The North Atlantic Project: Historical Ecology of the trans-Atlantic Marine Biota

This proposal seeks to develop the great potential of the temperate North Atlantic Ocean as a system for studying historical ecology, which is the study of ecological communities from a phylogenetic perspective. The scale of this project, intellectually, taxonomically and geographically, requires the large-scale collaborative effort which is the thesis of this proposal.

The trans-Arctic exchange of marine organisms in the late Pliocene established many species of Pacific origin in the North Atlantic Ocean. This natural experiment — along with episodes of trans-Atlantic migration of endemic Atlantic taxa — placed many of the same species on both coasts of the North Atlantic. These coasts differ dramatically in almost every way, including glacial activity, productivity levels, predominant substratum type, and biodiversity. By comparing the ecology and evolutionary history of sister taxa found on both coasts of the North Atlantic, we can uncover the importance of historical and evolutionary differences which otherwise are obscured by taxon based differences. In addition, scientists on both sides of the North Atlantic are working to determine anthropogenic effects, such as human-mediated species introductions. Coordination of their efforts would strongly enhance the usefulness of their results for policy makers.

Developing the North Atlantic as a model system for the study of historical ecology has been hampered by two major roadblocks to collaboration. The first is geographical, with American and European scientists only rarely collaborating to study taxa found on both coasts, or to compare the ecology of the northwest and northeastern Atlantic. The second is the culture of science, where scientists from different disciplines fail to attend meetings in disparate fields, and have difficulty attaining an entree into a literature full of unfamiliar jargon. Our tendency to work independently makes synthesis that much more difficult, since questions of pressing interest to a phylogeographer may not be central to the research program of a paleontologist specializing in the same region.

This proposal seeks to establish an annual meeting bringing together marine ecologists, population geneticists and phylogeographers, oceanographers, paleontologists and paleoclimatologists. These meetings are intended to accomplish five specific objectives:

- Bring together evolutionary biologists (phylogeographers, population geneticists, and systematists) specializing in marine fish, invertebrates, and algae to coordinate sampling efforts and analysis to synthesize patterns of geographic history held in common among these taxa;
- Synthesize knowledge about extant diversity on both sides of the Atlantic, exploring productivity and other factors as explanations for trans-Atlantic differences;
- Encourage collaboration resulting in a series of experiments comparing the ecology of sister taxa, and the parallel ecosystems they populate,on both sides of the North Atlantic;
- Bring ecologists and evolutionary biologists into contact with the oceanographers and paleontologists whose work is essential to understanding the long-term histories of the communities and organisms involved.

THE HISTORICAL ECOLOGY OF THE NORTH ATLANTIC: AN INTRODUCTION

What is Historical Ecology?

Evolutionary biologists define historical ecology as an attempt to understand ecological interactions from a phylogenetic perspective (Brooks 1985; Brooks and McLennan 1991). If two species experience a strong interaction, is the strength of this interaction due to a long shared history, or have they recently come into contact? Although this question has long been a part of ecological debate, phylogenetics has the potential to actually illuminate the "ghost of competition past". For example, consider two interacting species that are suspected of showing niche differentiation, such that one species is large and one is small. If a phylogenetic analysis shows that each species is the same size as its closest relatives from other areas, then it is not necessary to invoke niche differentiation to explain the differences in size.

With respect to community ecology, a phylogenetic framework can help to understand dynamics of community assembly (Cunningham and Collins 1998; Grosberg 2000; Ricklefs and Schluter 1993). Which species have been in residence for a long time (and how long)? Which species have arrived in the recent past (and how long ago)? Are there any generalities about which species have recently arrived?

A Grand Natural Experiment: the impact of the trans-Arctic Interchange on the Recent History of the North Atlantic

