



European TRACES Workshop Report

29-30 March 2008

Hotel Tivoli Almansor, Carvoeiro, Faro, Portugal

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TRACES coordinator

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Executive Summary

The Trans-Atlantic Coral Ecosystem Study TRACES is a collaborative venture between researchers studying 'deep-sea' or 'cold-water' corals in terms of their biology, geology and as palaeo-oceanographic archives.

This report summarises discussion at the first European TRACES workshop held at the end of March 2008. Fifty three participants from Belgium, France, Germany, Ireland, Italy, Norway, Portugal, Russia, Spain, Sweden, The Netherlands, the UK and USA met in Carvoeiro, Portugal to discuss ocean basin-scale research priorities to advance our understanding of cold-water coral ecosystems across four research themes:

- A. Linkages & connectivity
- B. Biodiversity & biogeography
- C. Coral biology & reproduction
- D. Climate change & palaeo records.

This meeting was preceded by a North American workshop a month earlier that followed the same agenda. In both workshops the participants were asked to prioritise research questions and consider: (1) key geographic sites and (2) methods and standardisation issues for each research question.

These two workshops set the stage for the TRACES Science Plan which will be prepared during the summer of 2008 and will provide the basis for coordinated grant applications in 2009 and beyond.

European TRACES workshop participants.



Acknowledgements

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1 Introduction

This report summarises discussion at the European workshop of the trans-Atlantic coral ecosystem study 'TRACES' held 29-30 March 2008. A delegate list is provided in Appendix 1 and the workshop agenda in Appendix 2.

The workshop was focused on two research themes, 'Ecosystem' and 'Climate change and palaeo records'. The first day of the workshop began with five talks reviewing these topics. In the afternoon the delegates split into four discussion groups:

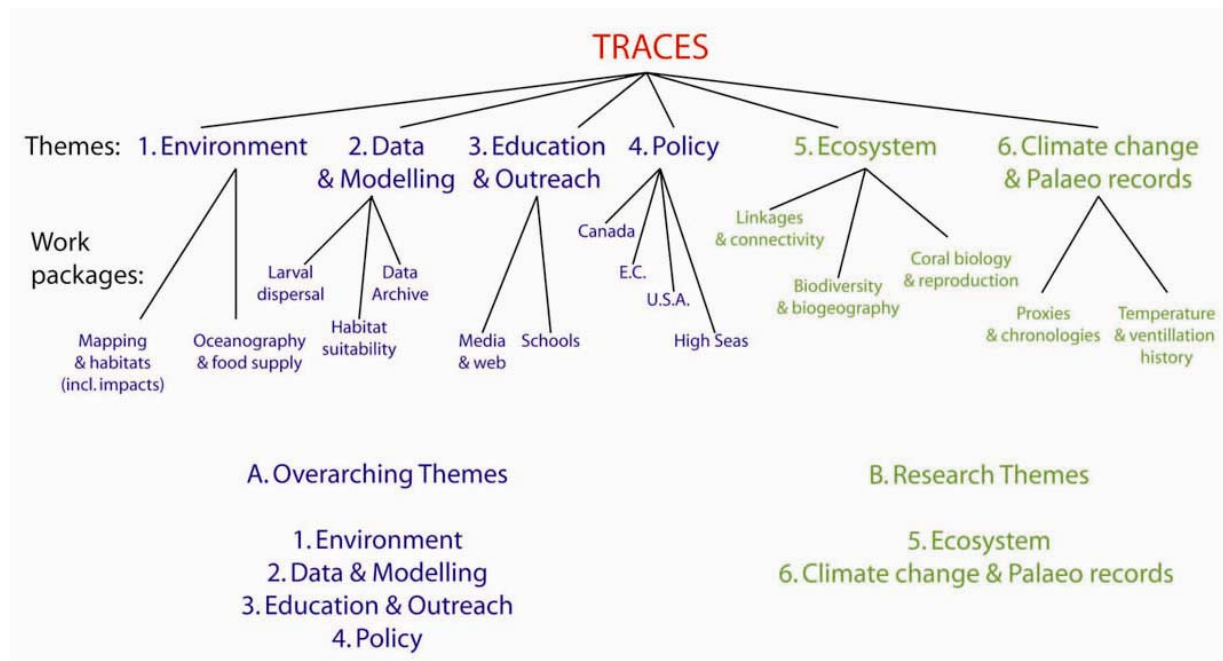
- A. Linkages & connectivity
- B. Biodiversity & biogeography
- C. Coral biology & reproduction
- D. Climate change & palaeo records

Each group was asked to identify three priority research questions listing for each: (1) Key geographic sites and (2) Methods & standardisation issues (brief and general). Suggested criteria to help prioritise research questions were:

- Scientific merit
- Trans-Atlantic relevance
- Policy relevance
- Feasibility

On the second day of the workshop discussion moved to ways in which TRACES could be organised and funded. A series of short talks on funding, projects and opportunities in Canada, the European Union and the United States preceded group discussion, this time in plenary. Some time on the second day was also set aside to allow delegates to comment further on the research questions from day one. These ideas were summarised on flip charts and are collated in Section 3 below.

