JON SHANKLIN

Edited transcript of a recording of Jon Shanklin interviewed by Chris Eldon Lee on the 29th November 2013. BAS Archives AD6/24/1/236. Transcribed by Andy Smith, 5 March 2017.

Part One

[Part 1 0:00:00] Lee: This is Jon Shanklin, interviewed by Chris Eldon Lee, on the 29th of November 2013. Jon Shanklin, Part 1.

Shanklin: Jonathan Shanklin, born 1953, September the 29th, in Wrexham, Denbighshire.

[Part 1 0:00:18] Lee: Oh right? North Wales?

Shanklin: North Wales.

[Part 1 0:00:20] Lee: I live in Shrewsbury, so I know.

Shanklin: I was in Shrewsbury in September actually.

[Part 1 0:00:24] Lee: What, professionally?

Shanklin: Amateurly because I am also a botanist. In fact I have just been appointed the Co-recorder for Cambridgeshire and there was a Recorders' conference in the Gateway.

[Part 1 0:00:39] Lee: Would you say your father was an educated man?

Shanklin: Yes.

[Part 1 0:00:42] Lee: Tell me about him.

Shanklin: Dad was a consultant geologist at McAlpines, the big construction company, and so he would go off prospecting all over the place. I remember when I was a child he had several visits to South Africa, when he was away for months at a time. Probably rather like me, going to the Antarctic for months at a time, repaying the compliment, if you like. My mum was also a geologist, but mostly a mother, but they were both members of the local geological society. Dad at one time was a president of it, and they had regular excursions, and as children myself and my brother would be packed into the bus which would go down lanes that were very very narrow. The bus drivers tended to think 'Err, I don't like this.' And in the end they sent us the oldest, grottiest buses they had, so they didn't mind getting scratched. And yes, Dad was very much a university graduate, and in many ways I followed in his footsteps.

[Part 1 0:01:50] Lee: You didn't actually. How come you are not a geologist?

Shanklin: Well, I did Geology Part 1 at Cambridge, so I did do some geology and I actually have done some geology in the Antarctic because on one occasion, when I was at Faraday (as was), Vernadsky as it is now, I was wandering, looking at the rocks and found sedimentary material there. At that time this was thought to be purely volcanic, and no fluvial material at all, so that was a little chunk in the evidence. And I have also published a semi-geological paper, because one of the things that used to be done at Faraday was the regular radio-sonde launches, and they generated the hydrogen by a chemical means. And the waste material from that was piled in a big heap, and I collected some specimens from this heap and that then went into a geological paper that was published in a chemical-type geological magazine.

[Part 1 0:03:04] Lee: What deflected you at Cambridge from your illustrious career in geology, then?

Shanklin: I had always wanted to be an astronomer really, so to be an astronomer you couldn't actually do Geology, so it was Physics was the thing. It turned out that I wasn't terribly good at Maths but I was competent at Experimental Physics. So in the Part 2 exams I specialised in Experimental Physics but the Experimental Physics was more Geophysics, where I could make it that. So we had various Geophysics field courses where we did things like letting off explosives to measure strata below ground, and used resistivity measurements for mapping a Roman road – lots of exciting things like that. In the end I didn't go into Astronomy professionally because my degree wasn't good enough for that, so I joined the Antarctic Survey instead.

[Part 1 0:04:14] Lee: Straight from University?

Shanklin: I did one year's Teacher Training first but didn't go into teaching either, in part at least because at that time (and probably still is today), the thrust of teaching was to push all children through the exam syllabus in a very narrow window, irrespectively of whether the children were capable of doing the syllabus, and I thought that was a total waste of time. You can teach all abilities things that are relevant to them but not if you are constrained by that syllabus. So I didn't really get on with the National Curriculum. It wasn't that then but it basically was teaching to an exam syllabus for the least able children. You could make learning fun for them, teach them things without them realising they were being taught, and actually give them a solid founding for what they actually need.

[Part 1 0:05:15] Lee: That would have been a career as a physics teacher, would it?

Shanklin: That would have been a career as a physics teacher but having done that because I now quite often go out to schools and give public talks, that really has equipped me very well for being able to pitch the talks at the level that the majority of people there will understand, which I think many of my colleagues, who have never done any teaching, try and give a talk to a general audience and they pitch it at far too high a level. Working out which things you can leave out, which things you can simplify, and how you simplify them, that's quite an important part of the teacher training.

[Part 1 0:06:00] Lee: Let's just pursue that for a minute because I know it is the other end of the story, it's the far end of the story, but how do you avoid being a 'doom and

gloom merchant' when speaking to children in schools. There is a quote in one of your lectures online about the fact we need three planets to carry on as we are because we are running out of resources. That's a difficult message to deliver to idealistic youngsters.

Shanklin: They take it on board very easily because it's fairly obvious to them that resources are limited and that you can't go on that way. So I think they are quite happy with the message. How you actually translate that into any action, that's another story, and one of the things that I usually say is that we have to have some population control of one form or another if we are going to survive for very much longer. I think at a young age, it's probably easier to accept that message than it is later in life when you have got your own children and everything else.

[Part 1 0:07:02] Lee: And a mortgage to pay?

Shanklin: And you want more and more of everything.

[Part 1 0:07:07] Lee: So do you come out of those schools feeling optimistic?

Shanklin: Yes.

[Part 1 0:07:11] Lee: Or are do you feel like a Harbinger of Doom?

Shanklin: The children are all very enthusiastic about what they have heard. Maybe it's just the pictures of Antarctica that go with it, but the feedback I have had from schools is (a) I make the children think and (b) that they keep talking about it for some time afterwards. So that I think is sufficient praise from them that I have done a good job. Whether they agree with me or not that doesn't really matter, but if I have got them thinking and talking, and that is the main …

[Part 1 0:07:49] Lee: But how are we as humanity going to convert that thinking into kids, the next generation, saving the Planet? You set the alarm.

Shanklin: The only way you can really do it is through a disaster, and to an extent we saw that with the ozone hole. It was blindingly obvious you couldn't ignore it. Right we will change how we behave. Admittedly in that case you could change how you behaved. There is lots of talk about greenhouse warming. It's a bigger problem than the ozone hole but nobody thinks it's bad, or very few people think it is a bad thing, partly because of the name.

[Part 1 0:08:33] Lee: A bit 'Percy Thrower', isn't it?

Shanklin: 'Greenhouse warming? That sounds quite nice really.' Particularly when you live in a dismal north temperate location, where you think 'Yes, it would be quite nice if the winters were nice and warm – 10C degrees the whole time. None of this +2C which is the really worst conditions.' But in other areas, it is only when there is a major national disaster that people's group behaviour really does change, and what I hope is it won't be too late by the time we have a major disaster, for those changes to take place. But I don't think scientists talking about it is going to have any more than a pinprick influence on the political and cultural climate.

[Part 1 0:08:28] Lee: When you say a national disaster, in fact you really mean an international disaster because national disasters are other people's problems. We have had two recently: Fukushima, and the worst ever storm in the Philippines, both of which are possibly a result of Man's folly and impact on Nature. And yet they are still generating nuclear power in Japan and the people of the Philippines are going to rebuild their towns.

Shanklin: Yes. Strangely they are stopping nuclear power in Germany, which is actually totally the wrong thing to do. What you should do is make sure that your safety systems are up to scratch. It's very difficult to legislate against the least likely combination of circumstances. That's always where the major accidents happen. It's A and B and then C and D and the probability of all those happening is vanishingly small. So once in a while you will have a disaster, that is generally manmade and to an extent unavoidable. We are human; things happen and to an extent you can't attach any blame to that. You can attach blame to what you do afterwards, but provided you have thought about everything that is reasonably likely, that's fine.

[Part 1 0:10:53] Shanklin: And a lot of the nuclear issue is a relic, I think, of the fear and lack of understanding that was behind the Cold War. There was this over-arching threat that we might have been blown out of existence by a nuclear war, and therefore nuclear is bad by association, whereas actually nuclear power has and will kill fewer people than coal. And yet there is now a mad dash towards coal where (a) the coal mining is quite dangerous, (b) the burning of the coal releases greenhouse gases, and (c) generally coal fired power stations put out more nuclear material into the atmosphere than a nuclear power station does because of the radioactive material in coal – one of the many little known facts. Actually if you are worried about radiation, you should not be burning coal.

[Part 1 0:12:00] Lee: So what magnitude of disaster would you suggest might make us wake up?

Shanklin: I think it has to be the sort of thing that wakes governments up, particularly. So for the UK, flooding over central London when the tide gets a bit too high, is going to be something of a wake-up call. So something of that sort of order is I think what will start to change the hearts and minds. It could be a repeat of the 1947 floods in East Anglia, the unlikely combination of winds and waves and tides that just overtop the flood defences. And then that in itself will produce us many other problems because how are we going to feed all our population when the best agricultural land is under salt water? Nobody thinks about the consequences of that.

[Part 1 0:12:59] Lee: But the flooding in London is another Fukushima isn't it? It's a disaster unlikely to be repeated so again we will just say 'Well it was just one of those things' and we carry on regardless.

Shanklin: You can say that but I think if it can be attributed then there is more likelihood of politicians finally waking up to it. But more likely, people just go on as normal. Inflation will suddenly be racing ahead. We will have famines and then Nature will take its own course.

[Part 1 0:13:33] Lee: Which will be what? The elimination of human population?

Shanklin: It's unlikely that we will write everybody off. But there will be a lot more famine, a lot more plagues because we won't be able to keep up with the medicine because the infrastructure will have collapsed. So yes, I think ultimately a doom and gloom scenario is more likely than the enlightened utopia which is within our reach. The science and the technology is certainly there but the mad rush for pyramidal growth will deflect us from it, I fear.

[Part 1 0:14:12] Lee: Let's move back a bit then. Did you have a physics teacher yourself, who was an inspiration?

Shanklin: I think the main inspiration was at university where we had Malcolm Longair as one of the lecturers. He was Astronomer Royal for Scotland but at that time he was Professor of Physics at the Cavendish and his lectures were so illuminating, so clear and so dynamic that you really wanted to go to those particular talks. And then at school we had some very good teachers. I went to Kings School, Chester, which was at that time a Direct Grant School, and the teachers pushed you as hard as they could. I don't think you actually realised it at the time but that's what they were doing. And you could learn as much as you wanted to really. Coming to Cambridge was actually a bit of a jump. I think it is for many people, where you find that instead of being one of the brightest in the group, you are pretty much average, but you are still way above the majority of the population. And so that was a bit of a shock to find that my maths wasn't actually quite as good as I thought it was.

[Part 1 0:15:39] Lee: So what was it then that made you decide to move into meteorology?

Shanklin: Joining BAS, really.

[Part 1 0:15:49] Lee: So BAS came before meteorology?

Shanklin: Oh yes.

[Part 1 0:15:53] Lee: Well tell me about applying to BAS then. What happened?

Shanklin: At that time I was really just a physicist and the advert that I saw … I can't remember whether it was the *New Scientist* or in the *Telegraph*, one of the job advertising things, was after somebody with a knowledge of physics, computer programming in FORTRAN and perhaps an interest in meteorology but not necessarily a meteorologist. I was looking for a job in Cambridge because I quite liked the area and at that time definitely wanted to stay in the zone (as it were). So I thought 'That looks fairly interesting.' So I applied and was called to interview, and I came second but the guy who came first turned it down so I got the job.

[Part 1 0:16:47] Lee: Who interviewed you?

Shanklin: I know, or I think I know that Eric Salmon was on the board.

[Part 1 0:16:55] Lee: This was 1977?

Shanklin: 76 or 77. '77 I think yes. I am pretty sure Joe …

[Part 1 0:17:07] Lee: Was Joe on the board? Joe Farman?

Shanklin: I think Joe was on the board. I thought Brian was on the board as well but memory is a funny thing. I certainly would not swear to any of that, but obviously I made sufficient of an impression that they were prepared to have me.

[Part 1 0:17:26] Lee: So the fact that the job was to do with the Antarctic, was that a secondary consideration?

Shanklin: That was very much secondary. It was more that data that was to be looked at, the fact that it was in Cambridge, that I had the skills to do it and some background. I wouldn't say that I had always had an interest in the Antarctic but my great grandfather's diaries have newspaper cuttings which include the news story of Scott's tragic failure and things like that, and Shackleton's trip across the Southern Ocean to South Georgia. So all of those things were a little bit of a background, if you like, and in another sense, the house where my father still lives was formerly occupied by not Hillary but the ones that might have got there.

[Part 1 0:18:44] Lee: Mallory.

Shanklin: Mallory, Leigh-Mallory[1] was the vicar in Dodleston and lived in the house. So Mallory himself must have spent some time there before going up Everest and being lost, and also he was a Cambridge mountaineer, so there were vague links there as well.

