



## **North American TRACES Workshop Report**

28-29 February 2008

Center for Marine Science, University North Carolina Wilmington

**15 April 2008**

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.

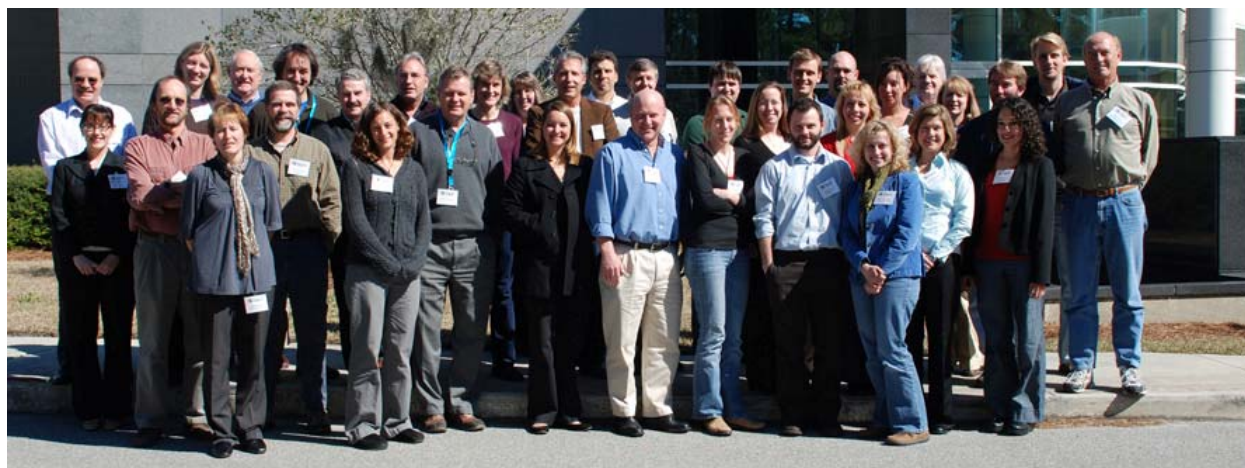
This report summarises discussion at the first North American TRACES workshop held at the end of February 2008. Thirty three participants from Brazil, Canada, the UK and USA met in Wilmington, North Carolina to discuss ocean basin-scale research priorities to advance our understanding of cold-water coral ecosystems across four research themes:

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

This meeting was repeated during a European workshop a month later following 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.

North American TRACES workshop participants.



## **Acknowledgements**

TRACES is sponsored by a grant from the European Commission (Contract No. MOIF-CT-2006-040018) and the North American workshop was sponsored by the Canadian Department of Fisheries and Oceans, NOAA National Undersea Research Center, Center for Marine Science University of North Carolina Wilmington, US Geological Survey, Environmental Defense, Oceana, Marine Conservation Biology Institute and the US South Atlantic Fishery Management Council. We are grateful to Dan Baden and staff at the UNCW Center for Marine Science for their help with organising the meeting in Wilmington. We also thank the following for additional support: Royal Society of Edinburgh, UK Natural Environment Research Council and Scottish Association for Marine Science.

## 1 Introduction

This report summarises discussion at the North American workshop of the trans-Atlantic coral ecosystem study 'TRACES' held 28-29 February 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:

