

Disclaimer from the minute-takers: These minutes are meant to record the overall flavor of the discussions, and are not meant to be a word-for-word script. We recorded the minutes to the best of our abilities, but sometimes not everything could be transcribed, and mistakes probably occurred. We apologize to everyone whose words are not accurately represented.

CORONA Thursday, Aug. 22nd, 2002 Morning Session

Introduction- Cliff Cunningham

Welcome to CORONA – Coordinating Research on the North Atlantic - I didn't want an acronym, but I kept getting suggestions: John Wares suggested NARC (North Atlantic Research Coordination) - so 'flexibility in the face of initiative' - I took Gary Rosenberg's suggestion of CORONA (Coordinated Research On the North Atlantic)! So, what's the motivation for the conference, what exactly is the network about? That was the most frequent question at the steering committee meeting. We have a cross-section of expertise in the room to direct the network in different directions

Historical ecology – used in many contexts especially in paleontological circles; Brooks 1985; important to have some historical information to distinguish between various different ecological hypotheses – Brooks - bringing in phylogenetic information to inform the study of ecological interactions; his dream was to take an entire community and evolutionary biologists would bring in knowledge of species, share with ecologists they interact with directly so the ecologists don't have to learn the arcane literature of creating cladograms so we could work directly together to find questions ecologists are interested in and the kind of info evolutionary biologists can bring, and then experimental ecologists can do the experiments evolutionary biologists are interested in; looking for historical associations between organisms, some may have come into being recently, while others could be older – how recently have they come into contact; this can also tell us to some extent whether organisms have been changed by interaction; idea was a great one I thought; but there's no community in the world where the evolutionary biologists have stepped up to the plate and said 'let's bring the info to the ecologists in a big way, and start looking at a community in general'; there's the Caribbean terrestrial fauna, there's been good work there, but I'm partial to the North Atlantic.

So why is the North Atlantic a great place for this? Why we should make this a system where others run to emulate what we're doing here? Getting evolutionary biologists and ecologists here to work together – just meeting is a barrier, since we go to different meetings; geologists are comfortable working together in big groups, but biologists have a plaid shirt mentality, usually working alone, we don't tend to work together in large groups; but times are changing: we've seen other initiatives – eg. Deep Green, where all the plant systematists chose a certain set of genes to work on and worked together and they solved a lot of problems in vascular plant phylogeny in short order

Reasons the North Atlantic is special:

1. Trans-Arctic interchange: began when the Bering Strait opened – generally 6-3.5 Ma; North Atlantic and Arctic basins were completely independent from North Pacific basin for a long time, the interchange was incredibly asymmetric; mostly from the Pacific to North Atlantic and this was preceded by a major extinction event in the North Atlantic; particularly in rocky intertidal communities – have North Pacific animals ending up in the North Atlantic; from

an historical perspective that makes this a tractable problem – they've only been here a maximum of 6 Ma; it simplifies the job of figuring out what species have been where; amphi-Atlantic biota – taxa shared between North America and Europe; in some cases the same, other cases sister species; that makes the North Atlantic a wonderful natural experiment; soon after exchange there were the glaciations, which bottled up temperate taxa –they were trapped in North Atlantic, then subjected to a series of major glaciation events, on two very different coasts; diversity is much higher in general in Europe than North America BUT NOT IN SOFT BOTTOMS; if I were to try to set up a situation where I wanted to track the history of species in different environments, I couldn't have done it better than in the North Atlantic; it's dramatically understudied as to its full potential. We haven't been working together (in general) to come up with a coordinated research program. It's waiting for its promise to be fulfilled;

2. Parallel experiments: we can set up parallel experiments in these very different environments, ask how do the same or closely related species interact in these different environments – how well have these different interactions been studied; Boris Worm has started looking at these differences; some of the potential is starting to be explored;

3. Compare species abundance and distribution on both coasts: in order to be successful, we need not only large-scale ecological studies, but we need also to compare distributions and abundances on both coasts; for example, *I. baltica* is marginalized in Europe, but it's much more abundant and sometimes top dog in North America;

4. Do phylogenetics for all species! It's tractable to do the phylogeographic analysis and historical analysis for virtually all the trans-Atlantic biota; 1000's of species from algae to fish; but I think if we get collection taken care of, this is a fairly trivial problem; not a huge problem as long as the collections are in place; given funding, significant collections can be obtained – need collaboration.

5. Establish sets of species with identical histories: Very briefly, another advantage to being able to get phylogeography for virtually all the trans-Atlantic biota is to answer a question many people have been puzzling over for a long time – are there generalities about the distributions of organisms, or is chance a bigger factor in affecting distributions? Compare sets of species that went extinct in North America and recolonized from Europe or from the Pacific, different sets of species with similar histories; is this driven by something in common between species, or is this chance? Resisting extinction in New England and the Maritimes – are there a certain set of characteristics that allow you to do that? Perhaps having good dispersal ability would allow you to hang on (Wares and Cunningham 2001) soft sediment taxa in Europe might be more prone to extinction than hard substratum taxa in Europe (Sally Woodin); etc. Until we have a really large set of taxa we won't be able to address this; the potential to answer age-old questions is high. There are essentially two levels of coordination going on – in order for this to work, we need geographic coordination (often we each study an amphi-Atlantic species on only one coast) and cross-disciplinary aspect – important; in next couple of days, not just saying wouldn't it be nice if we did this, etc. but steps toward really achieving a synthesis in the North Atlantic.

Structure of the meeting:

Today and tomorrow morning – raising research questions of interest in the North Atlantic; when presenting, not only give a capsule of important highlights that someone outside of your field needs to know, but also to raise questions that you think you need information from other fields; eg. I need help with a lot of paleontological/geological questions. We're avoiding

powerpoint, there's a time limit of 10 min for each presentation, informal, short, 15 minutes of discussion; make presentation directed toward starting discussion going; tomorrow afternoon – plans of action; specific plans of research that folks here would like to pursue; specific ideas of how to obtain funding; agenda is flexible.

Boris Worm – Could you give us one sentence on the product?

Cliff Cunningham – Many such products, one that I mentioned before – the idea of collecting sets of taxa that have had identical history and to see if a generality emerges from that; also we will identify longterm residents (shared history) and taxa that have come over in the last 20 kya from Europe; allow us to determine species in refugia, coevolutionary process...

Boris Worm – What about very recent stuff – last hundred years – the most recent introductions of species?

Cliff – We can rule out taxa that are introduced species by species (?) new paper by John Wares on *Littorina littorea*, for example

Steve Hawkins – Can we have a low tide break this afternoon?

Cliff – 5 PM

Geerat Vermeij: First of all, the North Atlantic is a biologically complicated place with various faunas; you can't understand the North Atlantic without understanding other areas – North Pacific; the North Atlantic and Pacific were joined at about 5.3 Ma, in the latest Miocene (Louis Marinovich's work, I recommend his Nature paper 1999?); found fossils of latest Miocene age – from the Kamchatka (I think) fauna of the North Pacific. The North Pacific and North Atlantic are remarkably similar considering different histories; probably less than 2% of the North Atlantic fauna moved to the Pacific, 23-46% moved from Pacific to Atlantic; I published paper on molluscs in both basins (1991)– 34 species that either moved into the Pacific or are descended from those; 261(?) that moved from Pacific to Atlantic. I am currently inclined to think that fewer went from Atlantic to Pacific; either very small taxa (overlooked in Pacific) or dubious taxonomy – no more than 24/25 that moved into Pacific; the asymmetry is remarkable and incredibly striking. Logistical problems have beset the whole history of the North Atlantic: the paleontologists that have worked on the faunas consist of largely Europeans and North Americans, Japanese and Russians; well until the early 1990s all these groups operated to an extraordinary extent independently; American and Russians literature developed largely separately. This has changed in no small measure thanks to Gladenkov and Marinovich, also Japanese collaboration; but still there's a surprisingly major separation between North America and Europe, eg. paleontologists that work in North Sea basin know little about North America, and vice versa, and Atlantic people know little about the Pacific. This needs to change; in particular, we need to establish common chronostratigraphy and try to coordinate when various extinctions took place – this is kind of known but not in detail. There are very large beautifully preserved faunas in the eastern US – Yorktown (VA), also in Iceland, Britain, Belgium, etc. Various specialists have studied incredible stuff independently and we don't know in detail how they are correlated with one another. Very likely they are consistent with one another but we don't know in detail. It's important to establish this in detail, also to correlate with the Pacific. The history of temperate fauna is utterly different from the tropical fauna. There are some pre-KT boundary fauna in temperate oceans; a substantial element besides from Paleocene/Eocene in Europe and probably North America as well that have always been only in the North Atlantic

(never made it to the Pacific) *Arctica*, *Astarte*, etc. Lots of taxa in the North Atlantic extend to the early Oligocene in the North Sea basin. They have always been in the North Atlantic, similar panoply of North Sea clades; still fighting about where the Eocene/Oligocene boundary is, and when cooling occurred, etc. Within the Atlantic component of native cold taxa, there's a quite interesting distinction between east and west. Species stuck to just the east Atlantic coast – *Patella*, *Arctica* (until late Miocene); *Cerastoderma*, etc. Conversely, North American side also has a substantial series of taxa, most are extinct today, but some survivors – *Placopecten magellanicus* (since middle Miocene), *Urosalpinx* (oyster drill) *Crepidula*, *Ilyanassa*; , and a bunch of somewhat deeper water bivalves as well. There must have been some cross-fertilization across the Atlantic in the early Miocene – there are clades represented on both sides. In the western Atlantic, there's a clade in late Oligocene until extinct in Pliocene. *Astarte* probably indicates an interesting trans-Atlantic invasion about which we know essentially nothing. We can learn further by looking at eg. *Astarte* from both sides, also scallop groups, extinct chasopecten (this is wrong, what is it supposed to be?) in North America and more in Europe (extant); some other species of bivalves; also *Homarus* across the Atlantic: there's an eastern and western Atlantic species, also a South African species.

Some oddball things – a genus typically referred to as *Ceronia* – mesodesmatids (?) are found in the western Atlantic, also found in Australia, New Zealand and Chile; fossil species from the Miocene, would like to know where Atlantic ones came from; most of North Atlantic temperate groups came from warmer groups; when did cold adaptation take place? It would be interesting to know this from Atlantic and Pacific – same time at both coasts, or not? We have both warm and cold water representatives in North Atlantic; getting somewhere with *Crepidula* (Rachel Collins' excellent work); amphi-Atlantic species – on both sides of Atlantic – although most of these are of Pacific extraction, more later; many are also deep-water native Atlantic taxa, or shallow water species, that we know little about. For eg. *Arctica islandica* – don't know much about it. There are also various native scallop taxa we know little about. On the whole, the trans-Atlantic species to which we assign the same name on both coasts are of Pacific origin. This raises an interesting point – the trans-Arctic interchange when it took place – probably means a series of events - resulted in a series of introductions to the Atlantic of species that have a broader distribution than either Atlantic species of that time or do today, based on phylogeny and the fossil record; timing straight – don't fully appreciate complications; Marinovich bases latest Miocene time of North Atlantic things moving into Pacific (notably *Astarte*), also a couple of bivalves; at least two major fish groups – *Gadus* (cod/haddock), *Clupea* (herring); there may well be others, but those are two I'm familiar with. This took place extremely early – latest Miocene to early Pliocene, but then at about 3.5 Ma, the tide changed or perhaps the current changed because of the closing of the isthmus of Panama – the general flow of the Bering Strait changed from north-south to south-north, though I'm not totally convinced, then the huge invasion from Pacific to Atlantic began, probably in waves. We know of earliest invaders from the fossil record – *Buccinum*, *Mytilus*, *Mya* in Yorktown; in Belgium we find some of the same taxa – *Buccinum*, *Mytilus*, etc.; in the late Pliocene – a whole flood of invaders, also see them in UK, Iceland, etc. document very well this flood of invaders into Atlantic basin; these correlate rather well with major extinction events; it looks as if not only were there the current changes in the Bering Strait, but a huge extinction or series of extinction events that eliminated a bunch of incumbents and perhaps made invasion easier; almost all the invaders from Pacific to Atlantic are known either from the western side of the Atlantic or from both sides; now no known example that's only in eastern North Atlantic; *Littorina littorea* would have been only example,

now wiped clean, but wasn't best example to start with, since it was known from the Pleistocene in North America.

There are 23 examples of Pacific to Atlantic invaders that are known as fossils in Europe, but are living only on the North American side; eg. carditid fossil in Iceland, living in North America; various buccinids, also true for a couple of Atlantic taxa – *Certadaria* – *C. siloqua*, etc. in banks of North America; *Atractodon* is an extinct genus of buccinid. It's extinct in Europe, also North America, but survived longer in North America. This suggests that during the Pliocene the American side suffered 2 times as much extinction; In the Pleistocene, the American side served as a refuge for some soft bottom taxa eg. *Certadaria*, *Atractodon*; *Mya arenaria* (*M. arenaria* was also introduced to Europe in 17th century, but survived on North America side throughout Pleistocene); needs more work.

From a biogeographical point of view, the invaders from Pacific to Atlantic have greater geographic distributions than the native fauna. We don't know when those trans-Atlantic distributions were established, how often they were established and whether they're being maintained today – in genetic contact.

We have an almost completely different understanding of environments from fossil and ecological data; most of our ecological intuitions come from rocky shores, marshes, shallow water, while most of our fossils come from shelf depth. The best fossil record is from an environment that we understand little about ecologically indeed; we need to not only track temperature but change in potential productivity issues. I have been extremely impressed with the work that Boris Worm has done, trying to understand the role of productivity - could be applied to the fossil record and vice versa. If we look at the fossil bivalves, they have large body size in the North Sea basin - eg. *Mytilus* is 150 mm; bivalves eg. *Pecten*, *Clammus*, cockles, are 1.5x the lengths of modern individuals there today. Some of the extinct taxa were immense animals, this implies, with geological evidence, that there was extremely high planktonic productivity on a widespread basis on both sides of Atlantic until Pleistocene? a long decrease in primary productivity affected the potential for maintaining populations. We can perform growth studies with and without isotopic studies – eg. growth increments and sizes in fossil barnacles from late Miocene for Maryland, *Concavus chesapeakensis*, enormously high growth rates, high productivity environment. We can look at growth rates in fossil and extant individuals of the same species, regional variations in geographical scale, and assess how productivity has changed, where and when, in order to get some sort of understanding of the role productivity plays in fates of taxa – the evolution of lineages. I feel deeply and strongly that if we're going to study any evolutionary history of species, we cannot ignore their ecological context. Pacific invaders may have “experienced the world” differently than native Atlantic species. Cliff wonders whether there were groups of species, and I think there were, but we also need to know about ecology of these groups – what were they doing? In these environments it is essential if we want to get a hold of North Atlantic, hemisphere histories.

It's likely that all the cold adapted faunas arose from warm water faunas, but where, when, and how are open habitats (?)? Pacific – Oligocene? Also Miocene, coming from deep water; in the Atlantic we know less, other forms about which we know essentially nothing; if we are going to understand history, include ecological history, can't rest our attention only on the North Atlantic, we have to look at the North Pacific, also cold southern representatives of these groups. Understanding where ecologically these species come from is a large part of studying North Atlantic history; since they're clearly all immigrants – it's kind of like living in the US – species come from different places, fulfill different roles. Clearly a majority of Pacific species did not

invade the Atlantic – why did some and not others? Look at the comparative ecology of those that did and did not, but not just dispersal – we have all these different roles – who fills them, and how do they manage to coexist?

Cliff – ... a different perspective from someone who works on genetics – I disagree with your interpretation of relatively few species in Europe. I see it as generated by bias in dispersal, not extinction.

Geerat Vermeij – No one's looked at these species genetically – species that were on both sides, and now are on just North America side.

Emmett Duffy – Geerat's talking strictly about soft sediments; Cliff, your data's from rocky shores.

Cliff – *Arctica*...

Geerat – *Arctica* isn't in this group, since it's found on both sides of Atlantic; the taxa we might want to quibble about are *Mya*, *Certhadaria*, we know they became extinct in Europe; you're probably right that things didn't disperse from North America to Europe, and perfectly likely that things reappeared in North America from Europe, or from the North Pacific (eg. *Strongylocentrotus droebachiensis*)

Susan Brawley – trans-Atlantic species are of Pacific origin?? I would say *Fucus* and *Ascophyllum* are clearly dominant organisms. There has been movement of *Fucus* species from the Atlantic back to Pacific;

Geerat – I would agree with that; the majority of mollusks and barnacles on both sides of the Atlantic are Pacific invaders, but not everybody. *Fucus* is a conspicuous exception.

Susan – ...start looking at small animals that could be carried on macrophytes.

John Wares – From Agnar's work – find a lot of these small organisms floating in rockweed 500-1000km offshore...

Geerat – *Idotea* could be another invader

Jon Witman – Do species with broad geographic distributions also have broad depth distributions?

Geerat – Depth distributions are often all over the place – we don't know enough; most of the trans-Arctic invaders are relatively shallow water species. Invasion of deep sea early in history of groups in the North Atlantic(?) some of these species appear to be intertidal – can't say exclusively intertidal – even for *L. saxatilis*, *M. edulis*; as for the idea that there are strictly intertidal species in the North Atlantic ... there are very, very, very few of them – the few I do know are native Atlantic taxa

Boris – The extinction that coincided with the invasion from the Pacific – is causality clear? Did extinction make room, or did Pacific invaders displace Atlantic species??

Geerat – The fossil record is time averaged, incomplete and spotty – causality can never be totally established; For invasions today – there's lots of invasion, but no extinction; with exception of endothermic mammals, and human effects, I would argue that invasions of marine organisms don't cause extinctions; Invaders may be good competitors, but they're not going to cause extinctions – there's always some kind of refugium. Invasions are fast, but not so fast the natives can't adjust to invasion. As far as I can tell, the extinctions are indistinguishable from invasions in terms of timing; I would prefer to think of it as happening in that order.

Diarmaid O'Foighil – As for the Pacific to North Atlantic invasion – the logo shows a bifurcating invasion – one arrow on either side of Atlantic, to each side of Atlantic – is this purely schematic, or is there any reason to believe there were two different pathways?

Geerat – We don't know; we think they came north of Canada...

Ellen Thomas – The Arctic was much warmer then.

Geerat – Good sampling of Arctic populations is essential; need to do with *Mytilus*, *Littorina saxatilis* group – this is knowable but right now we don't know.

Jon Norenburg – Is there any sense for what proportion of infauna vs. epifauna took part in the invasion?

Geerat – I've never calculated that explicitly, but around 75-80% of rocky shore species are of rocky shore origin; on this coast it goes down to 50% (on soft bottom, I think?) *Echinarachnius parma* is one, the calculation could be done.

Larry Harris - Two comments: most of the temperate fauna tends to have a warm water origin

Geerat – ultimately yes

Larry – may be a product of recent invasions – south of Cape of Cod, starting in warmer waters, moving north, bypassing coldest areas, ending up in warmer areas in Nova Scotia and the Northumberland strait, then cold adapting; also invasions through Arctic for trans-Arctic interchange...

Geerat – In early Pliocene the Arctic was much warmer. It's astonishing how rare cold adaptation really is; even in the late Oligocene, early Miocene, when it was warm, even 3% of northern taxa evolved cold adaptation. The American case is best understood – since the Pliocene we only know of about 2 clades that apparently have cold adapted – *Crassostrea virginica* and *Urosalpinx* – and neither has done particularly well – they're in warm bays, the Northumberland Strait, but not particularly widespread; very few such examples.

Geoff Trussell – Using enhanced productivity to explain big body size in suspension feeding mollusks ... including body size with increasing latitude (i.e. decreasing temperature) can we tell if temperature was the cause?

Geerat – Could use isotopes (I'm skeptical) but can get seasonality and growth rates out of it; I don't think clines in body size are as well established as you think they are; a lot more variation than we need to think eg. *Littorina littorea* – largest body sizes in Newfoundland; but big individuals in England, France as well (not as big, but still big).

Steve Carr – I'm excited I've come here – I'm a gadid worker – I've worried how things came back from the Pacific to Atlantic through Arctic – how does that happen? It's completely irrational to me...

Geerat – *Gadus*?

Steve - *Gadus macrocephalus* and Greenland cod

Geerat – *Gadus* in general as a genus has a long and rich history in the North Atlantic basin; I would interpret this as an example of going from the Atlantic to the Pacific; could be *Gadus morhua* evolved in Pacific and moved back into the Atlantic...

Ellen Thomas' session

I'm from Holland; there may be a lack of communication between paleo types and biotypes but between different types of paleo types, too. I'm a micro paleontologist. I've been in the US for 20 years; most of the time, I call myself a paleoceanographer. Geerat was talking about changes over time, the open ocean people say there was a biogenic bloom - high productivity - in late Miocene and early Pliocene – similar signals, should have talked to each other more; I work with foraminifera; some of you may not know what they are and that they have enormous importance. They're 1-celled, eukaryotes; fit in meiofauna; 63-250 microns in diameter, there

are a couple of big ones that reach about 15cm – pretty good for one cell; they cheat – intensive mixture of organic and inorganic stuff; we're rich in history (since Linnaeus), poor in ecology; we know an awful lot about the species distribution. We know more about what lives in the Arctic at what depths than any other groups. Because they're so small, it's easy to get many samples. Also can play games with the isotopes – get information on productivity, salinity, temperature... they occur in freshwater and saltwater, occur from the intertidal way down into the deepest ocean (Marianas trench). I have experience mostly with really shallow and really deep – salt marches in New England and England, also Long Island Sound, and > 1000m, mostly linked with ocean drilling programs – there's been a huge international research program, since the 1960s, officially ending in October 2003; trying to get it extended – it's the only program that drills into deep water. The Japanese are building another ship, and it'll be ready in 2007. In between, we'll be using mission-specific platforms – a Finnish vessel, and 2 other ships; what we hope to get from this ship is a history of at least small things diatoms/forams/radiolarians in the Arctic for the last 50 Ma! Ideas about changing patterns of water flow will change considerably in upcoming years.