[Part 1 0:19:05] Lee: Did you ever meet your great grandfather?

Shanklin: No.

[Part 1 0:19:07] Lee: So it was a child looking at his diaries?

Shanklin: Yes, yes.

[Part 1 0:19:11] Lee: Do you think that was a contributory factor, because those childhood images sometimes set off …

Shanklin: Probably overall I think. Science and natural history have clearly run in the family for a long time because my great grandfather was clearly a naturalist in the broad sense.

[Part 1 0:19:33] Lee: And interested in adventure?

Shanklin: Interested in possibly not so much adventure but the wider world around. So at that period in the Great War, there were lots of other things going on and having

[1] Canon Herbert Leigh-Mallory was the father of George Mallory the climber.

access to those diaries lets you see it in a much more personal way than you do in the news stories.

[Part 1 0:19:57] Lee: OK, so by good fortune you ended up working for BAS and then meteorology loomed?

Shanklin: Yes. Basically the work was pretty mundane. It was looking at the radiation records, this is the solar energy coming down through the atmosphere and being reflected back up; trying to work out when the recording system had gone wrong, exactly how far it had gone wrong; trying to correct for all those; working out the calibrations and so on. So that was all pure physics really. You didn't need to know any meteorology for that. And similarly the ozone data processing was something similar; it was essentially physics. You didn't need to know anything about how the atmosphere was supposed to work and the only bit which did require some knowledge of meteorology was processing the synoptic weather observations and trying to correct for failures in the observers, or supposed failures in the observers. Joe Farman had written a programme that went through all the observations and picked out what he thought were errors and then it was my job to go through the computer output, communicate with the guys on the stations and tell them 'You have got your observations wrong.' And mostly they didn't think they had made the observations wrongly and it wasn't really until I actually went South myself that I was forced to agree with them and decide that Joe's programme probably wasn't quite as good as he thought it was. You can get some circumstances where the meteorology supposedly says 'You can't have that.' But actually in the Antarctic, you can.

[Part 1 0:21:46] Lee: Can you give me an example of that?

Shanklin: One of the classic things was snow from strato-cumulus and Joe's programme said 'No, that is totally impossible. Strato-cumulus never gives precipitation.' Then go South, 'That's definitely snowflakes coming out of it and that is definitely a strato-cumulus and there is no argument about it.' So the Antarctic does give you weather that the books perhaps don't allow you to have and it was really on the strength of processing that meteorological data and arguing that to really understand it I needed to go there to see what it was like at first hand, that led to the first trip down. It was more looking at the weather at first hand than it was taking the Dobson instrument down, although taking the Dobson was a big part of it.

[Part 1 0:22:40] Lee: I will come back to your first trip in a moment. We are darting around. but doesn't matter at all. That division between the desk in Cambridge and the snowy field in the Antarctic has bedevilled Antarctic science, certainly in the past, and that was a big concern when you started doing your ozone work. Are their readings correct, that come back from the Antarctic because they are being done by fairly untutored men with frozen fingers? That has been a constant problem, hasn't it?

Shanklin: For BAS as a whole? I think it only does. Knowing your data first hand, is always quite important, so if you are going to be working on things, understanding how it is collected is essential, and I would definitely encourage BAS to send people down even if they are just working theoretically on data, to give them that first-hand knowledge of what it is actually like. Some people find that annoying because it doesn't match the expectations of the theoretical model or whatever, and some people

just prefer working in ignorance of the real world because the mathematical world is so much cleaner and everything. But again, because I was an experimental physicist, wanting to know the experiment, if you like, from start to finish, is quite important. And if you don't understand the experiment from start to finish, you will never understand when things have gone wrong with it. So I was lucky; I did eventually get to go to the Antarctic and consequently I think I have got a much better appreciation than many of the people working here of both the meteorology and the physics and the difficulty of making measurements in the Antarctic. I think all of that is very important.

[Part 1 0:24:46] Lee: When you joined BAS, ozone recordings had been going for twenty years, since the IGY. Why? Why was anybody bothering in the innocent days of the 1950s to measure the ozone holes?

Shanklin: The initial reason for doing it was twofold. One: it was somewhere new and if you go somewhere new, you always make new discoveries. I think that applies to science everywhere. If you can push the boundaries in any direction, you will make new discoveries. Secondly, it was in part the original ozone network was set up for weather forecasting, so the idea was you could see changes in the ozone layer and then subsequently you would get a change in the weather. And because that happened on a synoptic scale, it was very large scale, going to the Antarctic where you didn't have that network of stations that you have in Europe, you might be able to see your weather systems coming in by looking at the ozone and that would be useful on the station. I am not sure whether that ever was used in that sense, but that was one of the drivers for setting up a European network. And of course computers came along and you could do the forecasting that way instead. But for the Antarctic, I think primarily it was somewhere new. 'It's not been done before. Let's map the ozone field over Antarctica.'

[Part 1 0:26:25] Lee: But there was no kind of life or death imperative about it, so that again I wonder whether the scientists, the Fids doing that work in the 50s …

Shanklin: I think in the 50s it was new and exciting so yes, you did it.

[Part 1 0:26:38] Lee: There was due diligence?

Shanklin: Certainly.

[Part 1 0:26:40] Lee: And in the 60s?

Shanklin: Well starting with the 50s they found that the Antarctic was very different to the Arctic. There had been expectations as to how the ozone would behave and indeed the first ozone measurements were totally discounted because they didn't behave like they had in the Arctic. I think in retrospect they were probably quite OK and there was nothing wrong with them. But it is down in print that the 1956 measurements were suspect. I don't think anything changed in 1957 but they then realised that the atmospheric circulation surrounding Antarctica was quite different to the Arctic. That is why you had relatively low ozone values in the early spring – a massive rise in ozone amounts and then a fall away again and that was a key discovery that was much easier to see in the ozone data than it was for example from

the primitive balloon data because largely the balloons would not get high enough up to be able to see the temperature changes in situ. So that was something that you could tell about the circulation above Antarctica from the ground using the ozone measurements.

[Part 1 0:27:56] Shanklin: The 60s come along. You are getting more of an idea of how the atmosphere is behaving. You know a bit more about the circum-polar vortex but you don't know the year to year variation. So is it always the same each year or are there substantial variations? So you are beginning to plot the variance of the seasons, so again that is still quite exciting and there will still be due diligence. By the time you got to the 70s, then certainly the politicians and the bureaucrats are thinking 'You have published this paper.' This is Joe Farman's and Hamilton's main paper about ozone over Antarctica. 'You know what the variance is now. Why should we be continuing it?' Then of course we went and discovered the ozone hole and that was the answer why you keep doing it.

[Part 1 0:28:57] Lee: Yes but that was another 15 years later, about '85.

Shanklin: There were beginning to be hints in the late 70s.

[Part 1 0:29:05] Lee: Well tell me about those first suspicions.

Shanklin: What was happening was that the guys down South were complaining that the charts that they were using for the ozone reduction, the data was falling off the bottom of the chart, so one of the things I had to do was to try and extend the charts so they could keep doing it, doing the measurements. And that I think was one of the things that led to me looking more carefully at the data and eventually doing it systematically, but at that time it was just 'The data is off the chart. Right, let's extend the chart.' 'It's a bit further off this year so we will extend it a bit further.'

[Part 1 0:29:52] Shanklin: Then combining that with the fact that we had an Open Day here in Cambridge, and I thought 'Well there is all this fuss about *Concorde* and spray cans. Joe has published this massive paper that shows what the ozone layer was like over that 20-year period. I will put this year's data in. It will be the same and you don't need to worry about it.' But the problem was: it wasn't anything like the same. The spring-time values were clearly much lower than they had been, or at least clearly to me. But Joe said 'No no no, it's just a variance showing itself. Because of the way the Antarctic circulation forms in the winter, some years it will trap low-ozone air; some years it will trap high ozone air, and you will get this quite big oscillation, so next year it will be back up again.' Well next year it wasn't but at that point we had got quite a big gap between the early 70s and by then the 80s that hadn't …

[Part 1 0:31:00] Lee: A gap?

Shanklin: We had got the measurements but the data hadn't all been reduced because it was getting a bit painful.

[Part 1 0:31:08] Lee: It hadn't been processed?

Shanklin: It was written down. Some of the values had been worked out but not consistently. So that was part of my job, was to write the computer programmes, supervise the digitisation of the data and work out the final values.

[Part 1 0:31:25] Lee: So you were detailed to do that as routine work?

Shanklin: Oh yes.

[Part 1 0:31:29] Lee: You weren't looking for anything?

Shanklin: There was nothing we were particularly looking for. It was purely routine observations so that we had that long term data set. That was the focus of it all because the long term data sets are the key, and I think Brian and Joe had always got that view, that our group was assigned to making sure that those long term measurements continued. Probably less actually doing anything with them. The focus was 'This is the data and the data is what's important.' So yes, my job was just to do the routine stuff but I then started following up, filling in that missing bit, and then I wrote a draft paper that clearly showed that there was a systematic decline, and it was that draft paper that then forced Joe to put together the real paper that appeared in *Nature*.

[Part 1 0:32:32] Lee: When did you write the draft paper?

Shanklin: That must have been [Pause] probably '84.

[Part 1 0:32:44] Lee: When was *The Smoking Gun*, the Yorkshire Television drama *The Smoking Gun*, 1990? Thereabouts?

Shanklin: Something like that, yes.

[Part 1 0:32:57] Lee: When did you pin up the graph with that year's ozone chart? Or was that not true?

Shanklin: There were two things. One was the BAS Open Day and Visiting Group and certainly something did get pinned up, and I was told to take it down again.

[Part 1 0:33:19] Lee: Did you?

Shanklin: Yes.

[Part 1 0:33:20] Lee: Why were you told to take it down?

Shanklin: Because Joe didn't want to give the wrong idea because he wasn't quite certain that I had done the processing right and he thought 'If we have got it wrong, and we said there was an ozone loss over Antarctica, we would look really silly.' So grudgingly I took it down. But I then wrote this draft paper and I put it on his desk and Brian's desk and Michael Rycroft's desk, and Michael Rycroft sent it back with lots of scribbles all over it, saying 'This is really exciting. Go on with it.' And Joe never really got back at all, other than smoking his pipe very furiously, and then coming up with various drafts of what is now 'The Paper'. And I did have input into

that, so some of the graph drawing and everything else, was what I did. But I would say I was definitely the member of the team that really forced the issue by clearly pointing out that it was a systematic decline.

[Part 1 0:34:28] Lee: OK. So is it correct to say that Jon Shanklin discovered the ozone hole?

Shanklin: In a sense yes. You could also say that some of the Fids discovered the ozone hole because they called attention to the fact that the data was off the chart.

[Part 1 0:34:44] Lee: Right, but they didn't know why?

Shanklin: But they didn't know why or anything like that. I didn't know why either but I could show that it was systematic, which is something that they couldn't do, and also which the Japanese couldn't do.

[Part 1 0:34:56] Lee: Why not?

Shanklin: The Japanese had an expedition that went down to the Antarctic each year and measured the ozone layer, but each expedition was independent of all the others, so they were only getting single snapshots of what the ozone layer was doing, and one of those expeditions did say 'Our ozone data is off our charts too.' But they didn't look back and say it's systematic and we did and that was the key difference.

[Part 1 0:35:29] Lee: And did you also not talk to the Americans at all?

Shanklin: Yes. I even wrote to the Americans because at the time we were doing observations coincident with satellite overpasses and one of my jobs was to tell the teams down South 'Make measurements at these times because the satellite is going to go overhead or as close as it gets to overhead.'

[Part 1 0:35:52] Lee: This is Nimbus-7?

Shanklin: This was the TOMS[2]. I think it must have been on Nimbus-7. It might even have been an earlier one as well.

[Part 1 0:36:02] Lee: Sorry, carry on.

Shanklin: So they would make special observations co-incident with satellite overpasses. I would telex those to the States on a weekly basis, so the results would go to the States. And then once we found that the ozone levels were a bit low, I wrote to the satellite people saying 'the data is a bit low; does the satellite show this as well?' And fortunately I didn't get a reply. We had also done … about the same time we had done some special ozone sondes at Halley, again for an American team, or at least in conjunction with an American team, and I wrote to the people doing the balloon observations saying 'Does any of your data show this?' They said 'Our group stopped doing that but I will pass your letter on to this other group.' And they didn't respond either. So they were given quite a good chance to go to their data, well before

[2] Total Ozone Mapping Spectrometer

we published and make the discovery themselves but they didn't and the rest is history.

[Part 1 0:37:16] Lee: It is said in fact that you were trying to disprove the depletion of the ozone. Your intention was to do the maths to show that everything was OK?