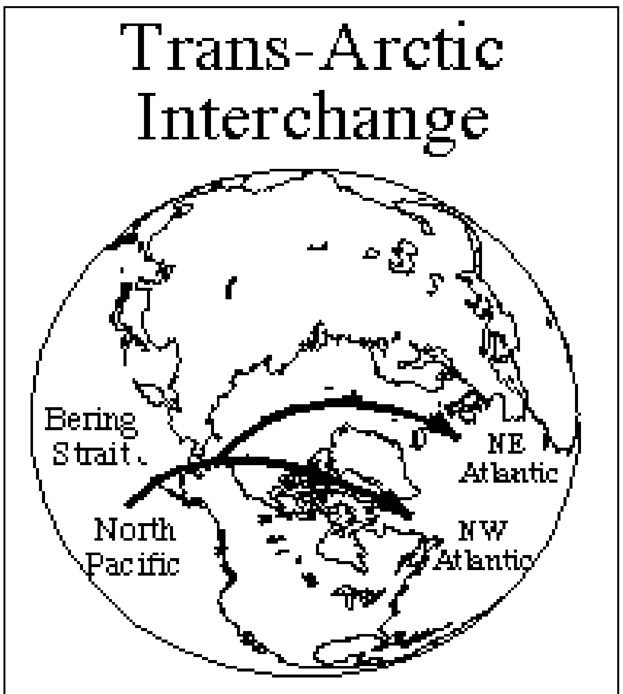

Figure 1

The temperate North Atlantic is an ideal model system in which to address issues of historical ecology because of a natural experiment in biogeography (Cunningham and Collins 1998; Vermeij 1991). A large proportion of species – approximately 80% of rocky intertidal benthic mollusks in New England – have arrived in the North Atlantic from the Pacific since the opening of the Bering Strait 3-5 Ma. (Marincovich and Gladenkov 1999) (Vermeij 1991). This trans-Arctic interchange united the cold water biotas of the Pacific and North Atlantic/Arctic basins, which had evolved independently until that time. Like most other biotic interchanges, the direction of interchange was highly asymmetric (Pacific to Atlantic, Figure 1(Vermeij 1991)). This natural experiment placed closely related species throughout the northern hemisphere, on coasts which differ dramatically in almost every way. This experiment allows direct comparison of the ecology of these closely related taxa, so that observed differences between regions cannot be attributed to taxon based differences. For example, the crustacean isopod *Idotea balthica* is found in a broader range of algal and seagrass habitats, in New England populations than in European populations, and plays a more dominant role in the New England community.

The differences between the northwestern and northeastern Atlantic can be used to investigate community assembly. The last glaciation was much more extreme in the NW Atlantic than in the NE Atlantic, and is thought to have caused local extinction of many benthic species (Vermeij 1989). In some cases, these extinctions may have been followed by post-glacial colonization from the NE Atlantic (Cunningham and Collins 1998). Population genetics, in a geographic context (phylogeography, Avise 2000), has the potential to distinguish between taxa that did or did not survive the last glaciation in the NW Atlantic (Wares and Cunningham in revision). Once the recent colonists have been identified, we can ask which are likely to have been natural or human-mediated introductions, and search for generalities such as what organismal characteristics allow species to survive glaciation in the NW Atlantic. Despite this incredible potential, there have been virtually no comparisons of species found in both coasts of the North Atlantic. Rectifying this situation is one of the central purposes of the North Atlantic Project.

Three Views of Generality in Historical Ecology and Biogeography

A major outstanding question in historical ecology, and biogeography in general, is what role organismal characteristics play in determining composition of communities. Although it may seem obvious that organismal characteristics determine range limits of species, the issue of how those species came to be found in a particular region is open to question.

Interestingly, two completely independent intellectual traditions in Biogeography downplay the importance of organismal characteristics. The first is island biogeography (MacArthur and Wilson 1967), and its intellectual descendants (Hubbell, 1997,2001). This tradition considers raw species numbers, and considers individual species largely interchangeable. Although dispersal and extinction are both central to these theories, the difference in dispersal abilities between individual species are assumed to average out in the end.

The second great intellectual tradition is vicariance biogeography (Humphries and Parenti 1986; Nelson and Platnick 1981). Whereas dispersal is central to island biogeography, in vicariance biogeography the emphasis is on the signal of past fragmentation that can be gleaned from the species that do not disperse from their areas of endemism. If species collected from the same areas show congruent phylogenies, this is considered evidence that they experienced the same series of vicariance events (geographic subdivision). Vicariance biogeography emphasizes huge events that affect entire biotas, regardless of individual organismal characteristics. In this sense, it is similar to island biogeography in that it seeks generality by downplaying organismal characteristics.

In contrast, a third view considers the possibility that organismal characteristics are important. Diamond's controversial assembly rules (1975) argued that the composition of many communities depends on organismal characteristics (see also the forthcoming book "Ecological Assembly Rules" (Weiher and Keddy 2001)). In this vein, Cunningham and Collins (1998) have argued that phylogenetic history has the potential to reveal the influence of organismal characteristics in biogeographic histories. If we are able to identify a set of species that have experienced a common biogeographic history, we can ask whether they share particular organismal characteristics. While this may sound at first like vicariance biogeography, it doesn't assume that there is a single overriding historical pattern (determined by vicariance) that defines an entire biota. Common patterns of dispersal, such as the trans-Arctic interchange itself, can generate patterns as well. In marine systems, with their porous barriers, it is unlikely in most cases that vicariance will affect more than a subset of the biota (with obvious exceptions such as the rise of the Isthmus of Panama). In many cases, we expect that subsequent dispersal between vicariated areas will be extremely common (Cunningham and Collins 1994).