Used to being Protista, but it looks like forams are going to have their own kingdom – Granuloreticulosum(?); forams are fairly different in the way they form actin and tubulin, and the way they move their pseudopods. Forams can be CaCo₃ or sand glued together or organic matter. They have a soft body inside and an outside shell. There's one small hole in the shell; shallow-water forms – we know how they move but hardly know anything about their ecology. They have both sexual and asexual reproduction – can do either exclusively or both. There are 5000 described species, forty are planktonic. There are 40,000 fossil described species. I don't know of any species that have been defined by biology, it's all based on the shell. We're just starting to get genetic info – Kay Darling in Edinburgh working on the planktonic forams; Jan Pavlavisk(?) and group in Geneva – working on the benthic. Genetically, there are many more species than what we'd think based on the shape of the test – this could change things enormously. It's the same for planktonic forams. Depending on where things live, different genetic composition, even though their shells are similar. You are forewarned that what I say about shells is not necessarily a biological reality!

Coffee break

(minutes typed by A. Govindarajan)

Cliff - Welcome back to the second half.

Ellen – Mention what we know about rare forms and migrations (hardly anything); can't support or contradict Geerat's (***didn't get everything**)

With shelled forams, don't see differences between North Pacific and North Atlantic. Most deep-sea forams are cosmopolitan; differences in relative abundance, same species everywhere. In the last 2-3 years, there have been cooperative efforts on taxonomy; hope to have cd out by end of year for the most common species. Common species tend to be cosmopolitan, rare ones endemic. Coastal salt marshes – same species in all temperate zones, same species also in mangroves at low latitudes, and North America slightly richer than European salt marshes. It's the same for very shallow water stuff. Long Island Sound, similar depths in Baltic; species live on vegetation usually on both sides of Atlantic Ocean. Remember – don't know what are true species, just based on tests.

For glacial episodes – records over several episodes, in detail, in the Pacific, Atlantic, many places. Strong coupling between surface production and forams at bottom. Food is most limiting to deep-sea benthic forams. In the last glacial maximum, migrate southward, same species at higher latitudes are at lower latitudes at last glacial maximum (***draws on map**).

Don't have information. New England information mostly since last deglaciation, decent records 8000 years ago to present. In the North Sea, records don't go back farther than 8-9000 years either. Almost all the information is since the last deglaciation.

Common species occur just about everywhere, rare ones seem to be endemic, in general. When looking at large samples see this. Fast dispersal rates one group of species called **?(*didn't get)** have information original from the southern hemisphere from time of cooling of ocean; forams dispersal states, gametes, etc must have motile states that disperse from the Pacific to Atlantic.

One more thing about temperature – interested in transfer of food to bottom of ocean; strong coupling with surface production, same pattern if you look back. Deep Ocean, which is close to freezing everywhere but in early Cenozoic about 12? deg everywhere; so everything must have adapted from 12 deg to near freezing; everything we know must have adapted from living at about 12 or so to near freezing.

John Wares – What does that mean about circulation? (***didn't get**)

Ellen – In the present day, deep water formed in the Arctic, rest from the Weddell. Deep-water circulation starts at high latitudes; in the past this was not the case; Mediterranean, salty-dense; in the Cenozoic, dominant circulation formed at high latitudes.

Daphne Fautin – Ecologically and physiologically too, temperature is a proxy for more things; it is easy to measure but other things correlate with it, and so that is another ecological factor to take into consideration, not just direct effects of temperature, but its correlates.

Ellen - At the time of rapid cooling, the temperature of the ocean everywhere was the same. If you look at oxygen isotopes, all water comes from surface at high latitudes. If you look at diversity gradients from high to low latitudes, see a gradient with more diverse deep sea stuff in tropics although temperatures the same, due to productivity, not temperature? not carbonate effect, not temperature effect;

Phil Williamson – size effect on distribution – once below a certain size, those organisms distributed everywhere, argument for freshwater, finding if you look hard enough you can find anything; manipulations in freshwater, change conditions and some species become more abundant.

Ellen – and for some forams, transport by birds or something like that, from lakes – forams show up. I don't know if it's size, since forams size range as ostracods, but see Pacific-Atlantic migration in ostracods, there's more evidence for migration in ostracods than forams., but same size range. We need to make more comparisons

Cliff – Tried to get (***didn't get**) to come.

Sally Woodin – Look at the marshes south of Montauk, where it hasn't been glaciated?

Ellen – No, but **?(*didn't get)** has, someone also in Gulf of Mexico.

Sally – Would be nice to know Cape Hatteras.

Ellen – Many species similar, carbon saturation may start to kick in, make thicker shells.

?(*didn't get) – What sort of temporal resolution can you get? Yearly?

Ellen – The best you can do is seasonal, variability in production, no bioturbation, in some places in Long Island Sound 4-5 years; in the deep ocean – some places at least decadal

resolution; strong seasonality means dominated by opportunistic taxa; in the equatorial Pacific indicates strength of El Niño.

Susan Brawley - If you were to draw the map for Northwest Atlantic, would you include North Africa?

Ellen – Yes.

Cliff – Thanks.

Karl – Thanks for inviting me, I'm from the Geology Department at the University of Maine, new project in Gulf of Maine, I'm a geochemist by training, in high-resolution ice core records for climate variability. Greenland ice core records provide a good record of climate variability in the whole North Atlantic region, 100,000-year records have found a number of rapid climate changes that occurred. A number that occurred with periodicity of 1500 years. What is cause of climate swings? Changes in thermohaline circulation, atmosphere, orbit, ENSO...

In the North Atlantic, variability is recorded in ice cores; also, large ice sheets – Laurentide and European ice sheets; influences coming together to produce variability. Don't understand all forcing factors. One thing – interaction? (***didn't get**) of ice sheet during retreat into Holocene and the paleo-oceanographic conditions. One place to study is along the (***points to map - America**) look at sediments in here, Gulf of Maine, moraines; go to ice margin sediments and find forams bivalves' interested in taking those shells and look at paleoceanographic conditions at ice sheet margin. Look at isotopic comp of shells; *Mytilus edulis*; collect as juveniles, culture at the Darling Marine Center, we do isotope work, to get calibration between water condition and isotopic comp, and use to reconstruct paleoclimate. We can provide some paleoceanography and climate variability in the North Atlantic, but I'm not a biologist, but understand from geological point of view. We can identify what species, but don't understand their environments, depth range, etc. Nevertheless, that's why it is great to be here and be included.

Cliff – Looking right at the margin of glaciers, great – the single *Littorina littorea* fossil is found in Nova Scotia, dated in 1977 as being 40000 years ago, at the height of glaciation. I wonder if it is misidentified, or what, whether temperate communities were found right up next to ice sheet?

Ellen – How did he date it?

Cliff – I don't think it was carbon, I'll check. Do you see *Mytilus edulis* right up by ice sheet?

Karl - We haven't find *Mytilus edulis* right there, but others. As the ice margin retreated, land rebounding, *Mytilus edulis* is there while ice margin was in region or soon after it left. We find different species but we need help with these assemblages.

Ellen – Do you have coverage for different time intervals?

Karl - It wasn't just a linear recession, there were times when it receded faster than other times when it advanced again - a very complicated retreat.

Geerat- It could also be that some areas were not completely glaciated. The Northumberland Straits are fairly warm today, maybe always.

Karl – Yes, it is very complicated. We've restricted ourselves to Gulf of Maine.

Steve Hawkins (?) – Is there parallel archaeological information, shell middens?

Karl – Yes, around 10,000 years ago onward although we haven't looked at them yet. Lots of *Mytilus*, it may be the majority in the middens.

(***??**) – Give different info than forams?

Karl – Don't know, isotopes – use different species but same calibration curve, but the curve may not be applicable to all species, so we do culturing experiments for the exact species we are using.

Ellen – Aragonite or calcite?

Karl – Both.

Vermeij – Calcite/aragonite ratio varies depending on the environment.

Try culturing several species at same time.

Karl – Hope to set up experimental methods that can use for other species.

?(***didn't get**) – Do you get *Arctica* in these assemblages?

Karl – Yes ... (***didn't get**)

Vermeij – But those are two different things.

Karl – People have done collecting shells in situ and calibrating, but there are still lots of unanswered questions, so that's how we got into culturing.

Ellen – Seasonality is important.

Cliff – Fascinating, thanks.

Phylogeography session starts

John Wares - 5 people, doesn't represent everyone but five that we could contact to give you some idea in the ways this can be useful to others. First Steve Carr and genomics, then go through the other experts.

Steve Carr

Seagulls – souls of grad students that didn't finish that now shit on our heads

I'm from ... University in Newfoundland, we have the eastern-most sequencing facility. I work on systematics and population biology in gadids, and the Atlantic cod in particular. Also, harp seals. Rather than discuss specific examples, I'll talk about approach.

The approach is genomic phylogeography. Don't have to define phylogeography. Cliff - well you might want to – it is to understand relationships in geographic context. We look at gene trees in their geographic context. Our approach is DNA sequencing, and looking at trees in an ecological context - an intersection of geneticists and ecologists.

Genomics – is to genetics what many is to one; it is the study of complete or very large gene sets, especially since the publishing of human genome. We work on the mitochondrial genome, about 17000 base pairs, very large but tractable. A new way of thinking about biological problems - genomic thinking – a horrible concept at first, as biologists we are trained that we won't have much money, so we design experiments to get a minimum data set, invest lots of cleverness in this. In genomics, don't want to spend a lot of time figuring out which gene so do them all. If you have the money and expertise, don't bother with single gene.

(***Drawing on board**) – a star phylogeny, there is a common genotype throughout the range of the species, then others differ by single mutations, and some are found only in certain populations, radiating from the central genotype. How are genotypes distributed? Let's do the whole 17000 bp, increase in data. What might we see? This is what we see in harp seals – the single genotype in the middle actually breaks into a couple genotypes, some might be distributed like this (***drawing**). It turns out that phylogeographic structure is very clear, there are groups of genotypes found only in certain populations. Some that appear to be identical are indicated to be parallel mutations. Therefore, in a fully resolved phylogeny, we can get very detailed information.

Harp seals – are in four places – Newfoundland, Gulf of St. Lawrence, Ireland, and between the White and Bering seas. Up to now, three separate populations (***pointed on map**). We looked at the complete mitochondrial genome for 10 individuals from each population, and

we saw two eastern populations with very ancient lineages confined to eastern Atlantic. The western North Atlantic is of very recent origin. Migration between the two western populations. Movement between the populations, eastern and western genotypes, but occasionally an eastern/western genotype in the opposite population, indicating migration. Unique genotypes to every individual, very powerful technique. New technique, which I'll talk about later on, where it may be possible to get the complete mitochondrial genome in a half hour for less cost.

Cliff – Get the top graph first?

Steve - No, don't bother. Go to Genbank, find reference species and get the primers, and send it out for sequencing. Don't devote cleverness to experimental design, but to doing the analysis after.

Cliff – I'm delighted you're here, good time to change perspective.

David? (*not sure) – Use one versus the whole genome, but how much information can be gained through nuclear genes? - the mitochondrion is really only one gene.

Karl – Yes, the advantage of mitochondria is that we know a lot about it for a lot of organisms, and it is relatively easy to do. Nuclear genes are difficult to crack. A lot of species I don't think we have any convenient way of cracking them. I thought you were going to ask about increase in precision, for mitochondria, about 4000 bp branch points are at 95% or greater.

Boris – What are the conservation implications of your work? Manage as one or two stocks? Does your work imply a rich population substructure important for the survival of the species?

Karl – Yes, harp seals are managed politically as two stocks, so this has been one of the questions. Politicians can twist arguments, there is gene flow, and so what you do to one affects the other.

Max Hommersand– If 4000 bp gives 95% confidence, why don't you do two genes of 2000 bp?

Karl – It depends on problem. For some, even 16000 bp only gives 80 %

Matt Hare – I like what you presented, focus on phylo part rather than geography part. However, depending on the pattern, sampling over geography is important to reach the correct conclusion - you have to reach a balance.

Karl – I chose to work on harp seals because this is the structure – they breed in only four places. For cod, there are two schools of thought – they are either all one population or lots of populations. Samples tend to be from management-designated areas. This is why an evolutionary biologist needs the ecologist - I don't have the expertise to say where and when to sample a species to capture its biology. We can apply the technology. A great partnership.

Meg Daly (*?) – For phylogenetic accuracy, what is more important than the number of bases is the number of taxa. Especially important in making sampling choices for people who don't have access to technology.

We'll try with parsimony, maximum likelihood, etc, but we don't really have phylogeny nailed down. when you have phylogeny with any model with all branches 100%

Suzanne? (*not sure) – what about invertebrates which are more variable?

There are things on the horizon that get at this. The limitation is that you have to know something about the gene to get the technology to probe that. Working on the technology DNA chip the size of a cover slip, with 100'1 of 1000s genes on it, company will make the chip but you need to make the information. For mitochondrial chips, you need to know complete genome - go to genbank,

Jon Norenberg – In terms of sampling strategy, do you say we need to consult ecologists, sample as many populations as possible? This collaboration will let us all get more samples.

If you're out there, do the sampling, do plankton trawls...

Cliff – We'll do more of this tomorrow afternoon.

Matt Hare – Back up, what can genetics do for us? People from lot of different areas, and data may not be sampled or analyzed the same way. Genetics provides two avenues: 1- focuses on polymorphisms that are neutral, informative about history, migration. This is the basis for phylogeography, a blanket assumption sometimes tested, 2- understand selective forces acting on the populations. For this, you need to be clever, know something about genes and physiological pathways. Then one can rapidly screen genome for genes that are not behaving neutrally. AFLP's – A method where you don't have to know anything and you have a rapid way of surveying genome, across whole nuclear genome as well. Look at 100 or more genes in a week. For *Littorina saxatilis* – many loci behaving similarly showing a neutral pattern, but a few are showing dramatic differentiation - targets of selection. We need to know what's shaping those, what's driving it. All of these avenues can be informative depending on question.

What's happening in terms of biogeographical discontinuities in the North Atlantic? My focus on oysters, other bivalves, marine mammals, in the southeast (western North Atlantic). been described for a long time based on range distribution boundaries. splitters and lumpers that see different patterns of similarity- where range limits pile up. Cape Canaveral in Florida, Cape Hatteras, Cape Cod, are fairly discrete boundaries. In Europe – the Iberian Peninsula, broad zone in the UK from temperate to boreal.

What's interesting for range distribution limits and what's molding them, is how are zones changing in recent times, and what's structuring communities to begin with. Intraspecific level for broadly distributed species – population structure for populations that could interbreed if they could exchange migrants but show genetic discontinuities. examine population processes and environmental factors shaping the discontinuity. Intra-specific level could inform us about inter-specific differences.

How are organisms seeing the environment (Vermeij this morning) – changing within narrow geographic zone – genetics and ecology can reinforce each other. candidate genes. ecologists do transplant or controlled experiments to test hypotheses that are raised.

Cliff – Ecologists – is there comparative studies across transition zone?

?(***don't know**) – in Europe, UK – Forbes. also, tip of Spain (not a continuous gradient).

Matt – For any group, you will see transitions – do they align with transition from other taxa?

Vermeij – Since you work on oysters, do classic discontinuities (Cape Hatteras) mean anything?

Matt – at Cape Canaveral there is a sharp transition. Hatteras is not a significant barrier.

Vermeij – Is it for anything?

Wares – Maybe not for near shore things, but maybe for offshore, since driven by the Gulf Stream.

?(***don't know**) – substrate types, algal species

Matt – That is part of the question. Good points, but what hasn't been taken into account is submergence, as northern taxa go deeper as you go south. Another point I want to make is a lot of times the focus is on macro taxa, but there is a parasite fauna that sees the environment differently. Let's not focus only on charismatic visible species. There's a community in every species with its parasites and commensals.

Ladd Johnson (*?) – Transplants are the first step or the follow up to genetic studies.?

Matt – Follow up, maybe because I'm a geneticist – I want to know what the history and relationships are between taxa that are transplanted.

?(***don't know**) – Not necessarily a sharp transition, do transplants at edge of range. There is an ethical issue.

Matt – Good point, there are disjunct areas on both coasts.

David Rand – Neutral versus selective markers. Sometimes see survivorship differences. A two-way street, in trying to get generalities, come up with list of candidate genes which may be part of physiological factor that affects discontinuities.

Matt – Yes, some candidate genes that are important. But don't solely take that approach. By random screening we can find things we didn't know were there. Both approaches are valuable.

Chris Maggs

I'm here to say something about algae. It's a term of convenience. What is different about algae than animals? (***lists the main differences**):

(phylogeographical point of view)

1. life history – haplo-diplo life histories – individual free-living haploid and diploid stages in most species.
2. red algae – complete lack of flagellae in reds
3. no planktonic larvae, may affect gene flow and so on.

life spans

1. some reds 1-2 yrs (***Mazzaella? written on easel**); but some 50 yrs, others, 100+ yrs – wildly diff generation times. *Ascophyllum* – around 25 yrs

molecular markers

1. chloroplast genome – around 180 kb, not 70. lot of work to sequence the whole thing.
2. extreme difficulties in developing microsatellites. 5yrs for one sp for example, Although powerful is difficult.
3. lack of fossil record – lack of molecular clock, difficulties in dating.
4. allozymes disappointing in how much resolution they give.
5. swot – strength weakness, opportunities and threats analyses.

strengths – haploid stage

weaknesses – lack of fossil record and mol clock

opportunities – variation in life histories and life spans

how this applies to 2 main approaches to date:

1. pattern-based – examination of patterns – look at dist of species, come up with lists of amphi-atl, amphi-oceanic, lists have been around a long time so target species can be chosen, Groningen ? group started this with study of temp tolerances to explain dist of species with temp, over 100 species seaweeds done like this; molecular markers – ITS – in ribosomal genes – species with bipolar distributions (*Desmarestia viridis*, a brown seaweed, amhipolar) – ITS showed there was interchange across the equator even though they can't survive equatorial temperatures.

Cliff – How do they date if there is no molecular clock?

Chris – extrapolate...

other (*Phycodris*, a red seaweed) previously thought to be one species, see sibling species in the Baltic, *P. rubens* in Europe, America, and *P. riggi* previously undetected (see map). *P. rubens* recolonized America?

Second approach – process – oriented- explained by Miriam Destaubé (?* didn't get); use microsatellites to look at mate selection in red algae, sperm competition. red algae – after female is fertilized, the diploid structure is stuck to seaweed- paternity analysis;

Jim Coyer – posters
fine scale resolution

Cliff – Let me say how inspired I am in their ability to cooperate...

Ellen- Surely there is a fossil record for algae?

Chris – Very few, one is *Halimeda*. stratified layers in which *Halimeda* discs are shed and fossilize quite well. The corallines just don't seem

Susan? – rich coccolithoporid record, forams, use fossil record to test what they see with temp data, a matter of getting algal molecular systematists to look at these records.

Chris – I think *Halimeda* is best bet for macroalgae

Johnson – How hard is it to do molecular work with algae? Is it always going to be hard?

Chris – There have been extreme problems in past due to DNA extractions, which has been overcome except in some browns. Why are there so few microsatellites? I think its genuinely different.

Cliff – Personally, gene genealogies are going to be easier to compare, I'd prefer to see you get gene genealogies than microsatellites.

?(*don't know) - The genome of algae is less known (***can't hear**) - can't mine databases in the same way.

Chris – Comparative work with same methods, you can't get them as quickly, the complete chloroplast genomes, don't have microsatellites, which is bizarre.

--- The *Chlamydomonas* genome is done. It is a matter of getting the right people to work together. Also AFLP's work well in fucoids. It gives population analysis quickly, this is something people can use.

---To reiterate what Cliff says, in terms of putting in genealogical framework, it can be very difficult.

Chris – Joe Zaccarello – his work hasn't come up in North Atlantic context – he works in Australia on tropical red algae but now he is in Leiden. He uses mitochondrial cox 2,3 spacer markers, sscp for rubisco spacer.

Wares – To get enough variation out of the algal genome, 180,000 instead of 70,000 bps, can be put on a chip.

Chris – Some of the genes we work with are quite big already. I'd be interested in seeing what you'd really gain.