Shanklin: There was certainly I suppose a feeling that (a) ozone depletion wasn't supposed to be happening in Antarctica, so there was a pre-view that things should be all right. There were these concerns about *Concorde* and spray cans, and because I wasn't a meteorologist, I suspect, I couldn't see how on earth any of that could transpire. So there was a view 'Right well we will see if it is there in the data.' And again I think again because of the physics education in Cambridge, doing experimental physics, where they did teach you to look critically at your data, I looked critically at the data.

[Part 1 0:38:18] Shanklin: Now Joe's philosophy was that the best time to look for changes was where the natural changes are smallest, and he had quietly shown that in the autumn the natural changes were very small so if you were going to see a change in the ozone layer, that would be the most obvious time to look. In the spring it is all over the shop so you are unlikely to see anything. But I slightly did something different, that I didn't look at monthly averages or anything else; what I looked at was the lowest 10-day mean, and sometimes that's early, sometimes it's later in the year, but it will generally be September or October and that was really where something clearly was happening. If you looked at a monthly mean, it was not so obvious, but if you looked at this 10-day mean, a shorter period, where you are using a sufficiently long data period that it will average out faulty measurements but not so long that it obscures what is actually going on. And that's what I used in the graphs and showed that it was systematic.

[Part 1 0:39:39] Lee: So was there an 'Oh oh' moment … was there a night when you went to bed thinking 'It's serious.'?

Shanklin: No, not for me at any rate. It was more 'Oh this is interesting. We have got a change. It's probably due to the CFC's and so on.' But it was a supposition that it was due to that, and I thought it was just an Antarctic thing. 'There is no evidence anywhere else for changing the ozone layer. It's not going to affect many people' and I was quite surprised just how seriously everybody then took it.

[Part 1 0:40:21] Lee: Well did they? Because this wasn't the initial … There's a whole chapter missing but I will come back to that, if I may. Wasn't the initial reaction to your work almost not exactly apathy but wasn't it just sort of 'Oh yes? That's interesting. Next?'

Shanklin: It was certainly thought by *Nature* to be sufficiently exciting that they would publish it.

[Part 1 0:40:43] Lee: Several months later.

Shanklin: That was their time scale then.

[Part 1 0:40:47] Lee: OK, five months later?

Shanklin: It took a lot of time doing the backwards and forwards and typesetting and all the rest of it.

[Part 1 0:40:56] Lee: And peer group review I suppose?

Shanklin: Yes. So although today you can get things into print much more rapidly, that was the way things were, I think. So I wouldn't say because it took *Nature* a long time, that proves they weren't terribly interested. The other groups? Well I suppose the Americans were a bit surprised but took it at face value very quickly and then they went back to the satellite and said 'Oh yes. Yes, we missed that.'

[Part 1 0:41:37] Lee: Did they confess?

Shanklin: Oh yes.

[Part 1 0:41:38] Lee: OK.

Shanklin: I don't think there was any doubt about that. I think if they'd had longer, they would have noted it sooner or later, but they had, I think, a different view (a) they were trying to calibrate the satellite but (b) the computer processing at the time was such that you couldn't do your modern fancy graphics where you envisage the whole of it just like that. So they were doing some pre-processing and the main interest then was what was the latitudinal gradient from equator to pole. They also had to do some quality controls so they said 'Naturally ozone isn't below that level in the atmosphere so we will flag all the lower values as suspect. We will get back to them eventually but flag them as suspect. Then we will take an average round a latitude circle for our presentation.'

[Part 1 0:42:37] Shanklin: The problem with the ozone hole is it's quite often offset from the geographic pole toward the Atlantic and there is high ozone on one side and low ozone on the other side, and when you average round a latitude circle you get average ozone. So in that presentation, they wouldn't see it. So it's quite easy to see a combination of circumstances where you don't make a discovery even if you have got the data. You probably should respond to letters that specifically address a concern but that was a part of the luck. Other groups tried to come up with different explanations. So in particular there were people who thought it was something to do with the Sun and said 'Well look, the solar cycle is doing this. Your ozone is doing that. It's quite a clear correlation between the Sun declining since '76 and your discovery and that is what has done it.'

[Part 1 0:43:34] Shanklin: What they didn't do was to say 'Actually this group has got data going back to 1956. That's two solar cycles and there is no evidence in the previous earlier data that there was any solar influence whatsoever. So it can't be that.' And that is a problem for quite a few scientific groups. They focus narrowly on their data and don't say 'Well is there anything else up there that confirms or denies our hypothesis.' And that's a point that I make in my talks. I am looking at the environmental issues. It's not just focussing on the ozone hole or focussing on greenhouse warming. You have got to look at all the environmental issues that are

affecting us and say 'What is the one underlying thing?' Which is why I say: It is us that is a problem, therefore we need to tackle us, not putting sticking plasters on all of these other issues.

[Part 1 0:44:39] Lee: What was the reaction within BAS? Did you show the paper to Dick Laws before you sent it off to *Nature* and did he comment? Dick Laws was Director at the time, wasn't he?

Shanklin: I have no idea. That would be something that Brian or Joe would do. I would never get involved in such lofty things.

[Part 1 0:44:58] Lee: Dick Laws doesn't really remember seeing the paper.

Shanklin: The policy was, I think, that the Director approved everything that went out from the building.

[Part 1 0:45:12] Lee: It certainly didn't … My memory of the interview I did with him some years ago now he didn't sit up at his desk and go 'Oh my God, This is important.' There was a muted reaction within the organisation. Is that right?

Shanklin: Yes, I think that would be certainly right. (a) It was very unusual for Joe to publish anything so actually getting something out would be good. Dick was a zoologist rather than a meteorologist so it would be outside his field and he might just say 'The grammar's all right. Fine.'

[Part 1 0:45:55] Lee: I was using him as a figurehead. Was there a groundswell of opinion about the paper in that gap between it being written and it appearing in *Nature* within BAS?

Shanklin: I don't think so because most people wouldn't even know it had been sent to *Nature*. That would be just a fairly small group of people, and that is still true today. You have got no idea who is writing exciting papers. We have got a much better PR system now than we had then, so a lot of people would tell PR that there was a really exciting paper about to come out and we had better do something about it. But others quite happily just do their own little thing, follow the scientific process and …

[Part 1 0:46:48] Lee: So there was no indication at that time that it was going to be the paper that …

Shanklin: Changed the Earth?

[Part 1 0:46:55] Lee: Well I was going to say enhanced BAS's reputation perhaps. Actually your ending of my sentence is better.

Shanklin: No idea at all. It was really just another 'Here's an exciting little discovery.'

[Part 1 0:47:11] Lee: OK.

Shanklin: I don't really think we understood the implications. It was 'This is a bit of science.' And actually it's created a big social change and underlined absolutely conclusively the need for long-term monitoring, because if we hadn't had that continuous data set we couldn't have made the discovery.

[Part 1 0:47:39] Lee: If it hadn't been for IGY …

Shanklin: Yes, but also the continued funding to make the observations, so it did underlie the risk that various working groups were starting to say 'Why are you still doing those ozone measurements?' And then thereafter we could say 'This is why.'

[Part 1 0:48:04] Lee: Because you never know?

Shanklin: That reason has been followed ever since and despite all BAS's financial constraints, that basic environmental monitoring still continues as a key part. Largely because we understand that it underpins a lot of research. If you don't have that baseline, you can't say 'My computer model suggests that this should be happening. It's not in the data so that particular version of the model must be wrong.' So there is a reliance on having that good quality data.

[Part 1 0:48:40] Lee: You commented about Joe Farman's lack of paper production. Other people have said the same. So let's go back now and discuss how that paper did get written, well how your information got acted upon and written, because you were the 'new boy on the block'; you were a rookie scientist. 'What does he know?' Was that a struggle?

Shanklin: I think Joe felt that if he didn't publish, then I would, and therefore something had to be done. He has always said that the order of the authors was based alphabetically and he felt that he ought to take responsibility, because if I was wrong, then that would damage my career.

[Part 1 0:49:29] Lee: He was genuinely prepared to take the rap, was he?

Shanklin: I think so, yes. He felt that he was the lead and therefore if it was wrong, it should be his fault, not the other two.

[Part 1 0:49:44] Lee: But to get to that point, you had to go to him, knock on his door and say 'I've got these statistics.' So tell me about the process of convincing Brian Gardiner and Joe Farman that you were right.

Shanklin: I think actually they didn't take much convincing once I gave them 'Here is the graph.' Because they could take one look and say 'Yes, the science speaks for itself.' And that was one thing about the discovery. It was so clear cut, there was virtually no escape for argument as to whether you had found anything or not, unlike the greenhouse gas debate: 'Is climate change happening or not?' The sceptics can come up with all sorts of arguments, mostly specious, that say 'Well actually you've not measured anything.'

[Part 1 1:50:31] Shanklin: So they say now 'The Antarctic Peninsula trends? No no, that's a load of rubbish. It's warming at the wrong time of year.' All sorts of things

like that. Whereas with the ozone hole, it's absolutely clear cut that over this station in Antarctica, there has been a dramatic drop in ozone. It has only happened since the late 1970s. It wasn't there in the 60s and 50s and early 70s. We also got away, I think, with plotting in reverse the increasing amounts of CFCs[3] so people would take a look at that one graph and say 'Yes, it's the CFCs. No question about it.' In fact the physics and chemistry in the paper was wrong. It wasn't the mechanism that Joe put forward; it was heterogeneous chemistry on ice clouds high in the atmosphere, but that was irrelevant to the success of the paper.

[Part 1 0:51:40] Lee: You got the right results for the wrong …?

Shanklin: We got the right results, and the results by themselves stood but the theory turned out to be not quite right.

[Part 1 0:51:50] Lee: Was it Professor Rowland, the American, who … ? Was it looking at his work that made you start looking at comparisons between your ozone graph and CFCs?

Shanklin: [Pause] I think it was, again from the scientific press at the time, that certainly in the early 70s, it was *Concorde* plus CFCs would affect the ozone layer, and I think *Concorde* slowly faded out of the arguments; it was just the CFCs. But it wasn't really expected that Antarctica would show anything because it should have been visible, if it was happening, across the Globe. The theory was that there shouldn't be anywhere special and so seeing something quite dramatic over Antarctica was unexpected.

[Part 1 0:52:50] Lee: So it was already accepted that CFCs were bad for the ozone layer?

Shanklin: Yes.

[Part 1 0:52:54] Lee: What you did was to show how bad?

Shanklin: In one particular place, and our paper was really just focussed on Halley, and we couldn't say that this was an Antarctic-wide phenomenon. It could just be a narrow little thing that happened to be over Halley. It was likely to be global, and there were hints of it in South Pole and the Japanese data and so on, so we were reasonably confident that other people were seeing it too, but they hadn't got the continuity that allowed them to say. On the far side of Antarctica, over McMurdo, they would be very unlikely to see anything because the spring warming happens there first, so by the time they can start the measurements, often the ozone depletion has finished anyway.

[Part 1 0:53:47] Shanklin: South Pole itself: there they can't start the measurements until early October, maybe a little bit later, and again by that time things are beginning to finish. So the ozone amounts are beginning to recover, because it just happens that it is late September/ early October that you see the lowest values. Halley is actually ideally placed because very often the ozone hole is centred over Halley and

[3] Chlorofluorocarbons.

you have the geometric conditions so you can start the observations, because Halley is sufficiently far north, unusually, that you have got the sunlight to make the measurements with the Dobson. So there were a lot of accidents that went into the discovery.

[Part 1 0:54:40] Lee: A heck of a lot! Does it occur to you sometimes that you might have missed it? Or would somebody have come up with it a couple of years later?

Shanklin: Somebody would have come up with it. That was inevitable. The Japanese were starting to get suspicions but didn't have the continuity. The satellite people would have looked. I don't think there's much doubt about that.

[Part 1 0:54:59] Lee: So there were two forces here then, working in that period up to the Christmas 1984? There was the young enthusiastic scientist called Jon Shanklin who was convinced he was right and had the desire to be first.

Shanklin: No, I think just convinced he was right. I don't think there was any desire to be first that came into it at that point. It was just 'Here's what we've got and you have got to go ahead with this.' And yes we would have been first but I don't think it was being first that was the driver. It was that we needed to make these observations available to the scientific community.

[Part 1 0:55:39] Lee: It would have been negligent (those were Brian Gardiner's words), negligent not to publish?

Shanklin: Yes.

[Part 1 0:55:44] Lee: But you had the old Smokey Joe, Joe Farman, who, I get the impression, was always reluctant to go into print until he was absolutely sure beyond any reasonable doubt, and at some point a compromise must have been reached between the three of you?