With respect to the North Atlantic, this perspective can be framed in terms of two likely patterns. The first is glacially induced extinction in the NW Atlantic (see discussion above). If a species experiences local extinction *without* recolonization from elsewhere, the range of this species has been restricted. Vermeij(1989) pointed out that paleontology is the only discipline that can unambiguously identify cases of restriction. Cunningham and Collins (1998) argued that population genetic and phylogenetic data can accomplish the converse, and unambiguously identify sets of species that have long endemic histories in the NW Atlantic, and have therefore resisted glacial extinction (Cunningham and Collins 1998 Wares and Cunningham, in revision). Since repeated extinctions and recolonizations may appear in a low resolution fossil record as a coninuous presence, genetic data are important in this context. In high resolution mcrofossil records, these repetitive local extinctions and recolonizations can be directly observed. These stratigraphic records can then be compared to the conclusions of phylogeographic studies.

The first observed pattern is one of long term residence on both coasts of the North Atlantic. *Homarus gammarus* in the NE Atlantic and *Homarus americanus* in the NW Atlantic are sister species, and have had independent evolutionary histories for roughly 1 million years or so (Tam and Kornfield 1998). This “reciprocal monophyly” is strong evidence that *Homarus* has been in residence in *both* the NE and NW Atlantic for at least 1 million years (Cunningham and Collins 1998). What is it about *Homarus* that has allowed it to resist extinction in the NW Atlantic through several glacial maxima?

The second is a population genetic pattern shown by many species strongly suggesting post-glacial colonization of the NW Atlantic region from the NE Atlantic (e.g. the seastar *Asterias rubens*, and the snails *Littorina obtusata,* and *Nucella lapillus* (Wares and Cunningham in revision)). What characteristics allowed these species to invade across the Atlantic? Since the latter two species have no pelagic dispersal, dispersal ability is not the only important factor in colonization ability (see also (Johannesson 1988)). Other factors inlude the ability to withstand the wide temperature fluctuation in the NW Atlantic, and the tendency to occupy dispersal vectors such as floating algae (Ingólfsson, 1995).

SPECIFIC AREAS OF RESEARCH COORDINATION

Although the range of fields represented in this RCN are very broad, we envision specific areas of concrete, mutually advantageous coordination. Through our regular meetings and through classes of information that will be collected at our website, we envision a rapid improvement in our knowledge of North Atlantic biology in the next five years.

Coordinated Phylogeography and Systematics of the North Atlantic Biota

By documenting the evolutionary histories of the temperate North Atlantic biota — and searching for sets of species with similar biogeographic histories — we can ask whether organismally-based generalities exist. For robust patterns to emerge, we need an ambitious coordination effort that will investigate hundreds of species in a comparable framework. This would be the first time such a comprehensive effort has been attempted for any community on earth. We already have 30 laboratories interested in coordinating our phylogeographic efforts (see list of network members below), and we expect this number to grow rapidly as our network expands.

The sheer number of cooperating laboratories is not as important as the taxonomic breadth. For sociological reasons, there is little communication between phylogeographers working with different taxonomic groups. For example, although algal biogeographers have an impressive history of research coordination and synthesis (consider the pioneering volume Evolutionary Biogeography of the Marine Algae of the North Atlantic (Garbary and South 1989), and BIOGAP (biodiversity and genetics of algal populations, coordinated by network member M. Valero) there is virtually no communication between phycological phylogeographers and zoologists — despite the fact that our organisms undoubtedly share many of the same sets of biogeographic histories. Even more than between plants and animals in terrestrial systems, there is an enormous commonality between the experience of benthic invertebrates (particularly when they are sessile) and marine algae, especially with respect to modes of dispersal. Even among zoologists,communication between fish and invertebrate phylogeographers and population geneticists needs improvement. Finally, foraminiferal specialists have historically been lodged in geological departments and only recently have started to develop cooperation with biological and genetic researchers.

Towards a Comprehensive Phylogeography of the North Atlantic Biota

Our coordination in this regard has four major goals:

<u>Eliminate Redundancy:</u> Assembling this network has already revealed that three independent groups have been working on trans-Atlantic genetic studies of the gastropod *Nucella lapillus!*

<u>Inspire Larger Scale of Analysis:</u> We need to think much larger than the few species we are currently studying. With routine PCR and sequencing, multiple species comparisons will become routine. By distributing responsibility for large parts of the trans-Atlantic biota, large-scale projects will become a reality.

<u>Use the Same Molecular Markers:</u> Where possible, we should use the same markers to allow combination of independently collected data sets.

Increase efficiency of Broad Geographic Sampling: We can coordinate our collecting efforts in two ways:

• First, individuals at cooperating marine labs can collect "wish lists" of species from individuals in the network. Where possible, modest compensation by the requesting laboratory will be provided to the collectors. This will allow a more uniform sampling regime across taxa, and allows those individuals most familiar with the local biota to do the actual collecting, which increases efficiency, and increases the likelihood of finding rare species.

