions from extreme environments
 - Genomics and molecular model organisms
 - Comprehensive CCAP knowledge base
 - Training, marketing and knowledge transfer

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National Facility 3: CCAP

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National Facility 3: Culture Collection of Algae and Protozoa

Strategic context

The Culture Collection of Algae and Protozoa (CCAP) is a key component of the underpinning scientific infrastructure of the UK. It is the national collection for marine, freshwater and terrestrial protists (algae/phytoplankton and protozoa) and cyanobacteria, performing all the roles of a 21st century Biological Resource Centre (BRC) including: *ex situ* conservation of protistan and cyanobacterial biodiversity; provision of biological materials and their associated bioinformatic data to the scientific community; acting as a source of advice on all aspects of algal and protozoan science (marine, freshwater and terrestrial). Its roles are central to the NERC and SAMS Science Strategies, underpinning research on Earth's life-support systems, sustainable economies and also climate change. In addition to CCAP's direct involvement in Oceans 2025, it provides a NERC Core 2 facility and is of vital importance to UK science, both academic and commercial.

The collection is located in a purpose-built, world-class facility, in the European Centre for Marine Biotechnology (ECMB) hosted by the Dunstaffnage Marine Laboratory of the Scottish Association for Marine Science (SAMS). The CCAP collaborates with all the major protistan collections world-wide; is a key constituent of UKNCC (UK National Culture Collection), established as a result of the government sponsored review of BRCs (Anon 1994); and is an International Depository Authority under the terms of the Budapest Treaty (1977).

Historical and recent developments

CCAP grew from the pioneering development of algal culture methods by Prof EG Pringsheim and his co-workers in Prague during the 1920s. The collection subsequently moved via London, Cambridge and Windermere to its present location at SAMS (see Day *et al.* 2004 for details). It became the UK protistan service collection in 1947 after a government review on biological resources (Anon 1947) and has continued in this role ever since. In 2004, as a result of changes in the NERC Centre for Ecology and Hydrology (CEH) and the consensus that increased critical mass within CCAP would enhance the value of the collection to UK science, the CCAP-F (freshwater/terrestrial algal and protozoan holdings) relocated with some key staff members to SAMS, Dunstaffnage Marine Laboratory where the marine algal section had been located since 1986. The reunification has created new synergies, increasing the efficiency of the operation of CCAP and adding real value to the collection and its ability to meet user needs. Highlights of developments since re-unification include:

- Increasing the size and diversity of the collection (400 new strains accessed since the relocation)
- The EU project COBRA (QLRI-CT-2001-01645), coordinated from SAMS, has improved our capacity to ensure phenotypic and genotypic stability of preserved protists
- An enhanced critical mass and skills-base
- Strengthening of the in-house (SAMS) and collaborative research role of CCAP, as reflected by a strong publication record. Ten ISI papers in 2004 and 10 in 2005, with an additional 5 peer reviewed chapters published in 2005
- Further improvements and streamlining of protistan maintenance regimes
- Maintained levels of culture provision over the period and expanded service activities
- The streamlining of order processing
- Improved website with increased functionality www.ccap.ac.uk
- Implementation of a new accession policy arising from the recent NERC Small Grant MACE (Marine Algal Characterisation and Exploitation, NER/T/S/2003/00723)
- Four new patent deposits and increased biotechnological activity
- Increased numbers of visitors and students, including two final meetings of EU projects/networks.

CCAP is unique amongst protistan culture collections because its holdings include cyanobacteria, microalgae, macro-algae and free-living non-pathogenic protozoa. These originate from a diverse range of environments (freshwater, marine, hypersaline and terrestrial) and include isolates from all climate zones, from polar to tropical. Currently (March 2006), CCAP holds 2400 strains in the public domain, of which 1300 are freshwater algae, 350 protozoa and 750 are marine algae. A further 1200 strains, including >200 *Ectocarpus* isolates, are held in research collections associated with the CCAP, which will soon be accessed into the public collection. Nine members of staff (7.6 FTE) are directly involved with CCAP: two curators, 5 scientific support staff, an administrative assistant, and its academic head.