Wares - A lot of what's come up over last 3 talks and my interest – variation in ecological interactions. The problem is, we need to find, what are these varying problems in ecological interactions. Population genetics covered in detail tonight. One project I've had a small part in - my friend Eric is working on North American amphipod, *Ampithoe*, (***writes on map**) on the eastern seaboard of North America, frequently found on in southern part of its range is *Dictyota* (***correct?**), a brown alga whose chemical compounds the amphipod tolerates. Eric did crosses between Connecticut and North Carolina populations, and found that chemical tolerance decreased in northern populations. It occurs over a gradient that is in our area of interest, and we

could look at with phylogeographic methods. Northern populations are not tolerant, North Carolina are tolerant, and, in the middle, it is more variable. Use a variety of typical markers – mitochondrial COI – get a clade of Connecticut and Rhode Island individuals and a clade of more southern individuals. The ITS gene (nuclear) get the same patterns – northern and southern clades, but not a solid break in terms of behavior. When to do quantitative genetics and behavioral work, to what extent can we design genetic, behavioral, phylogeographic etc studies? I'll turn over the floor now

Diarmaid –

People who study genealogical histories have lots to offer ecologists. If you study something that lives here here (***see map – amphiatlantic**) – try to put this variation in some context, phylogeography can see if the histories are different. With marine invertebrates – cryptic sibling species are everywhere. There are lots of tools to get a quick look at this. The bad news – patterns of cladogenesis are messy. Populations are isolated, differentiated, secondary contacts, introgression, so the markers chosen can be very important. Some groups – *Mytilus*- can be very complicated. In nature, cladogenesis is complicated.

In my work – the North Atlantic starts at equator – in center of North Atlantic (***draws on map**); dominant feature is the gyre which is unevenly distributed. Focus on boreal fauna-continuity of the Pacific component. Farther south, much less amphi-Atlantic species (although even farther south may be a pick-up). Mid-Atlantic ridge fauna from Europe. work on bivalve that was an exception to this, in crevices in intertidal, amphi-atl taxa. (***? Didn't get all of this**)

Lots of diversity, gets to the notion of sample size. For studies like this people should be pragmatic. If genetically depauperate, you may need to sequence the entire genome. For highly divergent lineages, get main haplotypes. (***draws on map**)- the major clades- may have something to do with currents. Don't know how this hold for rest of fauna.

Oceanic island fauna – unique, get there from elsewhere. Bermuda – an extension of the Caribbean. Many things missing. Though Bermuda clams would be a subset of lineages from Caribbean but it is not. ecological release – preserve rare mutants, predicts other fauna should show similar patterns. so, with gene networks can reflect ecology... (***note -didn't get everything transcribed here**).

lunch break

(Christy taking minutes)

Mark Costello – Species lists: on the European side, there's the list of marine species in Europe – 29,000 spp. – in the European Register of marine species; it's on the web – just lists, but will become more accessible later, with algae as well, the acronym is ERMS
There's also Biomare, a network run by Herman Hummel and Carlo Heip – it's a database and contact info on people who can identify species – not necessarily taxonomists – they'll be submitting a proposal this fall, can be funded for people outside Europe if you're in on the grant; want list of people with species lists from known areas Geerat and Gary Rosenberg – molluscs; Les Watling and I are doing amphipods and maybe cumaceans; Les is doing database of

octocorals. Others?? What do you do with lists? Need to be validated? Lots of the synonyms - a minority of spp have this problem; we need to have plan to manage these in a database because it needs to get done right away or it will never be done.

Daphne Fautin – I work on anemones, but also on OBIS; began building a database of the anemones of the world – all synonymies and distribution data, and type localities and images of specimens; but soon able to join ocean biogeographical information system (OBIS) – now has all hexacorallians – 10 groups in OBIS – taxon-based, and habitat-based – seamounts of the world; network – a distributed system – have own databases for their own purposes but magnify effect by having them interact in a useful way – together with those others have compiled. We don't want simply range data, we need specimen-based databases – it can be imprecise data, but we have to be able to plot them. Databases in OBIS are based on museum specimens; FISHNET – 35 museum collections around the world; mine is based on literature; just so we have some record of a specimen – can plot these are geographically referenced and taxonomically resolved; served through a common portal; www.obis.org – not just links to our ten individual databases but also a search – can do a search on, say, octopuses and cephalopods between certain latitudes – can look at ranges and see if they're coincident with your organism of interest – clustering tools – what spp occur together; map services – buying exclusive economic zones of world maps - \$1500/year; allow members of OBIS to analyze data with these maps; name service – search by the names you would call an organism, but also all the synonyms used for your organism; several hundred environmental parameters for marine environment – get suggestions of other kinds of analyses you would like to do; for geographically and taxonomically resolved data this is very practical; Phoebe Jiang is our webmaster at rutgers and can tell you what you need to join – the data forms you need; I have the script we have to show you how you make a call to OBIS – it's all in xml;

Cliff – What's xml?

Daphne – eXtended Markup Language – the future of these kinds of things – xml is platform independent; I have 20 copies of this, and I'll leave them out – attract those of you that have this kind of data ... one of Cliff's objectives is to form a database so that everyone can have access to this data

Ellen - What if you already have a database??

Daphne – That's exactly what it has to be – you can write to us, and join your database to ours – you need to write one of these xml scripts, and then your database will be on the OBIS site and your data can interact with all these others; if you have a database that has all these elements, come join us.

Ellen – How sophisticated does your database have to be?

Daphne – It only has to be resolved taxonomically and geographically.

Matt Hare – Is any database too small?? If I have a particular study can I put it in?

Daphne – We need a statement of how big your database is.

Matt – What about suggesting a broadening of goals – if you had a lot of independent studies – smaller databases – do you think that would be useful to archive more detailed information for biogeographic studies – compared to the larger databases you currently have?

Daphne – One species is OK – just so you say what your database covers.

Boris – Isn't it a concern that no one checks this?

Daphne – I own my data – your database is intact.

Jim – How do we know we can trust your identifications?

Boris – So these need to be published?

Daphne – No – you have to trust the database – whether or not it's accurate, it's a chance you take.

Terry Gosliner – There are indicators there – people have fields in their database for confidence level of their identifications, notes about how fuzzy taxonomy is...

Daphne – We're going to be instituting a 1 – 4 level of confidence in species, where 1 is professional; 2 is best judgment; 3 is possibly and 4 is caution.

Boris – I'm interested in biogeographic patterns – I can't check individual species...

Ann – Can you answer, Daphne, whether these databases have been reviewed or the level of review in the database?

Daphne – If you get an outlier – go straight to individual in museum and check it out to see if it's what you think it is; Gary's is more subjective in what he thinks of synonymies...

Geerat – I'm skeptical of databases in general.

Daphne – This might show you info you might miss otherwise, where to go in the literature, museums to get the information you need.

Cliff – Maybe we should do the hard work Geerat is suggesting to get a database that we trust because it's things we've done in a group.

Geerat – Gary's spent the better part of 15 years doing it, and not much else besides, and only has 3000 species – it's an enormous amount of work

Daphne – That's the benefit of OBIS – you can limit your database to what you're interested in.

Ann – To pick up on the same conversation about which is good for this forum - OBIS is a methodology rather than a database – it's an experiment on how to integrate information – if this is successful, it may grow to include more databases, narrower but deeper databases, site specific, etc. anything; this points out, Daphne, our need to have some kind of criteria for looking at databases – quality wise. The goal is if CORONA wants to have it's own database, let's link it into OBIS – OBIS is just a portal to provide access; one of the databases you can access through OBIS is Zoogene (www.zoogene.org); it's a geographically referenced database – we asked experts in the fields of copepods and euphausiids to send us specimens – sequences as part of mtCOI = becomes type sequences – COI behaves well in copepods and euphausiids – 1-4% within spp, 15-25% between spp; type sequences go into Zoogene and Genbank; anyone else who wants to identify a copepod just sequences the COI gene and then sends it to Zoogene or Genbank and sees what it is – it's a way of identifying copepods by sequencing:

species-specific PCR – so oceanographers can put a bug in a jar and figure out what it is – can do multiplexed reactions where primers are placed on different places of gene depending on spp – have done this for a number of spp; routinely spp are misidentified – species ranges are dubious; if you actually look at samples where *Calanus finmarchicus* is supposed to be, there are a lot of other species as well; we'll make species specific PCR reactions for your species.

Edie - What about use by public – need to keep people from using it as if it were perfect.

Ann – Perfection in terms of species identification?

Edie – Anything. They'll just think it's great – writing for public, or science writing.

Ann - I just came home from Taiwan, talking to morphologists telling them that this was an accurate way to identify spp – mixed reviews – they think morphology is the way to go.

Edie – I'm talking about lay people – I used to work for the Environmental Defense Fund; they didn't care about the level of a source – as long as it's some kind of literature

Terry Gosliner – I think that's an argument toward putting together a database we have confidence in rather than not making databases.

Ann (Bucklin) – In Zoogene, we're using verified specimens that taxonomists/experts have identified; ideally from the type location, so that we can sequence them – 11 people – we chose focus of Zoogene around the availability of experts – we're trying to preserve what they know – it's a Fahrenheit 451 project

David Reid – Do you think you're telling taxonomists that they're not important – what about molecular species (*paraphrased/missed this)?

Ann – We're not doing molecular spp – most simplistic thing that Zoogene is doing is that we don't need to go to taxonomists any more – the point is that no one knows any more – no one's trained; and could be more spp there – we're pointing out the importance of the spp level – how many species are really there; the navy would love to get rid of species – call them functional groups or biomass – we're alerting people to fact that biodiversity is that diverse.

Mark Costello – I think this is not making taxonomists redundant, but making taxonomists more important.

David Reid – I'm referring to molecular identification of spp...

Ann – It all goes back to an authority; we now geo reference and cite it and collector; this leaves a trail that allows you to evaluate accuracy.

Andy – thought about referencing, where you could go to find more info – what they are

Ann – there's another database that does have the information for another group (*missed this) but we need this

Cliff – Lets' hold off on more questions...

Ann – Phylogeography – very interested in the phylogeography that can be resolved by COI gene – large water masses, - different oceans – COI is able to differentiate between Atlantic and Pacific – allows us to calibrate the molecular clock from geographical history of ocean basins; also use COI gene for phylogenies – for congeneric spp it does a nice job

Mark Costello – BIOICE – Agnar Ingólfsson

Agnar – BIOICE has been going on for 10 years, started in 1992; sampling ends in 2003; bottom samples from down to 3000 meters (drew on map) with various types of gear; up to now some 4,000,000 individuals have been collected and 2 million have been sent to specialists for identification; BIOICE aim is to make database; it will take a few years till ID's are done and developed totally; there are about 60 specialists from about 20 different countries working on the BIOICE project.

Cliff – In April you mentioned it doesn't include shallow waters – what are its limitations?

Agnar – It goes from 200-3000m, benthic.

Geerat – How many new species have been described?

Agnar – At present only 23 new spp; 1900 spp identified; 800 were not recorded in Icelandic waters before; but it's not done yet.

Emmett – More will be found...

Mark – Just started looking at specimens

Mark – I want to remind everybody that there was a handout that has info on BIOICE – old web address

Cliff – I'm interested in merging American and European species lists is to address the questions Geerat was asking this morning – what species are trans-Atlantic and which aren't? – comparing spp – generalities can be addressed by presence/absence data; I think it's not just a database for it's own sake – it's able to test lots of different questions; the other reason to do this is to identify exactly what is the trans-Atlantic biota – what is the scale – how many spp are there? The question is exactly how is this integration going to happen and who's going to do it? Mark

Costello has indicated Huntsman might be interested in integrating the American and European databases.

Mark – We have the European lists in electronic form, another of other regional lists (*listed some names) could start putting these together, lists from western Atlantic, eastern Atlantic; within area comparisons, as well as between east and west – initially spp lists in excel files – look at data and see what kind of work is involved – if we need a database developed.

Cliff – Funding for this project is for this meeting itself, but databasing that is crucial to development of the network is also OK – we can spare the money. We can't just depend on people's good will to get this done.

Mark – Pierre Brunel has Gulf of St. Lawrence database needs a timetable and could probably get him to work with us.

(* **messed who this was**) –literature-based??

Steve Hawkins – station lists – Isle of Man marine fauna, French marine laboratories, etc. I think the French labs have recently had an internal project to update lists, update taxonomy and whether spp are still present or not; I actually put in a pilot proposal to census marine life – I could pick that up again; certainly on the European side the Roscoff, Clyde Sea, Isle of Man, Plymouth, etc. more marine faunas

Mark – More particular than we need, probably, but good sources.

Max- In the last 10 years, floras have been written for most of the regions of the world; eg. southern Australia, Japan; almost every region now has someone who has constructed the actual flora or well-defined spp lists; Mike Guiry has used this for compiling spp lists for the world; not databases like you're talking about, but huge progress with marine algae with this regard.

Daphne – Provides taxonomic core; a strength of this – if you have the current taxonomy with currently recognized names, then you can plot them and see based on geography alone whether these are synonyms or what.

Cliff – Susan, you said this is complete for the North Atlantic?

Susan – NEAS (North East Atlantic Society)'s longterm attempt to update this –just one step along the way; not lots of pictures; but every taxon has a geographic range scale; from Long Island Sound to the Straits of Belle Isle. When you collect, if you keep accurate records, there's a way of cross-referencing things.

Chris Maggs – algaebase.com – Mike Guiry's database – now going on to microalgae – spp of world

Max – Bear in mind that the taxonomy itself is still a mess...

Christiane –If you're going to do collecting, put some specimens in ethanol instead of formalin, so we can extract DNA.

Mark – There are a lot of species information projects and it's important that these are linked to the species list. There's a project called MarLIN (*Marine Life Information Network for Britain and Ireland) led by Keith Hiscock at Plymouth. It has full species descriptions, lots of habitat and other information, at www.marlin.ac.uk.

Steve – Not only spp names but other information; also beginning to do biotopes; the idea there is not just to list spp but to give information about them; biotope is a European idea to characterize a community by what lives there eg. *Ascophyllum* biotope;

Mark – There must be 3 reviewers before the info can go in the database; connected - mermaid – over 10,000 sites around the British coast that they've got info for.

Steve – Generally quite good; but necessarily incredibly helpful

Myra – When I've looked, my impression is that the Europeans are way ahead of the Americans; and the number of spp is going up.

Mark – From Linnaeus to the European Register of Marine Species, there's a linear relationship; Europeans are more coordinated because obliged to coordinate - you need at least 3 countries, 5 labs to get funding from the European union. Early collaborations weren't true collaborations, but they are now.

Myra – It really is hard to get a sense off what the relative diversity is across groups...

Mark – It must be done for us, but couldn't find it.

Geerat – For individual groups it's been done.

Mark – 170 people over 2 years, and 22 institutions

Steve Hawkins – These work in Europe, because people are paid to do it with very defined deliverables, not necessarily peer-reviewed papers – they've been funded, not by national governments but th EU.

Myra – If I want to know how many marine algae there are on both sides of the Atlantic, there is a 6 volume set for Europe and one skinny book for North America.

Chris Maggs – There are more spp in Europe, so it's not just a taxonomic bias.

Oceanography

Andy Pershing – As oceanographers, what can we or I bring to this – this is the ocean, everything we're studying is in it or on it; so understanding what's going on is important – large scale view - the area we're talking about is right on the edge of a transition zone. The Gulf Stream is what makes Europe habitable.

Cliff – As opposed to Canada?

Andy – Yeah, the other current is the subpolar gyre; also west and east Greenland currents; divides into 3 areas: one on US east coast, up east of Greenland, and up in North Sea (*??*). Variability in the climate of the North Atlantic is going to affect climate and zooplankton. North Atlantic Oscillation – variation in strength of low-high pressure system – there's a low over Iceland, and a high over the Azores. The ocean has a fairly predictable response to this pattern: when the NAO is positive, you get lots of deep water formation in the Labrador sea – intense convection in winter, forms bottom water, but not so much in the other two areas (* **drawing on map**). Positive NAO is when the low over Iceland is lower (difference is greater). This sets up a circulation pattern in the atmosphere; east/west see-saw. If Europe is warm, then Canada tends to be cold, and vice versa. In the Gulf of Maine, in 1998, noticed that *Calanus finmarchicus* had incredibly reduced abundance. In tracing these things back, eventually got to the NAO. Limited impact on weather over the Gulf of Maine - remote forcing from the Labrador Sea affects the Gulf of Maine; transport in Labrador Current is reduced in positive NAO; less cold water into US east coast region (Gulf of Maine), variability of copepods in Gulf of Maine since 1960's - were able to tie it to Labrador Sea fluctuations. *Calanus* does better when the warm water mass comes up, even though it's a coldwater spp. These are deep water masses, >100 feet deep, many ideas why; North Atlantic Slope Water mass – all the primary productivity in the surface water mass sinks in. When the Labrador Slope Water (less nutrients) comes in, it reduces nutrients, reduces the spring bloom and then *Calanus*; or could be associated with changes in the current system. We don't know if it's impacting currents up on the shelf – could be having some impact – *Calanus* population is reduced upstream and lower population gets brought in.

Cliff – Could you expand on the neat trans-Atlantic *Calanus* info you reviewed in one of your papers?

Andy – I have a poster on that with nice figures, but *Calanus* is found through the Atlantic. The NAO was very positive in 1960's, negative in the '80's. In the eastern Atlantic, *Calanus* had a negative trend, negatively correlated with the NAO. Mike Heath(*?) did a study in the eastern Atlantic... *Calanus* is slow growing, 1-2 generations per year, with an overwintering phase in deeper water. Even though it's abundant in shelf systems, it's really a deep water population – shelf populations are really expatriates from deep water populations. The relationship between *Calanus* and the NAO has to do with the formation of the Greenland Sea water mass. *Calanus* does very well when it overwinters there, so when production of the Greenland Sea deep water is high, then you have a good overwintering of *Calanus*; driven by physical features in the region – it's strongly tied to the physical oceanography - I don't have such strong forcing in the Gulf of Maine. I don't think *Calanus* grows fast enough that we could see changes of the magnitude we do just base on productivity. Not forcing – I think it's a physical factor.

Cynthia – How much do we know at less than 200m about dispersing, etc.?

Andy – We can model it, but the problem is getting right data into a computer, and initial conditions. If you can get the wind right, in the Gulf of Maine at least, you can do pretty well with just the tides and the wind, so opportunity to do coupled physical/biological modelling.

John Wares – Most of the time when doing population genetics, we don't think of the relationships between our sampling and that particular day's weather – so to what extent is this stable over different time scales?

Andy – That's a hard question. We've noticed one characteristic mode of variability - there are other levels on that – variability in physical conditions and the time-scale that your organism is in the water column.

(* missed some discussion here)

Steve Dudgeon – Do you see coupling between weeks and months vs. years in Gulf of Maine? (*????)

Andy – ...starting to get in the freshwater inputs in the Gulf of Maine

Ellen Thomas – In Long Island Sound, the overall input of the Connecticut River is important.

Chris – Is the temperature anomaly associated with the NAO??

Andy – There's temperature anomaly in the layer we were looking at; we have cold continental air masses in the winter, same processes producing deep water masses up in the Labrador Sea, winter mixing is strong enough, this signal gets mixed up in the surface.

Chris – Les told us about the death of a lot of organisms – one seaweed died, a boreal North American endemic.

Andy – There's the great tilefish kill – 1900s – a very strongly negative NAO year, and a mass of very cold water killed some of the benthic spp including tilefish.

Mark Costello – Local scales in some models show that wind can override currents - but on bigger scales... does that mean in practice that every species has the potential to get everywhere in North America over North Atlantic over the centuries with all these different anomalies?

Andy – pretty much

Mark – A lot of species have planktonic larvae.

Ann Bucklin – The more you know about the physical environment, the greater the power of your analysis – suggests the value of linking to physical data – the more power you have to understand where that packet (* of water?) came from, where it's going to, and where it sits in the oceanic environment.

Cliff – Pelagic?

Ann – Benthic – you know substratotype, but you don't know what the water is doing – so general not just planktonic, but benthic too.

Andy – There's also the historical context – is this a normal thing, or do you not expect this over time???

Max – Is this responsible for the rain in Dresden?

Andy – I don't know – the NAO is a Frankenstein type monster; if the rain happened in January, I'd have said yes, in summer the NAO isn't as strong.

Geoff – The snow in new England (amounts) are highly correlated with the NAO.

Boris – There's a paper on the biological effects of the NAO: most people have been correlating everything with the NAO and then only reporting the significant results, so many are spurious.

Andy – Right. Many of the original correlations were abundances of plankton in lochs in Scotland and the NAO.

Diarmaid – If you were to draw surface patterns in the North Atlantic 18 kya, what would it look like?

Ellen – The Gulf Stream moved south and over to Spain – didn't make it to NW Europe – toward Spain then curved toward the equator

Andy – Warm water is balanced by cold water transport by cold currents

Ellen – Much larger mass at deeper depths, and North Atlantic deep water didn't sink so deep; it was larger in volume but at different depths – not so deep.

Mark – The coastal temperature could be quite different. Bergen, also coastal Ireland – coastal waters can get 20 degrees warmer in summer – can override big patterns.

Andy – Lesson from the Gulf of Maine: seasonal changes ...

