HOUSE OF LORDS

Revised transcript of evidence taken before

The Select Committee on the Arctic

Inquiry on

THE ARCTIC

Evidence Session No. 7 *Heard in Public* *Questions 81 - 97*

MONDAY 15 SEPTEMBER 2014

9.20 am

Witnesses: Dr Jan-Gunnar Winther and Dr Nalân Koç

Please note: During the meeting Dr Nalân Koç made references to presentation slides. This presentation can be found as written evidence submitted to the Committee. The slides have been numbered for ease of reference and their corresponding numbers have been inserted into the transcript.

Members present

Lord Teverson (Chairman)
Lord Addington
Viscount Hanworth
Lord Oxburgh
Lord Soley

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Examination of Witnesses

Dr Jan-Gunnar Winther, Director, Norwegian Polar Institute, and **Dr Nalân Koç**, Research Director, Norwegian Polar Institute

Q81 The Chairman: I invite our first witness to speak.

Dr Jan-Gunnar Winther: I am Jan-Gunnar Winther. My educational background is in polar hydrology. I have a PhD from the Norwegian University of Science and Technology. I have worked for 20 years at the Polar Institute, first as a scientist and then gradually more and more in management. For the time being, I am an adviser to the Norwegian Government in the Antarctic Treaty Consultative Meeting and the Arctic Council. I was also lead author in relation to the last IPCC report and I am a member of a council in the World Economic Forum on the Arctic. Those are maybe the most important commitments that I have these days.

I will give you some background on what we do at the Institute but also on what is coming after me and in Svalbard for your delegation. Maybe the most interesting part of today's presentation will be Nalân Koç's presentation on climate change. I have heard many voices round the table and I know that that will be interesting. I will start with the Polar Institute and some examples of what we do. I am happy for you to interrupt or stop me to ask me questions or make comments, so please do that.

The Polar Institute is not a huge institution. We have our main office here in Tromsø. We also have personnel in Longyearbyen and Ny-Ålesund in Svalbard, as well as a year-round

station in Antarctica. The number of employees is around 165. We are what I often call a Polar Institute from A to Z, which means that we have our own logistical department that can equip any expedition on seas or on land at both poles. We have a library in the basement. We have a communications department and a research department, of which Nalân is in charge. We also have—and this makes us different from a university—an advisory role to the Government and we report to the Ministry of Climate and Environment. The ministry used to be called the Ministry of Environment, but the name was changed last fall to the Ministry of Climate and Environment. That may be a minor point, but it is not unimportant, as climate is becoming a central part of the former Ministry of Environment's portfolio.

We have an ice-strengthened research vessel, tracked vehicles equipment and responsibilities in the Arctic and the Antarctic. Unlike the British Antarctic Survey, we have more activity in the Arctic, which makes sense due to where we are located—it accounts for about two-thirds of our budget, with one-third in Antarctica. Our budget is about £30 million a year. Those are rough numbers, but that is how it is divided.

Our task is to be the main, central body for scientific information about the Norwegian polar-regions, especially on issues related to the environment. We are technical and strategic advisers to the Norwegian authorities. We are part of the Norwegian Government and report not only to our ministry, as I said, but to a wide variety of other ministries, with which we communicate on a weekly basis, not least the Ministry of Foreign Affairs, which is the clear number two in our communication with ministries.

As part of the Polar Institute A to Z, we also produce maps. If you go to the store in Longyearbyen and buy yourself a map of Svalbard, that map will have been published by personnel from the Polar Institute, who have been out doing the measurements in the field

and have used satellite images if they were needed—they prepared everything that was needed before it was printed. We do that for Dronning Maud Land, which is about a sixth of Antarctica, where we have a claim—like the UK, Norway has a claim in Antarctica. We make both topographic and geological maps from the Arctic and Antarctica. We also deal with logistics, as I mentioned.

We have this thematic mandate, but we also have a well-defined geographical mandate. We talked about Svalbard, but our mandate also covers the surrounding ocean and the volcanic island Jan Mayen, which is located further south in the Atlantic than what we normally think of as the high Arctic. An area that has become more and more important for the energy nation of Norway is the Barents Sea. Our role in the development of the Barents Sea is connected to having knowledge about not only sea ice but oceans and ecosystems as well. These are can be national or international processes. A recent example is that this year there was the opening of what we call the Barents Sea south-east area—another area that has been opened up for oil and gas activity. We use the knowledge that we have to feed into these processes and give our advice. The advice to which the most attention was paid in Norway was connected to the sea-ice edge—it is not a line but a diffuse zone where open water meets sea ice. Our advice, which was taken by the Government, was not to drill closer than 50 kilometres from the sea-ice edge. That is now a principle that is part of the guidelines and regulations that you have to follow as an oil company, for example.

The development in the Barents Sea has very much taken efforts from our activities in recent years. The Norwegian Government's view on development in that area is to approach it in an overarching, integrated way. I have mentioned the energy sector, but the fisheries, tourism and shipping sectors are also taken into account in a balanced way. You can see a map of the Barents Sea, which shows lots of squares showing a preference that is given to certain

activities in each of the different boxes. You might find areas where oil and gas activity is totally banned. You will find other areas that are open for such activity and some that are open for parts of the year, where the issue may not be sea ice but sea birds or other environmental factors. You have a shipping corridor, where you can have transportation, and you have especially vulnerable areas for spawning fish stocks and so on. The whole of the Barents Sea is like a patchwork.

Dr Jan-Gunnar Winther: A patchwork. The leading principle is that we want to work towards an integrated, sector-based and balanced way of having activity in the Barents Sea. No sector is number one here, in principle. You most likely know this, but while Norway's income is connected to oil and gas, the fisheries sector is also very important. It is the clear number two. There are promising prospects, with an increase in the export value. Last year, we exported fish, both from aquaculture and from the open seas, worth NKR61 billion. That number is increasing.

That was a detour. Then we have the area over which we make a claim in the continent of Antarctica, with two other smaller islands within the Antarctic Treaty area. Bouvetøya is located between South Africa and Dronning Maud Land, at about 54 degrees south.

The Institute was moved up to Tromsø in 1998 and since then we have focused more on relations and collaborations with Russia. Let me stop for moment. I know that I am talking a lot, but you may interrupt me if there are things that you want to hear about. As I said, over the past 30 years, Russia was the nation with which we had the most collaboration. That is not the case today, but Russia is still one of the major nations with which we collaborate, particularly with the counterpart of the Norwegian Polar Institute, the Arctic and Antarctic Institute in St Petersburg.

We have a bi-polar approach; we work in both poles. From our perspective, the UK would gain a lot if its activity, which so far has been concentrated more to the south, for good reasons, was more balanced with the north. Norway and the Norwegian Polar Institute would welcome that.

Q82 Lord Soley: Sorry, could you explain that? Are you saying that the UK balance should move to the north?

Dr Jan-Gunnar Winther: This is my opinion. Given your location in the North Atlantic, like Norway, with a great interest for many reasons in changes in the Arctic, including the effects of climate change upon the UK, it is logical that a nation like the UK has knowledge collection in a region that is important for the country. I do not want to walk into domestic policy here, but a lot of the expense is related to activity in the south. You said "change" [in the Committee's remit], and there is geopolitical change, business change and climate change—there are many changes going on. You are an observer to the Arctic Council, you are located where you are located and you are affected by climate change in the Arctic region. You have nice institutions that have a long record and are very well recognised; the British Antarctic Survey is one, and there are several others in UK universities. You have, as we have, a long record of good collaboration, particularly with other European—and maybe I should add North American—countries. Germany is one of these; not only Germany, but Germany is important. It makes sense to have increased activity in the north. This is why the Ministry of Foreign Affairs recently produced this framework document: to look into that. I just wanted to put that view from our side. We welcome that very much. The one institution with which we have had the closest collaboration over the years is the British Antarctic Survey. It is probably not the only answer for Britain in the Arctic, but it is one answer to this potential

increase. We would welcome that, and we would like to work with the British Antarctic Survey on developing it.