Principal science aims

The maintenance and provision of consistent high quality, traceable source material (cultures) and associated information/bioinformatics data remain at the core of the current and future strategy of the CCAP. Over the past five years the CCAP has met ~2500 external requests for cultures from ~1000 customers supplying >6700 cultures. The availability of standard cultures is fundamental to all aspects of microbiologically orientated science and is an absolute requirement for published research and biotechnological exploitation. Microbial strains in collections are *de facto* biological standards. Without them, comparative studies are impossible, or of limited value. It is therefore now expected that all defined algal/protozoan cultures cited in publications should be allocated strain designations (numbers) and made available to the scientific community via an internationally-recognised service collection such as CCAP.

The key curatorial aims of CCAP are as follows:

- *To provide an academic and biotechnological repository for protistan and cyanobacterial strains.* Since its foundation, CCAP has served the UK and global scientific community by ensuring the long-term safekeeping of relevant research strains, and their provision to new as well as future users. Expanding and enhancing the collection will advance polar research, systematics, biogeography and biotechnology. CCAP now holds reference strains for the SAMS toxic phytoplankton monitoring service for the FSAS and there is potential to set up a formal taxonomic centre supported by the Scottish Executive (Smayda 2006).
- *To provide advice consultancy and troubleshooting.* The experience and expertise of CCAP personnel provides significant added value, particularly to post-graduate students and non-traditional users of cyanobacterial/protistan cultures. CCAP deals with 10-20 queries a week where their expertise helps solve problems ranging from taxonomic and culturing issues to biotechnological exploitation.
- *To provide molecular services.* CCAP capabilities in DNA extracts, sequencing and related services has stimulated interest in algal systematics both within the Centre and across the phycological community.
- *Undertake species identification.* CCAP can provide identification services for freshwater and marine plankton samples and seaweeds. In addition to traditional approaches, molecular methods of strain verification are used for academic and commercial collaborators and customers,
- *To act as a genomics research depository.* CCAP has begun to underpin genomics research, serving as a depository for model strains used in genome sequencing projects. This facility is helping to drive post-genomic research in the UK.
- *To provide services for aquaculture and biotechnology.* CCAP currently sells starter cultures of a range of strains to marine fish and shellfish hatcheries throughout Europe. In addition, it acts as a Patent Depository and provides a range of services for biotechnology.

Main activities for 2007-12

1. *Enhancement of strain quality*

In common with all protistan collections, many of the holdings are not axenic (single species). Where technically feasible, we will improve the quality of the collection through a programme of cloning and/or purification of non-axenic cultures. This will require the employment of traditional and novel approaches such as flow cytometry with cell sorting (Bertz *et al.* 1984).

2. *Molecular information and bioinformatics*

As part of the overall knowledge base development (see below), we aim to obtain at least one phylogenetic molecular marker (e.g. SSU and ITS rDNA sequences) for every strain in the collection, and to make this information available on the website (by including GenBank accession numbers in the strain information). This information will be of direct use for the envisioned taxonomic revision (below). We intend to cover these strategic sequencing needs through access to the NERC Edinburgh Sequencing Facility (ESF) and collaboration with its director, M. Blaxter. A proposal requesting a suitable sequencing quota will be submitted to the ESF in parallel to this bid. Also, as part of the knowledge base development, we will gather any molecular information (i.e. non-phylogenetic data) that the depositors or other scientists may have published on CCAP strains.

3. *Cryopreservation and strain stability*

Phenotypic and genotypic stability are of paramount importance to all users of biological resources. Cryopreservation offers the most realistic option to apply long-term preservation to protists and cyanobacteria. The CCAP has been the most active centre for algal cryopreservation research in recent years and coordinated an EU project on this topic (see www.cobra.ac.uk). Historically, the focus has been on freshwater algae, but over the next 5 years we aim to significantly increase the number and diversity of marine taxa that can be cryopreserved.