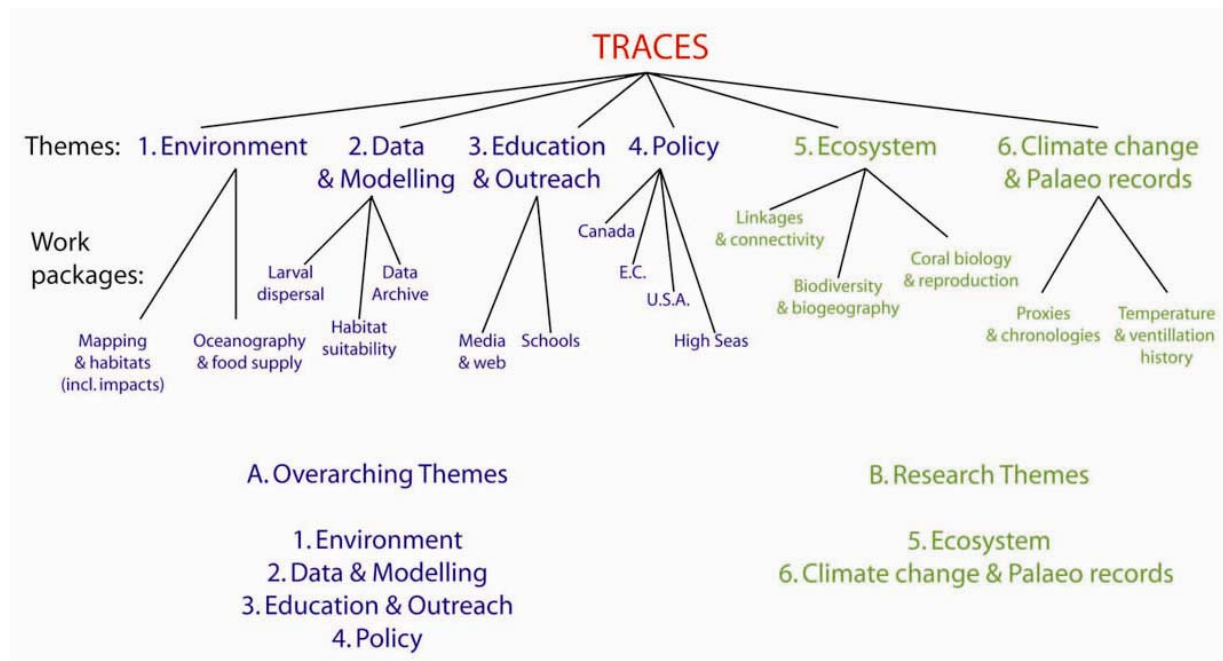
- E. Linkages & connectivity
- F. Biodiversity & biogeography
- G. Coral biology & reproduction (group discussion by email before workshop)
- H. Climate change & palaeo records.

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: Cheryl Morrison, USGS

Facilitators: Jim Howell & Amy Cobb, SBTDC at UNCW

#### **2.1.1 Initial Brainstorming: Linkages**

Working definition of population connectivity (from Tim Shank’s presentation): “The dispersal, survival, and reproduction of migrants, so that they contribute to the local gene pool.”

- What is the age distribution of coral species in coral ecosystems?
- What are the linkage patterns within seamounts? i.e. can each seamount be considered as a ‘population’ or, in other words, are individuals on one seamount more closely related than those between seamounts.
- What is balance between asexual and sexual reproduction in *Lophelia*?
- What is the level of fragmentation that a population can withstand and still remain viable?
- Identify ‘source’ vs. ‘sink’ populations
- What are the “evolutionary connections” between N. Atlantic and N. Pacific corals?
- What are the patterns of population structure in the N. Atlantic?
- What physical factors change in concordance with phylogeographic breaks?
- Can connectivity patterns help define protected access?
- How do we create marine protected area networks to benefit and inform us about connectivity?
- What types of anthropogenic influences have significant impact on connectivity?
- What are impacts of fisheries that alter coral ecosystem connectivity?
- How might vulnerability to fishing and climate change alter connectivity and prospects for persistence in cold-water coral assemblages?
- Can we identify key conditions or factors that may indicate the existence of unknown deep reefs?
- What predicts the available habitats for coral ecosystems?
- What are suitable models to enable predictions of status and trends among coral populations?
- Where are ‘common’ or ‘overlapping’ phylogeographic breaks between species?
- How do we overcome the key technical problems for assessing connectivity and gene flow (over temporal and spatial scales)? i.e., genetic resolution sampling?

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

1. Defining the spatial scale of connectivity
2. Identifying key processes that may generate connectivity patterns
3. Identifying threats to existing connectivity.

These ideas were reworded to try and encompass aspects of the various questions. The group then began to discuss sites and methodologies for each. The group never came to a consensus about how the third question on threats should be worded, or whether or not it was feasible to collect data to address it, so sites and methodologies were not discussed in detail. The group felt that the third question might be replaced with a better one later (see day two discussions in Section 3.1.1). The group also discussed whether or not ‘trophodynamics’ should form a component of research within ‘linkages and connectivity’.

#### **2.1.2 Priority research questions, key sites and methods: Linkages**

1. What are the spatial and temporal scales and patterns of connectivity?
2. What are the natural processes that control connectivity in Atlantic coral ecosystems?
3. How do anthropogenic influences affect connectivity?