TRACES overview diagram



2 Discussion Group Reports

Aim: To identify three priority research questions outlining key sites, methods and standardisation issues.

2.1 Group A: Ecosystem Theme: ‘Linkages & Connectivity’

Science Leader: Mikael Dahl, University of Gothenburg, Sweden

Facilitators: Ann Howard, SBTDC at UNCW

2.1.1 Initial Brainstorming: Linkages

The group sorted their questions into five major themes: (1) horizontal dispersal, (2) vertical dispersal, (3) evolutionary biogeography, (4) human impacts, (5) forcing factors.

Horizontal Dispersal

- Are populations in the Azores isolated or genetically connected? If so, are they connected to the east or west Atlantic?
- What are the habitat preferences of cold-water corals? Are they found in all suitable habitats?
- What are the colonization patterns of cold-water corals in the North Atlantic?
- What parameters promote dispersal or act as barriers to dispersal/gene flow? How does life history interact with these factors?
- What is the range of mean/maximum dispersal for cold-water corals?
- What are the horizontal patterns of genetic structure in cold-water corals and associated species: on a local scale (reproduction/ramets/heterozygosity?), regional scale (stepping stone, metapopulation), basin scale (large scale hydrography, topography)?
- How does clonality affect genetic structure? (more in depth local studies required)
- How does life history influence genetic structure in corals and associated species? Are there parallel patterns of evolution?
- Do isolating barriers prevent dispersion of deep-sea octocoral populations? What is role of canyons?
- What cold-water coral species live in the North Atlantic? And where?
- Connectivity of deep-sea octocoral (inc. pennatulid) species of Antarctica and Arctic – what are the relationships?

Vertical Dispersal

- How deep are corals in the Azores?
- What are vertical patterns of gene flow and species diversity?
- How important is pelagic-benthic coupling? (i.e. in larval link?)

Evolutionary Biogeography

- Are NW Atlantic seamounts more diverse than NE Atlantic seamounts? (corals – genetic diversity)
- What is the importance of cold-water corals for non-coral species?

Human Impacts

- What are the past, present and future impacts of fishing (and others) in cold-water coral communities?
- How do human activities (primarily fishing and climate change) impact genetic structure of coral populations (and diversity)?
- Sites with high genetic variation vs. sites with low genetic variation – management questions, how do we assign conservation priorities?
- How does genetic structure influence decisions related to design of networks of MPAs?

Forcing Factors

- How can geographical regions be constrained from the perspective of hydrodynamics?
- What are the environmental patterns forcing cold-water coral biodiversity?

- Do isolated genetically distinct communities have distinct forcing factors? (e.g. organic matter supply, etc.)
- Do cryptic species of cold-water octocoral exist or do they form different populations? How are these related in different oceans?

Questions raised which were beyond the remit of the group

- How do other potential model species reproduce?
- How do corals reproduce?

Notes/ideas on general methods

- Sample size?
- Genetic marker?
- Multidisciplinary approach
 - Larval ecologist
 - Modelling
 - Physical oceanography
 - Genetics
- Deep-sea genetic cruise? (collect X samples from X species → common questions)
- Possibility for use of technology development (acoustic, etc.) to map large scale distribution of cold-water corals?
- Build a permanent, *in situ* observatory for cold-water corals (e.g. Azores)
- Which species are interesting to use as model organisms?
 - Life history characteristics
 - Especially a long larval stage
- How can transport of larvae (ie. distance/lifeline/health) be measured?
- Can we build ecosystem models of the deep sea that take into account cold-water corals?
- Use of *in situ* experiments to examine larval settlement (larval settlement panels).

2.1.2 Priority research questions, key sites and methods: Linkages

During this discussion, the group came up with two major questions from this initial brainstorming:

1. How does dispersal of cold-water corals and associated species influence deep water community structure at a range of geographic scales? Sub-questions:
 - Is genetic structure driven by large-scale biophysical coupling or by regional- to local-scale hydrodynamics?
 - What is the role of life history in structuring processes?
 - How does the genetic structure of populations influence resilience to human impact?
 - How will climate change affect larval dispersal?
2. What historical events have influenced the structure of coral communities?
 - On human timescales
 - For the last 1 million years
 - On longer timescales

These ideas were reworded to try and encompass aspects of the various questions. The group then began to discuss sites and methodologies for each.

Question 1: How does the dispersal of cold-water corals and associated species influence deep water community structure at a range of geographic scales?