Conventional two-step cooling (Day & Brand 2005) will remain the method of choice for cryopreservation, together with high throughput methods of viability assessment, e.g. flow cytometry (Fleck *et al.* 2006). Alternative approaches such as vitrification using encapsulation dehydration (Harding *et al.* 2004) and the use of novel cryoprotectants to alleviate oxidative stress related injuries (Day *et al.* 2000) will be investigated and developed further for organisms recalcitrant to conventional methodologies. Where robust methods can be developed, with good levels of post-thaw viability, strains may be maintained only in a frozen state. This will greatly reduce the amount of staff-time and consumables needed for strain maintenance.

Cryopreservation research into the mechanisms of freeze-induced cell injury will continue using physical methods such as cryomicroscopy (Fleck *et al.* 2006) and Differential Scanning Calorimetry as well as biochemical approaches focussed on free-radical injuries and oxidative stress (Fleck *et al.* 2000; 2003). Some of these approaches have potential for environmentally orientated research (Johnstone *et al.* 2006) and it is planned to expand their application during Oceans 2025. In particular, research relating to stress adaptive mechanisms in polar microalgae will be investigated with reference to their avoidance of intracellular ice formation.

There is evidence that suboptimal preservation methods may influence phenotype or productivity of metabolites (Ryan *et al.* 2001) and this phenomena could also occur in algae (Müller *et al.* submitted). Studies on the effects of optimal and suboptimal cryopreservation protocols on phenotypic and genotypic stability will be undertaken. Growth rates, metabolic status, chemotaxonomic markers (e.g. pigments) and a variety of molecular biology approaches (including AFLP) will be used as stability indices for cryopreserved and cultured strains. Viability, cellular and morphological characteristics will be tested immediately after preservation and yearly thereafter. Organisms studied for genotypic

stability will include the recently-sequenced alga *Chlamydomonas reinhardtii* CC 1690. Much of the cryopreservation research will be developed with our scientific collaborators (see below).

4. Taxonomic revision

Over the past 10 years, molecular biology has helped achieve many advances in our understanding of protistan taxonomy. We aim to undertake a major revision of our holdings employing a polyphasic approach with a strong emphasis on the use of modern molecular methods (see below). This will enhance the quality of the services provided, by making a state-of-the-art taxonomic identification of every single strain available; it will also use CCAP as a large-scale resource for taxonomic research, with potential for significant research outcomes. A secondary output from this exercise will be the improvement of the quality of data in Genbank, where there are a significant numbers of errors as a result of contributors depositing data from misidentified or even mislabelled strains.

Most strains in our collection were taxonomically designated either by the depositors of the strains, or by the curators based on characterization by optical microscopes. Taxonomic revisions of a few systematic groups have been subsequently undertaken by external experts using molecular and morphological characters (e.g. *Cryptomonas* strains; Hoef-Emden & Melkonian 2003). Our aim is to taxonomically revise all CCAP holdings based on polyphasic approaches (phylogenetic analyses and studies of secondary structures of characteristic genes e.g. SSU and ITS rDNA sequences, studies of life cycles, biochemical markers such as pheromones, autolysins, mating experiments and others), in collaboration with other major protistan culture collections (SAG, UTEX, CCMP and NIES) and other external experts (see list below). We plan to:

- Use the polyphasic approaches outlined by Pröschold *et al.* (2001; 2005) for *Chlamydomonas*.
- Investigate inter-species variation by characterization of duplicated strains and multiple isolates of the same taxa held in SAG, UTEX, CCAP, CCMP and others by using the AFLP technique applied to *Chlorella vulgaris* by Müller *et al.* (2005).