### Question 1: What are the spatial and temporal scales and patterns of connectivity?

The group listed three spatial scales:

- a. Within populations? (e.g. relatedness among individuals of a cold-water coral species at a site, such as a seamount, bioherm, bank, etc., including degree of sexual vs. asexual reproduction)
- b. Between populations? (e.g. what is the degree of differentiation between populations of cold-water coral species, larval source vs. sink dynamics, etc.)
- c. Across regions? (e.g. decreased connectivity across known oceanographic boundaries?)

### Key Sites

- Need sites that cover a suitable range of depths
- Include these major habitat types or areas:
  - Mid-Atlantic Ridge (incl. St Peter & St Paul)
  - NE Atlantic Seamounts
    - Newfoundland seamounts
  - Continental Margins-
    - Gulf of Mexico:
      - Viosca Knoll
      - Gulfpen shipwreck
      - Green Canyon, MS Canyon
    - South Atlantic Bight:
      - Stetson Banks
      - Savannah Banks
      - North Carolina *Lophelia* Banks
      - Miami Terrace
      - Pourtales Terrace
      - Jacksonville & Cape Canaveral
  - Oceanographer Canyon
  - North East Channel
  - The Gulley (Atlantic Canada)
  - Shortland
  - Haldremand
  - Orphan Knoll (Newfoundland)
  - Greenland
  - Iceland & Faroes
  - Norway
  - Azores

Additionally, the group discussed the need for inclusion of sites in other regions of the Atlantic, such as the Caribbean, off the coast of Africa and in the southwestern Atlantic Ocean (e.g. off of Brazil). The addition of these sites would make geographic coverage of the Atlantic complete. Importantly, this conclusion supports the discussion of the palaeo group who outlined the case for equatorial Atlantic transects (see below).

### Methods

- Pros and cons of one major expedition with a mix of investigators and objectives vs. capitalising on existing projects and ships of opportunity (piecemeal approach). Likely will depend upon funding opportunities.
- Spawning studies (fecundity & behavioural)
  - Using *in situ* sampling & observatories
- Genetic studies to define dispersal patterns & recruitment dynamics at several taxonomic scales:
  - Systematics/phylogenetics (species identification, relationships between species - primarily utilizing sequence data)

- Phylogeography (broad scale patterns of connectivity within a species - primarily utilizing sequence data)
- Population genetics (select taxa: fine-scale patterns of connectivity - primarily microsatellites or other species-specific markers, requires standardization among labs and larger sample sizes)
- ROV or sub with sufficient sampling capabilities, bottom time, depth/imaging capability (high definition video most versatile), and navigation
- Trapping
- Sampling different life stages - e.g. settling plates for larvae, juvenile vs. adult cold-water coral individuals, etc.
- Taxa: Corals & associates (emphasize corals that have associates in order to obtain more information without additional sampling requirements)

**Question 2: What are the natural processes that control connectivity in Atlantic coral ecosystems?**

- Key biotic and abiotic factors that correlate with patterns of connectivity and may indicate processes shaping patterns at key sites
  - Depth/temperature
  - Cold-water coral reproduction –
    - Seasonality/timing of reproduction
    - Larval duration
    - Larval behaviour
    - Settlement dynamics
    - Survival
  - Currents/hydrodynamics
  - Latitudinal changes
  - Surface Productivity
  - Habitat Distribution

**Key sites:**

- Subset of those listed under question 1, include at least one site per region to collect long-term observations.
- Site prioritization may depend on preliminary connectivity results or known oceanographic boundaries

**Methods:**

- Physics & chemistry
  - Physical oceanography
  - Current meters
  - Long-term observatories with ability to collect environmental, photographic and current data
- Imaging surveys
- Mapping, e.g. multibeam sonar
- Recruitment blocks or settling plates

**Question 3: How do anthropogenic influences affect connectivity?**

Nothing was discussed in time available

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

Science Leader: Steve Ross, UNCW

Facilitator: Leslie Langer, SBTDC at UNCW

### **2.2.1 Initial Brainstorming: Biodiversity**

- How do species/groups utilize or benefit from framework corals?
- How is biodiversity on coral ecosystems related to ocean or ecosystem health (status)? (Is it related?)
- How does deep-sea reef biodiversity differ (functionally & in biodiversity) from shallow, warm water reef systems?
- How are cold-water coral communities structured or organized?
- Are there priority conservation areas? (Value)
- How do fishing impacts affect biodiversity?
- Refine biogeographic boundaries
- Are biodiversity or community structure patterns similar across habitats and/or across large distances?
- How does richness/composition/diversity vary with habitat and distribution (biogeography)?
- How are these communities structured?
- What kinds of deep coral habitats are there? How do we define them?
- What biodiversity exists on cold-water reefs? (structure)
- What are the threats to deep-water corals?
- Discover new coral habitats.