That is a nice thing for the UK and Norway. Because you have been leaning more heavily to the south and we have been leaning more heavily to the north, we are quite complementary in infrastructure capacity and the science. It is also a good starting point for the synergies of knowledge of one pole to be transferred to the other. We know very well now from nature that these things are connected. If you have a strong knowledge of, say, the Arctic, you can take advantage of that and transfer it to knowledge of the Antarctic. Britain and Norway fit very well together from that perspective.

Let us move on. I will speed up in some places. We have high ambitions for how to govern Svalbard. We know that there is a permanent Russian presence there, and there has been for a long time. There is also a permanent Polish presence, and now there is the Ny-Ålesund research village with a number of nations present, including the UK. We have very high environmental standards in Norway and would like that Svalbard is the best-managed wilderness in the world. This is an interesting footnote: Svalbard is clean, and we would say well managed, even though we still have coal mining there. There is a very interesting debate in Norway these days about phasing that out. Even the coal company in Longyearbyen has been thinking, quite recently, that there will be an end to this. We do not know when it will end, but no one is arguing any longer that it should continue for ever. That is maybe something that you can pick up on when you are in Svalbard. It does not have a strong local footprint but of course has a global footprint. Going eastwards from Svalbard through the Russian group of islands, Franz Josef Land, there are enormous waste issues from the Second World War and the Cold War. Of supposedly 1 million barrels there, at least 100,000 barrels are filled with fuel and chemicals. There are wrecks of planes and ships.

There are abandoned stations. It is a mess. The Russians have started to clean up, but it is a big job. That goes more or less for the whole stretch along the northern sea route, such as northern Siberia where there is so much abandoned equipment and waste from several decades. My point is that those islands are not very far apart. There is a strong gradient in the environmental dimension.

We also have duties in the south. We are the national authority when it comes to giving permissions for Norwegian activity in Antarctica. In addition to the science, Norway also has three businesses going on in the south. One is connected to cruise industry, Hurtigruten, and a coastal steamer that you may know of goes down south every year or so. Then we have a satellite receiving station—the Troll Satellite Station—for downloading satellite data. You will see the same company outside Longyearbyen on the mountain called Platåberget—I do not know whether you are visiting that. There is a satellite receiving station very close to Longyearbyen, and the same company that runs the Troll Satellite Station in Antarctica runs it.

Perhaps the industry with the brightest future is the krill fisheries, in which two Norwegian companies dominate and are, as far as I know, currently harvesting more krill than all the other nations combined. The volume of krill that is taken out from the South Atlantic is in the order of a few hundred thousand tonnes; our estimate is 300,000 tonnes. The estimates of total stock of krill in the southern seas are not very good, but marine biologists say that there are maybe 300 million to 400 million tonnes. Keeping in mind that the richest marine food stock in Europe is found in the Barents Sea, where the quota of 1 million tonnes of cod was taken out last year, there are enormous marine living resources in the south that are still not utilised to the level of sustainable harvesting. This is a point of awareness. Many nations are active but still at a very low level. These krill products are used in aquaculture for

feeding fish, and are now turning more and more to health products, such as krill oil. The latest thing I have read—I do not want to be named—is that they have found a positive correlation between krill oil and Alzheimer's. If that is true, which I think it is, there is a potentially niche but very important market. At the very end, of course, krill can be used as food for human beings; that would be an important resource.

I have said that we do mapping. We are also doing research into oceans, sea ice, geology, geophysics—including atmospherics—and we have a separate group working on ecotoxicology. One of the latest areas of focus within the ecotox group is plastic. There is a growing understanding that we unfortunately have a huge environmental challenge in plastic in oceans worldwide, not just in the Arctic arena. About 100 million tonnes of waste has been quantified as floating around in the world's oceans, and 60% to 80% of that is plastic products, from the very small microplastics to big ones such as a vessel from the tsunami in Japan, to take some examples. They are collected in gyres. We see these pictures of birds with nets around their neck and that is a quite dramatic illustration of this problem. Scientists say that about 15% of the plastic in the oceans is floating and 15% ends up on the beaches; we collect it just outside here and they collect it at Svalbard every summer. You are then left with 70 %, which is invisible to human eye. Probably the most dangerous thing is that it goes down into the water, and some of it is now found in microorganisms such as plankton. We find it on the sea floor at depths of several hundred metres. We find it in the Barents Sea in crabs. We found it in nine out of 10 northern fulmars, which are small brothers or sisters of the albatross, in Svalbard last summer. Like many other things, such as climate change and ocean acidification, the Arctic is also affected by pollution, and in places it is particularly affected and damaged.

On biodiversity, we have studied ecosystems in the Arctic, from the polar bear at the top of the food chain to plankton at the bottom. Of course, the research is multidisciplinary and international. This is our research station in Ny-Ålesund, and this is the air monitoring station close to this station on that mountain. That is an important reference station for feeding into the world network of similar stations. We also have an office in Longyearbyen and equipment in the Svalbard Science Centre. In the south we have a small station with only six people overwintering. There are more people in summer, of course. There is also this building.

I think I have overrun my time already. This Fram Centre, as we call it, is a collaboration between 20 legally independent institutions in Norway. When we decided to make the high north the first priority in Norway, the Government also decided to build up academic capacity. The Fram Centre was launched, and I think it is fair to say that it is the number one initiative, when it comes to the academic sector, for investing in the high north, which the Government decided to do some years back.

There are now about 300 people in this building. But what is more important is that many of the institutions that are here have their main office in other places in Norway and their branches here. My institute is here with almost everything. We are the biggest one in the building, but we have institutions here that have more than 2,000 people but that have their headquarters in other places. Fram Centre is relatively small, but it has a big base to tap into if needed. Social sciences, natural sciences and technology are included in this collaboration.

I will leave it there. Of course, there is much more, but I would use your time and my time, so I will stop there and thank you for bearing with me.

Q83 The Chairman: That is an excellent explanation and background. Thank you very much indeed. A whole load of questions come up there. Do not think that we did not interrupt you

because we were not interested; we are, but we have a whole package of questions to go through now.

We are going to make an official record of the meeting, but if there is anything in particular that you want to say to us that you would like to be off the record—we prefer things to be on the record—that you would not want up on our website or in the report at the end of the day, let us know and we can go off record.

Dr Jan-Gunnar Winther: That is quite easy to respond to. Everything that we say can be official. We are a governmental institution and part of the government structure, so everything that I have said and will continue to say, and Nalân is the same, is on the record.

The Chairman: That is fine. I sometimes give that facility, because people sometimes indicate that they would like to do that.

Dr Koç, would you like to introduce yourself?

Dr Nalân Koç: [*Dr Koç began her presentation with Slide 1*] As you can see, I have a very non-Norwegian name. That is because I was born in Turkey. I came to Norway nearly 30 years ago in 1985 and had my higher education at the University of Bergen, where I studied marine geology, paleoceanography—reconstruction of past ocean circulation, and climate. Then I moved to the Norwegian Polar Institute in 1999, after the whole institute had relocated to Tromsø in 1998. I started as a researcher, was then section leader for the polar climate programme, and then became research director in 2011.

Today I will tell you a bit about climate change in the Arctic. A lot is happening, but within the time limits that we have I will focus on temperature and sea-ice change. I will start off by talking about CO_2 emissions. As you can see in this graph [*Dr Koç moved on to Slide 2*], since the 1990s our emissions from fossil fuels and cement have increased by 58%. So we are emitting a lot. This is the amount of CO_2 that is in the atmosphere [*Dr Koç moved on to Slide*

3]. We are also seeing that the annual mean growth of CO_2 in the atmosphere has increased from one part per million per year in the 1960s to two parts per million per year. That means that every year we are adding two more parts per million of CO_2 to the atmosphere. This is the latest figure from the internet [*Dr Koç moved on to Slide 4*] on the levels of global monthly mean CO_2, and we see that today we are in the order of 398 parts per million. Usually these numbers do not mean much to people who are not experts on this issue. What does 398 say to you? It is difficult. Therefore I want to show you what the natural values should be for a warm period like the Holocene, the period we are in, in order to understand the meaning of 398 parts per million today. In order to do that, we can use air bubbles from ice cores [*Dr Koç moved on to Slide 5*], especially from the Antarctic, to get a longer record– from the present back to 800,000 years ago, or for shorter intervals air bubbles from the Greenland ice core. When we look at the CO_2 concentration record from these ice cores we can see 100,000-year interglacial/glacial (cold period/warm) period fluctuations, and that during the ice ages the concentration values of CO_2 is around 180 ppm and that during the warm periods the peaks are about 280 ppm. This is the natural fluctuation of atmospheric CO_2 between the largest climate changes that the earth has experienced in the past 1 million years. The difference between the warm period and the ice age is 100 ppm. In the Arctic we have already reached 400 ppm. Globally we are at about 398 ppm. This is 40% greater than the natural value of 280 ppm, which we should have had in the warm period. These figures are from the IPCC reports. This gives us a perspective on the amount of CO_2 that is present in the atmosphere today and which is a strong greenhouse gas. As we can see, the present level is 120 ppm more than the natural level, and as you can appreciate it is larger than the difference between an interglacial/glacial period, which is 100 ppm. It is a huge number.