Shanklin: I think it was between Brian and Joe, with pressure on Brian from me that was then transmitted to Joe, I think is probably more how it went.

[Part 1 0:56:13] Lee: So your junior status meant that you had to work through an intermediary?

Shanklin: I didn't like going into his office because it was so smoky. [Laughs]

[Part 1 0:56:26] Lee: The point I am getting at is: did you feel disadvantaged because you were new-ish?

Shanklin: No.

[Part 1 0:56:32] Lee: You were being taken seriously on this?

Shanklin: I was taken seriously. There is no doubt about that.

[Part 1 0:56:37] Lee: And was it taken off your hands then, by Joe?

Shanklin: The writing of the paper very much was.

[Part 1 0:56:44] Lee: Were you told that 'I will write this.'?

Shanklin: Yes. Not in so many words, but …

[Part 1 0:56:49] Lee: Rather more words? How was that for you?

Shanklin: I think initially quite disappointed but then quite pleased that it got into *Nature*. There were two sides. One: it was my thing and it seemed slightly unfair that everybody else's name should be on it, but the argument was that if you didn't have a theory, then the observations by themselves weren't much use. So Joe's view was that you needed to explain your observations as well as present the observations, and I couldn't come up with a theory other than saying there's a link to CFCs. Well you could say 'Yes, there is a correlation. It's 99.9% certain.' Whatever, but a correlation is not a theory and I think Joe was quite right. You do need to have an explanation even if your explanation isn't perhaps 100% quantified, but you do definitely need to say 'Here's our postulated theory for why this is happening', and then it hangs together much better.

[Part 1 0:58:15] Lee: Was that something that you couldn't write?

Shanklin: I didn't have the technical competence to do that.

[Part 1 0:58:20] Lee: OK. Also, is the paper better with three authors? Does it have more credibility?

Shanklin: It had more credibility in the sense that Brian was very good at making sure all the facts and figures balanced and checked, and was grammatically spot on, and that there weren't any possible mistakes in the computing and everything else. And I think the three authors we had all complemented each other. So I drove the observations, Joe drove the chemistry and Brian linked everything together and came up with a coherent whole, and I think without any one of those, it would never have got through.

[Part 1 0:59:08] Lee: Right. And then we get to December 1984 when it had to be written, redrafted and then posted. What are your memories of that pre-Christmas period?

Shanklin: Not much, actually. I can remember Brian coming to me and saying 'We need to re-do this particular graph.' But other than that, it was Brian and Joe that were largely doing the drafting. And I think also memories have faded. There was nothing …

[Part 1 0:59:45] Lee: Were you being kept in the loop at that point?

Shanklin: On the fringes of the loop, I would say.

[Part 1 0:59:49] Lee: Right, so were you aware of last-minute panics about 'Should we or shouldn't we post this letter to *Nature*?'

Shanklin: Not really, but I think I was aware that if they didn't post it, then my draft would come out again.

[Part 1 1:00:09] Lee: So there was another smoking gun, which was the one that you held to their heads?

Shanklin: A little bit, yes. I think they were aware of that: that if they didn't, then I would, and that was part of the deal, that we will do it together, rather than one of us doing it and it going off half-cocked.

[Part 1 1:00:30] Lee: So what was making you hold that gun to their heads then? Because you said earlier 'Being first didn't really matter.' What did matter enough to you to make them …?

Shanklin: Doing it, because as you said, Joe was always reluctant to actually publish anything and this was something I thought 'Yes. we need to do it.' However I think the same criticism can be levelled against me, that I have never published terribly much, at least for BAS. For some other organisations, one or two publications a year. Whether that is BAS not being able to utilise me enough, or management or whatever, is another matter. But through the BAS part of my career I have only got a relatively small number of papers. The focus was on the data; largely with data you don't publish papers on it. You just say 'Here it is and it is available.'

[Part 1 1:01:35] Shanklin: So for the BAS part of my work I have always made sure that the data is publicly available. There is a web page with it all on. You can just go and get it and help yourself. We understand it better, so beware of misinterpreting what we make available. And I follow that into many other areas of the science that I'm involved in, so one area is comets. So I am the Director of the British Astronomical Association's Comet Section and the Society for Popular Astronomy's Comet Section and all the data there is publicly available on the web page. But on comets I publish one or two papers a year and then again botany: I have published partly refereed papers, again one or two a year. But the data is there and publicly available, because I think that is a key thing that I've gained from here. The Antarctic Treaty says you will make all your data publicly available, so that's what we do. As soon as we get it, there it is; it goes up on the web.

[Part 1 1:02:42] Lee: Did you see the paper before it was posted?

Shanklin: Yes.

[Part 1 1:02:46] Lee: You approved it?

Shanklin: Yes, I had the copy.

[Part 1 1:02:48] Lee: Did you approve it or …?

Shanklin: I don't know. I think I just said 'Yeah, that looks all right. It's got a graph on it. All my data is there.' So I was happy that it had gone off.

[Part 1 1:03:06] Lee: OK. There is now a five month gap between posting the envelope and it appearing in *Nature* magazine in 1985, which feels like a very good time to have a smoko.

Shanklin: Right. OK, let's take a break.

[Part 1 1:03:21] [End of Part One]

Part Two

[Part 2 0:00:00] Lee: This is Jon Shanklin, interviewed by Chris Eldon Lee, on the 29th of November 2013. Jon Shanklin, Part 2.

[Part 2 0:00:10] Lee: Did you dash out and buy a copy of *Nature*?

Shanklin: No. I can't even remember whether I was given one. I was definitely given a pre-print of the paper, the bit with just our paper in it, and I don't think I got a copy of *Nature* itself until the 25th Anniversary when they did a reprint.

[Part 2 0:00:37] Lee: Right, OK. Was there any peer group review corrections or adjustments? Did you have to compromise your article after it had been sent out for peer review?

Shanklin: There certainly were referees' comments on the paper which mostly Brian and Joe dealt with. I don't recall particularly anything … From what I recall, they were mostly minor in nature. It was very quickly accepted. The main thesis of the paper was fine.

[Part 2 0:01:17] Lee: Very difficult to actually find somebody to review it, wouldn't it be, because it is brand new material?

Shanklin: There would have been experts, both in atmospheric chemistry and in general ozone measurement, which would be the two areas. So there was quite a large community even in the UK that were involved in ozone research in one form or another. And again obviously in the US, there would have been the satellite groups, And so – I don't know who the referees were but I am sure it would be relatively straightforward for *Nature* with all their contacts, to find a couple of suitable people who would have the background to be able to say 'This science is OK' or 'It isn't.'

[Part 2 0:02:04] Lee: So let's look at the reaction then to this, perhaps starting off with the press reaction. Were there journalists on your doorstep the next day?

Shanklin: I certainly don't recollect any coming in. And I think it took a little while before the realisation dawned that this really was something quite fundamental.

[Part 2 0:02:27] Lee: On you or them?

Shanklin: On the media, particularly. Yes, *Nature* highlighted it as one of the discoveries but I think even *Nature*, it took them a long time to realise that it was one of their top twenty papers of the 20th century. I think that was something that shocks me even more than getting the paper in the first place. A friend of mine who works in publishing came up to me and said 'Did you know your paper was in the top twenty over the 20th century that *Nature* has just published?' I said 'No. You mean to say we rank alongside Einstein and all the other major discoveries?' 'Yes.' I think that was even more shocking than the general recognition that this was an interesting discovery. It really is seen through the whole scientific community as being a fundamental game changer.

[Part 2 0:03:26] Lee: Was there anybody in the scientific community who was calling you a crank?

Shanklin: They called us 'the backroom boys', who were isolated from the real community but I don't think they called us cranks. It was quite often portrayed as David and Goliath with Goliath being the massive NASA research effort, and us as David with our little slingshot. Because we weren't that highly funded. We just kept tinkering away and did things, but I think we were always regarded as reputable scientists. There was no hint that this was idiosyncratic or anything else science. As soon as the evidence was published, 'Yes, that's all right.' There were alternative explanations put forward for what it might be due to, but they could be very quickly discounted.

[Part 2 0:04:35] Lee: So when did the press begin to wake up? How?

Shanklin: I think it was more as it became evident that this was going to really push the discussions on a treaty to limit the CFCs, and so the forcing behind first of all the Vienna Convention and then the Montreal Protocol, and once that envelope became more to the political forefront, then this paper was clearly very significant in that debate.

[Part 2 0:05:16] Lee: All right, so it was kind of the political activity which happened before the press activity?

Shanklin: It was the scientific activity that led to the political activity. There was a broad scientific push which linked in to the politics. Then once you have got politics, the press become much more interested than just the straightforward science.

[Part 2 0:05:40] Lee: So let's look at the political repercussions, then. How and when did you first start to notice those?

Shanklin: Again, this was something that Brian and Joe were much more involved in, particularly Joe, who did a lot of the politicking and pushing for more and more demands on limiting the CFC emissions and working with the Montreal process. I was just there supplying the data and kept feeding in the data and by and large doing minor talks to the public, rather than the major talks that influenced the political process.

[Part 2 0:06:26] Lee: How was that for you?

Shanklin: In many ways I was quite happy with that. I had always envisaged myself as one of the backroom boys, not at the forefront, and I remember as a child going to the dentist and talking about orthodontists and getting teeth straightened out and things like that. And when it was talked about having a brace to straighten the teeth out, so you have a good public image, I said 'I am going to be a backroom scientist. I don't need any of that.' And to a large extent, I have stayed as a backroom scientist. I provide the information and then somebody else forefronts doing the public speaking. Although I suspect I have quite a good reputation for public speaking.

[Part 2 0:07:14] Lee: You have, yes.

Shanklin: But I don't regard that as the primary role, certainly at that early stage in my career.

[Part 2 0:07:24] Lee: Lacked of confidence?

Shanklin: Almost certainly yes. That may be another reason why I didn't go into teaching, that I didn't have the full confidence to discipline a crowd of unruly pupils. I was quite good at teaching the science and getting the science done, but not so good at keeping the discipline. Whereas I think I now have learned how to discipline the kids. So if I do go into a class, or even into a group of adults, I know the technique to quieten them down and they do.

[Part 2 0:07:56] Lee: And what about the chemical industry? When did they start listening to Jon Shanklin's evidence?

Shanklin: They had always been surprisingly supportive, I think, and immediately after we published, they provided funding for an ozone sonde programme to actually investigate what was going on in greater detail. And there were no strings attached to that. It was 'Here's the money. Go and do the research and tell us the answers' which is quite illuminating in many ways. There is often a feel that industry controls the science and only allows the publications that they want. Well in this particular case, it was quite straightforward. 'We want to know what is going on. Go and find out what is going on. Tell us what the answer is and then we will worry about the industrial ramifications of that.' I think they were always of the view that perhaps there were things that they could definitely do, so there were alternative products that they could develop. And perhaps it was even in their interests that we were right. That was certainly how it was seen later.

[Part 2 0:09:17] Lee: Economic interests?

Shanklin: Yes, because the patents for the manufacture of CFCs were coming to an expiry date so that they become open source as it were, and so if you could come up with something else that was patented, then you could make much more money. So there probably were those sorts of views, but it was quite nice that they funded the science, and you went and did the science. Whether that is still the same for a lot of industry today, I don't know. My impression with the greenhouse gases debate, is the sceptics are largely funded by pressure units,

[Part 2 0:10:01] Lee: NGOs?

Shanklin: that don't want the changes that will be required by the science. So they try and rubbish the science.

[Part 2 0:10:11] Lee: I beg your pardon. Right.

Shanklin: So it's not the NGOs. The NGOs are probably too vociferous the other way, saying things that the science doesn't actually say. And it is a very grey area. There are issues where it is not at all clear-cut. So when I give talks I say 'Well, there are all these different things that drive the climate, but the balance of probability is now that we are changing the climate. It's not absolutely impossible that it might not be us but the evidence is so overwhelming that my view is that it's us.'

[Part 2 0:10:50] Lee: I will come back to that later, if I may, once we are on this other track. So do you think Joe's public work, ??? [incomprehensible] work was kind of forcing the hand of the chemical industry? I know that's a very big generalisation but they wanted to be seen to be good boys?

Shanklin: I don't know. Clearly they always liked to be seen in a favourable light but I don't think they particularly made much of the publicity of saying 'Look, we have funded the British Antarctic Survey to do these measurements.' So that was done out of the limelight as far as I am aware.

[Part 2 0:11:35] Lee: Did you find yourself in the limelight much?

Shanklin: No.

[Part 2 0:11:39] Lee: Again by choice?

Shanklin: I think more by chance than choice, that everybody wanted to speak to Joe because he was the first name on the paper, and so nobody particularly asked the third author's opinion.