Key Sites

- **E Atlantic:**
 - Norwegian coast – Røst Reef
 - Fjordic populations
 - Large banks of NW UK
 - Southern Europe
 - Mediterranean
 - N. Africa
 - Gulf of Cadiz
- **W Atlantic**
 - New England Seamounts
 - Gulf of Mexico
 - George's Bank
 - Blake Plateau
 - Corner Rise
 - Sites off Brazil
 - Bermuda
 - Caribbean (somewhere)
- **Mid-Atlantic Ridge**
 - Azores
 - Iceland
 - Charlie Gibbs Fracture Zone
 - Southern hemisphere

Methods

- Broad-scale oceanographic modelling (movement of larvae)
- Genetic methodologies – more loci, same across all research groups
- Build 3 permanent, *in situ* observatories (E Atlantic, Mid-Atlantic Ridge, W Atlantic) to study cold-water corals. These could include:
 - ADCP
 - Temperature
 - Particle traps (vertical & horizontal)
 - Larval traps?
 - Oxygen sensor
 - Fluorometer
 - Transmissometer
 - Time lapse camera
 - Genetically-friendly preservation equipment
 - Pressure chambers
- Larval settlement panels – barcoding
- Microchemistry traces, tagging
- Early-stage synoptic cruises (in order to complete genetic work)

Question 2: What historical events have influenced the structure of coral communities?

- Human timescales
- Last 1M years
- Long timescales

Key sites:

- Similar to those listed under question 1

Methods:

- Phylogenetics
- Palaeo work (climate)
- Community structure

2.2 Group B: Ecosystem Theme: ‘Biodiversity & Biogeography’

Science Leader: Jan Helge Fosså, Institute for Marine Research, Norway

Facilitator: Steve Ross, University of North Carolina Wilmington, USA

2.2.1 Initial Brainstorming: Biodiversity

- Do cold-water coral (communities) reflect established zoogeographic patterns?
- To what extent are cold-water coral communities isolated or connected?
- How do various physical processes affect or control cold-water coral ecosystems?
- What are patterns of cold-water coral community structure?
- How does geological history relate to ecological relationships in cold-water coral community?
- Why are there certain patterns expressed by cold-water coral communities?
- To what extent does island biogeography mask basin-scale biogeographic pattern?
- How are cold-water coral communities defined (habitat types?)
- What are the most important cold-water coral sites?
- Do cold-water corals support (and maybe export) increased biodiversity compared with other habitats?
- In terms of reef structure, how does underlying structure affect community?
- Do different species fulfil key equivalent traditional roles in cold-water coral ecosystems and in different biogeographical provinces?
- What is the connection among cold-water coral ecosystems in face of present diversity and biogeography?
- To what degree can life history strategies explain observed distribution patterns of associated species.
- What parameters are associated with cold-water coral reef “status” or health in development?
- Does biodiversity explain or relate to cold-water coral ecosystem status or health?
- Are geographical patterns of associated fauna and habitat morphology related?
- What is successional progression of a cold-water coral reef framework and its community?
- How does cold-water coral biodiversity vary with depth?
- What is optimal and suboptimal habitat?

2.2.2 Priority research questions, key sites and methods: Biodiversity

1. Do cold-water coral (communities) reflect established zoogeographic patterns?
2. Do different species fulfil key equivalent functional roles in cold-water coral ecosystems and in different biogeographic provinces?
3. Do cold-water coral habitats support (and maybe export) increased biodiversity compared with other habitats?

Key sites:

- Altair and Antialtair seamounts

Methods – these apply to all three questions:

- Standardisation of methods
- Inclusion of key sites related to question
- Selection of appropriate study species.
- Habitat definition
- Taxonomic expertise (regional experts)
- Sites need to represent whole area.
- Video grab

2.3 Group C: Coral biology & reproduction

Science Leader: Johanna Järnegren (Norwegian Institute for Nature Research)

Facilitator: Leslie Langer, SBTDC at UNCW

2.3.1 Initial brainstorming: Coral biology

The group established three major themes for questions from brainstorming session:

Biotic and abiotic factors that control cold water coral species and communities:

- Effects of local sedimentation rates and hydrodynamics on coral health status?
- Which cues trigger spawning? Temperature, salinity, others?
- Is there any clear trend in reproduction patterns of cold-water corals?
- Which are the mechanisms defining population dynamics of cold-water corals? Effect of coral fragmentation on coral survival?
- Endogenous biological rhythms in coral?
- Linkages between coral and physical habitat?
- How does temperature affect isotopic composition in *Lophelia*?
- How does temperature affect growth in *Lophelia*?
- Are reef formers altering physical patterns as they grow habitat modifiers?
- Why are corals different colours in areas with no light?
- Why does *Lophelia* have different growth forms, i.e. elongated vs. thicker?
- Role of mucus/skin in *Lophelia* for maintaining calcification/deterring colonisers and predators.
- Respiration rates over tidal cycle?
- Is there a main abiotic factor defining coral distribution?
- Growth and abiotic forcing.