This is the global temperature development since 1850 [*Dr Koç moved on to Slide 6*], for which we have instrumental measurements. This record shows us that there has also been a temperature increase in the past 100 years, but there is a special increase that we have been observing for the past three decades. This is the warmest period since 1850, but it is also most likely to be the warmest 30-year period for the past 1,400 years.

It is obvious from the studies [*Dr Koç moved on to Slide 7*] that this temperature increase of the past 30 years has been caused by our anthropogenic emissions. The warming is not homogenous [*Dr Koç moved on to Slide 8*] throughout the globe; we see that parts of the world are warming more than the rest, and we see that the Arctic is warming at almost twice the rate of the rest of the world, which we call the polar amplification. This is because of the special positive feedback processes that are taking place in the polar areas. This black line here [*Dr Koç moved on to Slide 9*] is the same instrumental record of global temperatures that I have shown you, and the blue one is the record for the Arctic. As we can see here, the temperature increase during the past 30 years is less than a degree for the rest of the globe but at least twice as much when it comes to the Arctic. If we look at the record for Svalbard, we can see very clearly the increase in temperatures in Svalbard during the past 50 years. We have satellite images of the Arctic since the end of 1978 [*Dr Koç moved on to Slide 10*], which then gives us, during a 30-year period, a record for sea-ice areal/cover change. We are seeing very clearly that there is a decline in the sea-ice extent during this period of about 14% per decade. We are also seeing that there is an increase in the decrease during the past seven to 10 years. Here you can see the two minimum sea-ice extent years of 2007 and 2012 sticking out. So the sea-ice area, from being about 7.5 million to 8 million square kilometres during summer—this is a September record for summer; September is the minimum summer extent—goes down to 4 million or 3.5 million square kilometres. As we can also see

from these images from the early 1980s [*Dr Koç moved on to Slide 11*], summer sea-ice cover, which basically covers most of the Arctic Ocean, to the last minimum year of 2012, nearly half the ice cover has gone, leaving a dark ocean surface. I can show you the variability between different years [*Dr Koç moved on to Slide 12*]; these are the September records from 2007 and 2012 for the minimum sea-ice cover. We can see that during 2007, for the first time in a very long time, the north-west passage was open but the north-east was not, whereas in 2012 we witnessed both passages being open for sailing. This is the previous minimum in 2012 and this is September 2013 [*Dr Koç moved on to Slide 13*].

The areal coverage of the ice was larger in 2013 than in 2012; that is just to make a point that there is year-to-year variability in the climate system [*Dr Koç skipped Slide 14 and moved on to Slide 15*]. Therefore, when we talk about climate, we are talking about 30-year averages and trends and not year-to-year changes. It is not only the areal extent of the ice that is diminishing [*Dr Koç moved on to Slide 15*]; we are also seeing that the thickness of the ice is changing. From being multi-year ice growing up to five to six metres thick, we are now experiencing that most of the ice in the Arctic is first-year ice and, as such, has a thickness of 1.5 metres to two metres. These figures show that in the 1980s we had (in white) five-year-old ice covering most of the Arctic; as we proceed to the past three years, we have seen that the dominant ice in the Arctic is the (in blue) first-year ice. The older ice is being concentrated in an area north of Greenland and the Canadian archipelago. There is a new Arctic emerging with dominantly thin first-year ice; which also tells us that the situation is more vulnerable since it is easier to melt first-year ice. If the conditions are favourable for ice-melting, in theory, most of this sea ice could melt within one season. But it does not necessarily mean that it will do so every single year—we saw an example of that from 2013 [*Dr Koç moved on to Slide 16*]. This figure illustrates the warm Atlantic water flowing into the

Arctic Ocean; what is known as the Gulf stream/the Norwegian Atlantic current. This current is flowing along the western coast of Svalbard and then along the northern slope of Svalbard and into the Arctic Ocean. This is the main source of warmth to the Arctic Ocean. The Fram Strait, strait between Svalbard and Greenland is the main conduit of transport of sea ice and cold and fresh water masses southwards into the North Atlantic. In this strait we have an array of oceanographic moorings measuring sea ice drift and thickness, current speeds, ocean temperature, salinity and chemistry. The mooring array is a collaborative effort with the Alfred Wegener Institute, which has the moorings on the eastern part of the Fram Strait, focusing at the Atlantic water inflow, whereas the Norwegian Polar Institute has moorings on the western side focusing on the sea ice and polar water outflow. This area sums up/integrates what is happening in the whole Arctic Ocean [*Dr Koç moved on to Slide 17*]; we are seeing very clearly that there is a change in the modal thickness of the sea ice, declining from 3.2 metres in 2005 to 2 metres and less today. These results fit very well with the satellite images.

As I was saying, in the 1980s and 90s the Arctic Ocean was covered with thick ice of up to five or six metres [*Dr Koç moved on to Slide 18*]. Thick ice also has a rough surface. During the early summer, as the snow on top of the rough ice surface melts, meltwater ponds form, but, since it is a rough surface, they are concentrated small and deep ponds. In the case of thin first-year ice, there is a much more level surface–so when it starts melting the meltwater covers large areas forming huge ponds. The reflectivity of the white surface is reduced with the dark spots (ponds) on the ice, escalating the warming in the Arctic. This is one example of positive feedbacks, which are strengthening the global warming.

Of course, the million-dollar question is: when will the Arctic have an ice-free summer season? The IPCC has shown that a nearly ice-free Arctic Ocean is expected before the mid-

century [*Dr Koç moved on to Slide 19*]. However, as I have shown you, if records continue to show predominantly first-year ice in the area and the summer conditions are right, it can happen at any time. However, as I said, that does not mean that it will be continuously sea-ice-free year after year. There is a lot of variability in this system. We also have to remember that because the IPCC report is a consensus report, it is conservative in what it is saying.

As I said, we now have a new Arctic Ocean [*Dr Koç moved on to Slide 20*]. It is very different from the one we used to have, due to its reduced, thin sea-ice cover during the summer. That changes a lot of the characteristics of how much is being reflected—the albedo—how much heating is being transported into the ocean and the ecosystem–in short the energy balance. Our models have been using algorithms for the old ice. During the 1990s there was a large American-led programme, SHEBA, which took measurements that were fed into our climate models. If we are to give a better and more precise prognosis for the future, we also now need to have measurements from the new Arctic situation. In order to do that, the Norwegian Polar Institute has decided to freeze its sea-ice-going vessel, Lance, into the ice north of Svalbard during winter 2015 and let it drift with the ice until summer. During a whole ice-freezing to ice-melting season, necessary measurements—physical, biological and atmospheric—will be taken to contribute to the modelling world with more precise algorithms. This project has both national and international participation, where scientists from the British Antarctic Survey will also be participating.

I was showing you that the conditions from the minimum in 2012 to 2013 were different [*Dr Koç moved on to Slide 21*]. We had more sea ice left in 2013 and the same is also true for 2014. This year we also have quite a lot of sea ice, even though it is predominantly first-year ice, but the areal extent is large. I am now showing you two maps of the atmospheric situation—the pressure systems. I shall not go into details but other than that they illustrate

that the atmospheric conditions were very different from one year to the next. In a world where we now have thin ice and lots of space for it to move around, the weather conditions, including the wind, have much more effect on the distribution of the sea ice than it had before, when the sea ice was much thicker and it was more difficult to move around it. In this new world of thin ice, it is also easier to affect the sea ice conditions. Therefore we are expecting a higher variability regarding the sea ice extent.