• Second, when collecting trips are planned – particularly those involving research vessels – collectors will canvas members of the network via email and through our website (see below), for wish lists of taxa.

Although phylogeographic studies are generally focused on variation within species, they usually turn up cryptic species not suspected by morphologists (see below). Our phylogeographic efforts will be carefully integrated with the efforts of our strong team of systematists and experts in biodiversity as described in the next section.

Re-evaluating the speciational history and taxonomy of the North Atlantic

To fully understand the evolutionary history of the North Atlantic, we must put studies of variation within species in the context of the origin of new species. This is impossible without re-evaluating the alpha taxonomy of North Atlantic species. As described below, the discovery of cryptic species in phylogeographic studies is very important in this regard. Our network includes individuals who have already spearheaded large coordinated efforts in this regard, and we hope to inspire other workers to emulate their work.

The Virtual Handbook of trans-Atlantic Species

Because existing handbooks are restricted to either the American or European coasts, it is difficult to determine which taxa are trans-Atlantic. Even when a species with the same name is found on both coasts, handbooks rarely mention the full extent of the species range, so that a collector won't be immediately aware that a species they have found is also found across the Atlantic. Compiling a list of trans-Atlantic species is complicated by two issues: synonymy and cryptic speciation.

Synonymy: For historical reasons, the same species is sometimes given different names on each coast. For example, the charismatic mega-invertebrate seastar genus *Asterias* had three named species in the North Atlantic; *A. forbesi* and *A. vulgaris* in North America, and *A. rubens* in Europe. A morphological analysis found that *A. vulgaris* and *A rubens* were synonymous, and proposed that American *A. rubens* populations are recent colonists from Europewere recently founded from Europe (Worley and Franz 1983). This has been confirmed by molecular analysis (Wares in press a; Wares and Cunningham in revision).

Cryptic speciation: In many cases, morphologically indistinguishable taxa are actually deeply diverged, and according to many species concepts, should be elevated to species status (Knowlton 1993; Knowlton and Weigt 1995). For example, in the North Atlantic, the isopod *Idotea balthica* is actually composed of at least three deeply diverged lineages, one of which is trans-Atlantic (Wares in press b; Wares and Cunningham in revision).

The systematists and phylogeographers in our network (often the same people!) will coordinate in the following manner to produce this virtual handbook, to be posted to our website:

- First, our systematists will determine the cases of synonymy in their groups (if they haven't already done so, and will recruit appropriate systematists to do so in other groups. For example, our steering committee member Gary Rosenberg's remarkable database of Western Atlantic mollusks (Malacolog 2.0 gopher://erato.acnatsci.org:70/11/.wasp needs to be checked for synonymy against the Eastern Atlantic equivalent (CLEMAM http://www.mnhn.fr/base/malaco.html curated by network member Serge Gofas).

- Second, our phylogeographers will identify potential cases of both synonymy and cryptic speciation, which will inform our understanding of which taxa are truly trans-Atlantic. Steering committee member Ann Bucklin has devised an online database combining DNA sequence and taxonomic information for crustaceans Calanoid Copepods and Euphausiids which can serve as a model for this aspect of our coordinated research (ZOO GENE http://www.ZooGene.org/). PI Cunningham has recently initiated a similar database for hydrozoans http://www.biology.duke.edu/group/hydrodb). For deep-sea benthic foraminifera, Norman MacLeod (The Natural Ghistory Museum, London, UK) has worked with US and European scientists to establish the first image data base and taxonomic compilation, which should become available within the next year. Synonymy of several taxa was established during this cooperation, during which specimens at the Natural History Museum in London were compared with specimens in the Smithsonian.

- Third, we will note which species appear to be human-mediated invaders from Europe (Carlton, 1999), including those indicated by phylogeographic studies

Inspiring and Coordinating trans-Atlantic Ecology Studies

If the North Atlantic is to realize its potential as a model system for historical ecology, we must take advantage of the replication proved by hundreds of trans-Atlantic species. The advantage of studying shared taxa under the different ecological settings of the NW and NE Atlantic is that it provides insight into how differences in community structure influence the distribution and abundance of species, while also allowing for the possibility of local adaptation. It also provides insight into the consequences of community change brought about by species introductions or extinction. Indeed, one of the most exciting prospects for comparative trans-Atlantic ecology would exploit the existence of particular ecosystems (e.g., eelgrass beds, rockweed beds, mudflats) common on both sides of the Atlantic which are very similar apart from the NW Atlantic biota being a consistently lower diversity subset of the EaNEstern Atlantic biota. This trans-Atlantic contrast in biodiversity provides a natural experiment, on a grand spatial and temporal scale, for addressing the pressing issue of how biodiversity loss is likely to influence the structure and function of coastal marine ecosystems. Such comparisons have rarely been attempted (but see the next section), in large part because they will require just the sort of large-scale, coordinated effort proposed here.