Energy supply to and flow through cold water coral communities:

- C-flux through coral ecosystem. Energy budget of coral reefs, carbon fixing?
- Trophic interactions of cold water coral ecosystems and food web, supply and quality.
- Dynamic energy budget models.
- Impact of coral reefs ecosystems to marine environment.
- How important is heterotrophy for the biological functionality of corals?
- Feeding cycles and current strength – thresholds?
- Biochemical heterogeneity of a coral reef.

The processes of coral reproduction and recruitment:

- When do corals reproduce? Dispersal distances/larvae behaviour. Document embryo and larval development of cold-water corals (including life history, reproductive cycle, etc.).
- What factors determine reproduction synchrony, cycles and fecundity?
- Link between coral biochemistry and reproduction.
- How does temperature affect reproductive cycles in *Lophelia*?

- How do environmental changes affect larvae compared with adult corals?
- Settlement and (a)biotic interactions.
- Determinants/tolerances/thresholds in response to environmental gradients?

2.3.2 Priority research questions, key sites and methods: Coral biology

Question 1: Biotic and abiotic factors that control cold water coral species and communities:

- Effects of local sedimentation rates and hydrodynamics on coral health status?
- Which cues trigger spawning? Temperature, salinity, others?
- Is there any clear trend in reproduction patterns of deep corals

Question 2: Energy supply to and flow through cold water coral communities:

- Carbon flux through coral ecosystem. Energy budget of coral reefs, carbon fixing?
- Trophic interactions of cold water coral ecosystems and food web, supply and quality.
- Dynamic energy budget models.

Question 3: The processes of coral reproduction and recruitment:

- When do corals reproduce? Dispersal distances/larvae behaviour. Document embryo and larval development of cold water corals. (including life history, reproductive cycle, etc.)
- What are the conditions that favour or hinder larval settlement?
- What factors determine reproduction synchrony, cycles and fecundity?
- Link of coral biochemistry and reproduction.

Question 1: Biotic and abiotic factors that control cold water coral species and communities

Methods:

- Sediment traps and CTD and current meters.

The following methodology and sites pertain to all three questions:

- Inshore Norway to Mingulay to Rockall to Mid-Atlantic Ridge to US S Atlantic Bight to Gulf of Mexico
- ROVs – documentation/sampling
- Video grab
- Landers – long term deployments recording instruments
- Water analysis – (for water “quality” e.g. POC, PON, PO, NO₂, NO₃ etc.) Biochemical analysis
- Sea floor observatory
- Gulf of Cadiz
- Trondheimsfjord
- North Sea oil rigs
- Offshore (e.g., Sula and Røst reef)
- Gulf of Mexico – Viosca Knoll
- Florida straits
- Kosterfjord – Tisler reef
- Two Mediterranean sites – east and west basin

Methods:

- Laboratory culture key species under well-controlled conditions
- Careful manipulation of growth conditions
- Experimental elemental/isotopic supplements

Key sites:

- Ready access to live coral

2.4 Group D: Climate Change & Palaeo Records: ‘Proxies & Chronologies’ and ‘Temperature & Ventilation History’

Science Leader: Tina van de Flierdt, Imperial College London, UK

Facilitator: Murray Roberts, SAMS & UNCW

2.4.1 Initial Brainstorming: Palaeo

The group sorted their questions into major groups:

The ‘mound record’

- Can we use cold-water coral mounds to generate a palaeoenvironmental proxy over 2.5 ma records across the Atlantic?
- What does the mound record tell us about vulnerability of contemporary reefs to collapse due to climate change?

Historical climate context

- What is the climate dependence of cold-water coral evolution?
- What is the role of intermediate water flow in vertical heat exchange?
- The ocean’s role in rapid climate change
- Can these corals record El Nino changes?
- Is the little ice age (an analogue for possible thermohaline circulation shutdown) seen all across the Atlantic? (other oceans?)

Tracers – basin-scale temperature reconstruction

- Is there a good salinity tracer?
- Can we use other species living on the mounds as temperature recorders?
 - No vital effects
 - Less dissolution/diagenesis
- Stable strontium isotope calibration for temperature reconstruction from NE Atlantic – basin wide
- Suspended sediments interaction with corals? Current tracers?
- Assess palaeo densities – depth, salinity, temperature
- Can we identify a multi-proxies multi-archives approach in the deep environment? Is it too time consuming?

Water mass/ventilation: cluster 1

- Understanding basin scale intermediate water ventilation and advection throughout major rapid climate events of the past 30 kyr.
- Can we trace North Atlantic overflow across the sills in Greenland and Iceland through the past 20 kyr?
- Do ^{231}Pa / ^{230}Th maxima in the sediments correspond to circulation stop, more nutrients?
- Reservoir age correction Deglaciation. -> Holocene.
- 0-300 kyr S. Atlantic growth periods -> N. Atlantic (paleocirculation events).
- Ventilation: Holocene -> back.
- 0-30 kyr reconstruction of deep water composition ($\delta^{14}\text{C}$, Cd/Ca at different times, water depths.