How does this affect our world [*Dr Koç moved on to Slide 22*]? Until recent years, the EU was not very interested in supporting research in the Arctic because the Arctic is was conceived to be far away and as such does not concern the Europeans much—it is at a distance. However, we now have this dark ocean opening up during the summer. Before, the summer sun rays were being reflected off this white sea ice and the water beneath it was isolated from the sun's rays. Now, the sea is in direct contact with the sun. As such, the surface of the Arctic Ocean is warming during the summer—it is absorbing the heat. During the autumn, as the atmosphere is cooling, that heat is being sent up into the atmosphere. Since 2005 we have a large heat anomaly—more than five degrees—in the atmosphere, especially on the Alaskan side [*Dr Koç moved on to Slide 23*]. As such, we can say that we are already seeing an atmospheric climate impact in early winter from the effect of low sea ice extent. That reduction of sea ice during the summer is heating our atmosphere during the autumn.

Our studies—and more and more studies are being done—are showing that [*Dr Koç moved on to Slide 24*], as the temperature gradient between the mid-latitudes and the Arctic is being reduced (because the Arctic is warming), the jet stream, which is fuelled by this contrast in temperature, is slowing down. We are also seeing that the wavy path of the jet stream is changing. It is getting wavier, with deeper troughs in the way it flows. It seems that the atmospheric is having an effect on the speed and track of the jet stream, which then

causes changes in the distribution of temperature and precipitation patterns. We can surely say that the Arctic is influencing climate patterns well beyond the boundaries of the Arctic itself. It is having an impact on the whole northern hemisphere. We know that the changes in the Arctic have a teleconnection to the monsoon systems. Studies have been showing this connection regarding the monsoon in China and the weather systems in Japan and Korea. A new study in press also shows a connection between the Arctic and the monsoon system in India. So the whole northern hemisphere is being affected by the changes that are taking place in the Arctic.

This slowing down of the jet stream is also increasing the probability of extreme weather events, such as Hurricane Sandy in New York. These weather systems used to flow much faster. Now, they are being blocked and are staying over a region for longer periods, and therefore also causing more destruction.

As I said, single events are difficult to attribute to large climate changes but we are seeing more and more such events [*Dr Koç moved on to Slide 25*], such as the extreme winter in the US and Canada this year, with this tongue of cold air coming all the way down to the east coast of the US and sitting there for quite a long time. You also experienced some extreme flooding events this winter in England [*Dr Koç moved on to Slide 26*]. So of course there is a worry that it is not only that the frequency of these extreme events is increasing, or that they are becoming stronger, but the fact that, combined with these changes in the jet stream, they might cause more destruction than they have before because they are being blocked.

To wrap up [*Dr Koç moved on to Slide 27*], I have not gone into all the Arctic climate changes. There is a lot happening with the permafrost and fresh water in the Arctic also. This is just to tell you that we are expecting more extreme weather events. The permafrost is also thawing

on land and in the oceans as the warming of the oceans increases. Methane is a product of this and it is 25 times more potent as a greenhouse gas than CO_2. There are also the issues of the increased sea level due to melting of ice sheets and glaciers and increased hydrologic cycles, but I also want make a point about surprises. Today the changes are happening faster than ever and this has become a new situation. As scientists, we are not up to date in understanding some important processes in the Arctic. So things are happening and we are going back and trying to understand what has happened. With the Arctic being a challenging area [*Dr Koç moved on to Slide 28*] in which to do science, logistically and resource-wise, we have more gaps in our understanding of the Arctic processes. I will end here by thanking you [*Dr Koç moved on to Slide 29*].

The Chairman: Thank you very much indeed. That brings it back home. I will ask one question. In the House of Lords we have a number of very strong climate sceptics. Are there people in Norway who say that none of this happening, or that it is not created by human intervention? Is there that stream of thought in Norway or not?

Dr Jan-Gunnar Winther: Yes, there is. As in most countries, of course, there is a small minority. It is a visible element in the climate change debate, yes.

Q84 Viscount Hanworth: It is noticeable that the climate sceptics in Westminster are changing their stance. Whereas they used to deny the reality of global warming, they are now saying that we can cope with it, that it is negligible and that it is well within our capacity to adapt. That is a substantial shift of emphasis. They will not admit that they have shifted their emphasis, but they have.

Dr Jan-Gunnar Winther: In that connection, we as an institution are leaning towards the IPCC. Our opinion is that we have overwhelming evidence of human induced climate change in addition to the natural variability. I will stop there.

The Chairman: Indeed. That was just a general question. Thank you both for those presentations. Perhaps we can now go through some of the things we are trying to nail down.

Viscount Hanworth: Can you remind me how far back your CO_2 records go?

Dr Nalân Koç: Eight hundred thousand years.

Viscount Hanworth: Is it worth speculating about things previous to that, such as the Permian period? Do we have any knowledge of what happened?

Dr Nalân Koç: Yes, we are. We know, of course, that there have been periods where the earth was much warmer than today and there was much more CO_2. That is in the geological history. However, both the orbital forcing and also the configuration of the continents were different before. They are not one-to-one analogues to what we are experiencing today. We did not have the Himalayas, the Antarctic had no circumpolar circulation around it. There are a number of different issues that change the whole equation.

Lord Soley: And the speed of change is the crucial factor.

Viscount Hanworth: May I ask another question?

The Chairman: I do not want to get too much into the history of climate change.

Q85 Viscount Hanworth: This is a contemporary issue. You said there was a major transfer of heat via the Atlantic or the Gulf Stream. Some 15 years ago there was a notion abroad that the Gulf Stream might turn off. Do you have a modern assessment of that possibility? I get the feeling that the possibilities are being discounted. Is that true? Can you inform us of current opinion?

Dr Nalân Koç: Do you know the latest?

Dr Jan-Gunnar Winther: Go ahead. I add more.

Dr Nalân Koç: It is a wind-driven circulation, so it is not easy to turn it off. However, you can cap it with fresh water. It would then be colder water.

Dr Jan-Gunnar Winther: The last bullet-point Nalân showed us was about surprises. I want to make one statement connected with that. We have consistently underestimated the rate of change in the Arctic. I am somewhat worried for future projections, but it is a fact that we have, in the past 10 years or so, consistently and severely underestimated the rate of change.

When it comes to changes and even regional cooling, there is one other issue in the scientific discussion, which you might know about, which is the freshwater accumulation in the Arctic Ocean due to melting. I can give the broad story, and perhaps Dr Koç can fill in. Due to the melting of the Greenland ice sheet and of the sea ice and increased discharge from rivers emptying themselves into the Arctic Ocean, there is an increasing volume of freshwater in the Arctic Ocean. From observations and measurements that we have, we know about quite substantial freshwater accumulation in the Arctic Ocean. We do not know if, how or when this will be released from the Arctic Ocean, but if that happens—most likely it will be released through the Fram Strait between Svalbard and Greenland—it would most likely affect the weather/climate in the North Atlantic. Such sudden cooling could have a devastating effect on the Icelandic fisheries, for example. It could also affect Norway, the UK and a larger area. This is a discussion in the scientific community for the time being.

On the Gulf Stream and shutting it on and off, the climate model shows us that that is not likely to happen in the next 200 years. As far as I know, that is the knowledge on that issue. Going back 15 years, a large programme between the UK and Norway called RAPID addressed exactly this: the instability of the Gulf Stream and sudden changes that could bring cooling to a warm region of the world in a global warming scenario.

The Chairman: You are saying that, in the shorter term, freshwater could have quite a significant effect on ocean life in terms of fisheries and even down into—

Dr Nalân Koç: And even the climate. It depends on how fast it is being released. It is a large body of freshwater sitting in the Beaufort Gyre. If it is released slowly—

The Chairman: That is an important area that I do not think we have come across in noting the direct, relatively short-term, effect on something that the UK is involved in.

Q86 Lord Addington: This is a question for both of you. What is the scientific and political value of being located here in Tromsø, as opposed to in Oslo? What is it about having a specialist unit here, as opposed to being part of the greater political centre? In the UK we are always told we are terribly London-centric and always fighting against that.