During this discussion, the group noted that trophodynamics and energy flow were important topics. This probably did not belong in this group, but it was suggested that it be incorporated into the linkages and connectivity group. However, trophic ecology relates strongly also to ‘food supply and oceanography’ which, given the limited time available at the workshop, was not singled out for detailed discussion. The group then voted on their priority research questions. It was generally agreed that question three above concerning the physical environment influence was more important than the voting process had indicated. So the top question (# 2 above) was modified to read: How are cold-water coral communities structured and by what? While not entirely satisfactory, this was left for now. It was also agreed that the main question was so broad that it encompassed almost everything ecological.

### **2.2.2 Priority research questions, key sites and methods: Biodiversity**

1. How are cold-water coral communities structured and by what?
2. How do species utilize coral habitat?
3. What is the resiliency of deep coral communities?

#### **Question 1: How are cold-water coral communities structured and by what?**

##### **Key sites**

- Porcupine Seabight
- Norway
- Mid-Atlantic Ridge (new areas needed)
- Azores (new areas needed)
- Bahamas (new areas needed)
- Orphan Knoll
- Newfoundland Seamounts
- Blake Plateau/Florida Straights
- SE Gulf of Mexico (new areas needed)
- Viosca Knoll
- Cape Lookout

There was some discussion that listing exact sites at this time may be premature and that this was a methodological detail driven by study design. Thus, the list above should not be considered the result of detailed discussion.

**Question 2: How do species utilize coral habitat?**

- Well characterized sites would be needed to address this
- Noted that word “utilize” is quite broad, perhaps needing more focus

**Question 3: What is the resiliency of deep coral communities?**

- Sites under potential significant human impact would be needed
- Again the word “resiliency” needs clarification

Issues that might overlap with other groups

- Trophodynamics (see above)
- Understanding microbial ecology as a linkage between and within coral communities
- What has happened to the coral communities over (paleo) time?

The group ran out of time and had little opportunity to address methods or study sites.

## **2.3 Group C: Coral biology & reproduction**

### **2.3.1 Initial brainstorming: Coral biology**

Unfortunately the members of this discussion group were not able to attend the meeting due to fieldwork commitments. Discussion between Sandra Brooke, Murray Roberts and Rhian Waller was carried out before the workshop and is summarised here.

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

1. What are habitat-forming coral species’ reproductive modes, fecundity and larval biology?
2. What controls the rate of coral skeleton growth and how does this affect palaeo-proxy record
3. What is flux of carbon through coral animal and how could this change under altered temperature and pCO<sub>2</sub> conditions?

**Question 1: What are habitat-forming coral species’ reproductive modes, fecundity and larval biology?**

Methods:

- Seasonal samples fixed for history
- Lab study live coral (e.g. to induce spawning)
- Population genetics (e.g. level clonality)

Key sites:

- Sheltered fjords for seasonal sampling (Norway)
- Sites with likely linkages (e.g. New England & Corner Rise Seamounts to mid-Atlantic Ridge)

**Question 2: What controls the rate of coral skeleton growth and how does this affect palaeo-proxy record?**

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

**Question 3: What is flux of carbon through coral animal and how could this change under altered temperature and pCO<sub>2</sub> conditions?**

Methods:

- Ecophysiological assessment in lab (e.g. respirometry, growth) under altered temp and pCO<sub>2</sub>
- Field assessments (benthic landers). Technical challenge

Key sites:

- Ready access to live coral

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

Science Leader: Laura Robinson, Woods Hole Oceanographic Institution

Facilitators: Jack Morrow & Ann Howard – SBTDC at UNCW

**2.4.1 Initial Brainstorming: Palaeo**

- Dating
  - What is the best dating method for each timescale?
  - Is coral growth rate linear in time?
  - What is the variation in initial 230/232 ratio (time/space)?
  - Can we exploit coral archives at “Arctic Gateways”?
  - Can we link up instrumental records and coral records
  - How does the deep ocean vary on both recent and glacial timescales?
  - Why is NE Atlantic *Lophelia* growth associated with interglacial whereas NW Atlantic *Desmophyllum* growth is associated with glacial periods?
- Proxy
  - Development of new proxies from deep sea corals
  - What error bar can we put on paleo-temp (and other) estimates?
  - Can we reconstruct ocean carbonate chemistry (“pH”)?
  - Can corals be used to find out what caused glacial cycles?
  - Reproducibility in proxies, both intra/inter coral
  - What are the best and/or easiest proxies to use?
  - How can we quantify (and account for) vital effects in corals?
  - Can we develop a way to “remotely sense” where to find deep-sea corals?
  - Do black crusts enhance the preservation of fossil corals?
  - Can we use lab growth studies to:
    - Follow growth (so we know how to sub sample corals)
    - Test proxies
- Issues
  - Follow carbon cycling and ventilation rates
  - How widespread are the rapid depth and spatial changes that we see in New England seamount corals?
  - Are rapid climate changes and circulation changes in the deep Atlantic simultaneous?
- Biomineralization
  - Does food supply affect the chemistry of the coral skeleton?
  - Calcification rates of scleractinians (and other corals) -cross basin, relationship to present day aragonite saturation state
  - How do corals make their skeleton, does the ambient CO<sub>2</sub> matter?
- Acidification

- Response of corals to ocean acidification
- Climate
  - Temporal resolution (high resolution potential of corals makes them valuable archives)
  - Deep ocean role in abrupt climate change
  - Role of intermediate waters in climate change
  - Glacial climate: large amplitude change which is most readily detectable by proxies
  - What is the relationship between rapid climate change and ocean circulation
  - Were circulation changes during the deglacial Associated changes in the heat flux?
  - Have there been changes in the deep ocean on recent timescales (decadal?)?
  - What are the spatial scales of deep ocean variability
- Oceanography & environmental controls on corals
  - What are the major controls on the spatial and temporal distribution of deep sea corals?
  - What will anthropogenic changes do to coral populations?
  - Are corals sensitive to sub-surface temperature
  - Is there a relationship between coral populations and the physical environment?
  - Why do cold-water corals have such a punctuated appearance in the geological record?
  - What is the deep circulation at the LGM south of 40°N?
  - How fast can / do cold-water corals populate an ocean basin?
  - What is the spatial and temporal distribution of fossil coral in the Atlantic?
  - Can we trace/follow deep-water currents using cold-water corals?

#### **2.4.2 Priority research questions, key sites and methods: Palaeo**

1. How reliable are chemical proxies for determination of age and ocean environment?
2. What can deep-sea corals tell us about heat transport and the carbon cycle on decadal and glacial time scales?
3. Coral growth distribution in the NW and NE Atlantic are sporadic over tens of thousands of years timescales, and different to one another. Why?

#### **Methods, for all questions**

- Locate
- Collect
- Precise & Accurate Ages

#### **Key Sites**

- **Recent:**
  - Orphan Knoll - North Atlantic Oscillation
  - High Latitude – “end member” values
- **Glacial, develop three transects:**
  - 40 degrees North
  - Equator
  - 20 degrees South

### 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 discussions groups on day one to identify and record opportunities and challenges related to each group's three 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

Our original question 3 dealing with anthropogenic influences can likely be addressed with data collected for first two questions. The 'Biodiversity and Biogeography' group suggested topics in trophodynamics should fall under "Linkages and Connectivity". Many members of the Connectivity group thought it most appropriate to replace the third question presented on Day 1, "How do anthropogenic influences affect connectivity?" with the following:

- Characterize the trophodynamics and the benthic-pelagic interactions of organisms associated with cold-water coral habitat:
  - How can trophodynamics be used as an indicator of connectivity?
  - How does energy flow link ecosystems or parts of ecosystems?