[Part 2 0:11:58] Lee: I have to ask you whether that rankled at all, despite your shy retiring nature.

Shanklin: I think although I have always said it was a team thing, it did always seem that Joe took rather more of the credit for the discovery than was perhaps deserved. But these days, that's how it is and so I stress that it was a team thing even though it was me that led to it.

[Part 2 0:12:36] Lee: And you were the junior man?

Shanklin: I was the junior member of the trio, yes.

[Part 2 0:12:41] Lee: Let's look then at the changes that took place as a result of that paper, both in the world at large and in Jon Shanklin. Let's start with you. Did it change you at all?

Shanklin: Probably not, or if it did, it was a very slow change, that in some sense would have come along anyway as I slowly progressed over the years with BAS. But you can't really tell what would have been the case if you hadn't done action A. The future is totally opaque and you can never re-write history. So I don't know how much it influenced me and how much it didn't.

[Part 2 0:13:27] Lee: I was thinking in a very personal way, that – let's use newspaper headlines – the guy who changed the world. You did make a sufficient contribution to the sum knowledge of our planet for other people to do something about rectifying damage.

Shanklin: We did but somebody else would have found it if we hadn't. So in that sense it didn't.

[Part 2 0:13:53] Lee: But it was you.

Shanklin: But it was us so it is nice to be in that position where you actually have made an impact and I think what is nicest is that everybody has heard about the ozone hole. So it is something that is a worldwide thing. There is no argument about it, and if you say 'I was one of the scientists that discovered the ozone hole.' 'Oh right, this is somebody really important.'

[Part 2 0:14:17] Lee: Well are you important?

Shanklin: Well obviously everybody else thinks I am, because I went to a botanical meeting in London last Saturday and I was introduced to a few people as 'This is the person that discovered the ozone hole.' And the people that I was introduced to subsequently said 'That was one of the most impressive things about the whole meeting. We met the person who discovered the ozone hole.'

[Part 2 0:14:45] Lee: But the other argument is that you just happened to be a junior scientist who happened to be in the right place at the right time, with the right information.

Shanklin: Yes I think that is an important bit about science. A lot of it is chance. You need the right people in the right place at the right time with the right background and any one of those strands, the discovery isn't made or somebody else makes it. What you have to be as a scientist is be ready to see the oddities in your data and that is probably why we made the discovery. I had sufficiently wide a background that I could see that there was a clear pattern in the data that needed to be followed up, and whether it was the scientific education at school and at Cambridge or whether it was my general interests in the environment and Nature or even bell-ringing. This jumper I am wearing has an embroidered pattern on it which are bell-ringing methods.

[Part 2 0:15:47] Lee: I had been wondering. It looks like a doctor's chart.

Shanklin: As a bell-ringer you have to memorise patterns, and be able to pick out patterns, and perhaps that is one of my abilities, is the ability to recognise patterns and you can see patterns in data, just as you can see patterns in bell-ringing. So I would

say that was perhaps another influence that led to the discovery, and it is just a combination of happenstances.

[Part 2 0:16:13] Lee: So if those same statistics had been in the hands of a man with a different mind-set, perhaps somebody who doesn't go bell-ringing, it may have been missed?

Shanklin: It might well have been missed, yes, and that is science for you. But when you are being taught, I think it is very important that you teach people to keep an open mind and also to try and have a broad range of interests, because I don't think in future that real advances will be seen on the narrow focus of science that generally we have today. You need a few more polymaths that will have a wide range of interests, that they can link factors together across a range of science, and that is where the real advances are most likely to come. And that is one where I have with today's increasing commercialisation focus of science.

[Part 2 0:17:16] Shanklin: The politicians want to direct where the science goes and that is a recipe for failure because in the past, the UK's strength has been this blue skies approach. Just go out and discover something, it doesn't matter what, and you can actually afford to invest in failures if the successes are so spectacular that they cover you. And that philosophy really doesn't translate into the politics today, which you must account for every little last drop of money that has been spent, whereas actually you shouldn't bother adding it up. You should say 'We can afford that ten or twenty percent of people waste the money because the ten or twenty percent that really come up with discoveries because they are unconstrained, more than outweigh those negative sides. But politicians don't like that approach.

[Part 2 0:18:09] Lee: On a personal front, before we start talking about public reaction to your discovery, is there a sense that you peaked early in your career? Have you been able to maintain that level of significance in your work?

Shanklin: There's been different discoveries. So whether it's discovering comets or discovering species new to the UK or whatever, or even unusual species in the Antarctic, I have kept finding things that other people perhaps haven't noticed. But it would be nice to find something hidden in our ozone data or climate data that nobody else has noticed. And there is possibly one thing in the ozone data.

[Part 2 0:19:00] Lee: You are working on something are you?

Shanklin: Yes, oh yes.

[Part 2 0:19:03] Lee: Secret?

Shanklin: No, I have told lots of people about it, on the grounds that I can see a pattern in the data and I need a theoretician to try and explain it.

[Part 2 0:19:14] Lee: What have you seen, Jon?

Shanklin: So it's a linkage between how the ozone is changing in the atmosphere compared with how the temperature is changing. Historically it has been a one to one

linkage between ozone and temperature in the ozone layer, and you can see that pattern quite clearly. But over the last decade or two decades in the high summer, there looks to have been a change and that may be telling us there has actually been a change in atmospheric circulation that we need to explain. Sometimes you get the theoreticians to come up with an explanation and that is just by me looking at the data and thinking 'That is a different pattern.' Whether it is a significant discovery is another matter but there is something a little bit odd going on.

[Part 2 0:20:08] Lee: So, putting my tabloid journalist's hat on, is this as big a discovery as the one in 1984?

Shanklin: I doubt it because we pretty much understand what happened in 1984. Could it be a switch in circulation? I think we would have spotted it in other ways if it was a real switch in the circulation of the stratosphere or something like that. But you never know. The principle is that people should be aware that something is happening and so if somebody else takes the credit now, I don't care because I have had my career and I have retired from BAS and I have a decent pension and I still have an office, which is really quite nice, at BAS.

[Part 2 0:20:58] Lee: But it was a fulfilling career? You weren't like a Hollywood starlet who glowed brightly in their early years?

Shanklin: No, I think I have always had fun with the science. I have had trips down to Antarctica. I have been to various places for meetings and the like. So in many ways it has been as much a hobby as a paid job and I think that is true for many people in BAS. It is very much a hobby and a pastime.

[Part 2 0:21:28] Lee: Between 9 and 5?

Shanklin: Well for many people it is not between 9 and 5. It goes on until late at night and weekends as well. So that in part is why it is much broader. I still look at emails at the weekends and if there is a query from down South, well you respond to it as soon as you can.

[Part 2 0:21:48] Lee: Let's look then at the reaction on a broader scale to the discovery of the ozone hole. It was quite substantial. It took a little while to get going, as you said yesterday, but it was actually quite substantial. Was it beyond your expectations?

Shanklin: Yes, I think so.

[Part 2 0:22:05] Lee: Tell me more about that.

Shanklin: I think I had always thought of it as: this is a small peculiar problem for Antarctica, rather than being a global issue that will lead to international treaties. And ultimately lead to a solution. It's quite clear in the latest ozone data from Antarctica that the ozone layer is beginning to recover. That is now I am confident is clear. It is still too soon to say we have had the worst ever ozone hole because you could get a combination of meteorological circumstances and geophysical circumstances that

could lead to the worst ever ozone hole. But that a recovery is slowly underway is undoubted.

[Part 2 0:22:48] Shanklin: So that is really amazing, that things can be perfectly OK 60-odd years ago. You can make a discovery that things are changing. It can lead to a political process and a manufacturing process, and then see the results that things are beginning to recover. It will still be another 60-odd years before we are back to where we were 60 years ago but we are getting there. So it shows that with the knowledge and the will you can make changes. So with a lack of knowledge you can make dramatic changes to the atmosphere that you didn't see, but with the knowledge you can then change the future in a positive way, and I think that is one of the key results of our paper, that the world's scientists and governments have made that commitment to change the future.

[Part 2 0:23:43] Lee: So that really ought to make you feel less gloomy and doomy about the future of mankind, shouldn't it?

Shanklin: It does in this one particular case.

[Part 2 0:23:51] Lee: It's an example that change can happen?

Shanklin: It's that change can happen but it happened I think for almost non-scientific reasons and that is: somebody very cleverly called it an ozone hole and holes are bad. You need to fill in holes, so immediately this is a problem, not something that looks quite nice. Secondly the ozone hole allows in more ultraviolet light which leads to skin cancers. 'Skin cancers are bad. We have got to do something about that.' And then finally there were alternative chemicals that could be used. So there was no major change to lifestyle. People just continued on as they had before. So all of those elements together: this is a quite straightforward thing to do something about.

[Part 2 0:24:44] Lee: So humanity got lucky?

Shanklin: We were lucky with this one because if we hadn't tackled the problem, then the scientific evidence is that global warming would be much worse today that it actually is. The rate at which CFCs are accumulating in the atmosphere would have led to a substantial temperature rise today and probably depleted ozone over most of the planet, rather than just over Antarctica and occasionally the Arctic. So we have changed things enormously for the better but equally the ozone hole was a total surprise and the worry is that while we think we understand the atmosphere better today than we did then, are there other surprises in store for us? And there is evidence from the past that the climate can suddenly switch in a fairly short space of time. It hasn't done that for many thousands of years. What happens if the switch occurs in the next decade? We will be stuck.

[Part 2 0:25:48] Lee: Do you know who actually did coin the phrase 'ozone hole'? Was it Joe?

Shanklin: No, I don't think anybody has quite come to a definitive answer on that. I don't believe it was us. It might have been the satellite people or it might even have

been the media saying ‘a hole in the ozone layer over Antarctica’, and that is the one that has stuck. Whoever or wherever, it was an amazing choice.

[Part 2 0:26:25] Lee: You touched on climate change. Let’s just explore your views for a few minutes on climate change. Where are we now on climate change? Are we anywhere better than we were ten years ago?

Shanklin: It’s steadily becoming clearer that the evidence is that we are responsible for what we are seeing. There’s a lot of fine detail that is not at all clear. Regional responses are much more complicated than we thought, and indeed over Antarctica it was widely held that the warming of the Antarctic Peninsula was a response to increased greenhouse gases and now we are thinking ‘Well some of that might have been due to increased greenhouse gases.’ Some of it might well be due to the ozone hole itself forming and changing the wind circulation around Antarctica, and some of it might just be natural climatic variation, and actually the climate of the Peninsula is highly variable anyway and we might have just got a number of things all working together and that might reverse in the future.

[Part 2 1:27:42] Shanklin: So both for the BAS science and the global science, there is a greater understanding of the complexity of the system but equally there is much better knowledge of the attribution, and the modelling is such that climate change is happening and we are behind it. What I think the public finds hard and some of the sceptics find hard is: there is this expectation that it should be linear across the whole planet and at the moment the sceptics are focussing on this so-called pause in the global warming which the latest evidence suggests might not actually be a pause at all because we haven’t included a lot of our Arctic data. But nobody ever said that it would be smooth or linear and that is probably a failure in communication. It was quite clear on all the graphs that it wasn’t going to be smooth and linear but nobody specifically spelled it out and my view is that yes, the climate may have stayed the same for a decade but so what? When we look at climatic normal, the period for a normal is thirty years.

[Part 2 0:29:01] Shanklin: Now if that standstill keeps going for thirty years, well that might be a bit more significant but ten years is a blink. So we need to look at the long term. And the other thing is understanding the regional patterns, and by a curious chance, a good part of the eastern US didn’t actually warm much in the last fifty years whereas western Europe did. And generally speaking, western Europe has been more vociferous about climate change than the US has been, and that is just a consequence of what you can see in your garden. If you can see that your lawns need cutting for later in the year and you need to start cutting them earlier, you can see that the climate has changed. If nothing has much changed since you were a child, then what is all the fuss about? So having a global perspective, is quite important in the debate, and I think a lot of people don’t have that. They have their little narrow perspective.

[Part 2 0:30:03] Lee: Is that why George Bush Junior was so sceptical, because the White House lawn was unaffected?

Shanklin: Yes, I think so. It’s what goes on in your backyard that makes the difference, and here in the UK it’s, I would say, blindingly obvious. We have still got leaves on the trees. We are nearly into December so in the courtyard here the birch

there has still got all its leaves. A lot of them are still green. So you wouldn't have had that when I was an undergraduate here in Cambridge. The trees came off in October and I can remember wading through huge drifts of leaves on the way to college rooms and the like, while it is now a steady trickle and they don't all leave until December.

[Part 2 0:30:52] Lee: So if you were a young thrusting meteorological scientist today, what would you be getting into? What would you be doing about this global climate change problem?