Dr Jan-Gunnar Winther: On 9 June 1993 the Norwegian Parliament decided to move the Polar Institute to Tromsø. There were arguments on both sides: not least, Tromsø University wanted to have this centre of competence here. One of the arguments that proved to be mistaken in hindsight was that it was a disadvantage for the institute to be located outside the capital. I am not sure whether this is something that is easy to transfer to the UK, but for us we moved from being a very small fish in a big pond in Oslo having hasty one-hour meetings with the ministries, and now we are a big fish in a small pond. That means that most people who want to go to the Norwegian part of the Arctic stop in Tromsø. Some of them go to Svalbard, like you. If they stop at Tromsø they will visit at least the university and the Norwegian Polar Institute. If they have more time they will cast their net even further. We now have closer contact with both national and international stakeholders than we probably would have had in Oslo.

There is a "but" to that story, which is that Nalân and I and a little group go to Oslo almost every week. It is still the capital; meetings still take place there. However, looking

retrospectively at this, it has been a pro for the institute to be two hours away from Oslo. No one saw that in the early 1990s. This was before the high north became the issue that it is today. I often say that that decision in 1993 was wiser than they could have known at the time.

Lord Addington: Do you think that is primarily because of where you are geographically, or because you are a set institution away from the other bits of government?

Dr Jan-Gunnar Winther: Both, I would say.

Lord Addington: That is a lesson to us.

Dr Jan-Gunnar Winther: Very many go to the north. They do not only go to Tromsø. If they have a military interest they will go to Bodø, south of here, because it has some military capacity. If they are interested in oil and gas they will go to Hammerfest, which is close to the LNG plant on Melkøya. If they are interested in relations with Russia they will go to Kirkenes. Many go on study tours to the north and then they visit Tromsø. When the Norwegian Government prepares state visits and have more time after visiting Oslo, they very often go north and stop by here. That is why I would say that many dignitaries visit, because Norway would like to show the rest of the world the importance of the high north, which we believe is very important for all of us, including the UK. We have some competent institutions located in the north also because they are working with the north as part of the district policy in Norway. It can be an advantage being located north of Oslo.

Lord Oxburgh: Is it worth repeating what Nalân said to me at the beginning: that you have the university here?

Dr Jan-Gunnar Winther: The University changed its name recently from the University of Tromsø to the Arctic University of Norway. They broadened that to cover the Arctic, thematically. It is growing. There are some merging processes in the education system in

Norway in general, but also in the north. The impact and influence of the university is growing; it is the biggest player in the university world in Norway when it comes to the Arctic. There is also the much smaller university in Longyearbyen, which is also dedicated to the specifics about the Arctic.

Q87 Lord Soley: You talked about the relationship with Russia. Can you give us examples of how helpful co-operation on the exchange of information and knowledge about what is happening in the Barents Sea is? Have the recent problems in Ukraine and so on made it more difficult, or are your scientific and other exchanges as good as they always were? I should add that I have a little concern about whether those agreements, which I would guess are quite good between you and your compatriots in Russia, translate into political action with Russia.

Dr Jan-Gunnar Winther: To the latter part of the question, I can say that at the institutional level—scientist to scientist or polar institute to polar institute—we have not been affected by the situation in Ukraine so far.

On the former part of the question, I had a question during our coffee break about what I meant when I said that our prime collaboration partner, looking over the last three decades, has been Russia. Russia and the former Soviet Union have been the most important collaborator with us on the science over that period. If you were to take a snapshot of today, Russia is not number one. That is not a critical remark. Today, it is not Russia we collaborate with the most. That is not to discredit our relations with Russia, it is just a natural development. We had long, very good relations and co-operation with Russia, during the Cold War period as well. We have a very solid institutional, structural base, people and programmes. We have a small branch of the Norwegian Polar Institute in St Petersburg. We have educated Russian PhD students with Norwegian funds. We will have a science-led

winter cruise with Lance in 2015, also with UK scientists participating. We also have Russian scientist in this project. There is a long, strong history of Norwegian-Russian collaboration in polar science.

The Chairman: Who is currently number one?

Dr Jan-Gunnar Winther: I should ask Nalân, but my guess would be Germany.

Dr Nalân Koç: Germany is definitely one of the countries that we collaborate with the most, but there is also the US. It changes with projects. We have several EU-funded research projects where we are collaborating with the UK.

Q88 Lord Soley: Can you give us examples of actual changes in policy that have come about as a result of your co-operation with Russia? I can see that the co-operation at times is very good. I just worry about the governance system and whether it translates into real changes on the ground.

Dr Jan-Gunnar Winther: I mentioned the integrated management plan for the Barents Sea. I did not mention that Russian specialists have also actively taken part in that process which is a management instrument for Norway. Because there is a border in the middle of the Barents Sea, which of course does not make sense in an ecological framework, we have invited Russian scientists within fishery and environmental management into that work. Russians also have developed some of their own thinking related to this Norwegian integrated management concept.

Lord Soley: So the management of the environment of the Barents Sea is driven not just by Norway but very much by Russia? They are literally taking initiatives that work with you. Is that a fair assessment?

Dr Jan-Gunnar Winther: We have invited Russian specialists in so there is input from Russia and Russian expertise in that process. We have ended up with a Norwegian management

tool covering around half of the Barents Sea. That has to be the case because there is a border in the middle of the Barents Sea, but of course the ecosystem crosses that border. We have very good relations with Russia, and I hope that lasts. The megatrend in polar science that has been introduced in recent years is the Asian countries: China, South Korea, Japan, India and, to some extent, Singapore. I think you will meet the Singaporean delegation while you are in Svalbard.

The Chairman: Yes, I met them in Canada and they said "We'll see you in Svalbard".

Dr Jan-Gunnar Winther: Yes. I would rank those countries in that order—maybe India and Japan could have switched places, I am not sure. Those countries have shown an interest and have stepped up their own scientific activity much faster than the relative increase in the UK, Germany, Norway and others. Those players were already active in the Arctic from the beginning. They were not starting from scratch. The level of increase from these nations has been very steep. That may be an exaggeration, but it is a large trend in the development in Arctic collaboration.

What is interesting, and where they can make a real contribution, not least within climate change, is that they are non-Arctic nations. I am talking not only about the A8 but about countries that are located very far away. As we heard from Nalân, when we have established connections, they can make a real contribution in understanding how things are climatically connected. I hope they will use that domestic knowledge so that we can learn more about this interplay between the Arctic climate and the rest of the northern hemisphere.

Lord Soley: I am not thinking necessarily of Russia now, but can you tell us the contribution that your institute has made to any environmental changes in relation to Svalbard or Jan Mayen? Have you given advice that has changed environmental policy in those two areas? I

am trying to get some hard examples of what changes when you give advice to the Norwegian Government, or whoever.

Dr Jan-Gunnar Winther: We are a technical and strategic adviser. The technical part is the science and the more advanced or strategic part is that we have the knowledge to keep an overview—and, of course, we feed into various processes. I mentioned the integrated management plan for the Barents Sea because that has clearly been the number one for the last five, or maybe seven, years at the Institute. There we have had a real impact on management, including most of the business development in this area. When it comes to Svalbard, there are national parks there and areas that have some kind of status when it comes to preservation and conservation. Of course ours is not the only voice but our voice is part of what has affected the final management regime in Svalbard. I think there are a number of examples of that.

Q89 The Chairman: One thing that our special adviser, Klaus, was bringing in was about defence forces and how information is co-ordinated. Do you co-ordinate with them, Mr Winther, in any way on these sorts of issues?

Dr Jan-Gunnar Winther: Let me put it this way. We are available for any part of the Norwegian governmental structure that would like to have information or advice. That includes many ministries.

The Chairman: Do they do their own research? Presumably they have data which they share.

Dr Jan-Gunnar Winther: I am not sure if I understand that question.

The Chairman: I know that this is going back, but a lot of the information about the Arctic comes from military sources because they do their own background research. I just wondered whether that was the case here or was significant. It may not be at all.

Dr Jan-Gunnar Winther: The military in all countries collect information on their own. I do not know what I do not know, so to speak, but speaking for my Institute we are available for the Norwegian Government, including the Ministry of Defence, when sharing knowledge, information and data.