##### *Additional ideas*

- Identify the symbiotic microbial community of coral colonies in different places and under different conditions
- It was noted that a Gully trophodynamics project is underway (Canada)

##### *Challenges*

- Challenge-site prioritization
  - Areas of potential phylogeographic breaks
  - Balance: many sites vs. intense sampling (e.g. population genetics)
  - Diversity of taxa to reflect different life history strategies
- Designing appropriate sampling design on same scale(s) as questions on connectivity
- Promoting consistent access to morphological and molecular taxonomy/systematics
- Obtaining sufficient samples for population genetics – numbers, preservation
- "Finding" the appropriate genetic marker for scale of connectivity question
- Obtaining co-located/co-incident physical and environmental data for interpretation

##### 3.1.2 Group B – Biodiversity & Biogeography

The following points were noted during morning discussion:

- Seems to be an overlap between this category and connectivity which needs to be resolved
- Lots of interest in Orphan Knoll among other groups, notably the Palaeo group
- Can we link palaeoceanography to fossil coral communities? Links well with European IODP on carbonate mounds and potentially Orphan Knoll
- Data management-regional/Atlantic GIS including: multimedia, MAP3, boundaries
- Challenge: Initial question on community structure too broad and needs to be focused
- Opportunity: Great current policy and management interest in impacts of deep-sea fisheries on the high seas (e.g., seamount fisheries) on habitats and biodiversity – vulnerable marine ecosystems
- Utilize (define better): facultative vs. obligate shelter, transient use (or not) feeding, spawning. Now, how to prioritize utilization questions?
- Define and get more specific regarding question two
- Why are there not more *Lophelia* bioherms north of Cape Hatteras?

- Determine patterns of coral mortality and bioerosion
- More methods for question 1
  - Videograb & ROV, video, transects, images, (note Johnson-Sea-Link sub <1000 m)
  - Standardizing across quantitative sampling devices
- Key sites for question 1 (listing incomplete)
  - Orphan Knoll
  - Viosca Knoll
  - SE Florida – Biogeographic changes
  - Biogeography of the Mid-Atlantic Ridge & New England seamounts
- Are coral communities spatially structured?
  - How does biodiversity change in relation to environment?
  - Do communities cluster into biogeographic provinces?
- Are coral communities temporally structured?
  - Links to palaeoceanography or seasonality
- Are there obligate reef species across the Atlantic?
- Where does this group fit? What is the process of coral mound/bank formation (what are respective roles of biology, physics & geology?)

### **3.1.3 Group C – Coral Biology & Reproduction**

- Challenge: Which taxa are best suited as lab models?
- Do we need to emphasize models from different subclasses e.g., Hexacorallia vs. Octocorallia
- *Oculina* – zooxanthellate vs. azooxanthellate morphology
- Opportunity: use fish (or other mobile close coral associates) to determine if larvae are carrying bacterial symbionts (vertical transmission)

### **3.1.4 Group D – Climate change & palaeo records**

- Importance of southern transect
- Palaeo-protocol Packet
- Need “Smart dredge”
- Palaeo work requires ZERO contamination by carbon-14 from previous tracer studies
- John Guinotte – send Murray target sites/method for ocean acidification research.

### **3.1.5 Overarching Opportunities & Challenges**

- Merge or at least consider TRACES plan with SAFMC & NOAA deep coral plans
- Outreach campaign for Federal agencies
- Funding: living ocean foundation “science without borders”
- Need to take a more serious look at previously developed documents – South Atlantic FMC Deepwater Research Plan addresses many of these same questions, as well as the methods needed to answer them
- Need to produce short “on deck” collections protocol for proper fixation of specimens for DNA-based studies... and for paleo work
- Create a “Craigslist” of sampling requests/types so all cruises have the potential to contribute to others’ work (e.g., if you collect extra \_\_\_\_\_, please preserve and send to Dr. X for \_\_\_\_\_ project)
- SAFMC “eco-research” database (in development) includes info on ecosystem research being conducted in the region. Could include a section for DWC research only
- Are all parties at the TRACES table? Are there partners who are not engaged yet?
- Trophodynamics – can we find synergy between biodiversity and connectivity?
- We need to articulate why the Transatlantic concept is important – why should this be the unifying theme for this program?
- Lots of interest in Southern latitude sites for new discoveries

### 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, any individuals listed in *italics* were not present at the meeting and some need to confirm their interest.