We will model our cooperation on the EUROROCK programme which did the same experiments on grazer/algal interactions and barnacle recruitment throughout Europe, which was coordinated in part by network member Stephen Hawkins.

<u>Preliminary trans-Atlantic ecological comparison of decapod crustaceans:</u>

The shallow marine fauna of the European Boreal is richer than the American Atlantic Boreal. For example, there are 41 brachyuran crab species in this part of Europe (Christiansen 1969) versus only 10 in the Gulf of Maine and Canadian Maritimes (Williams 1984). Similarly, in the North Sea there are 18 gadid and more than 6 labrid fish species, but only 12 and 2, respectively in the Gulf of Maine (Williams 1984).

Steering committee member R. Wahle found that in the Gulf of Maine, *H. americanus* and *Cancer irroratus,* the rock crab, were by far the two most abundant subtidal species in cobble, with C. *borealis,* the Jonah crab, typically less abundant. The introduced green crab, *Carcinus maenas,* was more abundant intertidally. By contrast, in Ireland and the Channel Islands, *Homarus* and *Cancer* were the *least* abundant genera of the European decapods. Four other decapod families dominated: xanthid crabs, galatheids, porcellanids, and alpheids with at least two to three species of each.

Very little otherwork has been done directly comparing the ecology of trans-Atlantic marine organisms. The only published work that we know of is by network members Lotze and Worm (2001), who compared the ecology of Baltic and Canadian macro-algae.

<u>Inspiring trans-Atlantic Ecological Studies</u>

Although the International Council for the Exploration of the Sea (ICES) regularly brings together applied ecologists from both sides of the Atlantic, there is no mechanism to bring together basic ecologists in the same manner. We envision three ways to encourage trans-Atlantic ecological research

- First, our virtual handbook of trans-Atlantic species (see above), will draw attention to species shared between the two coasts of the Atlantic.
- Second, each year network members will visit the American Marine Benthic Ecology Meetings and the European Marine Biology Symposium to recruit ecologists to carry out cooperative trans-Atlantic studies. As preliminary results accumulate, symposia will be organized at both of these meetings to highlight trans-Atlantic ecological research.
- We will post an electronic "bulletin board" of ongoing research projects on either side of the North Atlantic, to identify researchers with interests and preliminary research on trans-Atlantic species.

Reciprocal Illumination Between Ecologists, Phylogeographers, Systematists and Paleontologists

Coordination is useful not only within but between disciplines. When ecologists and phylogeographers are studying the same species, they can meet, and teach one another aspects of the species' biology and history that will deepen their understanding of their organisms. If an American ecologist learns from a phylogeographer that a particular species has colonized America in the past 20,000 years, that researcher can investigate the possibility of a bottleneck affecting the ecology of that species. Conversely, if an American ecologists learns from a systematist that a trans-Atlantic species is actually composed of two deeply diverged cryptic species, then the possibility of local adaptation on either side of the North Atlantic must be investigated. Fossil records of taxa can establish were species first were observed, thus possible the location of origin of the modern taxa.

Phylogeographers will be encouraged to study the set of taxa that will be targeted for trans-Atlantic ecological experiments. The annual meeting and electronic bulletin boards will help to bring these researchers together.

Educating Phylogeographers and Systematists about Geology and Oceanography

Although the evolutionary history of marine species cannot be understood without knowledge of geology and oceanography, few phylogeographers and systematists are trained in either discipline. As a result, the literature of these crucial fields can be opaque to those from other disciplines. This problem is compounded by the fact that questions that are of interest to phylogeographers and systematists may not be part of the research agenda of geologists and oceanographers. Each annual meeting of the North Atlantic Project will feature workshops to bring together scientists from these disciplines. This will also give geologists and oceanographers the opportunity to learn about, and to give possible explanations for, patterns found by the phylogeographers and systematists.

For example, the observation that many species of the NW Atlantic have colonized from the NE Atlantic since the last glacial maximum must be reconciled with information from paleo-climatology and paleo-oceanography (Cunningham and Collins 1998; Wares and Cunningham in revision). Similarly, the observation that some species with long fossil histories in the NW Atlantic may have experienced local extinction during glacial maxima followed by recolonization from the NE Atlantic (e.g. *Nucella lapillus* and *Littorina obtusata:*Wares and Cunningham, in revision) may inspire paleontologists to ask whether this lack of continuity is evident upon a closer examination of the fossil record. Also, as discussed above, paleontologists are uniquely suited to identifying cases of geographical extinction (Vermeij 1989).

The workshops at our annual meeting will give an opportunity for workers from these diverse disciplines to directly question one another, and to develop relationships that will allow them to delve intelligently into an unfamiliar literature.