Phil Williamson – The oceanographers prepared during break. www.nerc.ac.uk/mar.prod, www.globec.org;

Our program title is marine productivity which is too general; a word of caution; don't have too general titles! Funded by natural resource council (*???) NERC to the tune of \$7.5 million/£5 million. Sixteen UK groups, pelagic rather than coastal, started trying to look at shelf seas and open ocean - how do the shelf and open ocean interact? Started on shelf seas around the UK, and discussion of biological/physical interactions - we've got it pretty well sorted out for these areas (east side) Irish sea: 1 km horizontal, 10m depth resolution, probably around 30 min. time resolution. What you need to know physics at this resolution for - to know whether model is giving you reasonable numbers (*??). If you put zooplankton in the model for the Irish sea, 3 months later you find where they've gone to – 95% have been taken out onto the shelf somewhere – dead – eastern, etc. it's tough being a plankton. How do you survive and have any biogeography when you're being carried by your medium all the time? If all your life is a plankton and you're being taken one way, how do you get back upstream? Some don't care, and are all over the North Atlantic. Others do care, and maintain themselves in certain areas in the North Atlantic where they can survive. Fishery models are based on recruitment from year to year, not ecosystem processes. Part off the answer is in zooplankton and food webs they're built on. Trying (*??) to put UK universities together... GLOBEC – GLObal Ocean ECosystems dynamics project (*??)... If you only do it a few years, it's almost impossible to work out the patterns. For an historical perspective, you need 50 –100 years of data to make sense of the trends/changes you're seeing. In the UK there is one organization that has that data – the Sir

Alistair Hardy Foundation, funded by NERC – the continuous plankton recorder program – over the last 50 years they've gathered data from commercial shipping towing plankton recorders, with pretty standard methods – even if you have 50 years of data, there is no shortage of things to correlate with – depends what you need to correlate with. If you're a little bit economical with the truth, there are plenty of correlations out there, but interested in what are the causal correlations? For main field part of program, wanted to go not to the shelf seas but to the shelf of Greenland. *Calanus finmarchicus* from a taxonomic point of view is interesting – the first marine invertebrate to be described by the bishop of Trondheim – he called it an insect – they hadn't invented crustaceans then. There was a lot of *Calanus* around then, a lot now; it's 80-90% of the biomass in a large area of the ocean. Like the *Drosophila* of the oceans. Norwegians, Icelanders, Scottish, have all looked at it – everyone studies it. There's more *Calanus* than everywhere else off the east shelf of Greenland according to the continuous data recorder project. The UK research ships – 4 cruises to go out there - Iceland basin, Greenland basin, 2 shelves – in course of a year to find out what the mechanisms of that particular year were - what was going on – to put it in the context of the 50 year data. Can only do it at 10 or 20 km scale. Biologically realistic behavior: drop down in winter for 6 months diapause – might get carried in other way than when at surface, might get carried in other way in wintertime... anthropomorphically speaking the best time to come up is in the spring. On the taxonomic side, there are 25 people at Aberdeen looking at what was collected – it's a summer school of taxonomy, with two weeks training, then students are paid to sort species. Adult *Calanus* are easy to tell apart, but larval, etc. are hard to tell apart – PCR techniques can do it – if lots of eggs in water, then set up experiments and figure out what was going on – what species were there...

Cliff – I'd like to have Ann talk about the phylogeography of *Calanus*.

Ann – I'm associated with the marine productivity initiative. Graham Savage is leading a new population genetics study. There's a lot of attention on *Calanus*. North Atlantic phylogeographic domains are defined by major current systems. The sub-Arctic domain for *Calanus finmarchicus* is actually partitioned with that – Sea of eastern Greenland; three domains in *Calanus finmarchicus* based on (*??) reproductive biology: one is the Ehrlinger sea, one is the northwest Atlantic and one is the Nordic Sea. These very nicely define three populations of *C. finmarchicus*. The goal is to find a marker - Benjamin Plonk(*?) did this, been in search of markers to confirm this genetically. Microsats may be good for this, mtDNA may be too slow – it may be homogeneous within those domains is my guess, and heterogeneous between them. Back to what Agnar just talked about – within Icelandic waters, they have water from 3 distinctive origins – North Atlantic water, Nordic Sea water, and the East Iceland current – an example of three biogeographic provinces. I've concentrated on this area. My project is looking for a population genetic protocol for thousands of individuals to characterize the biogeography at this scale. There's excellent hydrography in Iceland, so you can put it in the context of the water masses you're in. I would suspect we would find differentiation at gyre scales.

Geerat – I'm curious – how possible is it that some of these widespread planktonic species depend on small regions that are responsible for maintaining these populations in the plankton?

Ann – Jeff Runge proposed that the Gulf of St. Lawrence was a *Calanus* pump that seeds the boundary current (Scotian current). Subsequent analysis of life history dynamics says Gulf of St. Lawrence is a closed population that doesn't seed the whole North Atlantic, but does export. Another possibility is that the mother load of *Calanus finmarchicus* is in the Ehrlinger Sea population. Being plankton is a hard existence – *Calanus finmarchicus* may not be resident in the

North Atlantic – it may stop along the Canadian seaboard, eventually get washed into the mid-Atlantic Bight and die; probably are source populations and then die.

Jim – How do you get domains from a pump?

Ann – Many populations stop here; there is some recirculation from those deep basins up and then back down again (go around Georges Bank); there are life history differences between three different domains, but not genetic.

Geerat – It seems to me that if there is such a thing as source populations, then we have to worry about tampering with the regions where source populations occur.

Andy – To help you sleep at night – the Ehrlinger sea may be the source population for *Calanus* but scales are very dependent on their growth rates – spatial scale is species-specific.

Phil – The NASA analysis published on web in 8 Aug; SEAWIFS color data for primary production; for the Pacific, a 30% decline; 18% decline in the North Atlantic in last 20 years with out there being really dramatic climate change. So if in the next 50 years if climate change does happen, then you ain't seen nothing yet. If there is genuinely a 20-30% change over a 20 year period due to subtle changes, that's bad; continuous plankton recorder analysis in Science showed that species have moved northwards by 1000 km, and there've been changes in species... (* missed the end of this)

Ann – I was invited to a conservation biology symposium to talk about copepods; the zones in the last glaciation shifted south – if you put the sub-Arctic distribution of *Calanus* in 20 kya structure – the range reduction has dropped – this is why you don't see genetic variation; over the last 2.7-3.1 Ma (dates from Ellen Thomas) since then, there have been pulses of glaciation. These species are used to this...

Geerat – Well, the fossil record is littered with extinct plankton...

(Annette taking minutes)

Low tide and dinner break

POPULATION GENETICS

David Rand (*see pad – notes written ahead of talk)

David – Population genetics and physiology (half of biology before sunset). Analogy – community ecologists study distribution and abundances of species; population geneticists deal with alleles, the distribution and abundances of alleles and processes that govern their changes in frequency.

Wares and Hare covered this morning - population genetics – intraspecific issues, as opposed to phylogeography and systematics. I'm not going into neutrality- neutral markers are important for phylogeography, but here, focus on selection.

Address what kinds of genes to use, candidate genes, multi-locus, genomics, and put in an ecological context; intra-specific problem with a trans-Atlantic focus.; physiological basis of genotype specific growth survival and reproduction.

System we've worked on with grad student, Bertness and undergrads. The approach taken is the candidate gene approach. In the old days - allozymes. Now, we've come back to them. A multi-locus or candidate locus approach, variation among locii, could be explained by neutral model. noncoding regions. find things that should or shouldn't affect the organism. things we've worked on are Gpi – fructose-Mpi

fructose-glucolysis-atp (*written on board and pad of paper, see paper)

Do an ecological assay of these enzymes. For the thermally-stressed high intertidal, and shaded low intertidal sites, find allele frequencies at these different habitats. From Paul Schmidt's thesis... the spatial scale, in Maine (*see graph on map). get zonation of genotype between extremes. Zonation emerges through summer; it is not present at settlement. No zonation at settlement. The neutral marker shows no zonation through summer.

Growth rates of these genotypes vary with substrate and (*didn't get)

Do in Rhode Island, find that the zonation is completely different. Flips direction in Narragansett Bay. Neutral marker - no zonation, but in allele marker, there is zonation. In Rhode Island, behaves as selective marker. Between high and low tides, one genotype is favored at one extreme, the other at other extreme. *Semibalanus balanoides*, the species we're working on, would benefit from trans-Atlantic collaboration with transplants or ... the basis for why they are zoned the way they are, due to carbohydrate resources, people who know algae, biochemistry, physiology, etc, an integrative approach. I'd love to collaborate at broader geographic scale, operating at multiple spatial scales.

Stewart – Allelic or genotypic selection?

Rand – It is balancing selection. Get selection coefficients for each genotype, plug into balancing selection models, and show this will maintain the polymorphism. Elusive problem, balancing selection, then neutrality, but here show balancing selection is important.

Stewart – phosphate isomerase for manose 6 phosphate

Rand – Don't know how many manose forms. Enzymes don't just go this way, as I've described, but can go backwards, things tagged with manose also ubiquitin...? (*didn't get) pathway.

Stewart – Are there polymorphisms for multiple substrates, temperature, salinity?

Rand- The enzyme assays show deterioration of activity with temperature stress, homozygous show different response. Great to have algae scientist – algae have manols? - as storage, may be oozing into barnacles. Community dynamics important.

? (*don't know) - Allozyme gel, or cDNA sequences?

Rand – Cloning now, these are allozyme assays, contrast with neutral models

? (*don't know) - Why invoke balancing selection, temperature stress may not be the selective pressure acting on the differences that you see, homozygotes are selected differentially but could be due to other factors?

Rand - Yes, that's why we need sequence data, so we can test or reject that model with sequence data.

CYNTHIA

Mytilus work, I'll cut to key points. *Mytilus* came up a lot today, there are lots of studies, especially for population genetics. Why? Because they are really abundant, easy to find, very obvious even for population geneticists.

First some *Mytilus* background. They're kind of weird in some ways. There are 3 closely related species, formerly all *Mytilus edulis*. 3 distinct species supported by allozymes and mitochondrial DNA. The center of origin is Pacific, and it participated in the trans-arctic interchange, 3.5 mya. Speciation occurred between the invaders and Pacific populations. In the Atlantic, it became *Mytilus edulis* and *Mytilus galloprovincialis*. *Mytilus edulis* is currently distributed from Iceland, and is amphi-Atlantic (*drawn on map). *Mytilus trossulus* is in the

Pacific, invaded Atlantic again more recently, perhaps also in the Baltic, a strange distribution pattern. Does anyone else know anything with this distribution pattern? *Mytilus trossulus* a mix of *trossulus* and *edulis*.

I'm interested in using multiple genes to get at selection and phylogeography. Mussels have a strange type of mitochondrial inheritance, so can use a multilocus framework. What happens is (*see drawing on pad) - female mitochondrial DNA acts as normal mitochondrial DNA, mother to daughter and mother to son. Sons don't pass on mitochondrial DNA. It is passed mother to offspring. But, there is a second type of mitochondrial DNA inheritance, in males only, passed from fathers to son. Females have one type, males have two. Look at history and biogeographic patterns across the Atlantic using both types of mitochondrial DNA and ITS (Cliff - it's nuclear). Divergence between the two coastlines is old, on the order of 1 million years, this goes against the idea of Cliff and John that perhaps many species today in North America are recolonizers. *Mytilus edulis* seems to have been in North America for at least 1 million years. North American populations may be older than European populations. The greatest diversity is in northern populations (Canada rather than US) - may have survived at least the last glacial maximum in a northern refugium. Also interesting is that there are very different estimates of gene flow for the different markers. For male mitochondrial DNA, there is no gene flow. Female mitochondrial DNA and ITS show a definite pattern of gene flow. If you don't account for gene flow, it has consequences for dating divergence. If you don't account for gene flow, divergence is very recent for trans-Atlantic divergence. The point is, look at multiple markers, because single locus could be misleading. It is important to account for gene flow, as it can mislead estimates of population divergence.

The other biogeographic pattern is the relationship between *trossulus* and Pacific *trossulus*. Divergence is really recent, or there is so much gene flow you can't tell if old. The 2 populations seem fairly genetically connected.

Looking specifically at the Baltic population, there are some really bizarre things, is it *trossulus* or not? The quick and dirty results - also have poster- (*see notes on pad)- the Baltic has really low salinity, and salinity is a candidate trigger for selection. There is a big difference between the Baltic and North seas. In the North sea- normal, in the Baltic- low. Looking at morphometric analysis, in the Baltic, looks like *trossulus*, look at allozymes, look like *trossulus*, but mitochondrial DNA is *edulis* (not my work). Some hybridization? Mitochondrial DNA introgressed across a hybrid zone. The nuclear markers are mostly *edulis* in the Baltic and North seas. So why the *trossulus* appearance?

Continue to investigate, with Paul Rawson.

?(***don't know**) - Why salinity? Everywhere in its range, *Mytilus* will meet low salinity. Why pick on this in the Baltic?

Cynthia - Sure, it could be other things. Salinity is an obvious thing that might be going on, but can't exclude other things. *Edulis* may be more tolerant to low salinity than *trossulus*, more questions that answers.

Steve Hawkins- There is a gradient, why look only at 2 extremes?

Cynthia - Allozymes track gradient, don't know about genes.

Joe Roman (*?) - Baltic and Black seas a glacial refugium?

Cynthia - Get that ref from you

Ellen - don't see how

?(***don't know**) - Just saying what Romano said. In any case, species appear to be shared

?(***don't know**) - What are you finding for female lineage and not for male?

Cynthia – What I think, there are a number of explanations, rule out demographic explanations, don't think it is differences in larvae, possibly some selection on the male genotype. Males migrate across Atlantic, but when they get to other coastline, are less able to reproduce. Some sort of interactions between nuclear and cytoplasmic genes. Just a hunch.

Cliff – Definitely testable.

Cynthia – Yes.

?(*don't know) – Why is it ridiculous that there are differences in the larvae?

Cynthia – I think it would be really questionable, if there were any data, sure...

Sally – There are *Mytilus edulis* on the salt marshes of Long Island – sedimentary refuge to the south? Unlike barnacles which don't; rather than think northern refugium, instead a southern withdrawal and then expansion?

Cynthia – But there is more genetic diversity as you go north, more unique alleles.

Cliff – I think there were 2 refugia, one in the north and one in the south.

Cynthia – I think you can't tell.

PAUL RAWSON

Candidate gene for looking at selection. Use DNA sequences, pattern of nucleotide substitution, to make inferences for selection. What kinds of genes to look at? One locus I'm interested in is glucose phosphate isomerase. Several systems include barnacles, etc. Association between this and growth and other fitness correlates. A highly polymorphic allozyme, lots of variation, seems to be associated with fitness. use as candidate gene.

The system I work in is the blue mussel. Allozyme work at Cohen's lab at Stony Brook. There is continuous distribution along the Atlantic coast, changes associated with Cape Cod. Thermal gradient – suspect thermal pressure. Found individuals homozygous of variants, found consistent with thermal adaptation. We're interested in taking a sequencing-based approach to look at sequence variation for allozyme type genes, to see if there is a signal that will tell us if there is selection. Ask from sequence data if the pattern conforms to neutrality or selection. If there is selection, what is the causative factor?

Isolate glucose phosphate isomerase from *Mytilus edulis*, from 15 full length sequences from Long Island Sound and Maine. There are sample size problems now, but work will continue. As Cynthia pointed out, taxonomic affinity in the Baltic. Allozyme loci in worldwide survey are *Mytilus trossulus* alleles. Look at sequences and find historical background in the Baltic. Extends to trans-Atlantic study. Another thing I'd like to do is use functional genomic approaches. Gulf of Maine range of *Mytilus trossulus* ends in the western Atlantic. Traditionally it is a low salinity species, but nothing that correlates at the end of its range in Maine. Temperature is strong candidate. Also currents. Another thing – everyone studies adults, but what about the larvae, what are functional genes that allow larvae to tolerate extremes in the Gulf of Maine? Larval tolerance ideas are not new; the range endpoints may be defined by larval tolerances. What sorts of loci might be involved, might be transported to other systems? Use comparative approach. May find generalities to extend beyond *Mytilus*.

Max - Not inducible enzymes?

Paul - Constitutive, but a lot can be regulated, increased expression.

Max - Any experiments, add manitol – increase enzyme activity?

Paul – Haven't done those experiments, can't ask if they were done 20 years ago.

David – Great question, don't think the data exist. Is there differentiable inducement? Add manose to growing barnacles and heat, it is bad for them. Heat is more important than substrate. Don't know how inducible.

Matt Hare – Frustrating to sequence those genes and not see signal. Look at regulatory ?

Paul – Would love to, the student who did this is out now, hopefully will get funded to do more.

David- Is there variation in levels of silent polymorphsim?

Paul – The signal isn't not strong enough, there are regions where changes don't correspond to amino acid changes.

Vermeij- There is a long tradition to emphasize temperature and salinity, because they are easily measured probably. But is this true? What about competitors or predators that do the selecting. What is this historical curiosity?

Paul – Yes, there is severe bias. If you can detect selecton at the sequence level, do experiments to see what causes it. If you get the signal of selection, it is something to build hypothesis.

Cliff – Also we know temperature affects enzyme activities. It is very logical from the biochemical perspective.

Paul – Productivity could also have an effect.

??? – The Baltic sea would be good test. And look at fucus – it releases gametes only at full salinity. Salinity is having a strong effect.

David – Transplant experiments of Paul Schmidt, no predation at high tide, allele frequencies after transplant, attribute to tidal height. Physiological question that is testable.

Ellen – The *trossulus - edulis* thing in the Baltic is really stange.

Cliff – *Trossulus* would have had to have been in North sea, then move in...(***didn't get**)

Ellen – (***didn't get**)

?(***don't know**) - Atlantic sturgeon – genetic and archaeological data in the Baltic, Oxyrhynchus? (***correct?**)

JOHN GRAHAM

Focus on one animal – *Littorina saxatilis*, amphi-Atlantic or trans-Atlantic. For variety of reasons, (including prejudice), divide the British populations into regional groups. In several, if not all, another sort of variation, for many reasons, might be be a reproductive barrier between these 2 populations (high and mid shore) (H and M) (***see pad and map**). In several places in the eastern Atlantic get behavior where differentiation between upper and lower shore populations.

John Wares – Is the Japanese *Littorna* doing the same thing?

John Grahame– Yes. Look at this further, don't know why didn't go for candidate gene, ask the animal if there is selection, and where...

use AFLP approach. I'm not a population geneticist. It's a shotgun approach for generating lots and lots of locii, look a their distribution in different populations (high and low on shore, etc).

The vast majority of locii were repeatedly scorable, over 300 locii. Looked at Fst , a measure of genetic differentiation, between diff populations. We plotted Fst between populations (see pad for graph) versus allele frequency, hump-shaped plot. What shape should be based only on drift, what should F st be? If you compare H and M, (***see pad**). Move to west coast, Isle of Man, get fewer locii, only about 6, but all in this group (?***didn't get**)

We seem to have selection operating at about 5 % of the genome between H and M populations; almost all sequencing information is not recognized in databases. One we may know – homology with Drosophila yolless. A candidate gene, possibly, that we may not have found if we checked

the literature. For the future- don't know where these AFLP's are, we don't know how close they are or islands of differentiation; get bac library and probe with AFLP's, sequence bacs, and screen populations. An "ask the animal" approach. If we are lucky we'll get an idea where these sequences are and what they might mean.

I have some reprints, or leave your email for a pdf.

?(***don't know**) – eggs bigger, thermal stress?

John - the eggs are bigger in H, but don't know if it is determined by thermal stress.

?(***don't know**) - number of offspring?

John - Bigger eggs, fewer offspring. We are reinterpreting known facts.

?(***don't know**) - Screen co-occurring organisms for differences based on egg size?

John – Interesting thought. Can't think of organism. I'm trying to sell this technique - I think AFLP's are wonderful. We spent around \$170,000 over 3 years, not too expensive.

?(***don't know**) – I get nervous about AFLP's. It is random. Can you defend why you look at random genes, or is targeting better?

John – Don't know that I can. This animal is a poor lab animal so we don't know enough about it. But, it seems to be a wonderful field system, and therefore this approach seemed to lend itself to us. We were all pleased when this approach seemed to yield something that made sense.

Thursday morning

MAX

Went to New Zealand in 1974-1975, then Tasmania in 1980. Tasmania was an epiphany, saw Australian algae in a world perspective. A paper is coming next year on Australian algae. Divide Australian flora into 2 components- Pacific and Indian. What happened originally Australia was attached to Antarctica, (***draws on map**); as Australia moved north, floras from the Pacific entered the Bass Strait between Australia and Antarctica, the floras of western side entered here, and you can still tell the 2 floras apart. See what's in New Zealand for a clue. The main pattern for distribution of Australian red algae, the algae spread along the Pacific ocean side of Antarctica, between west and east Antarctica to South Africa, coast of South and North America and Asia (***see map drawing**). Another pattern in the Tethyn ocean (***drawing on map-red**) Tethyn ocean pattern and Pacific pattern; most species in the North Pacific and those that reached Europe, original groups originated in Australasia, now this is a testable hypothesis with molecular phylogenetics, we started doing molecular phylogenies for red algae in 1992. 800, maybe 1000, species for rbcL (the gene coding for rubisco). Some people prefer 18s. Another group is doing 18s, but they haven't done as many taxa as us. But Suzanne Frederic? (***correct**) and ? (***didn't get**) grad students of mine who have gone on with sequencing, we've done ...ssu, improves bootstrap with addition of new genes, phylogenies in which Australasian taxa are basal, australasian taxa basal, topology of trees in which South American taxa are intermediate, Pacific North America more advanced, species in Europe or North America are at the top of the tree (***see map again**).

I bring this topic up yesterday speaker said how warm water species adapt to cold. I believe we can answer question of where, evidence from trees suggest along southern coast of Antarctica and Australia, the richest flora in world for red algae is Australia, almost 2/3 of the genera are there, a little less than half of the species are from there. Why was this archetypal flora preserved? It is so rich because there are really 2 floras, preserved because as cooling took

place through late Cretaceous, Australia moved north, keeping it essentially the same temperature, same climate, the great variety of species and genera that exist in Australia were preserved as a result. A few examples of South African algae show bipolar distributions to Europe, one of these is ... (***didn't get**). Another is *Rhodophylus*, (***see map**). None of these ever got to North America. That bothers me because we have pretty good evidence of rapid transport of species coming in the other direction, but none of the South African species are in North America, suggesting some barrier. Usually end up with one species at the top of the tree that makes it in Europe (***species names... didn't get**). Those species are richly represented in the Pacific coasts and North America, Japan. We've got one in Europe and North America - *Chondrus crispus*. So that's my story.