Q90 Lord Soley: I want to move on to the growing interest in tourism in the Arctic, not least from the United Kingdom. There seem to be a large number of tourists coming out. Does the institute have a view about the sustainability of increased tourism, particularly from cruise ships, and about any search and rescue policies that may be necessary? If you bear in mind the disaster of the *Costa Concordia* in Italy, if that happened in the Arctic it would be a very different ballgame in terms of search and rescue. So first, is it sustainable if tourism opens up here in the way we anticipate, given what we are learning about the climate change issue here? Secondly, what about search and rescue if something goes seriously wrong with a cruise ship?

Dr Jan-Gunnar Winther: Maybe my answer will not be as specific as the question you raise but let me start with Arctic shipping, then zoom into the tourism part. In all our minds, the potential for a substantial increase in Arctic shipping—I am not talking now about cruise tourism so much as transportation—is not only in transit or transportation between Asia and Europe, which is mostly what the newspapers cover, but due to the increased activity in that region we will also get increased activity that is not transiting between Europe and Asia. There has been a development. There is still a very limited volume but again, going back to the point about surprises, if Arctic sea ice continues to shrink in summertime, as it has done in the last years—it may be the case that it could even accelerate—then we will have an Arctic Ocean with a summer season that lasts longer and longer. In 2012, when the last

transit went from Kirkenes in northern Norway with LNG to Japan, it left Hammerfest on 7 November. That was the last transit that summer—7 November—and it took about 14 days.

What I am pointing to is that our societies have a bigger risk of underestimating this development than vice versa. Why do I say that? I think there is a smaller cost involved in being prepared for a quite significant increase in shipping than in not being prepared for it and in running after that development, which could be costly. So there is concern about shipping, including cruise tourism in the Arctic in ice-covered waters, for many reasons. The sea charts are poor; we know that from Svalbard, where we have good mapping on the west coast but not on the east coast. So the Governor of Svalbard does not allow the big cruise ships to sail up the eastern part of Svalbard. He does not permit them to do so.

Lord Soley: For safety reasons?

Dr Jan-Gunnar Winther: Yes, for safety reasons. You could also add the limitations there are on search and rescue, which are obvious although they have been improved. The capacity in Svalbard has recently been improved quite a lot. There is a new ship coming in and new helicopters are about to come. Nevertheless, there are huge distances. As part of the search and rescue agreement that was facilitated through the Arctic Council, Norway has an area of responsibility that goes over to the eastern and northern part of Greenland and over to Franz Josef Land, as shown on the map. It goes to Russia in the east and all the way north, to the North Pole, which of course we cannot reach today with helicopters.

Then there is pollution, of course. Oil in ice is an area we are looking at in the Institute because of the potential impact of having an increasing volume of vessels in the Arctic today. Regardless of what they are doing, that is of concern. We have the experience from the "*Exxon Valdez*": chemicals that enter the water and then go into the ecosystem have very long-lasting effects, much longer than we thought. There is no good way of removing oil

from ice-covered waters today. The skimmers—the way we traditionally do it in open waters—are not working.

The Chairman: That is a really important point, and one that was also made to me by someone else. There is no technology that currently exists to deal with oil spills under ice. Is that what you are saying?

Dr Jan-Gunnar Winther: Well, today you can dissolve it by using dispersion means. . Basically, when you wash your dishes you have soap; in principle, it is the same thing. You can dissolve it and get rid of it but it is going into the ecosystem—into the water, anyway. The other thing that has been experimented with is to burn it off using napalm, for example. You can burn it off but then quite a lot of pollution obviously goes into the atmosphere. That way of collecting up oil, as we are used to seeing it around the world when we have an accident, is not efficient at all. In a way, we have to force it into the ocean, dissolve it or burn it and bring it up to the atmosphere.

If I may put a last point, introduced species are also a concern, especially when you talk about transit between Asia and Europe. The North Pacific has a climate that is not that different from the Barents Sea and species that can follow a ship in ballast water or on its hull might actually introduce themselves into a different area. That is also of concern.

Q91 Viscount Hanworth: I suppose that part of Clive Soley's question concerned the degree of leverage that scientists have over their respective Governments in terms of the implementation of their recommendations. I would like to ask, maybe allied to that question, about what you called the patchwork of regions where certain activities are regulated or restricted. The question is: who has mandated those restrictions or regulations, to what degree can they be enforced, and by whom?

Dr Jan-Gunnar Winther: They are formally anchored in the Norwegian Government. The integrated management plan for the Barents Sea had a steering committee that consisted of several ministries, chaired by the Ministry of the Environment. It was a governmental instrument. There is now a sailing corridor along the coast which is also implemented in the IMO. That was a trade-off between not being too close to the coastline so that if you had an accident you would not get oil on the shore, and not being too far away for the search and rescue dimension. Therefore it has been a trade-off. Now a corridor exists, with a northward lane and a southward lane—that is one example. The oil companies have to stick to this patchwork arrangement with its limited permissions for drilling; for example, they are restricted in certain parts of the year, and you have to adhere to that. Therefore that is reinforced, if I understood your question, and it is the Government of Norway who has made the rules about the management of that.

The Chairman: Can I just get clarification that they have covered the whole of the Norwegian EEZ. Is that the limitation?

Dr Jan-Gunnar Winther: We started in the north, so it covers the EEZ and also has 200 nautical miles around Svalbard.

The Chairman: That answers the question, thank you.

Dr Jan-Gunnar Winther: And now we are working our way south and implementing a similar management plan for the North Sea.

Viscount Hanworth: You also said that there was an artificial line drawn through the Barents Sea. What about the Russians' interest in preserving these regulations and enforcing them?

Dr Jan-Gunnar Winther: They do not have a similar tool to ours in the eastern part of the Barents Sea. My observation is that Russia has had an improvement in its statements and actions in improving the environment. I mentioned Franz Josef Land, where there is lots of

waste. When Medvedev visited Oslo, signing off the border in the Barents Sea, at the same time that he was in Oslo and a ceremony took place there, Putin was in Franz Josef Land. He stated—I remember very well, and we read it in the Russian domestic media—that, "We are going to clean up here and there will be money to do so". That was back in 2010. I think it is fair to say that maybe not everyone thought that that would happen. However, the next year in the Russian state budget there was funding, and there has been real activity, and waste removal from Franz Josef Land.

Viscount Hanworth: There is a lot of nuclear waste there, is there not?

Dr Jan-Gunnar Winther: I am not sure about nuclear waste—I cannot answer that. However, there is a lot of nuclear waste if you go to the Kara Sea. The Russians have nuclear submarines there—especially on the east side of Nova Zemlya there is a lot of waste. I do not know about Franz Josef Land. However, the attitude in Russia as we see it is that there is more than words—there is also action, and wanting an improvement.

Viscount Hanworth: You mentioned that the approach is 50 kilometres from the margin of the ice, but of course that margin varies, so how is it defined more precisely?

Dr Jan-Gunnar Winther: That formulation of not closer than 50 kilometres from the observed ice—

Viscount Hanworth: From the observed maximum?

Dr Jan-Gunnar Winther: From the observed at any given time. Therefore you have to stop your operation. For example, if you start your test drilling in the Barents Sea if you are Statoil, and you are more than 50 kilometres from the ice, if the ice comes, you have to stop.

Viscount Hanworth: So it does not stop you from drilling somewhere where the margin shifts so as to bring you within the—

Dr Jan-Gunnar Winther: The ice edge is dependent on the time of year. It is not connected to the maximum.

Viscount Hanworth: So it is the current distance. Yes.

Q92 Lord Oxburgh: Perhaps we can talk a little bit about the science. It seems to me that the melting of the Arctic ice opens up a new scientific frontier in the sense that this area has previously been largely inaccessible, except to the very specialist organisations, and is now much more widely open. It is an area that we do not really understand in many important aspects. The Arctic and its processes do not understand about international boundaries—they cross them with impunity—so we have to view the Arctic system as a whole.

There are two aspects, one of which—certainly in the UK, and probably in Europe in general—is now much less well understood, or its importance is much less well recognised than it was 100 years ago. That is the importance of surveying, monitoring and data collection. In what is essentially a new frontier, that is extremely important—the necessity to do the kind of things that you are describing. By and large, universities do not do those things. However, there is a broad need for this monitoring and surveying, and of course a good example of that is the simple topographic surveying of the ocean floor. It is the same in the Antarctic, where there are real risks for cruise ships that go where the charting is not good enough. It is very easy for a ship to know where it is, but not to know the submarine topography and where it is going to get caught.