Water mass/ventilation: cluster 2

- Role of Gulf Stream/North Atlantic Drift variability on cold-water coral reef development.
- Important controls on intermediate water masses – links to surface water masses.
- Has the thermohaline circulation slowed since global warming began?
- Is this reflected in an increased southward recirculation of surface waters in the NE Atlantic?
- Gulf of Mexico – along the Gulf Stream

- Does surface productivity (links to surface water/Gulf Stream) affect cold-water corals at intermediate water depths?
- How does Southern Intermediate Water influence the salinity/temperature budget of the North Atlantic?
- Can we link oceanography and palaeo-records from corals?

History of cold-water coral ecosystem development and controlling factors

- Why are palaeo coral records mostly fragmented in a few kyr bits and pieces? (note: this is a very important issue examining the fundamental processes linking atmospheric and marine change)
- What are the environmental constraints limiting coral growth during glacials?
- What are the main physical parameters controlling cold-water coral ecosystem development?
- Do mounds reach a specific depth level = max. height?
- What are the factors triggering the development of coral ecosystems? Still not completely known!
- What are controlling factors and history of cold-water coral ecosystems?
- What caused sudden onset (coral) carbonate mound formation in Pliocene – is age well constrained in NE Atlantic Ocean?
- Is reef development synchronous across Atlantic (Northern hemisphere climate or regional hydrodynamics)?
- What caused cold-water coral ecosystem to restart off Ireland 10,000 years ago?
- Are cold-water coral ecosystem histories different on both side of the Atlantic?
 - Are there one or many refugia?
 - How is the timing of cold-water coral reef formation around the Atlantic and what are the drivers?

Questions related to Methods

- Is it possible to improve our understanding on “vital effect?” Can we better combine the skills of biologists and geochemists?
- From where do coral larvae come and where do they go? (oceanographic constraints)
- How far back in time can we use U/Th dating of corals? Diagenesis?
- What is the role of preservation/diagenesis on Palaeo record?
- Is it possible to speed up/make cheaper U/Th dating? (e.g. Hellstrom et al. 2004)
- Should we agree on a “standard” set of tracers/protocols?
- Can the “lines” technique be applied to trace elements? What would this tell us?
- Understand trace metal incorporation in corals.

Questions related to Sites

- Is there a simple/well-constrained region where we could test/calibrate proxies for temperature, salinity, productivity?
- Identification of key sites covering as many scientific objectives as possible.
- What about the S Atlantic?
- Where are coral mounds in the Atlantic?
- Which location(s) most likely reflect(s) initial start/demise of ocean circulation intermediate waters in the N Atlantic Ocean the best?
- Can deep sea corals be found in Antarctic waters? What are the major oceanographic changes here?

2.4.2 Priority research questions, key sites and methods: Palaeo

Five major questions came to light that regroup most of the more specific questions raised during the brain storming. Questions 1, 2 and 5 are open questions that will allow a strong link to the other research themes (biodiversity, connectivity, linkage etc) while question 3 was debated as to what extent we include a question in which the corals serve as an archive while the corals and the ecosystems they form are not the immediate focus of the question. There was a consensus to include such palaeo-archive questions

because TRACES will be a unique opportunity to tackle modern and past oceanography and climate using coral archives, and it will be of supplementary value to link such understanding to the coral ecosystem itself and the environmental factors associated with its development. Question 4 is a particularly specific question that makes use of a common idea to reconstruct water mass properties through time and space from coral archives to determine oceanographic conditions and, if possible, to see whether the boundary conditions in which corals occur can be resolved. Methods and areas have not been specified for each question; as explained below they are overarching to all questions with three transects identified and illustrated below.

Question 1: History of cold water coral ecosystem development.

Question 2: What are controlling factors on cold water coral ecosystem development?

Question 3: How can we improve our understanding of past ocean circulation through basin-wide studies of cold water coral ecosystems?

Question 4: Can we reconstruct past basin-scale intermediate water temperature gradients from cold-water coral ecosystems?

Question 5: What is the sensitivity of cold-water coral ecosystems to global change and ocean acidification?