Emmett—Are there comparable phylogenies for other algae and invertebrates? Other patterns like that, with the center of diversity in Australia that you can trace?

Max – For green algae, the taxonomy is confused. brown algae- patterns you see, more likely to be Tethyan. Basal taxa in *Fucales*, are down here but don't show this pattern, people have some idea of basal groups. ... (***didn't get**) ... are turning out to be basal, richest diversity is Australasian (examples). The answer is yes, but distribution patterns don't look the same, but these aren't cold water taxa. Cold water browns originate here, Australasia. Some relict species North America, but these are spotty, maybe just one relictual species that looks to be northern hemisphere.

Max – I'd be interested in bryozoans.

Cliff – *Membranipora* has a similar history, maybe slightly different.

Max- Don't know anything about animals, so can't comment. For other groups of algae, this seems to be a red algal pattern.

SALLY WOODIN

Sally – I'm going to attempt to set the stage for interactions among organisms in the sediment. Introduction to the session (sequence of events). My task is to give you sedimentary biology 101, then talk about digging predators.

Sedimentary Biology 101- organisms dramatically change their habitat. It is a 3-dimensional habitat, they burrow, build tubes, etc. I'm talking about macrofauna only, but other fauna do these things too. (meiofauna etc). There are a huge number of feedback loops. The 3-dimensional aspect is a very important component, can't ignore this.

This habitat is so important due to biogenic structuring of the habitat, biogenic-by organisms, structuring- they're altering it, much of it is vertical. talk about biotic mechanisms of community change. Will not talk about physical factors, although there are a lot of these.

The first thing to list is organisms that make biogenic structures of some kind. Things that alter habitat - large emergent tubes, *Diopatra*, for example, tubes emerge several cm from the sediment, and interfere with the ability of predators to feed. They also stabilize the sediment, change water flow. A typical example is *Diopatra* on this side, in Europe is ...(***didn't get**). In one case an onuphid, the other is terebellid. Important for mussel set or tunicates, hydroids, bryozoa, etc. emergent bivalves, like *Pinna* for example, that are important in this regard - worked on in Australia more than here - stabilize sediment and anti-predatory.

Reef builders – worms-and oysters. Reefs have been destroyed anthropogenically, vast expanses are not there anymore.

Seagrass going into the subtidal, the marsh system which is a biogenic structure. (***see pad for list**)

Stability event, then you have destabilizing event-bioturbators. I mean organisms which turn over sediment, take sediment and not just move it laterally (almost all these organisms do that) but rather organisms which move sediment down to depth or from depth to surface, or which plow through sediment (i.e., tellinids, cockles) remember ingoring epifaunal things that plow. They are important in aerating the sediment, move water so can see sediment rise, can see it go up 1/2 cm when it burrows, enormous forces, affects pore water, go into sediment – huge pore water things, oxygen and ammonia concentration, organisms change characteristics through moving through it.

Arenicolids – live in characteristic burrow, (***see drawing**), j-shaped burrow, see a feeding funnel on surface, get subduction zone. They subduct surface material, feed on surface material, change pore water character and change reactive material, change what sediment looks like for other organisms that live there. They change the reactive material as you go down in depth

The other groups that are important for this are the maldanids. They are feeding on surface material. Bamboo worms build tubes, every worm has 3-4 tubes, irrigate – the water goes down one and up another. They have anal funnel posterior (***see drawing**) - anal cirri, studied by Whitlatch and others, stick out anal cirri and hoe the surface. They are dragging reactive material down the tube and then feed on it. They also garden material down, aerated pocket, remove fines and deposit on surface, a layer at about 15 cm that water moves in so major changes in what sed looks like. Enormous structuring changes. If these organisms are present, they change the community enormously.

Organisms that aren't as exciting - that just repackage material - they do some moving through the sediment, some irrigation, but their impact is not as big. Important for repackaging materials into consolidated feces.

Fiddler crabs in marshes are important irrigators, in terms of burrows, in terms of sediment turnover and aeration.

We have things build structures and stabilize, things that turn sediment over. Then we have shallow stabilizing mats. Things that only build tubes, the algae, bacteria diatoms, little crustaceans, spionids, do this.. little spionids stabilize the sediments in these tidal streams very impressive, easily perturbed by large digging things but otherwise make the sediment stable.

Noxious chemicals – hemichordates, 7 families of polychaetes, make halogenated ring compounds, (such as...***didn't get**). These are not retained in the organisms, but are released in burrow walls and fecal material. 100's of ng per g of sediment of this material, turn off aerobic metabolism, cause tumors, etc

Cliff – anti-predatory?

Sally- affects recruitment, predators which manipulate the prey, that chew it up or process through gill rakers, spit out these guys.

A difference between American and European Atlantic is that there are very few shallow water hemichordates on eur side, while we have extensive hemichordates- balanoglossus, not high densities, 5 or so/cm², cause bed sediments to have bromophenols in the sediments, well in excess of what affects recruitment. Polychaetes from eastern North Atlantic include capitellids, cirratulids, terebellids.

There are things that affect the general area. There are other changes that are individual - run the gamut from competition for food, space, indirect interaction through food depletion, burrowing through someone else's space, defecating on their head,

So that's a crude description of what organisms in the sediment do to them. Things that are imposed on them- epifaunal predators. The only thing in list that was different was the presence of hemichordates, strikingly different; everything else is on both sides.

Cliff – done by different animals on same side?

Sally - Not same species, but can be, but often belong to the same groups.

Then go to predators, ask predation question, are types of predators on both sides the same?

Cropping- bivalve siphons, polychaetes defecate on sediments, sediment surface has emergent material that predators mow. Small crabs, shrimp, fish- partial predation well described in European waters, on this side, many people (***names, didn't get**) work on this. Loss of bivalve siphons, polychaete tails, tentacles of spionids. Small fish are responsible, small crabs, and shrimp on both sides of the Atlantic.

Complete predation – lots of fish, suction feeding fish that open gill flaps that suck animals out of tubes or burrows, on both sides of the Atlantic. That's why polychaetes have hooks. Some fish and crabs do this, and big shrimp.

Digging predators – are cool because get collateral damage, not only is prey eaten, other sediment with other organisms get exposed, put on surface, out of their sediment refuge- they destroy the sediment vertically – typically skates and rays, horseshoe crabs- *Limulus*, true crabs- *Carcinus*, portunids, large gastropods like *Busycon*...

?(***don't know**) - Gray whales?

Sally – Gray whales, yes, but not that important on both sides.

Skates and rays are interesting- no evidence of European colleagues working on skates and rays. I found this graph-fisheries landing data- (***draw graph**) - around 1950 they plummet, although they are present they are trivial. Here very large pits are very common, an enormous amount of sediment is excavated, changes sediment structure, pore water (1/2m deep), excavated material, all other animals thrown up for other predators, little fish and shrimp following them around picking thing off. *Limulus* horseshoe crabs, pits are more discrete 60-80 cm about 5 cm deep, all the little guys, juveniles, in to cm, have big impact on bivalves. Both Europe and America have digging crabs, but we have more diversity and higher densities. With crabs pits 20-30 cm width, 10-15 cm depth, depends on size of crab, prey size. With something like a ray, 1m x 50 cm that's a big pit, crabs you need a lot of them to make that. digging rates are not well known, but data for the western North Atlantic suggest turnover several times a month, while in Europe, typically maybe 30% of the flat in that time- the rate is significantly less. For gastropods, don't know enough, can't say.

The only other thing is one more anthropogenic effect – feral organisms – sheeps, cows graze on marshes, not exactly feral, but also common are pigs. They can have major impact on marshes, especially south of Cape Hatteras and sometimes north.

Vermeij- burrowing predators –the American gastropods, *Polynices*... are so much bigger than their European equivalents, is this also true for rays? I think it may be true for portunids, *Callinectes*, is that correct?

Sally – gastropods- you're absolutely correct for gastropods, and for portunids. I'm more dubious of the rays, because if you are desperate for evidence that there used to be rays in Eur, in art literature it was common for places to hire painters of seashore – of fish markets, and in those

paintings are pictures of very large skates and rays for sale, so the differences for skates and rays may be anthropogenic.

Stephen Hawkins - For skates and rays make the comparison with the American coast and farther south in Europe. In the Azores, found sting rays, some in Portugal and Spain. I suspect (***didn't get**) does quite a lot of damage, farther north in Europe, we have data they are skates, not stingrays and things, a lot of data on offshore things, for the south of Europe, stingrays and things. So for rocky shores compare here with the north, but for soft shores, make comparisons with farther south in Europe.

Sally – Yes, but given faunal barriers I'm trying to stick to, I want to ask rich benefactors to send me to find impacts on the bottom ...

Daphne – Northern coasts of Europe have been engineered so much longer, how much of these differences are due to more engineering and high density of people?

Sally – That's a hard question.

KARSTEN

Climate structuring on soft bottom benthos, marine macroinvertebrates strictly at edge of shore close to high tide line, should be tolerant of factors such as temperature. They might also have a wide geographical range, are not the ones sensitive to climate change. But as far as I know there is no systematic account of this, do they have wider geographical range? We don't have this because things are more complicated than this. Two European bivalves – (***brought shells with him to pass around**) - 2 cockles of *Cerastoderma*. They probably evolved in the eastern Atlantic 50 million years ago. The common cockle, *Cerastoderma edula*, is an open coast species, intertidal and adjacent subtidal, very successful, takes place of *Gemma*, *Mercenaria*, etc on the American coast. A sister species evolved later, in the Mediterranean sea, *C. glaucum*, further inshore, should have a wider geographic range. It extended north when the Strait of Gibraltar opened. It is genetically diff from *C. edula*. In the many glaciation events, the 2 species reacted differently. *C. lamarcki* due to genetic distinctiveness and breeding experiments. genetically heterogenous, extinction events are quite frequent. It is different from *C. edula*, very homogenous, probably during the ice age it went south, then went north in the interglacial. More differences for the *glaucum-lamarcki* complex. In the North sea, eggs are demersal and sticky, juveniles can attach to seagrass. May be transported by birds, but this is not a reliable form of transport. Lots of extinctions, lots of founder events, explains the higher diversity relative to *edula*. It may also explain why brackish water fauna are poorer than on the American side, because the estuarine sites are very disjunct in Europe. For example *Mya arenaria* - is it re-introduced or an invader, not known for sure. For soft bottom fauna from Maine and North sea, higher diversity on the Maine side, gammarids are more diverse in Gulf of Maine.

Short term responses to climate anomalies. The North Atlantic Oscillation (NAO) - Icelandic low, Azores high - species which are inshore, less restricted to intertidal, have a high power of resilience. The cockle *C. edula*, is killed in severe winters in the intertidal but then propagules of subtidal survivors successful. The predators were also hit by this hard winter, and their young are produced later - a temporal mismatch - so cockle young grow before their predators, so they make it. It is not the same with polychaetes – *Arenicola* is abundant on European tidal flats, less abundant in America. Speculation that it is introduced to America. This species has an intra-specific interaction. The juveniles have an offshore refuge, overwinter deep

water, and come back next summer. If there is a strong adult population due to a mild winter, they get marginal habitat. If the winter is severe, when they come back, they can establish. If center of population is offshore, more time is needed to recolonize the tidal zone.

Suzanne - What kills them during winter?

Karsten - Freezing, frost during winter, usually not immediately but next spring, bivalves slow death.

Stephen – Are there records from the British west coast of *Cerastoderma*?

Karsten – Same 2 species on all British coasts.

Stephen – Primarily on German and Dutch coast not British

Karsten – That's a continental winter. Lower frequency on the British coast, so higher diversity there than in the North sea.

Boris - Some intertidal algae have similar mechanisms of coping.

Karsten – Yes, moving between subtidal and tidal..

HERB WILSON

Shorebirds – some work in Bay of Fundy...

Shore birds are abundant. Don't obey CORONA boundaries, they breed in the north – northern winter in south, some are trans-Atlantic, some that are only on one side or the other.

Some migration features of shorebirds (***Writing on pad**)

1. episodic- predation is episodic, birds come through and spend a short period of time before moving on.

2. highly localized – birds migrate along broad front, but shorebirds use traditional staging areas, characterized by high productivity, where they can find food to fatten up for their journey. Where shorebirds structure communities are localized, effects may last but predation is over short period.

In the 1980's – how much production on a mud flat is removed, what are the effects of this removal? Try to exclude shorebirds, difficult to measure. Data from the Wadden sea, Scotland, North America, are unable to detect a significant reduction in prey. Birds aren't strong restructuring agents. Two case studies in the western Atlantic:

Delaware Bay – important in the spring – late May - horseshoe crabs come to lay eggs, around 4 mm diameter, and are food for shore birds, which are also eating polychaetes, etc . Exclusion experiments found no reduction in polychaetes and bivalves, but didn't look at the effect on *Limulus* eggs. But there are huge numbers of *Limulus*, they're not depleted – they come back every year.

Upper Bay of Fundy – is a staging area in August for the semipalmated sandpiper. In the summer, they breed in the central eastern Canadian arctic. After breeding, they go to the Bay of Fundy. They feed there on the most abundant organisms in mudflats – amphipods – *Corophium volutata*. 90% of these birds are in the Bay of Fundy in August, gluttony, they double their weight in 2 weeks, so this will be the place to see a significant predation effect. Birds wait for appropriate winds to take off, going south eventually to Surinam, 4000 km, 4 days of sustained flight so they need to put on the fat. Do exclusion experiments. *Corophium* in the upper Bay of Fundy life cycle – 2 generations/year – wintering generation – born in August, live until May or so. Then the summer generation, born in May, die in August. Iteroparous versus semelparous. *Corophium* reproduce only once, but they don't die immediately after reproducing. The birds are taking the hind end of the summer generation, so birds are eating summer generation amphipods. In exclusion experiments, where there are no predators, *Corophium* abundance goes down – there's an inter-generation competition going on. If old *Corophium* are not removed,

then the next generation have to go elsewhere. So the sandpipers are managing their resource by removing post-reproductive animals, to make way for next generation. This brings up evolutionary questions – circumstance, or selection here? In the lower Bay of Fundy, the water is significantly colder, and *Corophium* have only a single generation. It is colder, and there are no shorebirds there (so different than the northern Bay of Fundy). A Colby student (***didn't get name**) and I did sample *Corophium* at the Darling Center, where temperatures are similar to the upper Bay of Fundy, but there are no shore birds. The *Corophium* in the Darling Center have 2 generations/year like in the northern Bay of Fundy. This indicates that the shorebirds haven't driven this life history. But it is a serendipitous fit, and the timing of reproduction could be important.

Input from phylogeographers – *Corophium volutata* – allies more with European *Corophium* than American. Did it migrate from the east Atlantic to west? They don't have a good dispersal phase. Ballast water?

Cliff – algal mats?

Herb - It would be interesting to find out about these *Corophium*, what were sandpipers doing before the *Corophium*?

(***some comments, didn't get**)

Matt – I have data for *Corophium* – COI data – very little variation, recent introduction, other data-rapds – show variation in the Bay of Fundy. Want to get something more variable. The initial look suggests not a long habitation in Bay of Fundy.

BERTNESS

Salt marshes – as a tool for doing biogeographical things, then how good a tool are they to make these comparisons? do in a community ecology kind of way. apologize...

Marsh systems can be very good tools, tools along the eastern seaboard of the US. They are simple, easy to manipulate, and are important. Describe basic processes and patterns

(***drawing on pad**)

Zonation of species across a landscape – low intertidal area is dominated by one species in a striking band, mid intertidal, another band, and high intertidal, another band. A striking pattern generated in a simple way.

Lower intertidal – set by physical conditions, high intertidal - set by competition.

Underlying this simple set of rules, as Sally brought up, these are biogenic structures, there are positive feedbacks allowing organisms to live in this habitat in the first place. At the high level, there is the potential for salt accumulation - in New England, if you make a bare patch, in the summer, salt build-up will prevent organisms from living there and the patches will grow. Superficially marshes look nicely organized, actually have hierarchical organization, positive feedback. We've gone along eastern seaboard here (***draws on map**). We've done experiments with this landscape to see how processes that generate pattern vary with latitude - one thing we're interested in is the balance between negative interactions- competition- and cooperation or buffering from physical stress. In the mid marsh – where salt buildup can be important, we've moved plants into a vegetated area or open area. North of Cape Cod, interactions are mainly competitive, south of Cape Cod, it shifts to cooperative. These interactions modulate year to year based on climate...as you move south, salt stress gets so intense, get salt flats on marshes, driven by salt stress, we've watered these areas and then they fill back with vegetation, as you move south, this whole zonation scheme, the rules change with latitude. In southern New England, driven by waterlogging stress and competition. Farther south, salt build up becomes important in

the high marsh – high marsh bordered by physical stress, role of salt becomes organizing factor. The most recent thing we've figured out is marshes in North Carolina and Georgia is that salt becomes so important, it suppresses primary production on the high marsh. If we shade the high marsh in New England, we get a decrease grass production; in Georgia and Florida, if we shade, we increase production. Latitudinal solar suppression. Interesting patterns in predation/consumer pressure. Demonstrate that southern plants in marshes have better defenses than in New England. The case for using marshes as biogeographic tool is compelling. Other differences between North America and Europe – differences in abundance of fiddler crabs – bioturbators and gardeners, lacking in Europe; lack of *Geukensia* – important in North America – stabilizes, so there are some interesting comparative things. Are these systems a good tool? Emphatic no. They are so anthropogenically disturbed, that use as a tool is out of bounds. Striking pattern in North America across latitude – southern marshes have big salt pans, in New England, a totally different situation with nice zones of plants. We've just realized that that's probably an anthropogenic artifact. So heavily impacted by draining. Early colonists probably drained. In Connecticut and Rhode Island, people destroyed around 90% of marshes, impacted all of them. In Europe, it is even more severe. It is difficult to find natural marshes to work on. For some biogeography, marshes are ideal, for others, it is not.

Vermeij - ? (*didn't get)

?(*don't know) - *Spartina* introduced to the west coast. opportunity for comparative study?

Mark – need to dodge the biocontrol people. We are taking this biogeographical approach to South America. In the west coast, they look at *Spartina* as a nemesis, use as a tool is frowned on.

?(*don't know) - anthropogenic change is enormous. How long does it take to recreate natural ecosystem?

Mark – Quite a while. A long time to restoration, you can get the plants back, but it has been difficult to get the plants and the function back. Sometimes plant height, density, matters. Restoration people just think about landscape stuff, no importance to feedback. Set up zonations, but it takes decades for feedbacks to kick in.

(Christy taking minutes)

TRANS-ATLANTIC EXPERIMENTAL ECOLOGY

Geoff – I'm coordinating all this – our group consists of Susan Brawley, David Wetthey, Boris Worm...

Susan Brawley – “North Atlantic Yin and Yang” – I think the idea of yin and yang – opposites that make harmony – is an important concept for us here. Dualities of old/new and adaptation and acclimation, and descriptive ecology and experimental ecology. Fucoids – *Ascophyllum/Fucus* - give us these dichotomies in the Atlantic.

Fucoids have been very successful in the Atlantic. *A. nodosum* is trans-Atlantic, and there are about 8 spp of *Fucus*, some only in Europe, others trans-Atlantic. One is coldest water species, and has colonized the North Pacific. Today I'm just going to talk about three of these more briefly.

Fucus serratus is found from north Spain to the White Sea, Iceland, and there's an introduced population in the Northumberland Strait, Cape Breton, and then down south to Halifax and just south. I was interested in Jim Coyer's microsat poster on *F. serratus* – a lot of affinity between Iceland and Northumberland?!

Fucus vesiculosus is found from Morocco to White Sea, Iceland, Greenland, 20-30 miles south of Cape Hatteras. It has the broadest distribution of a trans-Atlantic spp of *Fucus*; also occupies a variety of habitats – low salinities, to high, in the Baltic... In the 1990's I took my lab to the Baltic because I was interested in why *Fucus* gets to where the salinity is 3.8 ppt. This is a remarkable area – as if you opened a natural history atlas to lake and ocean, cut out things and threw them together. There's a nice fossil record in the Baltic and you can look at species distributions with changes in salinity over time. In talking about old and new, there as been an immense amount of excellent work for 100 years on fucoid communities - understanding the structure and function of the fucoid communities. Baker published a series of papers in 1909 and 1910 in *The New Phycologist* – differences in stress tolerances and correlating them with zonations with species of fucoids. Within the Baltic, one of the things we did, in collaboration tested Iceland, western Sweden - Stockholm, etc. In the Baltic, there really is adaptation, meaning genotypic change for Baltic *Fucus vesiculosus* – looking at effect of salinity on sperm motility and rate of wall formation on zygotes. If you take *Fucus vesiculosus* from any of these marine habitats and put them under high salinity conditions, the zygotes burst. They can't make a wall. There's been steady genotypic change, real adaptation that has allowed *Fucus vesiculosus* to survive.