These approaches will be linked to other aspects of curatorial and research work at CCAP as follows:

- Characterization of the phylogenetic position of the CCAP strains by sequencing the SSU and ITS rDNA, or other molecular markers such as those recommended by the Consortium for the Barcode of Life (www.barcodinglife.org), especially of the authentic strains (derived from Type material).
- Determination of the secondary structure of SSU and ITS rDNA sequences.
- Studies of life cycles by cultivation under different conditions and photographic documentation.
- Where appropriate, induction of gametogenesis and mating compatible strains for studies of the biological species concept.
- Documentation of phenotypic variation under influence of environmental factors (e.g. spine formation in *Micractinium* under influence of grazers: Luo *et al.* 2005)
- Isolation and deposition of new strains (especially from extreme environments), which are phylogenetically characterized for expanding the biodiversity of the collection, and having representatives of all phylogenetic lineages in CCAP.
- Provision of axenic strains using isolation techniques for AFLP of duplicated strains.
- Where achievable, cryopreservation of the revised strains (especially of authentic/type strains).

External taxonomic experts will be involved in the project forming a virtual 'Taxonomic College'. Those named below have already agreed to participate and this list will be extended in 2006, prior to the start of Oceans 2025, to cover all the collection including the protozoan section.

D Mann (Edinburgh) - *Bacillariophyceae*
 RA Andersen (Bigelow Laboratory, USA), D. Honda
 (Kobe) - *Chrysophyceae*, *Synurophyceae*, *Pinguiphyceae*
 H Preisig (Zürich) - *Xanthophyceae*

L Krienitz (IGB, Neuglobsow) - *cocoid Chlorophyceae*
 and *Trebouxiophyceae*
 E Hegewald (Jülich) - *Scenedesmus* and *Desmodesmus*

T Friedl (SAG, Göttingen) - *Trebouxiophyceae*,
Streptophyta
 C O'Kelly (Bigelow Laboratory, USA) - *Ulvoophyceae*
 A Gontacharov (Vladivostok, Russia) - *desmids*
 B Marin (Cologne) - "*Prasinophytes*" & *Euglenophyceae*
 K Hoef-Emden (Cologne) - *Cryptophyceae*

L Hoffmann (Luxembourg), B. Büdel (Kaiserslautern) -
Cyanobacteria
 B de Reviere (Paris), DG Müller (Konstanz) –
Phaeophyceae
 JA West (Melbourne), C Maggs (Belfast), J Brodie
 (London) - *Rhodophyta*
 D Vault, L Guillou (Roscoff) – *eukaryotic picoplankton*

5. **Extreme environments**

Over the next 5 years we will continue targeted expansion of CCAP holdings. Target groups include organisms from extreme (especially cold) environments, some of which are under pressure by global change. In 2005, 10 marine algae isolated 'in house' from water samples collected by BAS on Antarctic and SAMS on Arctic research cruises were accessioned into CCAP and 80 freshwater/ terrestrial polar isolates deposited by external collaborators.

Resources will be committed to obtain additional polar samples from hypersaline, marine, freshwater and terrestrial environments. Where possible these samples and the strains subsequently isolated will be maintained at low temperatures, to avoid the selection of non-psychrophilic sub-populations. Master stock cultures of the isolated taxa will be cryopreserved. These strains will be studied at SAMS and also made available to the wider user community, for research in stress physiology, cryobiology, biotechnology and polar biology.

6. **Genomics and molecular model organisms**

CCAP has begun to underpin genomics research, serving as a depository for model strains used in genome sequencing projects. *Phaeodactylum*, *Ectocarpus* and *Chlamydomonas* species have been deposited to date. Other model strains will be added in the near future, and this role is expected to expand during Oceans 2025. This activity also strongly underpins ongoing in-house research at SAMS.

Every effort will be made to successfully cryopreserve these key strains and their genetic stability will be assessed using AFLP techniques (Müller *et al.* 2005).