Methods & standardisation relating to all questions:

- Concept of baseline station – 27 degrees N, 40 degrees S
- Drilling?
- Dating (need for many accurate dates!)
- Sediment proxies (comparison between coral records!)
- Coral proxies (including, excluding such influenced by vital-effects?)
- Landers and moorings (intercalibration to coral proxy data)
- Mapping – acoustic and visual
- Aquarium coral culture to “test” proxies (Live coral ecophysiology)
- Seawater chemistry (intercalibration to coral proxy data)
- Precision of analysis (standardization of techniques and protocols)

Key Sites

Northern transect

- Rockall
- Norwegian Shelf
- Faroes (NB. oil industry mapping may have taken place in this area)
- S. Iceland
- Orphan Knoll

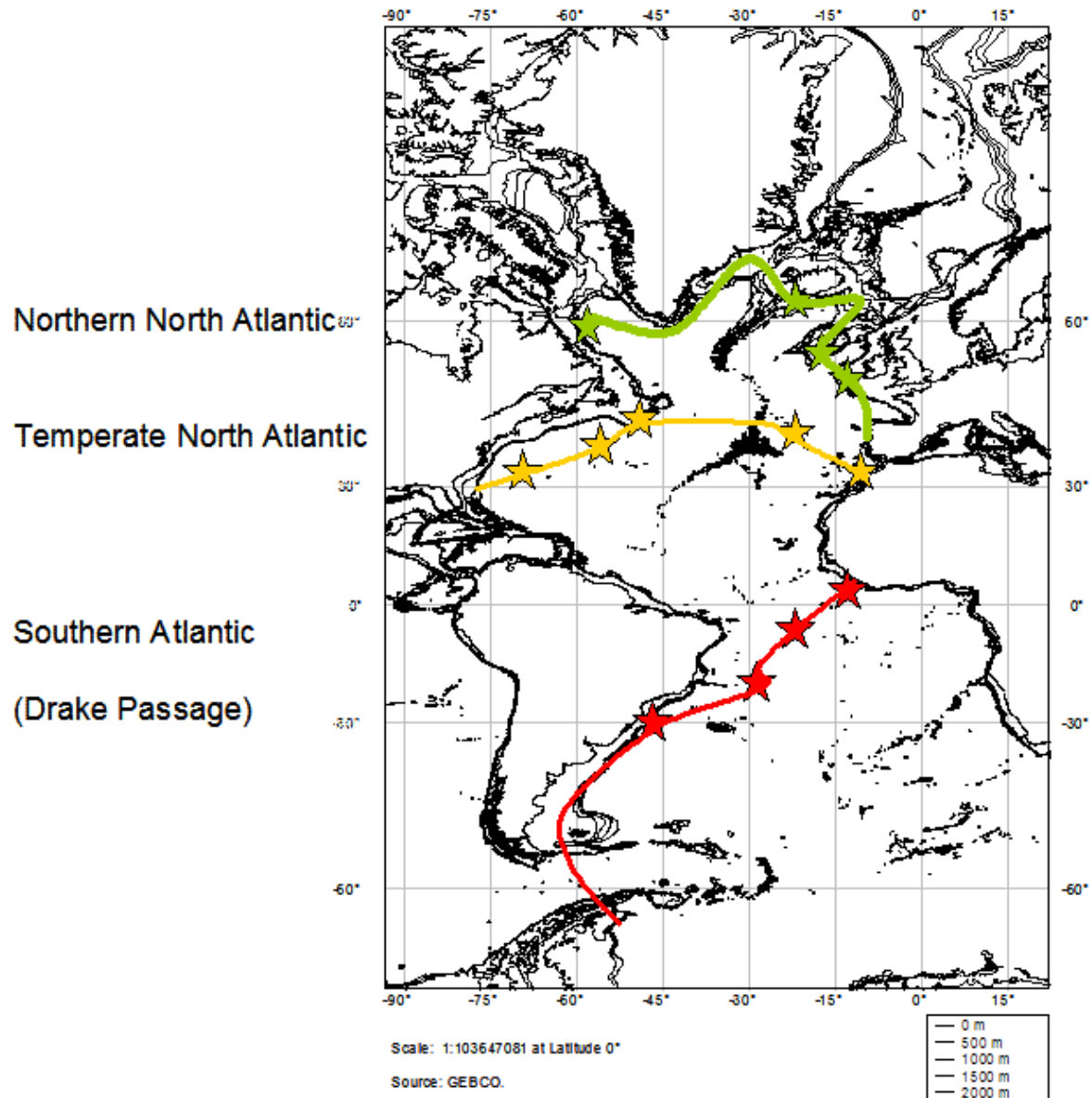
Temperate transect

- Straits of Florida
- Blake Plateau
- Mediterranean Sea
- Mid Atlantic Ridge (?) - New England and other seamounts

Southern transect

- Brazil – Campos Basin
- Africa – Angola
- NW Africa
- Drake Passage

Chart illustrating potential TRACES northern, temperate and southern transects.



3 TRACES management, upcoming projects and funding

The second day began with presentations on projects, funding and opportunities relevant to TRACES in Canada, the European Union and United States. Time was also set-aside to review work done on the first day of the workshop.

3.1 Review Outcomes of Day 1

The delegates reviewed the outcome of the discussion groups on day one to identify and record opportunities and challenges related to each group's research questions. The delegates also added information related to sites and methodology for each topic. These ideas were written on flip-charts and are summarised below, along with any additional discussion.