In addition to this broad span of *F. vesiculosus*, I want to talk a bit about what I decided just to call *Fucus distichus* for today – it matters whether you're a splitter or a lumper – *F. evanescens* in Japan, Atlantic, *Fucus gardneri* on west coast, etc.; it's a cold water *Fucus* species, has lifespan is 5-6 years. Basically found up in the Hebrides, and northern Europe, (*** on map**) also north from Long Island. What were Atlantic ecosystems like before fucoids? They probably looked like Honshu where you have filamentous reds, but without this big structure. So the question is what has come with it? In my lab we've done a lot of work understanding reproductive ecology in recent years – fucoids only release gametes under calm or almost calm conditions. Scandinavia, Britain, and North America there are lots of species, different habitats (***?? missed something here**). You see lots of high fertilization success – suggests dispersal is only short range, however adults can drift -*F. distichus* is monoecious... You see drifting *Fucus* of any sort, you start thinking about what is on their backs drifting with them – chance for some longer term dispersal of its own gametes and so forth.

Two ideas

1. We've stopped having enough descriptive ecology – I'm worried about it – people don't like to fund it, but what I'm interested in is whether things have changed on a shore. We want money to do some really simple transects, especially across this really broad area *F. vesiculosus* occupies – then would have to work out sampling, but we'd know what's there. The next level of ecology is all going to have to be built on finer resolution information on habitats, etc. I think this broad range of *Fucus vesiculous* is because of hybridization with other *Fucus* species. We need population geneticists to see where adaptation/acclimation boundaries are. Population geneticists can help us out with adaptation in ecology (*** missed a little here**).

Natural experiment: what difference does it make to a functioning of ecosystem whether there's a *F. vesiculosus* or *F. serratus* canopy – we really know the timing of introductions so we can compare over the last century. We can look in Europe, where there's big *Patella*, and then can look in Pacific and see effects on Pacific ecosystem.

Cliff – I want to echo a couple of your points. A focus on descriptive ecology is absolutely necessary. If we phylogeographers hope to find generalities in our patterns, we need to know what's there. This difference in adaptation and acclimitization is also really important.

Stewart Grant – Hadley center and NOAA – 3 degree temp increase in 50 years – mostly in northern, and northern cold temperate areas. There's a golden opportunity for biogeographers in the future to use this in an experimental way - numbers of extinctions in northern and southern areas, new colonizations in northern areas – can follow spp and sites.

Larry Harris – Talk to Jim Morin about the transect studies that the lab's been doing for 30 years. If you want to see extremes of *distichus*, go to both sides of Smuttynose Island. The extreme morphotypic variation in that species is mindboggling.

Susan – I had Art Mathieson collect forms out here. I valued his experience with these forms, so I wanted him to collect them, but there was little genetic differentiation.

Steve Dudgeon – Can they readjust to euryhaline (baltic) conditions?

Susan – No. They don't overlap and can't readjust. The stature of everything in the Baltic gets a lot smaller - only about 10 cm when you're way in the Baltic.

Geerat – ...obsessed with trans-Arctic stuff... one species you didn't mention - *Pelvetia*

Susan – Gave it a new name - it turned out not to be monophyletic. The name was retained in the Atlantic, others are changed. There are three species in the Pacific, one in the east, two in the west.

Emmett Duffy – What I'd like to do is pick up on Susan's last point – possible interesting things for ecosystem function in the loss of organisms from one side to another in the Atlantic – *Fucus*, patellid limpets, there are other examples. I'd like to back up a bit to a general discussion of biodiversity and ecosystem function and what we might be able to do with the trans-Atlantic biota. The issue of how diversity influences ecosystem function: productivity, invasion resistance... One of the primary themes in ecology over the last decade revolves around the question of how changes influence ecosystem patterns of stability and productivity. Age-old theoretical question: how does species diversity affect community stability? Also it's an immediate, practical concern given that extinctions are accelerating everywhere. What influence will this have on ecosystem services?? My interest was in whether we might use the unique situation on either side of Atlantic as a grand-scale natural experiment to look at some of these issues. Some of these ideas are going to sound naïve – I'm not familiar with the detailed natural history – I've worked further south, outside Cliff's definition of North Atlantic. The basic idea is straightforward: Darwin noted diverse pastures were more productive than monocultures – trait diversity increases with species richness – can use as a proxy for functional diversity - larger species diversity can increase total biomass production, etc. Here's a diagram (* **drawing**) from one of Dave Tellman's papers – 2nd niche space – light and nutrients as axes – a larger species pool has a larger range in traits. In a spatially heterogeneous environment, a larger group of species might be more productive. This is referred to in the literature as sampling and complementarity effects. If you think of plant diversity, and think of how total productivity changes with plant diversity... in a lot of empirical work in grasslands, the total productivity is the net biomass at the end of the growing season. As oceanographers we know this is not net productivity... if you randomly assemble plots of species, productivity asymptotes at some number – one way is complementarity – different species are using different parts of niche space – other mechanism is called sampling effect – in a large species pool, there's some range in species traits, productivity, for example – for statistical reasons in a large species pool, you're more likely to have a species that does really well under those conditions under a homogeneous environment. Each plot with one species, the signature is that some single species plot is approximately as productive as the most diverse plot, whereas in complementarity, the single

species plots are less productive than a combined plot. Terrestrial ecologists have been running up pages of Science and Nature showing interesting relationships between plant species richness and productivity, though there are some other response variables. Dave Tilman, BIODEPTH – and Hector et al. (*?) (cast of thousands) – are synthesizing assemblies of grassland plants with a random draw from a species pool at a number of sites through Europe – many show asymptotic relationship between species diversity and productivity... interesting studies by Shahid Naeem and (*?? missed this person's name) with aquatic microbial communities in the lab. Also empirical data - nice study by Jay Stachowicz, Rich Osman and Whitlatch in Science – showed increased species richness in fouling invertebrates reduces invasibility by other invertebrates. These are just highlights of empirical work done so far- frontier in this work is how diversity in more complete foodwebs influences it - there have been only a few studies with longer food chains. Top down forces seem important. Where I think the North Atlantic might be able to help us in this – I think these sorts of experimental studies are limited in scale and scope, even nicely designed ones like Tilman's - whether the patterns predicted by theory for these experiments are seen in surveys of unmanipulated ecosystems – one way we can make rapid progress as Susan suggested is to collate descriptive data - some doesn't exist yet – on distribution and abundance on different sides of the Atlantic. The western Atlantic at least for hard substrate taxa can be thought of as a depauperate subset of the eastern Atlantic fauna – productivity should be higher, invasibility lower, stability higher where diversity is higher. There are a number of questions that need attention even before we can start to get at this. We need to know if diversity is consistently greater in the eastern Atlantic – it doesn't seem to be true in soft sediments – which would be an interesting complementary way to look at this. Rick Wahle's poster – cobbles being more diverse in Ireland – can we find comparable sites that are abiotically comparable sites on the two sides? If we can find places to set up sites to see how diversity and these other response variables vary, that would be a place to get started. It's also of interest to ask which functional groups are not on one side or the other.

Karsten (??) – When you refer to invasibility and the number of species, we cannot compare the eastern and western Atlantic with a simple clade of fouling organisms; immigration success of a given taxon could just be greater...

Emmett – Yes, I'm talking very general terms and we need to focus down, be able to control for temperature, salinity, etc.

Steve Dudgeon – These are all species richness, what happened to idea of evenness?

Cliff – The kind of curves in Hubbell's new book.

Emmett – Especially true in natural environments, where you have very skewed natural environments. If you look at examples of keystone predators – there's a less clear relationship between biomass and abundance and species numbers. In plants there's a clearer correlation between impact and biomass.

Geerat – The claims of Tilman etc. are made on relatively few species. You're talking about diversity as a modern phenomenon. I have made the claim that it's not the diversity but the number of species lost. I think that correlates well with invasion success seen over time. To ecologists – don't think of just the present, but also in the past.

Emmett - I agree with you of course. It's true that the range of diversity that's been studied is low – 32 spp is relatively high. In all these studies, the level where it asymptotes out is relatively low. As far as the second point about historical loss of diversity – it's especially important over long term – eg. extinctions that allow radiations – an issue that this group could truly make a

unique contribution to – no on terrestrial side is looking at diversity history and functional processes at least over time.

Matt Hare – The disturbance regime is crucial for setting up these interactions; so also disturbance regimes are important to look at.

Emmett – When these are important to look at is when these are lost from the pool permanently.

Steve Hawkins – Thank you to Cliff; apologies to Stuart Jenkins - I left his poster... I've come to rocky shore ecology from a natural history perspective... I said learn the animals and plants, and then learn what's going on, and don't try to shoehorn into some trendy ecological theory. I also represent several groups of European researchers; I want to mention a few projects; I have at the moment two main interests – one is climate change – 23 partners in 20 some countries put in a project – failed being funded – BIOCLIMA – environmental context, patterns, processes, indirect effects of climate change, and then some modelling work on making some predictions. And then because it's an EU project, there's a load of socioeconomic bollocks. That proposal is on the stocks; I have a UK and Irish funded project just doing the patterns and historical changes. Going back and doing descriptive ecology – I reinforce Susan's point – descriptive ecology is not very fashionable, but if you do it right with good questions, it can be very important. I have put in an expression of interest for framework VI – I'm hopeful that we'll get some funding. That's pretty irrelevant... I'm not a bad loser – it's very un-British. EUROROCK is a consortium of my mates, who managed to screw a large amount of money out of the EU... we put together a well-structured proposal that got high marks... EUROROCK includes people in Portugal, Spain, Southampton, Italy... Chelazzi is the coordinator. We're trying to look at individual behavior – plant/animal interactions. Stemmed from a Liverpool meeting in 1990 – deals with interactions on a north-south gradient. As you go farther south in Europe, fucoids get rarer and rarer – we're trying to look at individual grazer behavior and then population genetics concentrating on barnacles – both recruitment and post-recruitment processes. Also experimental ecology; grazer-exclusion experiments – quite a strong technical module – developing techniques to measure grazing pressure. Also modelling – on individual population and community levels. Various papers are coming out and mostly published in MEPS; to start we have published papers on population work; sort of a slice of the things we've been thinking about doing across the Atlantic. I'll share some the experience for that in a minute... But what's going on on the shore?? Both positive and negative interactions before they became trendy... *Patella* and barnacles, fucoids interactions between – (*** on blackboard**) barnacles help fucoid recruitment – mediated by *Patella* grazing, fucoids are suppressed by the limpet grazing, etc. If you start moving to the west coast of the Isle of Man – *Littorina littorea* there, also *Littorina saxatilis* – go a bit further south in Britain to Plymouth – 2 or 3 spp of *Patella*, what used to be called oxilins, gibbula (***??? no idea if I got those right**); *Patella* has a big effect on epibiota and on rocks; that's just in Britain. Now if we start thinking about Plymouth, New England, a lot of these species are not there; a lot less *saxatilis* diversity here, more *L. littorea* here, and a lot more fucoids. If you compare Plymouths – not a strong comparison – you should compare New England with northern Scotland... I think the challenge really is how do you make comparisons where you have lots of additional species. Use very simple manipulations; a subset of experiments in England might be what's done here. The controls will be interesting for descriptive ecology. Personally, I'm interested in grazing, so looking at how the diversity of grazers affects an ecosystem. Production in system is primarily microbial films – could look at

extracted chlorophyll as an easy response variable; could look at ratios of microbial vs. macroalgal production... there are lots of opportunities, but the challenge is to turn a vague aspiration into something that is tractable. Do some simple things... whack out canopies, plus or minus grazer assemblage, plus or minus early colonizing species, and look at productivity. I would advocate simple tractable experiments. One of the good things about EUROROCK is we did some modelling - you have to think about individuals... as a community ecologist, you think species A zaps species B, but modelling forces you to look at individuals. We used wax disks set in rock, you can get an index of encounter rate between grazers and algae... could do it in Isle of Man, Devon, Spain, looking at biomass cycles of grazer intensity and production; also replicate wax limpets - crabs are stupid and try to eat them. We published in JMBA... crabs leave marks on the wax replicas, provide an independent way to get attack rate. Also an underwater camera array... can look at individual-based models, also was a model on individual-based model of grazing. If you want to know what's going on with interaction rates and encounter rates it's quite easy to do. From EUROROCK we learned that we had two shores, sometimes three shores in each place, so we had in-location variation; we needed several locations of within site or within region replication so we can untangle regional effects. We have to be very careful that our pet theories don't dominate our thinking; need to have these designs in mind at beginning, need to have lots of money. EUROROCK was only €1.3 million; one postdoc each. Basically abandon the Anglosaxon tradition of lone shark investigators...

Susan - I think your point about not using pet sites is important - want to do almost random selection of latitudes and longitudes within regions. Some sites around marine labs have long term monitoring, so don't want to exclude them, but even close to my pet sites, it's different... also need to do temporal sampling.

Steve - In EUROROCK, we had two random dates in December and January, and two in May and June, and everyone did random initiations. I don't have the ANOVA with me but extremely complicated - one of the notions was that perhaps light might be limiting in the north in the winter, and heat in the south in the summer in ephemeral alga. You have to think carefully about how you do temporal comparisons.

Susan - An important point there is larval supply - times of massive recruitment of algae - who holds space at a given time is important.

Steve - We got lengths of settlement seasons - it's very important. Here, this coastline is much more like Scottish coastline, much more larval recruitment here in bays, etc. - might override other patterns.

Agnar - Steve maybe you're dominated by your pet shores, but if you do comparisons of here and UK shores, it's not a good comparison - you need to go north.

Steve - Right.

Diarmaid - Interesting deletion experiments - so can you make predictions about what's happening here based on what you omitted?

Steve - Actually did *Patella* functional groups - 144 replicates in each site.

Geerat - One way of dealing with this in an evolutionary sense is in Europe you have large limpets; in the north Pacific, you have small limpets and chitons; in the northwest Atlantic, you have one little limpet; what about the characteristics, the phenotypes of the organisms they're grazing? Do you have a sense whether they're different? Do big chitons of the Pacific and big limpets of Europe graze the same organisms??

Steve - I've looked at individual scratch marks - and a limpet radula is a limpet radula. There's a bit of difference between species - one excavates the substrate more. With the exception of one

or two specialists, most intertidal limpets are feeding on microbial films with blue-greens and diatoms.

Geerat – So the question is does it make any difference?

Steve – Well, if they get there.

Geoff – polyphenolic content of fucoids – more grazers on fucoids in Europe. (* **missed some of this**)

Susan – Phenolic measurements from Norway, New England and Spain – you can change phenolic content based on stress the algae is subjected to, but there's not a good correlation, I don't think, with predation.

Steve – If you look at a limpet gut, there are barnacle plates- they just get what's there - microbes are on plate and they grunge up the whole plate.

Dave Wethey – Experimental Biogeography – work on trying to understand geographic limits on species. One of the points I'd like to make is that most of the community ecologists tend to think about groups of organisms and their interactions – tends to dominate our thinking when we talk about biogeography - we talk about the geographic limits of species. It's a funny problem in our thinking – in biogeography we have an autecological view, and when we think about a community we look at interactions, strengths, and who's killing whom. This sort of disconnect probably influences the kind of hypotheses we develop and may end up leading in a direction that may be wrong. One example – *Chthamalus* – the high shore barnacle that is in the UK, below it is *Semibalanus*, most have probably read Joe Connells' paper - the boundary between the two barnacles is set by a variety of nasty interactions; *Semibalanus* can beat up *Chthamalus* in Scotland; in New England; seeing massive distributions of *Chthamalus* on high shore – if you look at shores of different slopes and aspects, you see different distributions: south facing and horizontal, there's a broad *Chthamalus* zone, while on north side, vertical there's a narrow zone. The strength of interaction is strongly influenced by microinfluences on the system - presumably had to do with warm/cool microclimates; did a bunch of experiments – different types of roofs- found that in the shade you can reverse the outcome in broad *Chthamalus* belt – you could cause *Semibalanus* to win in shade. The difference was that in shade *Semibalanus* could survive nasty conditions of the high shore, and could kill the wimpy *Chthamalus* – on a local scale microclimate determines strength of interaction. So what sets geographic distribution?? *Chthamalus* goes from Cape Cod down to the Caribbean, so from autecological view, clearly *Chthamalus* can't survive because it's too cold or whatever north of Cape Cod. If you look carefully around Cape Cod, what you find is that along the Cape Cod canal, *Chthamalus* is abundant from the middle of the canal south, and around the south coast of Cape Cod until you run out of rock, common down in Connecticut. In Cape Cod Canal, on the southern bridge there are 1000 *Chthamalus* per square meter in a band on high shore; on north shore – there were 7 individuals of *Chthamalus* on northern bridge in spring and as of last week only four were still alive, and bridges are 5 km apart. Something's happening that's a really sharp boundary. It could be cold, but also could be that local factors are conspiring to set local limits. I took stones from Connecticut and drove them to Nahant, put them in a couple of locations - some were above the barnacle line, on the assumption that *Chthamalus* doesn't need heat (story about Southward and how he had a rock with *Chthamalus* on his desk for years, wetting it only occasionally, and the *Chthamalus* survived) also in barnacle line, and below; where *Semibalanus* recruited, *Chthamalus* were dead, in *Semibalanus* zone, where *Semibalanus* removed, could keep them alive – above zone, *Chthamalus* lived for 7 years; from my geographic research, I found

Semibalanus survived for 3 years. If you look in detail in Cape Cod canal, there is enough of a difference in conditions in 5 km apart – there's no place for *Chthamalus* to live. So what's the mechanism – temperature?? Glued temp loggers on bridges - what seems to be going on is at high tide, the southern bridge is bathed in warmer water, also have all the standard low tide heating things – conduction to rock, etc; rock is started out at high temp because of warm water, so eventually warms to higher temperature than northern bridge, even though they're only 5 km apart, the difference in the water masses causes a big effect.

Chris Maggs - What is the temperature difference?? Can be 10 degree Celsius difference...

David Rand – What are mpi and gpi frequencies??

Dave Wetthey – Likely there are some gradual differences versus a sharp gradient

Steve – If you look at a species in the UK, there are scraggly populations in the northern UK, and up in northern Scotland, they don't have a chance of a shag in hell.

...a whole population that isn't doing much only 100-150 km from where you have proper interbreeding populations.

Dave – In the UK, the eastern limit of *Chthamalus* is the Isle of Wight, and on the Scottish coast – different hydrodynamics and climate system – it would be interesting to look at the degree to which mechanisms translate across the Atlantic.

Steve – Looked at this in EUROROCK – the eastern limit in the channel is associated very strong offshore dispersal (* **missed a lot of this**) a strong headland effect, not so strong in Scotland where it tends to dribble all the way around from the north – doesn't reach Whetland (*?).

Brian Helmuth – there's a disconnect – what's going on during low tide is largely decoupled from sea surface temperature – we shouldn't rely solely on water temperatures – conditions at low tide are dependent on wind speed, convection, etc.

Dave – I agree.

Susan – Looked at this – found very different survival of larvae in microclimates.

Boris Worm – I'm a post-doc at Dalhousie – trans-Atlantic personality commuting between Baltic and Dalhousie; going back next year – 2 year turnaround time. I'd like to give a rather personal view of how this has played out for me - modest insight I've gained and direction I see all this going in the ecological realm. The theoretical basis – community ecology has been attacked recently both within and without for being too focussed on small experimental scales, and local processes and species interactions, demonstrating the enormous importance of things like keystone species. Community ecology has progressed a great deal using this approach – may need to progress a little bit and use aggregates – small spatial scales is a valid criticism. Need to merge with experimental ecology to test theories on larger scale; reciprocal interactions between three properties – stability, diversity and composition (keystone species, habitat-building species/ecosystem engineers, dominant spp.) also productivity (ecosystem function like carbon storage and nutrient cycling) this framework captures the fundamental aspects of every community, the quantity, quality and dynamic features for all intents and purposes. Some sense of how constant the community is, how easily it returns to equilibrium after perturbation.

Steve Dudgeon – Are you including disturbance under stability umbrella?

Boris – Yes. These can be measure in different ways, talked about in different ways, but still can related them in meaningful ways – a lot of recent attention has gone (Emmett's work) into looking at effects of diversity on productivity – found positive interaction; my work and Lotze,

others have gone in other direction – negative. Found in Baltic negative; but positive in North Atlantic – an order of magnitude lower productivity.