List of Network Members and Institutions

Before discussing the mechanics of how our network will operate, it is important to document the remarkable response to this initiative from a diverse group of scientists. In just a few weeks, PI Cunningham has formed a network of 85 members that have expressed interest in attending our first meeting scheduled for Summer 2002. This list includes the 21 members of our steering committee, and 20 European scientists interested in trans-Atlantic research collaboration.

International Collaborators in italics
*Indicates members of steering committee with bios in supplementary information

Ecology	
*Mark Bertness	Brown University
*Susan H. Brawley	University of Maine, Orono
*J. Emmett Duffy	V.I.M.S and William and Mary
Eugene D. Gallagher	UMASS/Boston
**Stephen Hawkins*	*Director,Marine Biological Association UK*
Mark Hay	Georgia Institute of Technology
Gudmundur Vidir Helgason	*University of Iceland, Iceland*
**Roger Hughes*	*University of Wales Bangor, UK*
Lew Incze	Bigelow Laboratory for Ocean Sciences
Sara Lindsay	University of Maine, Orono
Glenn R. Lopez	S.U.N.Y. Stonybrook
Heike Lotze	*Dalhousie University, Canada*
James G. Morin	Shoals Marine Laboratory and Cornell
Trevor Norton	*Univ. of Liverpool Marine Laboratory, UK*
Richard W. Osman	Academy of Natural Sciences
Henrik Pavia	*Tjärnö Marine Laboratory, Sweden*
Gareth Pearson	*University of Algarve, Portugal*
Robin Hadlock Seeley	Cornell University
Ricardo Santos	*University of the Azores, Portugal*
**Ester Serrão*	*University of Algarve, Portugal*
Ulrich Sommer	*University of Kiel, Germany*
*Robert S. Steneck	University of Maine, Darling Marine Lab.
*Geoffrey Trussell	Brown University
*Richard A. Wahle	Bigelow Laboratory for Ocean Sciences
David Wethey	University of South Carolina
*Sarah A Woodin	University of South Carolina
Boris Worm	*Dalhousie University, Canada*
Biogeography and Biodiversity	
John C. Briggs	University of Georgia
Jim Carlton	Williams College, Mystic Seaport
**Mark J. Costello*	*Huntsman Marine Science Centre, Canada*

Serge Gofas	*Campus de Teatinos, Málaga, Spain*
Gudmundur Gudmundsson	*Museum of Natural History, Iceland*
**Agnar Ingólfsson*	*University of Iceland, Iceland*
*Gary Rosenberg	Academy of Natural Sciences
*Les Watling	University of Maine, Darling Marine Lab.
Biological Oceanography	
*Ann Bucklin	University of New Hampshire/Sea Grant
*Charles H. Greene	Cornell University
Lauren Mullineaux	Woods Hole Oceanographic Institution
Andrew Pershing	Cornell University
Phylogeography, Systematics and Population Genetics	
Fish	
Paul Bentzen	*Dalhousie University, Canada*
Giacomo Bernardi	University of California Santa Cruz
*Brian Bowen	University of Florida, Gainesville
Steven M. Carr	*Memorial Uni. of Newfoundland, Canada*
Stewart Grant	Alaska Department of Fish and Game
Christopher T. Taggart	*Dalhousie University, Canada*
Joe Quattro	University of South Carolina
Eric B. Taylor	University of British Columbia
Invertebrates	
**Thierry Backeljau*	*Institute of Natural Science, Belgium*
*Clifford Cunningham	Duke University
Thomas Dahlgren	Woods Hole Oceanographic Institution
Ken Halanych	Woods Hole Oceanographic Institution
Michael Hellberg	Louisiana State University
Hans De Wolf	*University of Antwerp, Belgium*
Matt Hare	University of Maryland
*Michael W. Hart	*Dalhousie University, Canada*
*Jerry Hilbish	University of South Carolina
**Kerstin Johannesson*	*Tjärnö Marine Laboratory, Sweden*
Stephen A. Karl	University of South Florida
Irv Kornfield	University of Maine, Orono
Catherine S. McFadden	Harvey Mudd College
Jeffrey Mitton	University of Colorado, Boulder
Jon Norenburg	National Museum of Natural History
*Diarmaid Ó Foighil	University of Michigan
Steven Palumbi	Harvard University
David Rand	Brown University
Paul D. Rawson	University of Maine, Orono
David G. Reid	*The Natural History Museum, UK*
*John P. Wares	University of New Mexico, Albuquerque
Algae	
**Chris Maggs*	*Queen's University of Belfast, UK*
Lynne McIvor	*National University of Ireland, Ireland*
**Jeanine L. Olsen*	*University of Groningen, Netherlands*
Myriam Valero	Biological Station of Roscoff, France
Charles Yarish	University of Connecticut