3.1.1 Group A – Linkages & Connectivity

Additional ideas

- Food supply to cold-water coral ecosystems both sides of the Atlantic – differences, similarities
- Productivity and dynamics that control the fluxes
- What about trophodynamics?

Opportunities for collaboration

- Genetics projects on both sides of the Atlantic

Challenges

- Lack of principle knowledge of reproduction – needs ties with reproduction questions
- Selection of a core set of species for commonality between projects
- Palaeo DNA (development of methods and markers)
- Standardisation of markers

3.1.2 Group B – Biodiversity & Biogeography

Opportunities for collaboration

- Mutual exchange of technologies
- Taxonomic expertise (make a list!)
 - E.g. Naturalis Museum (Leiden, Holland)
 - Bert Hoeksema (scleractinians) and Leen van Ofwegen (shallow soft corals of the Indo-Pacific)
 - Smithsonian Institute, USA (Stephen Cairns for scleractinian and gorgonian corals)
 - Helmut Zibrowius (retired since 2006)
 - Specialists at the P.P. Shirshov Institute, Russia (e.g. brachiopods, stalked crinoids, bivalves, hexactinellid sponges and others)
 - COMARGE have prepared a list of taxonomic specialists (available from Tina Molodtsova)
 - NIWA (Wellington, New Zealand)
- Species definition: collaboration/challenge, between taxonomist and genetics.

Challenges

- Taxonomic expertise
- Standardisation/definition of scales – spatial and temporal
- Selection of species (=key species) for broad-scale/trans-Atlantic approach
- Understanding of DSC communities at basic levels: succession/recruitment

3.1.3 Group C – Coral Biology & Reproduction

Opportunities for collaboration

- Environmental gradients at different study sites (Trans-Atlantic component)
 - Thresholds
 - Genetics in adaptive response
- Time of spawning in different places (Gulf of Mexico, Mid-Atlantic Ridge, Mediterranean, SE Atlantic, NE Atlantic, fjords) Might give us ideas on triggering?
- Strong overlap with palaeorecord theme.
- Build a long-term observatory in the DAR (Azores). There's a need for some technology and expertise.
- This theme seems linked with most of the other themes: understanding the coral biology is often a basis for the other work.
- This theme has broadened their scope beyond "corals" to include communities, which crosses into the Biogeography/Biodiversity and Linkages and Connectivity themes.

Challenges

- Better knowledge on reproduction strategies giving key to better interpret genetic data.
- Measuring/estimating energy/food fluxes.

3.1.4 Group D – Climate change & palaeo records

Opportunities for collaboration

- Biogeography
- Biotic and abiotic questions (hydrography and sedimentation)
- Energy = food = water masses?
- Overlap between sub-themes below
 - Calibration of tracers and proxies, projects like GEOTRACES, EPOCA, THOR (risk of thermohaline circulation changes – palaeoceanographic aspects, ocean modeling)
 - Ocean observatories (esp. people planning new ones). Note Sascha Flögel is currently supervising the construction of a new lander system for long-term deployment at IFM-GEOMAR (so far CTD and ADCP). All sensors are about 40 cm above the sea-floor to measure within the corals and not 1-2 m above. The Scottish Association for Marine Science also operate a coral 'photolander' and are developing a novel 'microlander' for site-specific work in coral habitats.

Challenges

- Temporal snapshots of palaeo information on large geoscales.
- What do ocean/atmosphere modelers most need to know?
- What can corals specifically contribute? What about carbonate mounds?
- Allow scope within this theme for the 2 approaches to palaeo records – 1) using coral organism proxies and 2) interpreting reef development/sediment proxies (Is this 2 sub themes?)
- Go from coral ecosystem to climate reconstruction and the other way around!
- Can we obtain the precision required for e.g. palaeo-temperature reconstruction required by models? (0.5 degrees C) → anthropogenic time scales = last 2000 years
- Projects: NEWTON → www.anr-newton.fr

3.2 TRACES Science Plan

The TRACES Science plan scheme was presented and participants then volunteered to lead or contribute towards different sections. Those who volunteers are listed below, individuals listed in *italics* were not present at the meeting and need to confirm their interest.