Also depends what level you're looking at – the direction of these opposite results is reversed between North Atlantic and Baltic in most systems today, probably a negative relationship because of eutrophication of coastal systems today. Diversity and stability – a lot of people say that diversity to stability is a positive relationship, stability on diversity is a plus minus relationship – condition dependent – relationship of productivity potential. It's fairly complicated in my experience, the relationship between productivity and stability is negative – pore productivity to stability is less stable/more fluctuations; but a more stable community tends to have higher productivity – ex. tropics tends to be more stable, but very productive, but really put big question mark here for stability and productivity. It occurred to me this morning whether we have self-regulating feedback loops maintaining large equilibrium here; a lot of species-specific work fits into diversity aspect. How? And should we do this on both sides of the Atlantic? My personal rationale is that I like Canada, but scientific rationale nowhere in Europe do you find coastal systems that have really low productivity besides maybe way up in Arctic or Mediterranean, so have to go to other side of Atlantic with low productivity, to test hypothesis that low productivity is responsible. So how do we do it? There are fundamentally different approaches. In my case, I did experiments in the Baltic and did the same experiments in Nova Scotia. I think this is really important to do it exactly the same – everything I could possibly control for was exactly the same. I walked tens of km of coastline to find an area with the same feel – partly intuition, my personal view is that it is important that one person in sophisticated experiments is doing it or at least supervising it on both sides - or one person on each side doing it together on both sides – you have to immerse yourself in these environments. I have been involved in one project just about to be published doing comparative studies all over world looking at effects of UV radiation on algal succession – this was a different approach – everyone sat in their little place, Kiel being one, I was in Halifax, Antarctica is another one, and we all met in South Africa and discussed how to do it. It didn't work out very well – everyone does it their own way, and everything falls to pieces. We had fourteen sites, and we had to throw out six sites and eight were usable. I'm optimistic about people getting together and travelling to different places to do it – that's the first lesson I've learned. The other lesson I've learned is that a good rationale – for doing something in exactly the right locations – must be well-founded in theory why you're doing the experiment, not just for comparison's sake. I had a Nature paper rejected twice before with criticism that you can't really compare these things - everything's different – salinity is different, etc. I had done it in one site on each side, it took 3 years, but that is a problem if possible – re-emphasizing what Steve Hawkins said - is do it at multiple sites, as in EUROROCK project, but you have to do simple projects. Third lesson – it is very crucial when you have done your small-scale experiments to see if you have transient dynamics and if you are anywhere near equilibrium – need to look over evolutionary time scales and see if the same things are happening. I looked at broad scale patterns in many sites to see if they matched my predictions; took all my work and redid over again. I had a good feeling – had integrated various scales and transported it across the Atlantic and gotten good comparisons. Even when I was doing it myself it was difficult to adhere to the same methodology over the three years; replicated between sites or add some other information between sites with something simpler like a field survey to get some idea. Also merged with model predictions in Nature paper, compared existing datasets and tried to see if overall the results were supported by my experimental results –using

meta-analytical tools – fortunately they were. These are community ecology large-scale things - can't do it all over again. It's a wonderful lifestyle, but alone you don't get very far.

As we heard yesterday from Phil about oceanography data - need to get data over time, use meta-analytical tools to look at species interactions at large scales. We do interactions between a large predatory fish - cod and prey – crustaceans. There are other prey, (small fishes) but data are trickier. We have wonderful trawl surveys on both sides of the Atlantic. There's a little correlative work but very sparse, combined from the Gulf of Maine all the way up over to Skagerrak, etc. Whenever cod are going down, shrimp are going up, and when shrimp are going down, cod are up – to our surprise, this was consistent across the Atlantic with one exception. ...take all these datasets and series to use random effects meta-analysis to analyze the data – I'll be happy to talk to you about this later today.

Steve Dudgeon – I think we all share your concerns with different people having same effects, also I think a big problem is doing these same experiments at different times.

Boris – I don't think it's necessary to do these at the same time, since because of the NAO the climate is going to be different. I wanted to emphasize that you have to have some feeling about where you're working.

Steve - With EUROROCK we had one advantage the project had been in my head for three or four years before we got the opportunity, so I'd been to all the areas and had one big workshop at the beginning. We had some problems, but they were strong effects we were looking at, and simple experiments; we were planning to do more complex experiments but couldn't. The most interesting were simple. You need to have one or two people visit all the sites.

Boris – I think your idea is excellent that people have to groundtruth everything

Rick Wahle – Regarding site selection, I want to emphasize the importance of making sure the physical environment is the same on both sides – need to select sites that are environmentally/physically similar; figure out what your gradients are, and conduct your experiments across those gradients on both sides of Atlantic.

Boris – There are people in Dalhousie that do transplant experiments on *Codium* and *Membranipora* across the Atlantic – have already done comparative trans-Atlantic transplants.

Ladd – We have better and better ways to measure air temperature and wind speed, etc.

Susan – I think everyone who's here who's been in science a while has had a bad collaboration, but we've also had good ones. We have more tools for measuring the physical environment, also population genetics. You've looked at sites you chose based on number of species which was an interesting comparison, but if I'd done it, I'd have compared Canada with Norway- more similar physical environment (but not diversity) – there are multiple approaches, you need to develop good collaborations.

(Annette taking minutes)

PHYLOGEOGRAPHY GROUP

sampling strategy

assigning groups

coordinating collections

Cliff – welcome, couple of brief things – don't know what we'll walk out with, but let's come up with specifics on what to do, plans of action. If you have a little money sitting around, and you

might be able to focus on the north Atlantic. Also ideas for fairly major funding. 3 things to discuss at the minimum – 1- sampling strategy – to some extent comparable, include what sequences to obtain, Steve’s idea about whole mitochondrial genome, 2-assigning groups, 3-coordinate collections – so that my students don’t have to...just kidding. Very inefficient, maybe 4-5 taxa, for really big phylogeography project, think 100’s of taxa, with few collecting trips where many contribute to, or line up marine labs across natl participate in exchange system, investigaor responsible for accurate identification. If at any point this is not for you, you can leave, no offense.

Matt – What questions, specifically what to focus on, do them all? Or this isn’ the time to think about what is do-able, brainstorm after so many perspectives?

Cliff – I chose not to start this way, people want to do groups they’re familiar with, a matter of what we’re equipped to do

Daphne – What does do a group mean?

Cliff – Lots of hypotheses, I’m more interested in getting the histories and testing hypotheses after we get the histories.

Diarmaid- If you really want collaborative effort, with ecologists, then we need to listen to them, have them identify 10-15 taxa,.

Cliff – Great idea, can somebody run to other group, have them come up with their top 10 species?

Maggs – Sequencing is not free, neither are students, postdocs. Money for phylogeography has to be tied to climate change or something, what ecologists propose essential.

Wares – ?(***didn’t get**)

Matt Hare – one- refuges, nice to nail down whether there were glacial refugia, and where they were; two - recent introduction versus historical invasions, pick taxa that show evidence for invasibility, communities where can make comparisons.

Maggs – important for funding

Vermeij - identify places that serve as sources for other populations, for conservation tie-in, really need to protect

Cliff – In many studies we’ve done, mainland Europe is a source for North America.

Vermeij – Source has more export than import – tie in to ecology, hypothesis that sources are highly productive areas

Cliff – something we can get phylogeographic data.

John – It’s not easy to do comparatively, lots of genetic data rather than lot of species, but vital question, trickier than baseline idea that were talking about.

Cynthia – I don’t think its doable. so little effective gene flow can mask pattern.

Chris - Miriam asked me – she’s interested in gene flow – she gave me a list of groups they work on, include hydrothermal vent species,...using microsats, some here who have tools and desire

Terry – phylogeography at the population level and recent divergence in the Atlantic basin are easy to sample for, but concern about what Vermeij said, you have to look at the Pacific, not only at Friday Harbor, but look at the Russian far east and Japan, where clear assoc w s amer and other places, emphasize the phylo part, look at monophyletic groups that have radiated.

Cliff – writes identify monophyletic groups. Not always easy to get things from Japan and Russia.

?(***don’t know**) – Canadian arctic were like Pacific ones.

Cliff – Greenland, haven’t had any there yet.

Vermeij – Have a meeting there.

Jim Coyer – hybridization (*complete???)

Terry – one starting point beyond ecological context, strictly biogeographical context, species Vermeij hypothesized from the Pacific, really focusing on those taxa, vast majority of taxa where we have good monophyletic groups with robust species-level phylogeny, only a handful, Mytilus, littorines, most taxa ecologists and biogeographers are interested in haven't been done.

Cliff – Have echinoderms been done?

Terry – *Asterias* not well known

John – I think it is (*?complete?)

Cliff – good point, to do it right (*complete?)...

John – Sister species groups in the North Atlantic, where one species is trans-Atlantic, and the other is not, *Littorina* for example. A focus on these situations might be a comparative situation for ecologists.

Cliff – initially thought someone to do sea stars... people more interested in hypothesis-driven, I thought less practical...

Daphne – My question before, what do you mean do a group? What are the questions that will get done, we need those first.

Jon N - find out what people want to work on, so at least it overlaps as much as possible.

Steve – I think everyone wants to work on the group they know, that's good, suggest harnessing some of the new technology, high throughput sequencing is cheap, (but not free) but lower energy of activation, so if someone wants to do their group they don't have to set up their whole lab, there is a facility

Cliff- Responsibility of the pi's to make sure group is taken, then a central facility would get the data...

Steve - Or provide training.

Edie - say when writing a grant – say I can send my material here, etc

Steve - opportunity here

Phil – overall rationale – to make attractive to funders – link to climate change, the groups here will have to have additional links to people with credibility, circulation systems, coastal physical oceanography

Cliff – I'd rather test hypotheses that I truly care about, not which ones are most affected by climate change.

Chris – It's a difficult funding environment.

Cliff – I'm not ready to give up yet.

Daphne – Do some sort of meta-analysis, using a tool like we have where you can plot on a map, and environmental correlates, gives you a predictive tool, use as a potential invasive spot to tap into these funds.

Vermeij - I worry about simply accepting, this bullshit factor, responsibility to be honest, not bend ourselves to junk science just to satisfy bureaucrats, we shouldn't compromise the interesting questions.

Cliff – I agree.

Maggs – We're not compromising ourselves, just using the vehicle they provide us, we cloak it, dress it the way they want.

Cliff – I think this will be worked out when we're writing grants. I'm more interested in the scale of what people are doing, I know what I'd like to see done, how interested are people in basin-wide phylogeography?

Edie – is a goal that genetics be done, something like Carr’s proposal?

Steve – Don’t want to limit work on a taxon by money,

Cliff – path of least resistance, once set up, people will use it. I agree with you Steve, 1-2 centers where most of the work will be done. I think large sequences are necessary to find subtle patterns. There’s no reason for everyone to have it in their labs

Jon Norenburg - go around the room- nemertean systematist, interested in their evolution, I’ve been collecting all over the North Pacific and North Atlantic. I have collections already, do some more sampling if we do more sites, basic phylogeny of phylum, and Atlantic gene flow, I came to see if I fit in, or if any collaborations to see if I can get what I want.

Cliff - How many nemertean species?

Jon N - In Europe, most diversity but know the least. about 80 species. We have almost no samples from soft bottom subtidal.

Cliff – Sounds like perfect group to work on, especially for soft sediment habitats.

Matt – I’m interested in coastal transition zones, in the western Atlantic, what’s shaping some of the sharp genetic variation, analyze some of the reproductive interactions, and ecological questions. My other interest is using genetics to understand patterns of invasions and invasability. *Corophium*.

Christy - Amphipods, especially in the maritimes, postglacial invasions, disjunct distributions,

Annette – Hydroid systematics, evolution, phylogeography, dispersal, especially Campanulariid hydroids.

Daphne – sea anemones – meta-analyses across taxa, how distributions correlate with environment, large scale meta-analysis

Steve Carr - Population structure, fishery populations, what do you learn with a maximally resolved tree, what do really large data sets tell you.

Paul – population structure, dynamics of hybridization in *Mytilus*, some limitation sampling in the Canadian Arctic and Pacific. Student doing population structure of sea scallops, we’d be looking for assistance in collections. Limitations with sampling.

Diarmaid - curator of molluscs – evolution of divergent life histories, Caribbean *Mytilus*, none of my active research part of this forum but I’m interested.

Jim Morin - Inferring evolutionary history of luminescence in Caribbean ostracods, but as director of the marine lab I have lots of interests, where are the fauna around here and how they relate, and as a service provider, in hosting this meeting.

Terry – opisthobranch molluscs – phylogenetics on a broad scale, in major clades, biogeographic implications of those phylogenies. Many taxa in the north Pacific, lots of trans-Atlantic species, higher diversity in European Atlantic than American Atlantic, about 120 species in Europe, 35 in the western North Atlantic, 180 in Pacific North America. Those 35 virtually all shared with Europe.

Tom Trott – benthic ecology – priapulids- only 2 species in the North Atlantic, only one shared with Europe, they are their own phylum, deep water, further south, intertidally closer you get to arctic, I’m here also to see how I can contribute to collecting material in Maine and Nova Scotia.

John Grahame– extend comparative work with *Littorina saxatilis*. It seems to be an experiment in regulation of variation, wonderful system, open for offers, start with shells – cheaply, maybe AFLP’s, maybe not; harp seal work, whole mitochondrial genomes.

Jim Coyer- *Fucus*, expansion and timing from glacial refugia, hybridization zone. It is an artificial trans-Atlantic species, introduced to Nova Scotia; *Ascophyllum*, *Zostera*

Phil – dynamics and history, could offer plankton samples, but in formalin, can collect extra plankton,

Suzanne – biogeography, tropical things, bivalves,

Ellen - benthic forams, big problem – deep water stuff, goes back to challenger expedition, if you don't check, you don't know if it's alive or dead – whole set of species with ranges to modern time but now think maybe extinct x 1000's of years ago, don't think can start sampling in deep sea, start with simple classification of what we have, once done with that I can think of some morphological taxa, those groups should be first to start with genetic work

Max - phylogenetics, systematics of red algae, especially correlating molecular data with reproduction, maybe 80 red algae species here, some sister taxa, some recent descendents

Chris Maggs – seaweeds of the British Isles, systematics of red algae, green algae, some species very old, others have no structure throughout the whole world.

John Wares - genetic patterns that emerge from col comm, are communities open or closed.

Cynthia – interplay of history contemporary gene flow and natural selection, in blue mussels, history of Baltic biota- hasn't been available habitat very long – adaptations, where did all these things come from, since not there for long?

Meg - phylogenetics and systematics of sea anemones – 2 groups, one with high diversity especially in Europe, one in high diversity in Pacific and eastern Atlantic, no members – artifact? Want samples from Scandinavia.

Joe Roman - *Carcinus*, recent invasion in North America, use phylogenetics to look at patterns of invasions, and characteristics of invasions

Agnar - reconstructing biogeographic history of north Atlantic biota, postglacial history, intertidal, shallow subtidal, animals and plants, willing to provide specimens to anybody interested.

Stu Grant - scallops and large crabs – no good phylogeny for ... scallops , also fishes, invasions of some genera into north Atlantic, try to understand why there are boundaries in fish, Pacific cod, Pacific herring, what are the dynamics, why haven't they expanded, invasions and biogeographic boundaries.

Christiane - sea urchins, amphi-Pacific, amphi-Atlantic, south to Cape Cod and Scotland, 2 closely related species, other close species is purple sea urchin whose whole genome will be done soon

Vermeij - history, effects of extinction, invasions, their timing, fossil record, fossils only source of past distributions, include areas not from today, very broad interests, will consult with any of you about fossils,.

Edie – delighted that molecular genetics people are less at war with organismal people

David - molluscan systematist, gastropods, littorinids, *Littorina*, Patellidae (true limpets), mainly tropical groups now, student whose looking at European trochids (*?correct?), importance of looking at entire monophyletic radiations, viewpoint of museum-based systematist – most based outside of museum, museums are storehouses, enormous collections, even for molecular research. Also think about voucher specimens, even for ecological work, museums will store these.

Chris – for Miriam- (*couldn't get – too fast)

Cliff – range from people with 100's of species to those with a few, let's take a break and then start on feasibility, then how to obtain large scale funding,

John – bryozoans – are a group that could be very useful, *Celleporella*, amphi-Atlantic story for *Celleporella*

Jim Morin - groups not represented....

Cliff - after break – two groups collection plan – workable including as many marine labs as possible, can't be done for free, approximate cost per sample; Mark and Agnar are going to lead that group, bring Jim Morin in, too; way to request samples through a central source, or some other way....

Terry – At least a couple of museum folks should be in on the discussion – not just collecting specimens but getting vouchers in, too; other group outlines of large proposal nuts and bolts as to what elements this is going to involve – meeting downstairs; collection group will also talk about sampling strategy;

Cynthia – What about uniformity of genetic markers?

Cliff – We'll discuss that in the grant writing section.

(Christy taking notes)

Collection Strategies Subgroup

John – We need to have fairly dense geographic sampling. So, first thing – where are all the marine labs?

Paul – Can CORONA website evolve into clearinghouse for posting needed samples and how to get them to people?

Ellen – If someone goes really far out, like the Arctic, it wouldn't be that much more money to collect for others.

Cynthia – Might be worth writing into a grant – trips to long distance places that would include several people with several different areas of expertise.

The list:

Greenland, Iceland & the Faroes

Faroe Islands – museum?

Arctic Station, Disko Island, Greenland

Institute of Biology, University of Iceland in Reykjavík

Europe

Aberdeen, Scotland

Bergen, Norway

Centre for Estuarine and Marine Ecology, Yerseke, The Netherlands

Cork, Ireland

Flodevigen, Norway

Galway, Ireland

MARS/BIOMARE network

Plymouth Marine Laboratory

Queen's University Marine Lab, Portaferry, Northern Ireland

SAMS Dunstaffnage Marine Laboratory, Scotland

Spitzbergen, Svalbard

Tjärnö Marine Biological Lab, Sweden

Tromsø, Norway

Trondheim, Norway
Umeå Marine Sciences Centre, Norrbyn, Sweden

North America

Acadia University in the Minas Basin, Bay of Fundy, Nova Scotia
Dalhousie University, Halifax, Nova Scotia
Darling Center, Damariscotta, Maine
Duke Marine Lab, Beaufort, North Carolina
Eastport, Maine
Huntsman Marine Science Centre, St. Andrews, New Brunswick
Jackson Marine Lab, Durham, New Hampshire
Lewes Marine Station, University of Delaware
Memorial University in St. John's, Newfoundland
Nahant Marine Science Center, Massachusetts (Northeastern University)
Shoals Marine Lab, Isles of Shoals, New Hampshire
Smithsonian Environmental Research Center, Edgewater, Maryland
St. Francis Xavier University, Antigonish, Nova Scotia (David Garbary)
University of Connecticut, Groton, Connecticut
University of PEI?
Virginia Institute of Marine Science (VIMS), Gloucester Point, Virginia
Woods Hole

General ideas, people & names I didn't quite get:

Cape Breton??? Dave Garbary? (St. Francis Xavier University)
Drobak – south (*????)
Pierre Brunel – Gulf of St. Lawrence Region
We need to get two or three sites in Newfoundland

General Discussion

We need a protocol about how to collect, in what, how to ship them....

We should include Pacific sampling – Alaska, Japan, Russia, Friday Harbor, Bamfield, Kodiak
Fisheries lab, Vladivostok,

There's no station on the Faroes – but a museum and fisheries lab.

Garbary (*?) could maybe get the Canadian navy to take them around Baffin Island;

You can get a commercial flight into Resolute – it's possible to get up there on your own.

Any time someone in the network gets specimens – needs to get a voucher into a museum and into database.

For specialized groups, need specialist to do the collecting.

List of stations, contact all of them, say, look this is a big group, we want to collect at all these marine labs – not much more we can do at this point

Should be more formal in the auspices of CORONA– write letter to each of these labs – we're interested in collecting organisms, what are your limitations/requirements – diving restrictions, permits. You don't need collecting permits in Europe for all except protected species, but should probably get a letter from the marine lab director saying that you don't need a permit. We should

contact them as a formal initiative – it would smooth things out quite a bit - say do you have an expert who'd be interested in joining the network; updating faunal lists??

David Reid – I'm concerned about focus on marine labs; I've always focussed instead on finding a specialist; maybe finding out when cruises are taking place.

and the biota is contaminated around marine labs;

formal way in which we do present ourselves to any expert or marine lab – say I need this is there any way my expertise can be used in exchange...

Need some statement that lab would facilitate visits by CORONA

Also think about it ecologically – what you're used to looking at, seeing, - not necessarily what you work on but the other groups you often see and know how to identify and fix;

sampling really needs to be reasonably dense – even though we've delineated CORONA boundaries – need to survey things throughout species range regardless – really strange things can happen at edges of range;

standard for collection – voucher, GPS, salinity and temperature, substrate type; Start with obis database and start putting specimen location that we already have,

pool a CORONA database of useful references on geology, paleontology, ecology, etc.....

get expeditions and literature and records; theoretically could be just linked into OBIS;

TRED – taxonomic resource expertise directory – for North America

CORONA setting up it's own bibliographic database?

What should go into proposal – money for hitting hard to get to sites; people who know how to find and identify organisms

We need fish people; copepod people???

We need a well-managed website/database information clearinghouse to make sure whatever has been done gets updated – sampling from whole species range and covered densely enough – need to be able to pick up fine scale stuff;

We should consider a book about what is already known – ask Cliff to edit book – ask people to write chapters; it gives us a product as well.

We could have a standing agreement with courier service to transport our samples from labs that collect for us.

Need money for some cruise time, several expeditionary trips – if we want to cover the Arctic, we need at least 2 trips. We're going to need a real office with a real website, etc. etc.

Also – get on existing cruises

Project database – about what's going on in CORONA – current and future projects.

(*This is just a general idea of what went on in this Collection Strategies subgroup meeting – Mark Costello took a short list notes on suggestions, and the map has a lot written on it as well.)

(Christy taking minutes)

Summary of meeting, Aug. 23rd, 2002 Morning Session

Cliff – Five minutes each by each group – working group/bubble

Suggestion to recruit marine labs across North Atlantic to join a CORONA network of labs to collect organisms – very centralized collection strategy. CORONA contacts the labs, then when

you want samples, write to CORONA, CORONA distributes request, and there's a formalized set of procedures for collecting/packaging/shipment – everyone deals with CORONA. You pay CORONA and CORONA pays the marine labs – some form of pricing structure. I'm very excited about this – the only impediment to massive phylogeography in North Atlantic is collection.

John – Try to make sure every thing that's collected is archived.