Paleobiology and Paleoclimatology	
Richard Aronson	Dauphin Island Sea Lab
Harold W. Borns	University of Maine, Orono
Thomas M. Cronin	US Geological Survey
Stephen J. Culver	East Carolina University
David Jablonski	University of Chicago
Patricia H. Kelley	University of North Carolina, Wilmington
Rowan Lockwood	William and Mary
P. Lozouet	*Muséum national d'Histoire naturelle,France*
Louie Marincovich	California Academy of Sciences
Kaustuv Roy	University of California, San Diego
*Ellen Thomas	Wesleyan University
Geerat J. Vermeij	University of California at Davis

ANNUAL NETWORK MEETINGS IN AMERICA AND EUROPE

The North Atlantic Project will meet annually, alternating between locations in America and in Europe.

- First meeting is scheduled for August 20th- 23rd 2002 at Shoals Marine Laboratory in New Hampshire, hosted by network member and director of the Shoals Marine Laboratory, J. Morin;
- Second meeting is scheduled in Reykjavik, Iceland, hosted by steering committee member A. Ingólfsson. Given that Iceland is literally central to coordinating North Atlantic research, this will help increase involvement of Icelandic scientists in our effort.

We envision these first meetings as being fairly small (60-80 participants), to allow easy communication between disciplines, and to prevent concurrent sessions from fragmenting our group. The question of how large to allow the meetings to become is of great importance, and will be decided by steering committee (see below).

To reduce fragmentation of the group, most presentation of scientific results will take place during poster sessions, which in a small group will work to cement individual relationships. These meetings will include workshops approved by the steering committee, but topics will include:

- Coordinating trans-Atlantic phylogeography and sample collection;
- How to identify introduced species from phylogeographic data;
- Coordinating trans-Atlantic ecological projects;
- Constructing electronic bulletin boards to encourage trans-Atlantic and cross-disciplinary collaboration;
- Paleo-Oceanography of the North Atlantic;
- Constructing the virtual handbook for trans-Atlantic species, and integrating existing databases of biodiversity;
- Coordinating research teams seeking joint funding from the United States, Canada and the European Union.

THE NORTH ATLANTIC PROJECT STEERING COMMITTEE

Twenty scientists from eight countries bordering on the North Atlantic have agreed to serve on the steering committee, including representatives of every major discipline included in our network (see project summary for list). This group does not include all researchers who have indicated their enthusiasm in playing a central role in our coordination network. We see the role of the Steering Committee as being primarily administrative, as we will regularly seek input from network members on all topics of scientific importance such as designing workshops and facilitating research.

Nevertheless, a project of this scale must be carefully organized by a group of manageable size. The main functions of the coordinating committee will be:

- To meet at Duke University in the Spring of 2002 to plan the first meeting at Shoals marine laboratory. Subsequent meetings of the Steering Committee will take place as part of the annual meetings, and will include preliminary plans for the following meeting;
- To approve topics of workshops suggested by network members;
- To approve applications for travel funding from network members, and to manage the funds sought in this proposal. At first, this will be restricted to funding travel for American scientists and meeting costs for all attending scientists. Additional travel funding will be sought from Canada and the European Union for international collaborators.
- To decide the locations for the next three meetings. This decision will include the maximum size of each meeting (see below).

Size of Annual Meetings and Expanding the Membership of the North Atlantic Project

The North Atlantic Project cannot function without a large number of participating scientists. Our commitment to inclusivity is illustrated by the large size of our steering committee, who are charged with expanding the membership of the North Atlantic Project. On the other hand, larger meetings will inevitably become fragmented according to discipline, which is explicitly contrary to our central purpose. We will attempt to resolve these conflicting forces in three ways that highlight inclusivity.

- The annual meeting is only one way in which scientists can contribute to the North Atlantic Project. Our website and listservs will include summaries of ongoing research and invitations to cross-disciplinary and trans-Atlantic collaboration;
- Recruiting interested scientists by organizing symposia at regularly scheduled meetings, including (in North America) the Evolution meetings, the Ecological Society of America Meetings, the Marine Benthic Ecology Meetings, and the meeting of the Society of Integrative and Comparative Biology; (in Europe) the annual meeting of the European Evolutionary Society, the October 2002 meeting of the Italian Biogeography Association in Ischia, Italy, and the annual meeting of the European Marine Biology Symposium. To improve communication with geologists, representatives of the network will make presentations at the foraminiferal FARMS 2002 meeting, and at the North American Paleontological Convention, and the International Paleoceanographical Meeting.

- If the size of the annual meeting is not enough to include all interested participants, we will give preference for travel funding to scientists who have not yet attended an annual meeting.