7. **Comprehensive CCAP knowledge base**

The CCAP website is an important facility to those looking for specific taxa and users of protistan or cyanobacterial cultures. Currently, 3500-6100 visits to the CCAP website are recorded each month (see www.ccap.ac.uk/stats). The development of a one-stop-shop for protistan and cyanobacterial data associated with the CCAP will further increase the value of CCAP to the scientific community. The CCAP website is currently being enhanced to offer multi-faceted information about the collection's strain holdings. In addition to the taxonomic identity of a given strain and its strain number, CCAP is now adding images, bibliographic, molecular and chemical information. This undertaking will cover the entire collection during 2007-12. It is expected that this bioinformatics facility will act as a platform for future developments, stimulating increased scientific, bioinformatics and biotechnological exploitation of the CCAP.

The accession information form will be expanded to obtain additional relevant information from depositors of new strains. We will also carry out literature searches for existing CCAP strains.

8. **Training**

CCAP is used extensively by NERC post-graduates and post-doctoral researchers. Training and advice are provided via the website, e-mails and by telephone. CCAP scientists are authors of the most recent publications on protistan maintenance (Day *et al.* 2006; Day & Brand 2005; Lorenz *et al.* 2005). CCAP also provides much of the basic phycological training for students and visitors to SAMS. Over the next five years CCAP will continue to develop general phycological courses and also specialist courses (e.g. algal taxonomy) for post-graduate students, aquaculturists, ecotoxicologists, water companies and biotechnologists. It is intended that CCAP will host increasing numbers of both visiting and full-time

PhD students and post-docs in the next few years. CCAP will continue to play a major role in public scientific outreach.

9. Marketing

This will involve both direct marketing to targeted customer groups and general marketing by raising the profile of CCAP scientifically through publications, scientific meetings and networking.

Approaches that will be developed include: enhancement of our website; the use of e-networking opportunities such as AlgiNet; targeted articles in appropriate trade journals; targeted marketing to the aquaculture sector; improved provision of materials for university practical classes and cross collection marketing via the UKNCC.

Links to other parts of Oceans 2025

Over the past five years CCAP has helped underpin science at MBA, NOC and PML through the provisions of cultures (24, 12 and 50 strains respectively), advice and training. Links with other parts of Oceans 2025 are not yet particularly well-developed; nevertheless CCAP has potential to contribute to nearly all the Themes in the programme, as summarized below.

Theme 1	<ul style="list-style-type: none"> Sea-ice community and biogeochemical parameters: sea-ice algal, bacterial and protozoan composition, abundance and biomass (SAMS) Pelagic community and biogeochemical parameters: phytoplankton, bacterioplankton, protozooplankton and metazoan zooplankton composition, abundance and biomass (SAMS)
Theme 2	<ul style="list-style-type: none"> Cellular and molecular responses of calcification to rapid climate change (MBA) The biological carbon pump and its sensitivity to climate change (NOC) Marine biogeochemical cycles in a high CO₂ world (PML)
Theme 3	<ul style="list-style-type: none"> Topographic regime control over shelf sea systems (SAMS)
Theme 4	<ul style="list-style-type: none"> Is knowledge of benthic dynamics essential for understanding pelagic ecosystem functioning in shallow seas? (PML) Ecosystem stability and resilience in coastal seas: links with food-web theory (SAMS)
Theme 5	<ul style="list-style-type: none"> Experimental biogeochemistry of the deep-ocean floor (NOC)
Theme 6	<ul style="list-style-type: none"> Dispersal, transport and settlement of early life-history stages (SAMS)
Theme 8	<ul style="list-style-type: none"> Supply cultures as required for standardization purposes (e.g. for novel biosensors)
Theme 10	<ul style="list-style-type: none"> Supply cultures for standardization purposes (e.g. links with SAHFOS re phytoplankton taxonomy)

Other collaborations and links

CCAP-SAMS science linkages (outside Oceans 2025) include:

- Diet trials with CCAP strains as a potential food source for cold-water corals
- FSAS phytoplankton monitoring and related research
- Surfactants from algal-bacterial interactions

There is also CCAP involvement under negotiation in the EU project, SPIES-DETOX, relating to active biological monitoring and removal of toxins in aquaculture ecosystems and shellfish

The following list gives a snap-shot of our main UK and international collaborators at the end of 2005:

<i>Algal genomics</i>	Alison Taylor (MBA), Mark Cock, Benedicte Charrier & Philippe Potin (CNRS, Roscoff)
<i>Protistan phylogeny</i>	Mark Blaxter (Univ Edinburgh)
<i>Red algae (esp mangrove algae)</i>	John West (Univ Melbourne)
<i>Diatom taxonomy</i>	David Mann (RBG, Edinburgh)
<i>Dinoflagellates and HABs</i>	Jane Lewis (Univ Westminster); Christopher Bolch, (Univ Tasmania, Australia)
<i>Brown algae</i>	Akira Peters (Univ Pierre et Marie Curie, Paris / Station Biol de Roscoff, France) Dieter Müller (Univ Constance, Germany)

<i>Cryopreservation and cryoinjury:</i>	Erica Benson & Keith Harding (Univ Abertay Dundee); Thomas Friedl & Dr Maike Lorenz (SAG, Göttingen); Alena Lusekova (ISB, Ceske Budejovice, Czech Rep) ; Josef Elster (IB, Trebon, Czech Rep); Rosmarie Rippka (Insti Pasteur, Paris); Roland Fleck (NIBSC, South Mimms)
<i>Phenotypic & genotypic stability of conserved strains</i>	Thomas Friedl & Julia Müller (SAG, Göttingen); Alena Lusekova (ISB, Ceske Budejovice, Czech Rep); Rosmarie Rippka (Inst Pasteur, Paris)
<i>Ecophysiological research</i>	Erica Benson & Keith Harding (Univ Abertay Dundee)
<i>Naked amoebae</i>	Dr Susan Brown (CEH Winfrith)
<i>Systematics & molecular phylogeny of Chlamydomonas and relatives</i>	Annette Coleman (Brown Univ, USA); Michael Melkonian (Univ Cologne, Germany); Robert Andersen (CCMP Bigelow, USA); Ralph Lewin (Scripps, LaJolla, USA); Thomas Leya (Fraunhofer Inst, Berlin)
<i>Systematics and molecular phylogeny of coccoid green algae</i>	Thomas Friedl (SAG, Göttingen); Lothar Krienitz (Inst Freshwater Ecology, Neuglobsow, Germany)
<i>Systematics and molecular phylogeny of Ulvophyceae</i>	Michael Melkonian (Univ Cologne, Germany); Charles O'Kelly (Bigelow, Maine, USA); John West (Univ Melbourne, Australia)
<i>Natural products from CCAP cultures</i>	Marcel Jaspars (Univ Aberdeen);Geoff Codd (Univ Dundee); Gabriele König (Univ Bonn, Germany); Robert Jacobs (Univ California, Santa Barbara); Carl Carrano (San Diego State Univ, USA)

Stakeholder relevance and knowledge transfer

CCAP is relevant to every user of protistan and cyanobacterial cultures worldwide. These range from students to senior academics, ecotoxicologists (including the Environment Agency), engineers and biotechnologists. CCAP cultures are extensively used by the scientific community and are cited in numerous publications, as well as being recommended in internationally agreed ecotoxicity testing guidelines including; OECD 201 and 87/302/EEC. The collection is also active in the development of policies associated with the conservation and exploitation of biological resources being a member of ECCO, and the WFCC, and most recently participating in the consultation exercises on the future of microbial science and biological resources by the BBSRC.