Shanklin: I think the exciting thing to be doing would be to look at the extremes, and that is the extremes of the models. Largely they are thrown out as being unrepresentative.

[Part 2 0:31:16] Lee: But the ozone hole proved that was the wrong way to think it, wasn't it?

Shanklin: That might be where we ought to focus. Some of the models say an 8° warming in a hundred years' time. That is really extreme, but could that be possible? And if some younger scientist could show that actually, although we have been throwing out all these extreme models, because they don't represent the past climate terribly well, actually they are a really good representation of the future climate. So I think that is probably the area that I would suggest looking at. Look at the things that people don't think of as mainstream; there might be something in it. And similarly with the data that we are accumulating. Don't just focus on the mean temperature or the maxima or the minima. Look at some other, seldom looked at, parameter and see maybe there is something hidden there.

[Part 2 0:32:17] Lee: Let's look at your time South. You have been 19 times. What have you been doing in all that time?

Shanklin: Amazingly, I think each trip has been different and I have really enjoyed going down. So it has either been different places, doing different things, different teams of people. So I spent time at Halley, Rothera, Faraday, Grytviken, Bird Island. A very brief period of time at Signy but mostly just day trips as it were to there. So I have had experience of all the BAS stations and that is a privilege not accorded to many in BAS. Yes, the VIPs will pass through all of them but they are mostly just there for a few days. All of those stations I have been there for weeks and that gives me a really good feel for how the stations operate, and also on most of the trips I have not been narrowly focussed on just the science that I needed to do down there. Again, in recent years, most people, they have got to just go in, do their science and then go out again. So I have had time to look at what other people are doing, help with the daily duties and so on, and I think that people on the stations have really appreciated that as well. And also being able to do that has made the stays much more enjoyable. So I think one of the really memorable ones … They have all been memorable in one way or another.

[Part 2 0:33:52] Lee: Pick an example.

Shanklin: Going to Bird Island. I had been through Bird Island lots of times on the way to Halley and I had always thought of it as a horrid place. There's all those fur

seals on the beach and it is always drizzling. Who on Earth would want to go down there? But I had the opportunity to go to install an automatic weather station on the island and the first day I was there was a brilliant day. There was not a cloud in the sky. We went and had a picnic up in the hills behind the station and it was lovely, and I got used to the fur seals fairly quickly. Surprisingly we were all scientists. There was nothing in the way of technical staff there. We all got on really well; we helped each other out, did things and made a really nice team and it was a fantastic stay.

[Part 2 0:34:49] Shanklin: So Bird Island is a well-kept secret, and similarly my last trip South to Halley. I was rather dreading the stay because I had been told 'You will be sleeping in a container. It is going to be incredibly busy.' But I ended up being on the old Halley V station where there were only twenty of us at peak time, and commuted to the new station as and when I needed to, and it turned out to be a really nice stay there. And again, towards the end, I had time to help other people out. So we started dismantling lots of things from the old station and the guys that were left saying 'This is the chap that discovered the ozone layer. He's got a screwdriver in his hand; he is taking bits off the wall.' That was really good.

[Part 2 0:35:42] Lee: Did you enjoy that?

Shanklin: Yes. It's part of understanding the science, that if you know how people normally live on the station, you need to be part of that as well to get that more distant perspective.

[Part 2 0:36:00] Lee: You are one of the few Fids who has been to Halley III, IV, V and VI.

Shanklin: Yes.

[Part 2 0:36:05] Lee: If not the only one? Certainly one of the few.

Shanklin: I think Mike Pinnock must have been to all of them as well.

[Part 2 0:36:11] Lee: And you were involved in the design and the delivery of the current Halley VI?

Shanklin: Yes, and Halley V.

[Part 2 0:36:19] Lee: OK.

Shanklin: Probably more so of Halley V, for the Simpson Platform, than Halley VI.

[Part 2 0:36:25] Lee: What criteria were you insisting upon, for either or both?

Shanklin: Well for Halley V, we wanted the scope to be able to do our measurements on the Sun, so you had to have somewhere where the Dobson could view overhead. And at that time we had the Ångström pyrheliometer which needed to be able to view the Sun directly. So the only windows that opened, on the entire Halley V station, were the windows in the Simpson, where we had opening windows so that we could make these observations. At Halley VI one of the key things, again, was to have

access for the Dobson through the roof so you could see the Sun directly. And for meteorology you needed a round vision of the station, so we have got the science module with its upper deck where there are spectacular views all the way round, and where the Dobson can, with its big periscope, stick straight up out of the roof. So we have actually got I think the best platform for doing our meteorological measurements at Halley VI that we have ever had. The only slightly down side is getting to the science modules, where if it's a bit too windy, they can't actually travel across.

[Part 2 0:37:54] Lee: Did you have to fight for that? Were there those who were saying 'You must be joking!'

Shanklin: Yes. There was a strong view that we can't afford this upper deck. We have got to down-scale and perhaps go out on the surface. But I was quite insistent that in order to do the science that is almost one of the primary functions of Halley, we need that facility, both to support science and to support the aircraft operations, because again it is the meteorologists that do the weather observations for the pilots, and if you can't see all the way around, you might miss that bank of fog that is going to come in and block off the runway.

[Part 2 0:38:34] Lee: So it doubles as an air traffic control?

Shanklin: It doesn't double as air traffic control. That is in the command module at Halley VI but it is the observation deck which feeds the weather observations in for the aircraft.

[Part 2 0:38:50] Lee: 'We haven't got the money' is always a very powerful argument. How did you overcome it?

Shanklin: I think just by digging in my heels and I suppose because I was such an important person, they listened.

[Part 2 0:39:01] Lee: My next question was: if a man who discovers the ozone hole digs his heels in, is that an advantage?

Shanklin: I think for this case, it was, and also because in part it was within the architects' vision of what they wanted.

[Part 2 0:39:18] Lee: It wasn't an extra, then It was …?

Shanklin: It was something that was to an extent key to the development.

[Part 2 0:39:24] Lee: Were you there for the handover?

Shanklin: Yes. I helped raise the flag for the first time at the new station and I took down the flag at the old station as well, which was a really nice thing. The guys at the old station said 'You are doing it.' And similarly at the new station, they said 'You are doing it.' Which again showed what sort of esteem they hold me in, but I think if I hadn't mucked in with doing lots of the other stuff, I wouldn't have been. So because I get my hands dirty, and discovered the ozone hole, 'We will let you do this.' And that was, I think, really one of the nicest things that they could have done and at

Halley VI they wanted a picture of me. 'Here you are.' Then as a complete surprise, one lunchtime, they would bang on the table and make this presentation of the picture and said 'This is the first picture that is going to be hung on the new station and we are putting it in the ozone module and we have got permission to put it up on the wall as well. And that was a really nice compliment.

[Part 2 0:40:40] Lee: Is there anything else about Halley VI which is really going to further the cause of science? I asked that question of Steve Colwell and he just said 'Well it isn't going to fall in the sea very soon.' But is there something else? Are there other things about Halley VI which really advance the science that you are keen to do properly?

Shanklin: One of the key things is that it has got all the scientists together. So at Halley V there was the Simpson platform and the Piggott platform and there were two separate groups almost. Now it is one team of scientists which makes a difference. In theory it's easier to put new stuff in. Whether that actually works in practice, because of some design features, is another matter but we have got an outstanding platform I hope for the future for doing new science. So that was a key part of the vision, was making it sufficiently flexible that we can do things that we are not doing today. We have got no idea what they are going to be but we can put them in. That philosophy worked very well at Halley V,

[Part 2 0:41:46] Shanklin: because Brian and I, with paper and pencil, did a layout of what we wanted and that worked fine for twenty years, and I think that was quite amazing, that the Simpson platform which we designed was actually the most successful of all the Halley V buildings. It wasn't too big; it wasn't too small. It met our requirements perfectly. We could do some modifications internally and we could probably have kept using it for another twenty years if all was said and done, if we'd had to. So I think Halley VI should be good. The one slight downside is: if we have to move it, because if we have to move it, we have to stop all the science because there will be no power, and that is really bad for long term monitoring. So we are going to have to come up with a strategy that lets us keep at least part of the science going where it is and start up the science at the new location at the same time. So that will require a bit of planning.

[Part 2 0:42:54] Lee: One of the questions I have got to ask you – it is on my list of absolute musts – is to ask you to give us a soundbite, or an explanation if you like, as to why long term observations of surface and upper atmosphere meteorology and ozone is so important? This is a standard schoolboy question.

Shanklin: The long term monitoring is key because without it you don't know if there's been changes, and that was really exemplified by the ozone hole, where we had continuous data. The Japanese didn't. The Japanese couldn't say that something systematic was happening. We could, and that basis occurs time and time again in environmental monitoring. A lot of the time you have snapshots and you can say 'Well that has changed but is that a one-off?' If you don't know because you haven't got that sequence, you can't make any deductions. It might just be that the way that year had been unusual. So you need the context and that is what our long term monitoring gives. It gives us the context. You can say straight away 'Right, this is an

unusual circumstance. That is why this year is different.' Or 'Actually everything else is the exactly the same, but that data is totally different.'

[Part 2 0:44:14] Shanklin: So it is needed not only for the physical monitoring of the atmosphere but for the biological studies. It was something actually in a talk I went to on Wednesday. Somebody had been looking at the number of swifts in Fulbourn and they were saying 'Because it is going down, and this last year it has gone up again.' I didn't query it at the time but after the talk I went up to the chap and said 'Well look, I can see your data points and that one is sort of 120, that's 80 and that's 70 and that's 60, and then it is back up to 80. Now why wasn't it 82, or something like that?' Clearly the data had been rounded to the nearest ten, so that immediately says 'Well there is probably an error bar of certainly ±5 and probably ±10. So those last three years there is no actual real difference between them.' Then: 'Have you compared this with either someone else that has been looking at swift numbers, or the weather? Because you don't know whether that trend is linked to what you are doing in Fulbourn or whether it is linked to external forces.'

[Part 2 0:45:34] Shanklin: He said 'Oh, no I hadn't thought of that.' 'Go and get the Oxford data and see if they have got the same sort of pattern.' And if you haven't got that reference, you can't answer those questions. So you might draw totally the wrong conclusion about the effect you are seeing if you don't have that background. So that is why it is important and equally why we must keep doing it in the future because we won't know how effective we have been in our controls. So with the ozone hole, if we'd stopped immediately after we had discovered the paperwork: 'We have found the discovery now. We don't need to do anything.' I couldn't say today 'Actually the Halley data shows a very slow recovery over the last twenty years, but it has taken twenty years to find that actually there is a slow recovery after twenty years.

[Part 2 0:46:25] Lee: You are in your early sixties now. Are you likely to go South again?

Shanklin: I hope so. It would be nice to have a 20th visit there. Whether I will go with BAS or sign up to a tour ship and go down as a guest lecturer, I am not sure.

[Part 2 0:46:40] Lee: What's making you want to go? What's the attraction?

Shanklin: The Antarctic is wonderful.

[Part 2 0:46:47] Lee: Elaborate please.

Shanklin: It's a combination of the people, the scenery, the atmosphere, and I am addicted to it, I suppose.

[Part 2 0:47:03] Lee: Have you ever had any awkward moments, close calls, close shaves?

Shanklin: Yes.

[Part 2 0:47:10] Lee: Ones you can talk about?

Shanklin: Probably, I'm not sure. There was certainly one trip from Faraday where we were going boating to stay at Petermann Island and we'd had this thing planned for ages and then the day we went: nice blue skies, calm conditions. 'Right, off we go.' So we got to Petermann and then one of the things we had planned to do there was to go outside our boating limits and do we weren't supposed to do, which was sail on a little Seagull (fibre-glass boats with the Seagull engines) up the Lemaire Channel, round the island and then back. And as a meteorologist, I should have been looking up at the clouds but wasn't and off we went and it was fine going up the Lemaire, really spectacular.

[Part 2 0:48:11] Shanklin: I'm not sure how many people have been up the Lemaire in a little fibre-glass boat but we did it. But coming round the other end, we were now exposed to the wind and the waves and they were getting bigger and bigger and bigger, but we had arranged to rendezvous with a French yacht in a little bit of a harbour. We made it through to them but they could see we were quite wet and cold so rather than going on back to Petermann, they said 'Come aboard; have a nice warm meal. Get yourselves dried up.' 'OK, this sounds a good idea.' So we tied up the boats on the back of the yacht.. But the wind kept getting up further and further, which I should have realised because I could have seen the cirrus first of all, coming in, and then the cirro-stratus, a nice halo, and I think the weather charts (if I had bothered looking at them), the long range would have shown that there was this big system.