Recruiting a Young and Diverse Coordination Network

Recruiting a new generation of workers to trans-Atlantic research will be an easy task. Many of the scientists in our network with the most direct experience in trans-Atlantic research are at the post-Doctoral level (e.g. T. Dahlgren; G. Trussell; B. Worm; H. Lotze; represented on steering committee by post-doc J. Wares). The promise of exciting large-scale research questions should attract a large number of young workers.

The network has a strong commitment to increasing participation from under-represented groups. The leadership role played by women in North Atlantic research is reflected in the high proportion of women in our steering committee (38% vs. 20% in our network as a whole). PI Cunningham has a demonstrated commitment to encouraging minority representation. He currently has Hispanic-American and African American undergraduates working on North Atlantic research in his laboratory; the latter, Audrey Abrams, attended the 2001 SSE meetings in Knoxville supported by the Diversity Committee of the SSE, and is seriously considering a career in evolutionary biology.

We also envisage communication of our results and use of our web site in pre-college education. Steering Committee member Thomas has worked in adult education and is active in developing teaching material in direct cooperation with middle and high school teachers, within the Program for Increase of Mastery in Mathematics and Sciences (PIMMS) at Wesleyan University. Steering committee member Bucklin is working with to develop a high school curriculum module for molecular systematics aand marine biodiversity for her Zoo Gene website.

To encourage young scientists, and scientists from underrepresented groups, PI's will be encouraged to bring at least one colleague to the meetings who belong to one of these categories. In allocating travel funding, the Steering Committee will favor their applications.

FUNDING ALLOCATION

Allocation of Funding to American and International Collaborators

The RCN program intends for international collaborators to seek their own funding to attend meetings. Therefore, this grant would primarily fund travel by American scientists, and fund accomodations and meeting costs for all scientists. Michael Hart and Mark Costello are planning to seek Canadian funding, and several network members have expressed a desire to apply for EU funding. In the interim, most international members have indicated that they have enough funds to travel to these meetings. Because it is unreasonable to ask international collaborators to travel twice to the US during the first year, we will ask for funds to help steering committee members travel to the organizational meeting at Duke University.

Administrative Personnel at Duke University and Supervision of Website

The North Atlantic Project will be coordinated by Cliff Cunningham at Duke University, who will supervise a Duke graduate student responsible for maintaining the website and for handling correspondence and travel reimbursements in coordination with Duke Biology accounting staff.

RELATION TO EXISTING EFFORTS AT RESEARCH COORDINATION

Although this proposal has emphasized the coordination efforts we will initiate, we are well aware of, and inspired by, the many ongoing efforts at international and cross-disciplinary coordination in North Atlantic research. Many of these efforts are aided or coordinated by members of our own network.

Applied Ecology

For applied ecological problems, the International Council for the Exploration of the Sea (ICES) is multi-disciplinary – bringing together oceanographers and fisheries biologists – and is explicitly trans-Atlantic in its scope. Its efforts overlap to some extent with the aims of this proposal (both are interested in identifying human-mediated species introductions), but in general do not extend to basic ecology or evolutionary studies.

Biodiversity

International efforts to document marine species diversity are impressive in their scope, and serve as an inspiration to the kind of collaboration we hope to foment. These include the comprehensive Census of Marine Life (http://core.ssc.erc.msstate.edu/censhome.html) , which includes many initiatives including the innovative History of Marine Animal Populations (http://www.cmrh.dk/hmappros.html), which takes a historical perspective on species distribution and abundance on a relatively short time scale (hundreds of years), which is directly relevant to identifying species introductions, and interpreting the relevance of current ecological studies to conditions that existed before large-scale human impact. The Census of Marine Life also oversees the Ocean Biogeographic Information System: (http://marine.rutgers.edu/OBIS/), which is a database of global marine animal and plant distributions, and whose Gulf of Maine Biogeographic Information System is under the supervision of our network member (Mark Costello). He a model of trans-Atlantic research coordination in that he just moved to Canada from Ireland, where he founded the European Register of Marine Species (http://erms.biol.soton.ac.uk/).

Finally, two comprehensive and unique databases on molluscan distributions in the North Atlantic are represented by participants in this proposal: Malacolog 2.0, a database of Northwest Atlantic mollusks created by steering committee member Gary Rosenberg (see bio: gopher://erato.acnatsci.org:70/11/.wasp), and Check-List of the European Marine Mollusks under the curation of participant Serge Gofas (listed above, www.mnhn.fr/base/malaco.html).

Other important European initiatives including Fauna Europaea (http://www.faunaeur.org/), and BIOICE (http://www.hi.is/pub/smc/bioice.htm), which is organized in part by network member Gudmundur Vidir Helgason, and is being integrated with a census of the Gulf of Maine (Les Watling and colleagues).

Interdisciplinary Coordination in North America:

Within North America, the Regional Association for Research on the Gulf of Maine coordinates research among multiple institutions and individuals, including two of our network members (Lew Incze and Chuck Greene).