CCAP is active in scientific outreach; hosting placement students, visiting schools, participating in scientific fairs and holding open-days for the general public. CCAP has provided training in algal and/or protozoan culturing techniques to visiting students and staff from BAS, Cefas, the Environment Agency, Knoll Microcheck Ltd and SEPA. The website www.ccap.ac.uk will continue to form the cornerstone of CCAP knowledge transfer activities for the academic community. In addition, CCAP is a member of the NERC BlueMicrobe Knowledge Transfer network, providing links to the DTI Biosciences for Industry KT initiative. The CCAP is interested in commercialisation and projects under development include: production of novel sun-screening compounds, screening for bioactivity, non-traditional use of algae in foods and the development of aquaculture feeds. Funders and collaborators of the pre-competitive development of these projects include: Local Enterprise companies, Hebridean Biotech, DDL and Unilever.

CCAP personnel will continue to publish in ISI-listed journals, other specialist literature and contribute to national and international meetings. CCAP will also “tap into” the Knowledge Transfer resources of SAMS particularly with respect to the development of biotechnological applications.

Deliverables 2007-12

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| 2007-12 | <ul style="list-style-type: none"> • CCAP will provide a platform for the development and underpinning of UK and European algal-orientated projects • CCAP will hold more strains and have a greater biodiversity of holdings • Higher quality holdings: axenic, identity confirmed, good data set, high quality images, molecular data • A significant number (>50) of peer reviewed papers and chapters |
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2008-12	<ul style="list-style-type: none"> A comprehensive knowledge-base, including images accessible via the web to all users Update the strain data information by including the accession number of sequence data and linking to Genbank on our web page.
2009-12	<ul style="list-style-type: none"> CCAP will be the global protistan patent depository of choice for blue biotechnology
2010	<ul style="list-style-type: none"> CCAP service standards will be among the best (if not the best) in the world
2010-12	<ul style="list-style-type: none"> Extensive additional knowledge on protistan taxonomy Extensive additional knowledge on algal cryobiology CCAP will provide NERC with a centre of excellence for protistan-orientated research
2012	<ul style="list-style-type: none"> Up to 50% of the collection's holdings will be cryo-preserved

The overall outcome is that CCAP will become a 'model' Biological Resource Centre for the future development of sustainable bioresource management.

Research plan

	2007-08	2008-09	2009-10	2010-11	2011-12
Enhancement of strain quality					
Molecular information/ Bioinformatics					
Cryopreservation					
Taxonomic revision					
Extreme environments					
Genomics & molecular model organisms					
Knowledge base					
Marketing (main effort)					

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Acronyms

AFLP	Amplified Fragment Length Polymorphism	KT	Knowledge Transfer
BAS	British Antarctic Survey	NERC	Natural Environment Research Council
BRC	Biological Resource Centre	NIES	National Institute for Environmental Studies (Tsukuba)
CCAP	Culture Collection of Algae and Protozoa	NOCS	National Oceanographic Centre Southampton
CCMP	The Provasoli-Guilliard National Center for Culture of Marine Phytoplankton	MACE	Marine Algal Characterisation and Exploitation
Cefas	Centre for Environment Fisheries and Aquaculture Science	MBA	Marine Biological Association
COBRA	The Conservation of a vital european scientific and Biotechnological Resource: microAlgae and cyanobacteria	OECD	Organisation for Economic Development
ECCO	European Culture Collection Organisation	PML	Plymouth Marine Laboratory
ECMB	European Centre for Marine Biotechnology	SAG	Sammlung von Algenkulturen
ESF	Edinburgh Sequencing Facility	SAMS	Scottish Association for Marine Science
FTE	Full Time Equivalent	SEPA	Scottish Environment Protection Agency
FSAS	Food Standards Agency Scotland	SSU	Small SubUnit
ISI	Institute for Scientific Information	UKNCC	United Kingdom National Culture Collection
ITS	Internal Transcription Spacer	UTEX	Culture Collection of Algae at the University of Texas at Austin
		WFCC	World Federation of Culture Collections