Workpackage	Leaders	Contributors	
Linkages & connectivity	Alex Rogers	Mikael Dahl Telmo Morato	Julie Reveillaud
Biodiversity & biogeography	Ann Vanreusel Pål Mortensen <i>Roberto Danovaro</i>	Tina Molodtsova Filipe Porteiro Alex Rogers	Sandra Schöttner Marco Taviani
Coral biology & reproduction	Johanna Järnegren	Andy Davies Kim Last	Cova Orejas Tomas Lundälv
Climate change & palaeo records	Norbert Frank	<i>Dominique Blamart</i> <i>Sam Burgess</i> <i>Christophe Colin</i> Carin Dahl Ben De Mol Boris Dorschel <i>Eric Douville</i> Dierk Hebbeln	<i>Gideon Henderson</i> Augusto Mangini Paolo Montagna Andres Rüggeberg Dan Sinclair Andy Wheeler Tina van de Flierdt <i>David Van Rooij</i>
Policy	<i>Sybille van Hove</i>		
Mapping & habitats		Ben De Mol André Freiwald Anthony Grehan Veit Huenerbach	Veerle Huvenne Tomas Lundälv Pål Mortensen Cova Orejas
Oceanography & food supply	Martin White	Gerard Duineveld Sascha Flögel Kostas Kiriakoulakis	Furu Mienis George Wolff
Modelling: Palaeo	Dan Sinclair	<i>Jean-Claude Dutay</i>	
Modelling: Larval dispersal			
Modelling: Habitat suitability	Andy Davies	Anthony Grehan (Coralfish project) Veerle Huvenne	<i>Genoveva M. (Lundälv)</i> <i>Alex Rogers</i>
Data management		Ben De Mol Veit Huehnerbach <i>Jan Mees (VLIZ – Flemish Marine Institute, Ben De Mol)</i>	<i>Gerry Sutton (Wheeler, WP leader on Coralfish)</i>
Media and web		Autun Purser Filipe Porteiro	<i>Sarah Knight (M. White)</i> Dan Sinclair
Schools		<i>Vikki Gunn</i>	<i>Nadine Tisnerat-Laborde</i>

Appendix 1: TRACES European workshop delegate list

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Appendix 2: Workshop agenda

Day 1 – Science Plan Objectives & Structure (29 March)

Morning aim: Review research needs and policy drivers

0815 Meet

0830 Welcome and introductions

0845 Goals and objectives of the meeting, meeting guidelines

0900 Overview TRACES programme and outline for Science Plan

Review Research Theme ‘Ecosystem’

0930 Linkages and connectivity – *Alex Rogers (Institute of Zoology, UK)*

0950 Biodiversity & biogeography – *Pål Mortensen (Institute for Marine Research, Norway)*

1010 Coral biology & reproduction – *Cova Orjeas (Institut de Ciències del Mar, Spain)*

1030 Coffee

1100 Review Research Theme ‘Climate change & Palaeo records’

1100 Proxies & chronologies – *Dan Sinclair (Scottish Association for Marine Science, UK)*

1120 Temperature & ventilation history – *Norbert Frank (LSCE, France)*

1140 Questions & discussion

1200 Lunch

Afternoon aim: Identify research priorities

1300 Breakout group process - outcomes explained

1330 Split into 4 groups. Research Theme groups to refine questions with three priority areas highlighted.

1600 Coffee

1630 Theme group reports

Identify three priority research questions listing for each:

- Key geographic sites

- Methods & standardisation issues (brief and general)

1630 Ecosystem Theme ‘Linkages & connectivity’ – *Mikael Dahl (University of Gothenburg, Sweden)*

1650 Ecosystem Theme ‘Biodiversity & biogeography’ – *Jan Helge Fosså (Institute for Marine Research, Norway)*

1710 Ecosystem Theme ‘Coral biology & reproduction’ - *Johanna Järnegren (Norwegian Institute for Nature Research, Norway)*

1730 Climate change & Palaeo records Themes ‘Proxies & chronologies’ and ‘Temperature & ventilation history’ - *Tina van de Flierdt (Imperial College London, UK)*

1750 Wrap-up review & outline for Day 2

1815 End Day 1

End of Day 1 Goals

- Research questions, sites and methods, opportunities outlined.

- Three priority topics for each section of the Science Plan identified.

2000 Dinner at hotel

Day 2 – TRACES Management, upcoming projects & funding (30 March)

Aim: Discuss TRACES management, relevant projects, funding and agree on North American Science Plan writing team

0815 Meet

0830 Welcome and any new introductions. Summarise Day 1 and introduce Day 2.

0900 Canadian projects, funding and opportunities – *Kim Houston (DFO, Canada) talk presented by Murray Roberts (SAMS & UNCW)*

0920 US projects, funding and opportunities – *Steve Ross (University North Carolina Wilmington, USA)*

0940 European projects, funding and opportunities – *Murray Roberts (SAMS & UNCW)*

1000 Review outcomes Day 1. Identify opportunities and constraints: (1) opportunities for collaboration through existing and planned projects; (2) constraints on developing international, trans-Atlantic approach.

1100 Coffee & snack

1130 Agree European Science Plan writing team and actions assigned from meeting

1300 Lunch

1400 Meeting ends

End of Day 2 Goals

- Discussion of TRACES management and structure
- Identification of existing projects & relevance to TRACES
- Discussion of possible funding routes & mechanisms
- European section leaders for Science Plan identified
- Agreement on actions and timetable arising from meeting