OFFICIAL REPORT
AITHISG OIFIGEIL

Environment, Climate Change and Land Reform Committee

Tuesday 30 January 2018

Session 5

The Scottish Parliament
Pàrlamaid na h-Alba

Tuesday 30 January 2018

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ENVIRONMENT, CLIMATE CHANGE AND LAND REFORM COMMITTEE
4th Meeting 2018, Session 5

CONVENER

*Graeme Dey (Angus South) (SNP)

DEPUTY CONVENER

*John Scott (Ayr) (Con)

COMMITTEE MEMBERS

*Claudia Beamish (South Scotland) (Lab)
Donald Cameron (Highlands and Islands) (Con)
*Finlay Carson (Galloway and West Dumfries) (Con)
*Kate Forbes (Skye, Lochaber and Badenoch) (SNP)
*Richard Lyle (Uddingston and Bellshill) (SNP)
*Angus MacDonald (Falkirk East) (SNP)
*Alex Rowley (Mid Scotland and Fife) (Lab)
*Mark Ruskell (Mid Scotland and Fife) (Green)
Stewart Stevenson (Banffshire and Buchan Coast) (SNP)

*attended

THE FOLLOWING ALSO PARTICIPATED:

Dr Adam Hughes (Scottish Association for Marine Science)
Michael King (Scottish Government)
Professor Nick Owens (Scottish Association for Marine Science)
Chris Stark (Scottish Government)
Professor Paul Tett (Scottish Association for Marine Science)
Dr Lindsay Vare (Scottish Association for Marine Science)
Professor Eric Verspoor (University of the Highlands and Islands)

CLERK TO THE COMMITTEE

Lynn Tullis

LOCATION

The Robert Burns Room (CR1)

Scottish Parliament

Environment, Climate Change and Land Reform Committee

Tuesday 30 January 2018

[The Convener opened the meeting at 09:45]

Decision on Taking Business in Private

The Convener (Graeme Dey): Good morning and welcome to the fourth meeting in 2018 of the Environment, Climate Change and Land Reform Committee. We have received apologies from our colleagues Donald Cameron and Stewart Stevenson.

I remind everyone present to switch off electronic devices because they might affect the broadcasting system. I will allow everyone some time to do that.

The first item on the agenda is for the committee to consider whether to take in private items 4 and 5. Do we agree to do so?

Members *indicated agreement.*

Salmon Farming Environmental Impacts Inquiry

09:45

The Convener: The second item on the agenda is to take evidence on the Scottish Association for Marine Science Research Services Ltd's report, "Review of the Environmental Impacts of Salmon Farming in Scotland". I welcome to the meeting Professor Nick Owens, Dr Adam Hughes, Professor Paul Tett, Dr Lindsay Vare and Professor Eric Verspoor. I thank you all for the work that you have done on our behalf for the report. As you can imagine, we have a number of questions to get through, so we will just kick on, if that is okay.

First, can you outline for us briefly the expertise that was deployed in producing the report and the qualifications of the various scientists who contributed to it?

Professor Nick Owens (Scottish Association for Marine Science): Indeed. The typical way that we do such a review is by assessing what work is needed. We all have very good international and national networks in our specific fields, and we chose to help us people whom we consider to be the best available experts. A number of those people are, of course, from within our own institutes: we particularly sought the advice of colleagues in the University of the Highlands and Islands and other institutes that are in the marine alliance for science and technology for Scotland.

The Convener: Okay. As we know, the environmental impact of salmon farming is a contentious subject. How did you ensure, and satisfy yourselves, that the report is impartial, in so far as it can be?

Professor Owens: The principal way in which we do that is by using the very well established peer-review system. A better way has not yet been found of ensuring complete objectivity and, as near as possible, accuracy at the limits of knowledge. In fact, all the written evidence that we pursued had, in some way or another, been peer reviewed.

The Convener: That is fine. We will move the questioning on, with Kate Forbes.

Kate Forbes (Skye, Lochaber and Badenoch) (SNP): I thank the witnesses for their work. The review is an update of the 2002 report, "Review and Synthesis of the Environmental Impacts of Aquaculture", although with a slightly different focus. However, some of the scientific conclusions and some of the problems in particular seem to be similar to those in the 2002 review. In the process of writing the report, did you identify any significant

changes in the environmental impacts of salmon farming since the review in 2002? If so, in which areas? If not, in which areas did you recognise that very little had changed? I realise that there is a lot in the review, so the question is more just about headlines.

Professor Owens: I ask Professor Tett to kick off on that.