Therefore my first question is: are you content with the present arrangements for both topographic surveying underwater and the collection of other kinds of environmental data that need to be done Arctic-wide? Universities will come into this and do the bits that look interesting—the bits where they can understand processing. It is not that that is

unimportant, but at this stage the monitoring and surveying are absolutely crucial. I do not know what your views are on that.

Dr Nalân Koç: In the Arctic, as in the Antarctic, the space is huge, and that is an international factor. This is not something new; we have done it before, but as it becomes easier to access the area and because a new situation climate-wise is taking place, there will also be a need for even more and better co-ordination of efforts.

Lord Oxburgh: So how does that come about?

Dr Nalân Koç: On the co-ordination, there is a new task force, for example, in the Arctic Council. That is hopefully a strong tool for that. Otherwise, collaboration usually happens also through the availability of hard cash. Therefore, if countries are interested in solving some common topics, they should allocate funds for their scientists to do that collaboration. They have bilateral co-operation, but they could also co-operate on circum-Arctic larger projects.

Dr Jan-Gunnar Winther: If you ask the scientific community, you will get a very positive attitude to joining forces and data, and to establishing a common data centre. However, your question is also highly relevant to talking to the commercial players. They have a motivation that is maybe not so much in the direction of sharing information and data. Therefore this is a very important part for business.

Lord Oxburgh: Is there any group in the Arctic Council—I guess it would be one of the working parties, or something like that—that tries to carry an oversight of what is being done Arctic-wide, that might say, "Look, there is an urgent need to collect this or that sort of data in this or that area"? In other words, is there any panoramic view of the need, and if so, who has it and who might do something about it?

Dr Jan-Gunnar Winther: The short answer is no.

Lord Oxburgh: That was my worry.

Dr Jan-Gunnar Winther: However, if you will allow me, I am not convinced that the Arctic Council is the right body to give guidance about where to work. In the Arctic Council you have scientists and science, but you also have a lot of non-science, so to speak. Therefore if that is the body that should direct science—

Lord Soley: Which is the right body?

Dr Jan-Gunnar Winther: I am not sure whether that body exists.

The Chairman: I met someone called David Hik.

Dr Jan-Gunnar Winther: Yes, from IASC, the International Arctic Science Committee. It has the same role in principle as SCAR in the south—the Scientific Committee on Antarctic Research. IASC is community-based, international, and widely topical, and covers the science for the Arctic. That body does not have money in its pocket. It can give advice based on a very effective international scientific consideration, but to implement its advice there has to be something more.

Q93 Lord Oxburgh: Apart from national Governments, the Arctic Council is the one body that could potentially have money and then ask a particular group or have a contract with it to collect particular sorts of information where it was needed.

Dr Jan-Gunnar Winther: I agree that the position is that the Arctic Council is, very wisely, the body that can show direction and capture the work done in the Arctic regions but such a body must also lean towards scientific bodies like IASC and others. It must be solidly based on advice from experts. At the top of the pyramid, so to speak, we see that the Arctic Council has a key role in this.

Lord Oxburgh: In terms of collecting monitoring information and a timed series of observations, any commercial organisation that does any kind of exploitation, oil or gas

prospecting or anything like that could be required to make a series of environmental observations before it starts and to continue those observations during the time of its operations. Is anything of that kind required by the Government?

Dr Jan-Gunnar Winther: This is covered under national legislation. When Statoil performs its activities it is under national legislation, as with other companies. There is no reason to think that the Arctic Council needs to take over that. Maybe I misunderstood your question.

Lord Oxburgh: But who determines what Statoil should monitor and measure before, while and after it carries out an operation? Are you consulted over that? Who is?

Dr Jan-Gunnar Winther: It is within the Norwegian governmental structure. It depends on which matter. We are not the key institution in this kind of work. The Directorate of the Environment oversees and sets that, in some cases the Norwegian Petroleum Directorate.

Lord Oxburgh: That is within the ministry, is that right?

Dr Jan-Gunnar Winther: Yes, the Directorate of Environment is the sister organisation of the Norwegian Polar Institute, also under the Ministry of Climate and Environment, that gives the rules and also looks after things if there is, for example, a zero-release requirement. It adheres to the national rules and legislation.

Lord Oxburgh: How much work is going on to look at the effect of the melting of the ice on the biosystem, ecosystems, biodiversity within the Arctic Ocean and the changes in those systems? Those systems have to change in response to the new conditions.

Dr Nalân Koç: There is quite a lot of new work going on. Part of the work of our Centre for Ice, Climate and Ecosystems is geared towards that issue. The University of Tromsø and the Fram Centre here are also working on these issues. There is also international interest in this new topic.

Dr Jan-Gunnar Winther: The rate of change in the Arctic is very much connected to sea ice, as we have seen. The ecosystem changes are taking place at a phenomenal rate. We know that living here. We have seen it with our own eyes outside Tromsø or in Svalbard. Every year, there is migration of species and new species. There is a phenomenal response in the ecosystem to the physical changes but this has not received as much attention in the media as it should.

Viscount Hanworth: I understand that there is an unprecedented affliction of insects.

Dr Jan-Gunnar Winther: Yes. There are many things going on.

Lord Oxburgh: It is worth emphasising the point Nalân made. If you remember her early diagram of the rises and falls in CO_2 in the atmosphere over the past 800,000 years, you can see a frequency associated with these, a time constant every 30,000 or 50,000 years, or something like that. The difference is that the current rise in CO_2 is, geologically speaking, instantaneous. Whereas there has been time in the past for ecological systems to accommodate, species to migrate and what have you, we are into a totally new ball game here. We just do not know what is going to happen.

Dr Nalân Koç: Another issue that I have not mentioned is ocean acidification. One-third of our emissions are being absorbed by the ocean, so there is the ocean acidification problem. The IPCC in its last report said that, due to global warming, natural agricultural land areas will diminish and we will look more and more to the oceans as a major source of food for the increasing population. However ocean acidification is a potential threat to our future food source.

Viscount Hanworth: Lord Oxburgh made the point about the gradualism of the previous climatological evolution but there is also a notion abroad that there have been tipping points

that led to very rapid changes. Is there anything in the paleo-planetological record that shows a very rapid change and the consequence of passing a threshold?

Dr Nalân Koç: There have been rapid changes. However, as Lord Oxburgh points out, none of them is as rapid or has this magnitude. There are always small rapid changes but this magnitude of change is very large.

Q94 The Chairman: Can I just go back to basics on this research, as someone who has not been involved in this area at all? Clearly, you can do endless amounts of research on anything. You could spend the world's GDP on research if you wanted to. Following on from Lord Oxburgh's point about the seabed, are we anywhere near knowing what we need to know about the Arctic to meet the challenges before us? Are we 10% or 90% there? Is this a real crisis in terms of needing lots more research, or is there maybe a capacity constraint anyway—even if we had huge budgets, we would not have the staff to carry it out? I am trying to understand the scale of the challenge in the short to medium term for research. With everybody from the ocean states getting involved, are we getting to a point of coping with it or is this something that, as a globe, we really need to concentrate on far more?