[Part 2 0:49:06] Shanklin: The winds kept getting up and the skipper of the *Odyssey* said 'Right, we are in danger of getting ice-bound here so we have got to go out in the bay.' And the wind kept getting up. Every now and again the yacht would go right the way over. 'Oh we've had it.' But it was a skilled skipper and he got us out. One of the boats was completely awash by the end of the gale. We lost the medical box, both the diesels were flooded but we bailed everything out and went back to Petermann, got ashore, tidied things up a bit and told the base commander that there had been a very high tide and it had washed away the box. But that was a fairly close call. We might not have survived that particular one.

[Part 2 0:50:07] Lee: I asked that question because you became a very active union rep on the Health & Safety Committee at BAS?

Shanklin: Yes.

[Part 2 0:50:14] Lee: And most Fids have got one, if not more than one near miss. So I am wondering whether the near misses informed your involvement in that organisation?

Shanklin: Yes, but not in the way you might expect actually.

[Part 2 0:50:29] Lee: Go on.

Shanklin: One problem I had was that BAS would always try and wrap people up in cotton wool, and stop them doing things, but actually what you need to do is inform people what the risks are and let them experience some of those risks. That is quite important, that actually wrapping people in cotton wool makes life more dangerous because you can't see what the risks actually are, and so in the Antarctic, yes you do

need boundaries but you also need people who are capable taking and evaluating risks. So you don't want to put yourself in danger but you do need to be able to see: 'Yes. I can do that.' The regs may say you can't but actually because of this and this, it is perfectly safe and you need to let people use their skill and experience rather than constraining them. And that is the approach that I always try to take here, but equally. sometimes you get very minor risks but everybody takes part in them and there you do need to put in controls even though the odds of any one person being hurt are very very small. But if everybody in the building takes part in it, you are sooner or later going to have a problem. One example was the front doors into the Reception.

[Part 2 0:51:59] Lee: Here, at BAS HQ?

Shanklin: Here at BAS HQ. Everybody has to come in and out of the building and the old doors were on an automatic swing and there was a very small gap between the two and it was quite dodgy to go through if you were by yourself. But because of this automatic closure, every now and again it would give you a bit of a knock, and I said 'Look, this isn't safe. You've got to do something about it.' Nothing happened. Then a child coming in was hit by the door and I think they eventually took it to hospital. I said 'Here is a Union Improvement Notice. You must do something about it now. We have had enough messing around, saying we will do something at some point.' There it was a small risk but because everybody was exposed to it, the chance of a problem was much higher than the BAS Management had really thought about. So there's two sides of the argument. Yes, you need people to be able to take risks but you need to be able to control them so that you are aware of what the risks are. So that's what I try to do as the union rep.

[Part 2 0:53:20] Lee: That's counter-conventional thinking though, isn't it? Most Health & Safety Officers traditionally perhaps, legend has it that they try and stop things from happening.

Shanklin: Yes.

[Part 2 0:53:33] Lee: Whereas you are actually trying to facilitate things happening?

Shanklin: I would much rather facilitate and educate so that people know what it is that they are doing because then you are much more careful. So another example with my bell-ringing hat on: we have a vertical ladder to get up to the bells and Health & Safety said 'You need hoops round it. That will make it much safer.' But when you want to try and take something up the ladder, the hoops actually make it more dangerous because you have got lots of things to catch on. So knowing how to climb the ladder safely is the key thing, and I have taken children up there. 'Right, you have three points and you always do that and you go up safely.' All this is: 'Actually, yes, it's risky but I am in control. I am doing it safely. There is not a problem.' If something goes drastically wrong, there is a problem but they are being taught how to do the thing safely and that's fine. So Health & Safety say 'On no, we can't have that.' But I am saying 'Yes, you can have it but (a) you are aware of what can go wrong and (b) this is how you climb safely.

[Part 2 0:54:52] Lee: So were there lots of contentious discussions in the Health & Safety body at BAS?

Shanklin: Not many really. It was remarkably consensual, and again, that's how it ought to be. Union side and management should be working together to help the process because it is in both parties' interests. You don't want accidents, both because for management there is a huge cost involved and for union side because it's a personal cost involved, so if you can work together, work together.

[Part 2 0:55:28] Lee: But how successful were you in imposing Health & Safety regulations on a couple of guys in a tent in the middle of the Antarctic?

Shanklin: I never actually had to do that and what I always tried to do was: if it was being discussed here in Cambridge, then I would try and say 'Well look you need to let that guy out in the tent but you need to train them in how to put the tent up.' And BAS has always actually been pretty good at training people.

[Part 2 0:56:01] Lee: These days?

Shanklin: These days. There were issues certainly with the cooking stoves and that was one of the big issues, carbon monoxide, but largely I think most of the carbon monoxide problems were self-inflicted because people didn't do exactly as they were supposed to do. They quite often took a few short cuts, but you couldn't say you weren't briefed about the dangers of carbon monoxide because all the training tells you carbon monoxide is an issue.

[Part 2 0:56:37] Lee: On that particular point, there are numerous Fids' stories which I have collected over the years where the ventilation aspect of the tent got clogged up with snow and nobody realised.

Shanklin: Yes, and that can happen. I remember myself at Petermann Island at the Argentinian refuge where we stayed. This had the triple-decker bunk and a coal fire. It was really nice having this coal fire blazing in its little stove but I think we always woke up with headaches the next morning and almost certainly that was carbon monoxide that was doing it. So at that time we didn't probably realise the dangers but that was in the 1980s and I think it wasn't really until the 1990s that we started realising that actually carbon monoxide is a bigger problem than we thought it was.

[Part 2 0:57:32] Lee: I was a little bit surprised to realise that there was an active union at BAS.

Shanklin: It can be a little bit hidden but yes, there's always been the two main unions in BAS: Prospect and PCS. Prospect, by and large, tries to do things consensually and work with management. PCS has traditionally been a much more vociferous union and more prone to go out on strike, but I have been on a union-called strike here in BAS.

[Part 2 0:58:09] Lee: About what?

Shanklin: I think it was pay and conditions. It was many many years ago, and then I actually, following that, resigned from the union, because I thought 'No, I don't want to do this any more.' And then some years later, I think it was David Peel asked me

‘Would you like to be the union rep for Health & Safety?’ I didn’t think it would be a good choice myself. I said ‘I am not actually a union member.’ ‘Oh well you can join again.’ ‘OK, right. I will become a union rep and rejoin the union.’

[Part 2 0:58:40] Lee: But there is a bit of a dichotomy between … You were saying earlier and I can understand that completely, that many people working in this building and in the Antarctic regard it as a hobby for which you get paid and they really really want to do, and the traditional view of a union which is more designed to protect people who are doing jobs they don’t really want to do.

Shanklin: Yes. In BAS it was not … I think everybody wanted to do things. There were very few things that we didn’t want to do, so that’s why it was quite consensual and perhaps why not that many people are union members. I think it is about a hundred or so of the total staff that are union members. So it’s reasonable number, but on Health & Safety, we represent everybody not just the union members and that was one of the big differences. As a union Health & Safety rep, it’s everybody that was involved and I always stressed that: ‘Even when you are not a union member, if you have got any issues on Health & Safety, come to me and I will get them sorted out.’

[Part 2 0:59:53] Lee: Has there been a big incident, in your time on that committee that you have had to consider?

Shanklin: We’ve had a number of things where there’s been a board of inquiry. One was a carbon monoxide incident in the Arctic which led to the realisation that (a) not all countries have the same Health & Safety practices as others, and (b) that we are slightly two-faced about how we do Health & Safety in the Antarctic. It’s very strict and quite well regimented but you go to the Arctic and it was rather less controlled. If you were on Svalbard it was fine but you could do fieldwork elsewhere and some of the processes weren’t quite as good as they should have been.

[Part 2 1:00:46] Lee: Were you involved in the aftermath of the death of Kirsty Brown ten years ago?

Shanklin: Yes, I was, but that particular incident was another of these unlikely combinations of circumstances. Nobody had ever been attacked in the water by a leopard seal before and that was certainly a result of the inquiry, that this was a very unusual event. And it resulted in changes in operation being put into place, that so far has been successful in controlling the risk. And that was quite a shock, her death, because I knew her from when I was at Rothera the year before. So yes, we have had deaths over the years. That perhaps was one of the few where it was actually the person doing their job rather than at least part recreational linked. So a lot of the other tragedies, it’s people going out on their ten-day trip or whatever.

[Part 2 1:02:12] Lee: A jolly?

Shanklin: Or taking pictures of a plane as it goes overhead and came a little bit too low for safe passage. Or you are trying to get back to the station for Saturday night, and things like that and your travelling conditions aren’t quite what you are supposed to be travelling in. Whereas Kirsty, it was … We thought we had done everything and actually no, we had forgotten that, that one thing.

[Part 2 1:02:43] Lee: Which was the …?

Shanklin: The leopard seal. Actually if there are leopard seals around, best practice is not to be in the water just in case.

[Part 2 1:02:54] [End of Part Two]

Part Three

[Part 3 0:00:00] Lee: This is Jon Shanklin, interviewed by Chris Eldon Lee, on the 29th of November 2013. Jon Shanklin, Part 3.

[Part 3 0:00:10] Lee: Up until your retirement, John, you were responsible for the Meteorological and Ozone Monitoring Unit at BAS. I was just wondering how things have changed technically and intellectually over those years, from the hand written observations to the more automated.

Shanklin: Yes, when I first joined the Survey it really was: everything was done by hand and in many ways BAS was in the forefront of technology. So we developed our own computer, which was the "BAS Micro Computer" and then that was interfaced to an automatic weather station. And then we went more commercial after that and so on, and today we've got stations that are sending back via Iridium and the data is on your desk five minutes after it has been measured. So technology has certainly been a big player and has also allowed us to have automatic stations where we have never had stations in the past. So we have a much better network of stations in the British Antarctic Territory now than when I first joined. So that has been one big change.

[Part 3 0:01:26] Shanklin: I think in the past sometimes we have tried to do too much in house. It's actually much better to just go and get a commercial system, but equally being able to recognise which are the good commercial systems and which are the less good ones. So it is not always the case that you should go to the cheapest supplier. Sometimes going for one of the little more expensive saves you money in the longer run. Computing itself has changed enormously, so when I first started here we were just getting a VAX computer which filled essentially an entire room, and nowadays the mobile has got more computing power than that system ever had, which gives you an idea that the scale of computing and we get much better visualisation of data through computer graphics. So you can see patterns more clearly than I think you could in the past, and theoretical knowledge has progressed as well.

[Part 3 0:02:33] Shanklin: We understand in part what we should be looking at much better and we have increased what we measure as a consequence of that theoretical understanding. So for example one aspect was we did, when I started, the traditional solar radiation measurements and that was mostly done all manually and a chart plotted with the records. And then Brian Gardiner took the decision 'Right well we have got a 20-year or so period. We think we understand everything. We have been told to cut some things. We will cut that.' And then a greater theoretical understanding came along and started saying 'Well actually, no.' Our computer models can input the solar radiation data directly, and that is just as valuable as the temperature because knowing how much solar energy is coming through the

atmosphere is a first order thing, whereas the temperature is a response to that. So if we know what's coming in, we get a much better idea of the physics.

[Part 3 0:03:46] Shanklin: So we started some of that by attaching solar radiation measurements on to the automatic weather stations and equally replacing eventually the Ångström instrument which measures the amount of aerosol material in the atmosphere, modernising that to a continuously reading photometer which basically is the same data, but far more frequently. With the ozone, we have stuck with the Dobson instrument for continuity and what I have said is that once we are confident we have seen a worst ever ozone hole, we can probably go to an automated one. Or at least I would be happy with that but my colleague who is now in charge of the Unit says 'No. We should keep the Dobson going, to provide that continuity.' And yes, we will have the automated instrument in as well, and we will keep running them in parallel for the moment.

[Part 3 0:04:44] Shanklin: So having that access to technology makes the measurement easier but it has a downside too. When you did everything by hand, you were intimately involved with the measurements and it was much easier to see if something was wrong. Nowadays there's a great temptation to think 'Well it's on the computer; it must be right' without stopping to think 'Actually does that make any physical sense?' It's not only ourselves but many other countries follow the same approach and it's one thing where we make a difference to the Antarctic observing network. We are actually looking at the data from other stations that are coming back, not just the British ones but the Argentinian, the Chilean and the American and saying 'This isn't right. Can you go out and have a look as to whether your sensor is behaving itself.' And very often it is not behaving itself, they need to go and look at something.