Professor Paul Tett (Scottish Association for Marine Science): I would like to distinguish between effects and impacts. The scientific process that Professor Owens has described is designed to tell us whether there is a causal link between salmon farming and changes in aspects of the environment. If the scientific evidence for it exists, we can establish with confidence the link between salmon farming and an effect. However, effect is value neutral, and impact requires evaluation of the effect. That evaluation will depend on the criteria that are applied, which are formal legal criteria and understandings of ecosystem health, but they also relate to societal concerns.

I was involved in the 2002 review. One of the most obvious changes to me is the way in which societal concerns have altered over the period. Looking back at the conclusions of the 2002 review, I agree that not a lot seems to have changed. The first conclusion in 2002 was that waste and nutrients would be unlikely to limit expansion of the industry in the future. It is still the case today that, although we can detect effects on the environment of organic waste and nutrients from farms, they are not of concern in relation to the ecosystem as a whole.

Kate Forbes: Do you mean that they are not of concern scientifically, in terms of their impacts?

Professor Tett: I drew a distinction in that regard. Science can tell us, for example, that the effect of the organic waste from a fish farm is to change the population of animals and micro-organisms in, say, 3 per cent of the sea loch beneath the farm. Then, there is the question whether society should be concerned about that. From an ecosystem point of view—I am an ecosystem ecologist—the answer is no, because we know that sites that are subsequently left fallow will recover, and the areas are only small proportions of sea lochs. In contrast, if a farm happens to be close to a protected habitat and the 3 per cent that is affected includes the protected habitat, that would be a considerable concern. That is where regulation comes in, to ensure that farms are not sited close to protected habitats.

The Convener: I have a question on that point. Your report mentions that

"in 2003, 16 of 346 operating farms ... were sited above maerl beds."

Do we have a more up-to-date figure?

Professor Tett: We do not, as far as I know.

The Convener: Maerl beds are protected features. Your report goes on to say that even two years of fallowing does not allow recovery of maerl beds.

Professor Tett: You should remember that we were asked to review the scientific literature. There may well be such evidence available from Scottish Natural Heritage, which monitors such situations. All we can say is that no scientific papers have appeared since the paper that is cited in our report.

The Convener: You are not aware of an update on that figure.

Professor Tett: That is correct.

The Convener: I just wanted to get that on the record. I apologise to Kate Forbes.

Professor Tett: I think that you will get similar answers on a number of issues.

To return to the 2002 report, the second conclusion was that the most likely issues that would limit production were

"medicine usage and sea lice transfer to wild populations",

which continue to be of concern today. Professor Verspoor is more qualified than I am to talk about that.

The third issue was that

"The rate of escapes of farmed salmon is probably unsustainable and represents a major threat to wild populations."

Again, I will pass over to Professor Verspoor if members want further information on that.

The fourth issue was that

"Changes in fishmeal supply may affect the sustainability of the industry".

Two decades ago, most of the raw material in fish feed came from wild fish. Today, much of that has been substituted with vegetable protein, although there are still concerns about the supply of fish oil and omega 3 fatty acids.

The Convener: We will explore those topics during the meeting.

Professor Tett: In general, therefore, we have the same set of concerns now as we had in 2002. It is worth remembering that the industry went through rapid expansion in the late 1990s—the early figures I have are that it produced 83,000 tonnes in 1996, rising to a peak of 170,000 tonnes in 2003—and the review was based on scientific information from the earlier part of that period, when production was lower. Since 2003, there has been no upward trend, but there has been

fluctuation up and down. Production did not again reach the high of 2003 until 2015, when it got to 171,000 tonnes.

The industry has continued to produce between 130,000 and 160,000 tonnes in the period from 2002 to 2017. In looking at the recent literature, we were looking at a period in which production of salmon was roughly twice what it was when the literature was reviewed in 2002.

In very general terms, and with lots of caveats, there is no published evidence that effects are more widespread or more general now than they were in 2002.

Mark Ruskell (Mid Scotland and Fife) (Green): I hear what you say about the early growth of the industry and the current production level of 171,000 tonnes. The prediction for 2030, however, is that 300,000 tonnes will be produced. How robust is the peer-reviewed evidence of what has come before, given the enormous expansion of salmon farming that is anticipated?

Professor Tett: I will start on that question: colleagues may also wish to come in.

Extrapolating from today, and without additional mitigation, we would expect more widespread effects. We suggest in the review the additional mitigations that would be necessary: many are already in train or are being considered.

Kate Forbes: This may be an unfair question, but given the expansion over the past 15 years and, as Mark Ruskell said, what is to come, does it surprise you that the conclusions of the 2002 review are largely the same as those in this review? Does it surprise you that there has not been more scientific evidence published over the past 15 years and—I presume—that there have been very few changes in practices in salmon farming?