Cliff – We won't do identification, but PI's need to send us records for the museum voucher. Also phylogeographers met for NERC group – whole mitochondrial – integrate NERC proposal with Mark Bertness, Geoff Trussell, Steve Hawkins – and the set of taxa they decide upon, phylogeographers will do phylogeography, and if there are fossils, integrate them as well. Not only focus on mitochondria – some taxa it's easier to get nuclear genes as well – eg. fish – get nuclear genes to groundtruth mitochondrial pattern. Also focus on molluscs – because they have fossil record – can groundtruth mitochondrial patterns with fossil record.

Steve – Need to do algae as well!

Cliff – Didn't I say that? Focus on algal/animal interactions, the history of those taxa will be taken into account as well – Chris will come up with large section of chloroplast genome to compliment the mitochondrial genome for the animals; if people from that group have some things to add, I'm going to open it up for additions...

Cynthia – We've discussed organizing some expeditions to really remote places...

John – To cover more places – we can mine museum collections for some of that, but we need to try to get into the Canadian Arctic, Disko, northern areas off Norway – we possibly ought to be looking at maybe 3 expeditionary trips.

John Wares – The idea was that whoever wants to go would supply money for that...

Cliff – I think there are sources of money for this – a good enough idea – if one of you could take the lead.

Ladd – There are programs in Canada to get people up there. There's a huge oceanographic project that started last fall, just got a dedicated ice breaker... I'd be happy to facilitate contacts.

Sally – Are we going to have collection trips associated with the Iceland meeting? It's relatively easy to get to Greenland from Iceland.

Cliff – Great idea – our first expedition is to Greenland.

Sally – We had such a trip planned off our polychaete meeting from Iceland – fell through, but it didn't sound like the logistics were too hard.

Agnar – It's difficult, but possible.

John – Everything has to be shipped in.

Cliff – John could I ask you to organize this and look for little pots of money to fund this?

Steve – We probably need to get some Danish involvement

Cliff – Christianson... (* sp?)

Karsten – Petersen... (* sp?)

Cliff – Maybe Spitzbergen the following year...

Steve – If anyone wanted to go there - need to get in touch with Polish people and hitch from Gdansk on one of their cruises.

Cliff – Any more feedback?

Mark Costello – (* I missed this – he gave another Polish name as a possible organizer)

Steve – Despite having really poor resources, Polish marine biologists are usually very good and very enthusiastic and desperate for contacts.

Mark – We wanted an endnote bibliography of relevant literature.

Cliff – It will happen if someone takes the lead on that.

Mark – I will ask the people who spoke to send me references.

Steve – We talked about the possibility of commissioning some literature searches...

Cliff – What does this entail?

Steve – Marine Biological Association Library is a good library, and where abstracting is done in UK; not only do you get web of science, but gray literature, books and other things. MBA was going to make contribution to this meeting and Cliff was going to recycle it back to commission searches to turn up older literature.

Cliff – If you would like one of these searches commissioned – talk to me – they're subject searches.

Mark – We talked about a network of labs – mailing list – BIOMARE and TRED databases for persons and contact persons – not just marine stations but also people who go collecting. We also discussed deep sea and offshore sampling – didn't really discuss this in detail - needs to be cruises.

Ellen – ...cruise to Siberia to 88 north –to do drilling. Once you're drilling, you're stuck to shore. Three ships - nuclear ice breaker, supply vessel, drilling ship; in past we were able to piggyback small projects on – two additional ships don't have a lot to do – have to bring your own supplies and you're not a priority of the ship, but can get stuff done.

Cliff – Ecology bubbles...

Emmett – First thing, we talked quite a while – broke into bubbles – the group I was in detailed what was called assembly rules and plant/herbivore interactions and how these knock on to ecosystem level processes we talked about yesterday – me, Geoff, Mark Bertness, Boris Worm, Steve Dudgeon, Stuart Jenkins, Steve Hawkins....

Geoff Trussell will actually be writing this and Steve has some connections to NERC; the experiment (or series) that we're envisioning at this point is to get at manipulating the grazers in the mid-intertidal of sheltered shores, start with one sort of standardized environment that we can look at up and down in several different places, account for both regional and continental variation; get understanding of how plant grazer interactions are working in areas with different species pools or diversities, though we would go out into sheltered mid-intertidal, manipulate from 0 grazers to full complement of grazers at that site (differ from west to east) or full complement not at site, but at local region. Gradient in grazer diversity; still talking about how to make gradient – random assembly or by talking out large organisms as we go down – both sides of Atlantic, a northern and southern site and two sites within each region - not a lot of sites, but considering four grazer treatments, crossed by presence/absence of predator yet to be determined... out of that one set of experiments, we would learn something about (response variables – usual things – percent cover of different benthos primarily algae, final biomass, species richness, evenness, etc; also carbon, nitrogen storage, final biomass, grazer biomass) how grazer diversity is influencing interactions in these sites, etc. also a lot of interest in what Susan and others talked about – targeted descriptive studies...

Steve – one of the response variables – microbial benthic chlorophyll – is easy to get right on both sides of Atlantic. I think though it's extra work, it's important to add a moderately exposed site; *Patella* doesn't do well on sheltered shores. I thought it would be very useful to add gradient not to extreme exposure, but to moderate exposure. It would be interesting to see what happens here – very useful to add that as an environmental modification of these interactions.

Emmett – Before we broke up we were also interested in trying similar sorts of experiments in a variety of different habitats.

Boris – Tiles hanging in the cages that were colonized by microbenthos – can get at entire different producer community by the same work – just hang tile (in Baltic) different size range of organisms; just have to scrape them off and stick them in lugol and send to expert to ID; process structuring the microbenthos were similar to macrobenthos; another easy thing to do and would basically double the experiment.

Steve – You could just take rock chips and stick them into ethanol, get chlorophyll.

Cliff – Not as comparable as tiles?

Steve – Tiles are artificial...

Boris – Assumes you have some bare rock left at the end of the experiment.

Stuart – Depends on what community you're working on.

Matt Hare – In terms of what you'd like to see from an historical side of things – how long-lived are these communities, how long have these organisms been together on either side??

Emmett – We developed sort of a flowchart of how these things come together - obviously these organisms are coming together on geographical scale – different community contexts - good to know for major players – *Ascophyllum*, *Fucus*, *Littorina*;

as Dave Rand brought up – looking at adaptation process itself. The most obvious thing to my mind is knowing the biogeographic history of the major players.

includes Dave Wethey, Ladd Johnson, Karsten, Sally Woodin, Dave Rand... (* missed quite a few.....)

making contrast between rocky and sandy habitats – rocky habitats – were refuges, conditions are driven by local environment to much greater extent than sediments are because of the ability of animals to crawl down into sediments. The idea is to compare ecological genetics of some key players in these systems looking at both rock and sandy habitats, starting to look at Dave Rand's system in New England, expand across a greater number of taxa, rock/sand – *Balanus*, *Chthamalus*, a fucoid, *Nucella*, *Macoma*,; *Corophium*, therax (*???) (lives high up in sand – wouldn't have refuge others would have).

Geerat – I assume that for the rocky shores, a lot of the things you mentioned the intertidal is not the only environment they occupy, and could be marginal for some of them – is the intertidal the only habitats you are going to look at?

Dave – Many are really intertidal, but it's definitely an issue. Also if we pick some members of the fouling community – ascidians, etc. they're easy to get, don't require boats – comparative example – *Ciona*, etc. – driven by climate(???) intertidal may be a marginal not ideal habitat, you're right...

Geerat – Depends where you are...

Dave – *Arenicola* tend to have adult distribution in intertidal, juveniles in subtidal, etc... so moving around – all three habitats – oceanic, extreme intertidal, and midzone.

Susan Brawley – Bubble included Larry Harris, Steve Hawkins, Andy Pershing, Myriam Valero, and myself. We discussed ways to assess patterns of change on both sides of the Atlantic – some of this should be integrate and not stand alone. Andy had a good idea – look at databases for stuff like sea surface temperature, etc. over last 20 years to look for hotspots for rates of change – can think of anthropogenic climate change as a disturbance factor. How are these affecting community dynamics and choose places to try and assess how these are affecting things across the Atlantic – in areas where we have records (long term) Steve Hawkins does, Shoals does, CORONA might build an effort where we really make an effort to try to use these data together better, also new study sites where there seems to be a lot of variation year to year over last 20 years... Also open ocean sites as well. Larry had idea to look at subtidal communities that

have to do with *Membranipora/Laminaria*, interactions, *Codium* coming in, so that the shallow subtidal is a place that we should devote some effort to monitoring across the Atlantic. Also thought about particular organisms we could identify as very likely retreaters/advancers with climate change, eg. *Alaria*; then made list of organisms that we thought might be good for genetic information on – *Chthamalus*, *Semibalanus*, *Tectura*, *Nucella*, *Ascophyllum*, fucoids, missed a bunch, so some ideas but no clear action on them – for most of these things experimental and descriptive ecology need to go together, and soft sediments, too; our things need to be built on the other groups.

Boris – Could be built into site selection process in experimental bubble - multiply our efforts, build on the experimental.

Sally – For sediments, part of the problem is the effort involved in looking geographically – if you choose specific components – arenicolids and others are easy to monitor, and there's potentially money to do that at least in near sites - could acquire data over time for a variety of habitats.

Cliff – Is there one of you who is interested in assembling databases and interpreting them? There needs to be someone who's willing to do that...

Steve – I would take a little bit of issue as looking at climate change as disturbance – extreme weather associated with climate change as disturbance – colder winters, more/less precipitation, also more integrative effect of changes in climate – climatically-generated forcing of reproduction – number of broods per year in Portugal vs. Plymouth vs. Isle of Man. Primarily through reproduction affects competitive balances of northern and southern species – also need to look at both disturbance and integrative components of climate change - both are very important - I actually have a project funded on this in Britain and Ireland completing the broadscale surveys from the '50's and '60's. Also, mapping exercises come up with sites in clusters, use hierarchical approach to tease out regional vs. coastal comparisons; but we're having to use old methods. We need to merge the semi-quantitative methods with naturalists who know things. Timed searches are sometimes a much better way of quantifying species at the edge of their ranges than quadrats, so we're trying to combine both methods. I'm hoping it would be possible to create parallel projects over here.

Cliff – How about Shoals – is Jim here?? Jim Morin is planning on getting his long term information in a database this year.

Susan – Larry was mentioning several organisms here that were reproducing differently here.

Boris – ...paper on climate change impacts in Pacific...

Steve – Paper on plankton stuff from UK – [* at this point Steve gave a bunch of citations I didn't get]

Boris – Use all the data we have, combine them in a meta-analysis, and see if we see patterns or if they vary between northeast and northwest assemblages.

Steve – Need to have within site variation and broader scale pattern.

Dave – That's the great power of the Southward/Crisp data you've been involved in ... the key is getting a lot of types of data on a geographic basis.

Cliff – Is there common ground between what biological oceanographers and biologists are interested in? This seems to be it – decadal climate variability – what biological oceanographers are interested in in the pelagic zone.

Sally – There are also long term sedimentary datasets of this kind – Karsten, (* someone else ??)
Bruce Poole – benthic samples from South Carolina for 20 years.

Steve – Since 1982 when we started recording physical parameters, we've had periods of cooling and periods of warming – it's a very messy trace, a lot of inter-year variation - but within 5-6 years, average lifespan of a limpet, you see good years and bad years. If global climate change is having any effect, we predict that we will have higher abundances than 1950's. Also I never use the monitoring word – longterm research to answer scientific questions.

Geerat – One tool that paleontologists often use are isotopic signatures in individual organisms. It would be fairly easy to get profiles from several sites to get an idea of growth conditions from several different sites, if we're interested in change over large geographical scale...

Chris – There is a project on North Atlantic scale – with *Arctica* and some other species as well. They have a website...

Cliff – Any synthetic revelations???

Steve – One thing that is quite evident is that when European ecologists get out on shore, we look at things in a different way – with more of a natural history focus – quite interesting trying to design experiments - different approach in Britain/Europe and North America. I think it's important that best parts of these two traditions emerges in these trans-Atlantic studies. Lots of work has been done in the States; but few time series, but lots of blokes in Europe have been pottering out on the shore on the weekend on their own time, and that's a good tradition.

Boris – The vision mostly promoted by Geerat to merge present-day ecology interactions with historical context and history - I think we made a lot of progress there, but we haven't found that yet. Maybe that will only emerge by doing it.

Andy – I have a comment on what Steve was saying – the east/west difference in how you view biology extends to biological oceanography. An eg. - the continuous plankton recorder – if you chose to design something to do this, you wouldn't do it this way, but it can be towed behind any ship, so you get long datasets... If we're going to do descriptive work, need hypotheses...

Diarmaid – One possibility is to test things in predictive way – does history matter much in terms of ecological patterns? If you have long associations vs. short associations, does it matter???

Emmett – As far as I know this kind of diverse group of people with scope of entire region is entirely unique.

Ellen – I've been changing my ideas of the philosophy of paleontology. When I was a student, 'the present is a key to the past' – however when I started to realize more and more – I work 55 million years ago – the more you go back in the past, the less this is true. In many cases, our associations are chauvinistic – we think that now is the normal state of things, but the present world is fairly unusual – the present day is unusually warm, and CO₂ levels are unusually high on a 2 million year scale. If you use a larger scale, the world is unusually cold – it's unusual to have ice caps on both poles. Bering Strait – the whole idea of refugia has been starting to stick in my mind. Before this meeting, I talked to people about the Arctic. There are people at Woods Hole and U Mass with research programs in the Bering Sea. This (* **diagram**) gives the Bering Strait history since the last glaciation. During the last glaciation, the Bering Strait was closed. If we plot the size of the ice sheet back in time, then what we have is if you look at the size of the polar ice sheets combined, you get a sawtooth pattern – rapid deglaciations. It is relatively easy, since ice volume is directly linked to sea level, to figure out over how much of the last 125,000years the Bering Strait must have been closed. I haven't plotted this, but it can be done. If you make a similar plot on a very different timescale, for 900 kya you have large fluctuations

with a 100kya periodicity. I think over these last 900 kya and 1 Ma years the Bering Strait has been closed most of the time.

Cliff – I think this explains a lot of what phylogeographers have been seeing has been explained by this – you either see a 3.5 Ma of divergence, or recent divergence.

(Annette taking minutes)

STEERING COMMITTEE MEETING

Cliff – new members- Steve Carr to replace Brian Bowen, Phil Williamson since low on oceanographers, Ellen wasn't at the April meeting, Andy Pershing replaced Chuck Green but Chuck is still on.

conversation with Vermeij, Bertness, and Trussell – some of their comments –

The main purpose is to decide on the specific structure of the content for the meeting next summer.

First idea – give priority next year to people who came this year, open to debate, but those who came this year have idea of what's going on, but this is more exclusionary.

Susan – How limited is this group?

Cliff – Can't remember, up to 80,

Sally – How many here?

Cliff – About 55.

Susan – Some people who are not here may still want to participate.

Steve- It's important to keep momentum, to get a good balance, recruit some Norwegian, Danes, Scots.

Cliff – more paleo representatives, etc. In terms of the structures of presentations – let's move beyond introductions to our fields. This morning suggested the talks should be more specifically synthetic. Steve Hawkins - present pairs of people to do presentations, to cause them to work together to make synthetic presentations. for ex – compare the descriptive ecology of the 2 coasts. Another possibility to take something well studied on one coast and see what patterns on opposite coast.

Andy - Presentations should be more formal, with aids

Cliff - compromise – allow Powerpoint, but keep the number of slides to 5, people can come with handouts, require this if speaking.

Susan – Encourage people to bring reprints.

Sally – Need to prioritize to people who've been involved otherwise need introductory stuff --- people contribute most who've been there before.

Cliff – Allow different sessions to self-assemble, like they did this year, I think it worked very well. Overall topics lets brainstorm here so, suggestions

--look at various tax groups,

Cliff – one session with specific quantitative numbers

Mark -life history traits, ...

Steve Carr – phylogeographic patterns , how many fundamental patterns

Sally – Taxa, and also habitat, are you both talking about the same thing?

Mark - I was thinking habitat.

Steve – I was thinking taxa.

Cliff – Do we have enough for that?

Steve – Yes, for some.

Cliff – Part of a session.

Chris - Species list, state of where its gotten.

Cliff – Part of session that's marks envisioning

John Wares - A distributional map to see where amphi-Atlantic species are, that may include the Mediterranean for certain taxa

Cliff – distribution is one of its organismal characteristics.

Steve H - European side – flora and fauna coming from south, some come from the north, but many from the south.

Sally – And if we go to Hatteras, there is an extensive southern fauna coming up.

Cliff – What ideas have grown from this meeting, that have been making progress, give them a chance to tell us about it.

Di - To tie things together, emphasize the phylo part; it gives the study continuity.

Chris - A review of current thinkings on past temperatures and sea levels etc, that's crucial, it is hard to study the literature on all topics yourself.

Cliff – So a geological session?

Chris – A recent history of the north Atlantic.

Susan – Karl could have done analysis of Greenland ice cores, how they can show the history of the north Atlantic, someone like him to give a presentation would be great.

Cliff – I agree.

Ellen – Different people work on different time scales, depends what you want to emphasize.

Susan – (*missed)

Ellen (*missed)

Rick - Organize into habitat groups , start with history part, sets us up to look at ecological processes, for example – soft bottom, rocky shore.

Susan – I agree with Rick, not organize whole meeting, but for an afternoon, it would be good, then right oceanographers, phylogeographers, ecologists, can be together, because one problem I thought was it split the ecologists and phylogeographers in ways that didn't work well.

Cliff – But on the other hand it was essential.

Andy – There's a number of ways to slice the group, reassemble on different days.

Cliff – That's ok for 6 days ,but this in only 2 days; we need a balance.

Sally – We need to organize around questions.

Cliff – Seems like this year we did organize on assemblages.

Sally – Cross-fertilizes each other better.

Cliff – taxa-based comparisons, habitat assemblages, idea-based, (3 different suggestions).

Sally – Say a whole day of geographic distribution questions, within that have fish people, etc, different experts to talk about their taxa. If all asked to address a common question, better than if divide strictly by habitat, etc.

Cliff – How do people feel about a question-driven session?

SteveH - Have series of formal talks, then short breakout sessions, split one way, then the other way integrating, do different themes on different days.

Andy - I like the idea of the questions, that really motivates, let's brainstorm the questions we'd like to see.

Cliff – Let's throw out ideas now.

Emmett - Duration of association?

Ellen – Impression there is no continuity

Susan – I like Emmetts' idea, it combines phylogeography, ecology, etc.

Cliff – Invasions and their consequences?

Ellen – Refugia? I really wonder about that,

John Wares – I talked to Joe Reed at Duke, we could have session on that sort of information

Ellen – How did it really look during last glacial maximum?

Cliff – I think it would work nicely.

Phil – disjunctions

Di - Potential refugia, between the two sides.

Steve H. - Refugia past and present.

Cliff – Excellent idea.

Ellen – During the last glacial maximum, lots of stuff wiped out, an extreme maximum, where might have refugia existed before last ice age.

Steve H. - Coastal pollen analysis – coastal cores to reconstruct climate.

Ellen - Thompson Web? At Long Island, reconstructed vegetation since the last glacial maximum

Emmett – Something about local adaptation,

Cliff – trans-Atlantic syst- some with long divergence, some not,

Emmett – And that's where phylogeographers can inform ecologists.

Cliff – Although local adapt can happen fast,

Emmett – Difficult for those with direct development.

Steve H. - Easier to travel when there's a Saturday.

Cliff – Lets' talk about the date – August

Agnar - Meeting August 18-19.

?(*didn't get) - Check out the tides.

Agnar - Start meeting on the 18th

Cliff – Let's move the meeting one day earlier so people can come on a Saturday? Increase by a day so people can go to the field; Agnar and I will talk about this and get back to the group.

John Wares – The meeting won't be during a good tide, a neap tide.

Sally – What refugia look like, in terms of soft substrate, but indentations in the coastline, what did coastline look like?

Cliff – How easy is it to do time series map?

Ellen - Have for some places, but not others.

Cliff – Very useful, any more suggestions?

Chris – List of potentially expected people.

Sally – What depth distribution of species are is a very important, makes *Mytilus* very problematic while barnacles less so.

Ellen – do we know these things?

Sally – Yeah – some organisms truly restricted, others not at all.

Cliff – Let's include depth in these synthetic studies.

Steve H. - Quite a few intertidal species are eury-everything;

Sally – The restriction to the intertidal, may be biotic, some of the biotic restrictions may not be there from last glacial maximum.

Steve H. - From Andy's talk, obvious things out of phase on both sides of the Atlantic, another good reason for the proposal.

Sally - That was the thrust of the group I was in yesterday,

John Wares – Do ecological and phylogeographical studies need to be carried out over 2 yrs on both coasts, if they are out of phase?

Andy – Assemble some kind of time series.

John Wares – Is there any evidence the NAO is becoming more frequent?

Andy – Global warming people say there should be an increase in positive NAO years. A trend from 1960's to 90, then leveled off and a few negative years.

Sally – Do manipulations to make habitat into what reverse pattern would be.

Cliff – (*didn't get)

Agnar – practical aspects, people interested in fieldwork, what about a 3-day meeting with a day in the middle

Cliff – Good idea, lets see what it costs.

Sally – Tides, if plan around field work, need the field.

Cliff - Even on a bad tide worth it? Work out details. What's feasible in terms of cost and booking. Several suggested symposium of Icelandic marine biologists to give us their perspective, could this be done? it is so important to this issue.

Agnar – OK.

Cliff – OK. Thank you.