[Part 3 0:05:43] Shanklin: But that is because we have got this hands-on approach. We don't necessarily assume that the computer is right. 'No that doesn't compute.' So I also give feedback to the Ukrainians at Vernadsky because they are sending me their ozone data and I am doing Quality Control on that. Certainly this year there's been quite a few cases where the numbers coming out might be OK but the data definitely is not. 'Can you go and look at this? Can you try this? Can you try that?' Eventually we have come up with a solution and it's now looking perfect again but without me giving the input, I suspect they wouldn't have spotted the error.

[Part 3 0:06:28] Lee: So the implication of what you are saying is that technology hasn't necessarily made science better. It's made it faster and you can perhaps do more of it but it hasn't necessarily made it any better.

Shanklin: It's made it better in many ways. So you've got more data; you've got a broader range of observations over a greater area of Antarctica, but it hasn't necessarily improved the quality of the data. It hasn't necessarily improved the understanding of the data. And that I think is probably a worry for the future. We have got all of these systems scattered around the Globe busy gathering data but how many people actually have the depth of knowledge to say whether it is right or wrong,

[Part 3 0:07:17] Lee: Is that slipping away, as the next generation of young scientists …?

Shanklin: I think it probably is. There is a huge reliance on computers to do everything and rather less looking at the natural world and saying 'Do the two actually match up?' And we continually see things in the data. Another example was the troposphere, the upper troposphere, which is the 12 – 18 km part of the atmosphere, above Antarctica. BAS scientists noticed that that part of the atmosphere is warming and it wasn't supposed to be. Why? The satellites didn't show it. The problem is that satellites are looking through quite a broad part of the atmosphere and so it smears out. So again that's something where the manual observations beat the satellites.

[Part 3 0:08:18] Lee: OK. I have to ask you about the relationships between BAS and the Met Office. I'm not quite sure why I'm asking that question. Is there something that is not quite right there, or hasn't been quite right?

Shanklin: It is actually pretty good because the Met Office actually provide us with all the radio sondes for use at Halley, and we've always had pretty good cooperation in a whole range of fronts, at least with what we do. So we have done Dobson calibrations with them. We've visited the Met Office sonde stations to do a lot of our training. We used to go up – when I first started we went up to Lerwick and had a really nice fortnight's holiday. We were working quite hard but a holiday as well, up there. Then we went to Camborne or to the Norfolk Coast, and Herstmonceux. So a lot of that we've worked really well with … They send us all the Antarctic data, straight to our site through the FTP system. So we are doing that and we give them feedback when something of theirs hasn't worked because again we are looking at the data.

[Part 3 0:09:39] Shanklin: Just last week the monthly CLIMAT message from Mount Pleasant Airport in the Falklands hadn't come through. So I contacted one of the people in the Met Office and said 'Can you ask them for this and put it out because it's one of the key CLIMAT stations. The world needs the data.' They said 'We'll do that.' So they asked for it and it has now gone out, but again, without us just keeping an eye on things, that wouldn't have happened. So I think that relations with the Met Office at the operational level are very good, and I couldn't say at other levels, but certainly we cooperate very well.

[Part 3 0:10:24] Lee: I got the impression that you have got something of an ice fetish? Because when you are not in the Antarctic, you spend half your time standing on ice in a goal in ice hockey matches?

Shanklin: I haven't played ice hockey for a while now. When there is a little mini ice rink on Parkers Piece in Cambridge I go and play on that, but yes, I was quite a keen ice hockey player and it started as a bit of an accident. I had this old pair of strap-on skates. I learned to skate in the Cambridgeshire Fens, skating on a frozen coprolite pit. I could skate backwards and forwards on this quite happily but if I tried skating backwards, the skates fell of so I never really got terribly good at that.

[Part 3 0:11:12] Lee: Goalkeepers aren't supposed to go backwards, are they?

Shanklin: Well I started off as a forward actually and I then got my own pair of skates and one day I went to Peterborough rink which is our local rink to get a bit of practice

and it so happened that some of the Cambridge University ice hockey players were there. So I got chatting to them and they said 'Do you want to come and see a match. We have got a match tomorrow night. It's not starting until 11 in the evening, because that's when the ice time is cheap.' So that's when they go and play. 'I will go along and watch.' And that was pretty spectacular because they were playing the Peterborough team, and they had a guy on the Peterborough team who had played in the American national hockey league. So he was a top class skater and the contrast between him and everybody else on the ice was amazing.

[Part 3 0:12:09] Shanklin: And so the next term I signed up to be part of the team to try and learn how to play with a view perhaps to going on to coaching or refereeing or something like that. And then the guys discovered I was old enough to drive the university minibus, so I then became a key member of the team because I was the driver. If you have driven, you might as well play. I think before I'd had one practice and then I drove the bus to Oxford University and got one or two shifts on the ice which the less said about the better. But then I stood in goal for the women's team because we were practising together so I thought 'I will just give you somebody to shoot at' because it's nice to have somebody in the way and they never shot terribly hard. And then it turned out that the Cambridge goalie had to go on a field trip for their Varsity match so we negotiated with Oxford and they said 'Yes, it's fine. Jon can go in goal. He's not played in goal before. No problem.' So I appeared as Joanne and the rest took about ten minutes to work out that I wasn't a girl.

[Part 3 0:13:34] Lee: Did you have a beard at the time?

Shanklin: Yes. So I had the rare distinction of having played both for the Cambridge women's team and the men's team in the Varsity match. Not many people can say that.

[Part 3 0:13:49] Lee: Were you any good in goal?

Shanklin: I won the Man of the Match award in one of the Varsity matches.

[Part 3 0:13:55] Lee: That's because you were the only man.

Shanklin: No, this was in the men's match and we had a very weak Cambridge team and although I let 19 goals in, I saved about 60 shots as well, so I was being absolutely peppered and they reckoned I probably deserved the Man of the Match award.

[Part 3 0:14:18] Lee: Have you ever played ice hockey on the biggest ice rink in the world, known as the Antarctic?

Shanklin: I have played a sort of ice hockey in Antarctica. One year when we were moving from Halley IV to Halley V, the garage at IV was underground, along with the rest of the station but they had moved all the vehicles out and in the summer you used to get a bit of a melt pool forming down there. But towards the end of summer it started freezing over. So as all the garage people had gone, and it was this nice empty space, I encouraged the melt pools somewhat by taking buckets of water down. We emptied all the old fire extinguishers down there and gradually enlarged it and I had

my skates there. So I improvised a stick with some copper piping, and a puck from an old film tin and played ice hockey underground. I've also been skating on the sea ice at Halley. That was actually quite hard or quite difficult because the ice there is so hard and it was now melting so even with a good pair of skates, there's no bite and they tend to be slipping sideways a little bit. That was quite fun, to actually skate in Antarctica.

[Part 3 0:15:38] Lee: Let me get this quite right. You played ice hockey underground in the Antarctic on your own?

Shanklin: Yes.

[Part 3 0:15:43] Lee: OK. And the final topic of conversation, which is very very topical here on the 29th of November 2013 is: you have discovered seven comets. Have you seen the new one?

Shanklin: I have seen the new one.

[Part 3 0:15:59] Lee: What's it called?

Shanklin: It's called – I will give it its full correct title – 2012/S1 (ISON). This is a comet we discovered from a Russian observatory by two amateur astronomers and it was found while still quite some way from the Sun. It soon become obvious that it was going to come very close to us, about a million kilometres from the Sun when it was closest, which was now about 12 hours ago, 18 hours ago, something like that. Some people said 'This is going to be the comet of the century; it's going to be incredibly bright and it's going to be visible in broad daylight.' I was always a bit sceptical about this and my scepticism was proved correct because it has now whizzed round the Sun. However it seems to have survived. This is the latest, hot off the press. So I think there is a chance that we will get a spectacular comet in our December skies, probably widely visible from the end of the first week of December[4].

[Part 3 0:17:07] Lee: A week from now?

Shanklin: A week from now, if we get up early in the morning it's beginning to look like there might be something quite amazing to see in the morning sky.

[Part 3 0:17:17] Lee: You've seen it already, you say?

Shanklin: I've seen it already. I saw it on its way in towards the Sun.

[Part 3 0:17:21] Lee: By telescope?

Shanklin: Through a pair of binoculars, from the middle of Parkers Piece. I got up 5 o'clock in the morning ten days ago. I think it must have been about that, and because I live very close to Parkers Piece, and I wanted somewhere where I had a decent horizon. It was a three-minute walk to get to Parkers Piece. I had my binoculars on a little photographic tripod. I looked and there was this not terribly spectacular comet

[4] In fact it faded rapidly after 29 November 2013 (source *Wikipedia*).

with a short tail and sitting above the swimming pool that's on one corner of the Piece. The data up to then showed that it wasn't really brightening as fast as many comets do and so I said 'This isn't likely to become the comet of the century.'

[Part 3 0:18:10] Shanklin: Then it entered the field of view of the satellites that observe the Sun, indeed the satellite where I discovered my seven satellites from which is called the SOHO satellite and it has a particular coronagraph that gives you a view of the immediate vicinity of the Sun. It entered the field of view of this and was steadily brightening. 'This is looking really good!' And then as it got very close to the Sun, it faded away almost completely and I think we have learned some new science from this. What I think is happening and this is just really as it happens in science, is that the solar environment is so fierce that all the available material is just swept off the solid part of the comet and everything else just shuts down. Once it gets further away again, activity resumes and it suddenly brightens up and then the tail regrows and that is what we should see in December.

[Part 3 0:19:14] Lee: But isn't the core of it ice?

Shanklin: It's a mixture of dust and ice.

[Part 3 0:19:18] Lee: This is your ice fetish again, isn't it?

Shanklin: This is the ice fetish. A comet was traditionally described as a dirty snowball. I think now it's more likely that it's a snowy dirtball. A lot of it is dirt. Some of them are going to be quite loosely held together, and in fact we know that some comets and what are called contact binaries. There are two objects with a sort of neck between that's full of dust and if you give it the wrong forces, and some of these objects, because they've got jets of material coming off, they can be accelerated, a little bit like some of these steam engines where you get a spinning disc because there is a jet of steam coming out of two vents. A comet can do the same and if it spins too fast, the two halves fly apart. This comet that we have just seen seems to be more of a solid object, because it appears to have survived, and maybe 3 km or so across, and I think this particular one has been a very dirty object. Not gas but a lot of dirt, and it is the very fine cloud of dust that we are now starting to re-see.

[Part 3 0:20:39] Lee: What's the fascination?

Shanklin: Well I first got interested in comets from a previous Comet of the Century which was visible in 1973. This was what was called Comet Kohoutek.

[Part 3 0:20:53] Lee: I remember it.

Shanklin: Which was supposed to be incredibly bright, visible in broad daylight. I had just come up to Cambridge and I had joined the University Astronomical Society and we went and observed it. It wasn't terribly bright, but it came round the Sun and was really quite a pretty object in the January sky of 1974. So having started that interest in comets, it has been with me ever since and in fact another comet started a bit of my interest in astronomy. This was Comet Bennett which was supposed to be one of the nicest comets of the 1970s and at that time I was still a schoolboy and I thought

‘Everybody is making a fuss about this comet. I will get up and look through the house window and it will be obvious.’

[Part 3 0:21:48] Shanklin: I looked through the house window and it wasn’t at all obvious. I never saw it in the end but that taught me that I needed to know my way around the sky a bit better. So I got my astronomical interest up and was able to navigate my way round. Coming to Cambridge and having access to the telescopes at the University Observatory here had been a really great privilege. So I am using today, still, the telescope that didn’t quite discover the planet Neptune – this is the Great Northumberland Refractor with its 30 cm lens – and it is still in everyday use. That’s really amazing, that you can use an antique instrument but still make valuable scientific observations with it.

[Part 3 0:22:37] Lee: It’s been fascinating, Jon, so thank you so much.

Shanklin: Right. Not at all.

[Part 3 0:22:43] [End of Part Three]

ENDS

Possible extracts:

- [Part 1 0:29:05] Discovery of the ozone hole.
- [Part 1 0:34:56] Why BAS beat the Japanese and American groups.
- [Part 1 0:49:44] Ozone hole and greenhouse gas debates compared.
- [Part 1 0:58:20] Contributions of the three Nature paper authors.
- [Part 2 0:17:16] Directed science versus blue skies approach.
- [Part 2 0:26:25] Thoughts on climate change.
- [Part 2 0:32:17] Different experiences of all the BAS stations.
- [Part 2 0:36:25] Input to the Halley V and VI designs.
- [Part 2 0:42:54] Importance of long term monitoring.
- [Part 2 0:47:10] A close call: boat trip from Faraday.
- [Part 2 0:50:29] Health & Safety.
- [Part 2 0:56:37] Carbon monoxide.
- [Part 2 1:00:46] Death of Kirsty Brown.
- [Part 3 0:04:44] Advantages and disadvantages of technology.
- [Part 3 0:14:18] Ice hockey in the Antarctic.