Dr Jan-Gunnar Winther: Starting on the heuristic side, we could do with the UK's GDP. The serious way to answer this is to look back in time and take the view that these areas—Antarctica in particular but also the Arctic—had not been investigated to a very great degree, purely because of inaccessibility and there was not really much interest, few people living there and so on. That is as close as you can come to a fact: these have been under investigated compared to other areas of the world. Even though there has been a steep increase in investigations since then, this takes time. If you add the importance, which we understand more and more, that these areas have for their regions but also beyond the regions, my answer is that they are heavily under investigated. But it is hard to give you a

figure: whether it should be doubled, tripled or tenfold. My argument would be that for societies—this is a valid argument for a nation such as the Republic of Korea, as an example—if you invest one penny in studying the Arctic, you gain more in improving your domestic management of your resources. Examples where climate teleconnections are important outside the region are the monsoon, flooding, drought and so on. There is a benefit from investing in Arctic research because you reduce costs in your domestic society. We are seeing what happened in the US and the cold breakout of air last winter there. The *Washington Post* had an insightful article on this. Of course, the debate in the media was, "Where is global warming? It was cold, windy and snowy. We are almost dying from this harsh winter and you speak about global warming". The *Washing Post* ran a very insightful article with a few illustrations. One was that the cold outbreak of air from the Arctic was due to the reasons that Nalân explained: a weather phenomenon connected to the weakening of the circumarctic atmospheric circulation. Then it had this beautiful illustration of 30 years, or slightly more, of temperature over the US in the winter months. It took exactly the part of the year when this happened and showed the development in the past 30 years in the US. Then you could see that the US has warmed in the winter, the east coast more than the average, and the US more than the global average. There was a decadal increase in winter temperatures in the US of 0.64°C. The public discussing and mixing weather events from climate trends had not really captured that: they said, "We cannot have global warming and at the same time this happens". So this was a very strong illustration of the difference of climate and weather.

The Chairman: Say that by a miracle we managed to double the amount of research that was done next year. Can the scientific community deal with big increases, or do you need to have

specialists like yourselves? Can you just draft in capacity to do scientific research or does it not work that way?

Lord Oxburgh: You cannot just talk about scientific research in that way.

The Chairman: That is exactly the point I am making.

Dr Jan-Gunnar Winther: I can use the Institute as an example. We have increased our research by 80%, if not 100%, over the past 10 years. We would manage to do that on such a scale not from one year to another but over a certain number of years. That is one institution and you could apply that to the whole scientific community. We are capable of absorbing this.

Lord Oxburgh: Would you agree that one sort of answer to Lord Teverson's question is that there is an urgent need in the short term to establish the, if you like, environmental background: to do work on the topography, monitoring and measuring a series of levels against which in future changes can be measured? It is important to do this now before exploitation really takes off in a big way. I suspect that there would be quite a strong case for a surge over the next few years, maybe the next decade, after which things could die down a little bit. Does that seem a reasonable approach?

Dr Jan-Gunnar Winther: Yes, but I would not focus that in isolation and so much on the topography.

Lord Oxburgh: I was using that as an example.

Dr Jan-Gunnar Winther: We have quite a good overall understanding of the atmosphere, the sea ice and the ocean in connection to climate change but it is not sufficient. I think we have reached a balance where the money spent on this activity is still paying off in the domestic manner in the UK and Norway. Topographic mapping on the sea floor is more of an interest

for business activity that is a driver of climate change or natural sciences. I would not focus that much on that as, at the moment, the most critical need of knowledge.

Viscount Hanworth: One of us was advocating increasing greatly the scientific budget. One of the principal issues is trying to change the perceptions of politicians among the public in general regarding what scientists know to be a major hazard. Our experience in the House of Lords is germane to this issue. There are people who simply will not be convinced, and it perplexes some of us as to how well educated and rational people can maintain such opinions. That is really one of the principal issues. It may be that our report will make an important contribution. To me it seems to be one of the leading issues, because I have been engaged with this over a period of 25 years or so. I look back at some of my writings, and the question that was raised at the very start was: "How long will this take to sink in?" I am afraid that I have a very big report to deliver about this matter.

Dr Jan-Gunnar Winther: Of course, it is a very big paradox because in other parts of human behaviour we pay for insurance even though risks are much less certain than what we face in connection with climate change.

Q95 The Chairman: There are a couple of other areas that I want to cover. I come back to the climate change issue but in a micro sense. One of the things that our report wants to consider is whether there are policies specific to the Arctic that you feel ought to be pursued in terms of mitigation or adaptation. I am not talking about the big IPCC issues, but perhaps including black carbon. I do not know what else there might be, but are there things that can be done regionally that help to mitigate, or with which we can prepare for adaptation to the effects of climate change? Can anything be done, or is it just a matter of covering emissions globally?

Dr Jan-Gunnar Winther: There is maybe a twofold answer to that. The answer to your question is yes but, given the fact that the Arctic is warming twice as fast as the globe, we know that what happens in the Arctic affects the rest of the world. So it is a strong showcase for climate change. Then we can add a layer of very good collaboration—let us take the Arctic Council as an example. That is a very good fundament for introducing very concrete action in this showroom, the Arctic, which arguably could be used as kind of an export for the globe. Black carbon is such an example. A heavy fuel ban for vessels would be an unrealistic ambition today, but we need ambitions beyond what is possible today. It is easier to implement this kind of future world reality—today they are almost unrealistic ambitions—in this showroom, the Arctic, to show that it can work and has an effect. Then it can be exported to the global arena. We could use a few of these interesting ambitions for the Arctic which might actually work.

The Chairman: And those are?

Dr Jan-Gunnar Winther: Black carbon is one. Heavy fuel is another. A change in the energy mix—there is a lot of gas in the Arctic region, and there could be all sorts of alternative energy sources to operate in communities. There is a relatively long list, including technology development on vessels. The most important thing would be that if you could show that it worked—for example, turning vessels operating in the Arctic to LNG instead of using heavy fuel—the industry would see that, and you could get momentum in research and development that could be activated on a broader scale. The strength of the Arctic, despite the depressingly rapid extent of climate change, is that it could be used as a showroom for international co-operation, action, ambitions and real projects that could help us to move into the world that will have to look at things differently.

Q96 Lord Addington: What role do you think bodies such as the World Economic Forum could play in the Arctic region, given that the NPI is member of the forum's Arctic group? Also, how good are you at getting out to talk to other people and say: "The Arctic is disappearing rapidly as an ice sheet. This actually means that there is an economic consequence"? There is clearly a disconnection at the moment, and this is what we are going on about. We have already mentioned that in Great Britain, if you started talking to someone and said: "By the way, global warming is why your insurance bill has doubled, and the house that you bought now can never be sold because part of it disappears every time there is a rainstorm", that is the level at which we have to operate to make this important. It is what we call "nimbyism" in Great Britain—"Not in my back yard". This is so strong in everything we do and in other forms of activity. How do you get out there? Any thoughts, because that is the big one?

Dr Jan-Gunnar Winther: That is a hard one. Maybe I am not the person to whom you should address your question directly, but in research done on how you change people's opinion on matters it turns out that grown-ups, adults like ourselves, hardly change their opinions. You stick to your opinion, almost whatever you take in and read. So one part of the answer is the young people who are still absorbing information, and you have to have a long-term perspective. The issues that are at stake and which we are discussing today are well understood by world leaders. The issue of climate change, its complexity and severity, and what it could cost at the end of the day—

Lord Addington: Just to jump ahead, you are basically saying that we are on a short-term political cycle, which is determined by things such as elections, and that is getting in the way.

Viscount Hanworth: It is also denied by politicians—

Q97 The Chairman: I think this is getting into another area. I am going to wind up and thank you both very much indeed. Can I just ask one final question? If you were writing our report for us, what is the most important thing that you would include in our recommendations? Is there anything that you think: "This is the thing to say to the world in our report"?

Dr Jan-Gunnar Winther: It is important to have a good balance in all the issues relating to challenges and problems arising from what is going on in the Arctic. We have paid most attention to that in this meeting. The balance also applies to the opportunities that open up. There is no doubt that the future Arctic may contain a lot of opportunities that are not there today, but it is important to find the right balance that provides sustainable development. The Arctic—you mentioned World Economic Forum—is a part of the world in which many other nations would like to see increased development, income and activity. Then, on the other hand, we have the environment and potentially severe impacts of activity. This is absolutely not black and white. We need to find a balance. We often use shipping as an example. We often address the oil-spill issue. If there would not be any accidents related to Arctic shipping between Asia and Europe; that would be a good thing for the environment due to shorter distances and reduced CO2 emissions. It is not black and white. That is a very roundabout answer to your question but it is extremely important that we get these things right with a balance that is sustainable.

Dr Nalân Koç: I would re-emphasise the fact that what is happening in the Arctic has far-reaching consequences, and that needs to be understood by the societies living in Europe.

The Chairman: That is a very strong message to put at the very front of what we say. Some of the things that have come out today have emphasised that. I shall formally end this session and say thank you very much indeed for giving us such a really good grounding in the whole area.