Workpackage	Leaders	Contributors	
Linkages & connectivity	Tim Shank	Cheryl Morrison Scott France	Alberto Lindner Amy Baco-Taylor
Biodiversity & biogeography	Erik Cordes	Lea-Anne Henry Charles Messing Steve Ross Martha Nizinski	John Reed Amanda Demopoulos Amy Baco-Taylor <i>Les Watling</i>
Coral biology & reproduction	Sandra Brooke Rhian Waller		
Climate change & palaeo records	Jess Adkins	Chris Myrvold Laura Robinson Gregor Eberli John Guinotte	Brendan Roark Allen Andrews <i>Owen Sherwood</i> <i>Evan Edinger</i>
Policy		Tom Hourigan (USA)	
Mapping & habitats		Kathy Scanlon John Guinotte Tom Hourigan	John Reed Gregor Eberli <i>Mark Grasmueck</i>
Oceanography & food supply		John Bane <i>Lauren Mullineaux</i> <i>Dennis McGillicuddy</i> <i>Harvey Seim</i>	<i>Tom Shay</i> <i>Jim Leichter</i> <i>Chris Mooers</i>
Modelling: Palaeo			
Modelling: Larval dispersal		<i>Ana Metaxas</i> <i>Lauren Mullineaux</i>	<i>Tom Shay</i>
Modelling: Habitat suitability		John Guinotte <i>Peter Lawton</i>	<i>Pat Halpin</i>
Data management		Kathy Scanlon <i>Karen Stocks</i>	<i>Pierre Clement</i>
Media and web		Charles Messing Jennifer Schull	SAFMC <i>Compass/Seaweb</i>
Schools		Andy Shepard <i>Lundy Spence</i>	<i>Liz Baird</i> <i>Ivar Babb</i>

## Appendix 1: TRACES North American workshop delegate list

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## **Appendix 2: Workshop agenda**

### **Evening before meeting**

1900 Drinks reception and buffet food (UNCW Center for Marine Science)

### **Day 1 – Science Plan Objectives & Structure (28 February)**

#### **Morning aim: Review research needs and policy drivers**

0800 Coffee

0830 Welcome and introductions

0845 Overview TRACES programme and outline for Science Plan

0900 Goals and objectives of the meeting, meeting guidelines

0910 Review Research Theme ‘Ecosystem’

0930 Linkages & connectivity – *Tim Shank (WHOI)*

0950 Biodiversity & biogeography – *Erik Cordes (Harvard University)*

1010 Coral biology & reproduction – *Sandra Brooke (University of Oregon)*

1030 Coffee

1100 Review Research Theme ‘Climate change & Palaeo records’

1100 Proxies & chronologies – *Brendan Roark (Stanford University)*

1120 Temperature & ventilation history – *Jess Adkins (Caltech)*

1140 Questions & discussion

1200 Lunch: Keynote Review ‘Policy & Outreach’ – *Doug Rader (Environmental Defense)*

#### **Afternoon aim: Identify research priorities**

1300 Breakout group process - outcomes explained

1330 Split into 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’ – *Cheryl Morrison (USGS)*

1650 Ecosystem Theme ‘Biodiversity & biogeography’ – *Steve Ross (UNCW)*

1710 Ecosystem Theme ‘Coral biology & reproduction’ – *Murray Roberts (SAMS & UNCW)*

1730 Climate change & Palaeo records Themes ‘Proxies & chronologies’ and ‘Temperature & ventilation history’ – *Laura Robinson (WHOI)*

1750 Wrap-up review & outline for Day 2

1815 End Day 1

#### **End of Day 1 Goals**

- Research questions, sites and methods. Initial opportunities outlined.

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

1930 Meet at Rucker Johns for dinner at 2000

## **Day 2 – TRACES Management, upcoming projects & funding (29 February)**

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

0800 Coffee

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

0900 Canadian projects, funding and opportunities – *Ellen Kenchington (DFO)*

0920 European projects, funding and opportunities – *Murray Roberts (SAMS & UNCW)*

0940 US projects, funding and opportunities – *Andy Shepard (NOAA Undersea Research Center)*

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

1130 TRACES management scheme

1200 Agree North American Science Plan writing team and actions assigned from meeting

1300 Lunch and continued discussion

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
- North American section leaders for Science Plan identified
- Agreement on actions and timetable arising from meeting