Professor Tett: I will not comment on practices in salmon farming.

I noticed a pattern in the scientific evidence. In the first decade, many papers were published on harmful algal blooms. In 2002, there was concern that the industry was perturbing nutrient ratios in the sea and causing greater frequency of harmful algal blooms, which had harmful effects on farmed salmon and on farmed shellfish. That led to international reviews, work by the European Commission and other normal scientific work. The review publications all suggested that the cause of harmful algal bloom lies offshore—not in the salmon-farming industry. As a consequence, research into the topic died away.

John Scott (Ayr) (Con): Will you comment on possible effects of climate change and sea-level temperature changes?

Professor Tett: That is the big question of our age.

It is possible to see changes in ecosystems in the west of Scotland. It is hard to understand what is causing the changes—whether it is climate change, fish farming or other human activity, including disturbance of sea beds through fishing and removal of top predators from the food chain. We do not have enough information to be clear on that.

John Scott: In summary, then, there is a multiplicity of potential effects. It is a dynamic situation that will inevitably change constantly, with fish farming as part of it.

Professor Tett: Yes. We need to accept that natural ecosystems fluctuate of their own accord, even without human influence.

John Scott: Indeed.

Professor Tett: On top of that, there is recovery from ice ages, human-induced climate change and a number of other human pressures. Those are changes that take place over decades.

We need long time series information—first, to understand what is happening, and secondly to stand a chance of being able to correlate what is observable with what human pressures on the sea have changed.

10:00

We are collecting long time series information, and the routine monitoring of salmon farming is providing a lot of data, but I advocate that more attention should be paid to synthesis and analysis of that data in respect of what is changing in ecosystems, which does not seem to be possible at the moment.

John Scott: That appears to be a gap in the research since 2002.

Professor Tett: I agree; we are not doing as much of that sort of research as we did before 2000.

The Convener: I will follow up that point with a layman's question. Could you quantify for us the scale of the task if we were to address those points? How big a job would it be and how long would it take to get a body of robust science to inform our understanding and get on top of the situation?

Professor Tett: That would depend on the particular aspect of the ecosystem and the particular area of concern. I can speak to benthic and pelagic impacts, which are not of concern at the moment. In terms of benthic impact, a very large amount of data is collected from routine monitoring of lochs that contain fish farms. A

relatively small amount—a few person-years—of continuing activity is needed to put that data together with information on other causes of change.

The Convener: If we were to embark on an extensive piece of work over the next five years and you were to come back to committee in five years, how much more confidence would you have—if the work had been put together properly—in coming to conclusions about the impacts of salmon farming on the environment? Is it a five-year or a 10-year job? Those are layman's questions, but we need to get a handle on the matter. How far away are we from really understanding the issues?

Professor Owens: I will try to answer that: it is a fascinating question that we are struggling to answer because it is not particularly specific, but I will try to help.

I have just returned from a conference at which we talked about observation of the global ocean. In order to pick up some of the big ecosystem changes that are happening because of climate change and so on, work needs to be done over decades and by whole nations. In Scotland, that would mean doubling or trebling our current efforts to get a better understanding of the natural changes and the climate-change induced changes versus the changes that are much more local. My sense is that we probably need a decade of really intensive work: we would have to up our game by some order of magnitude. That was certainly the conclusion of the conference that I was at recently. Whole nations need to invest very seriously. We are talking about a very specific issue in fish farming, but the ocean has a considerably wider impact on the whole of society, particularly in Scotland.

The Convener: That is useful.

John Scott: In terms of the scale of the problem that you define and the order of magnitude of increase in research that is required to reach a definitive view of the whole picture, is there any part of the picture in which you perceive a problem that is in much need of research and could be addressed, and that we in Scotland should focus on?

Professor Owens: Yes. There are probably two key areas identified in the report. There is the sea-lice issue on which SAMS is beginning to embark on some tractable work that will help, but that work needs investment. Professor Verspoor is better able to comment on that than I am.

The question of organic material is also interesting. Paul Tett knows better than I do about it, but I think that we could do more research in that area.

John Scott: It seems to me, from the little that I know, that an engineering solution is required to capture organic material by harvesting it—scooping it up, taking it away and doing something intelligent with it.

Professor Owens: Perhaps Adam Hughes can respond to that.

Dr Adam Hughes (Scottish Association for Marine Science): There are certainly engineering solutions out there. The Norwegians are leading the technology in that area with closed-containment systems from which sludge is removed. That engineering solution, however, obviously has an economic cost.

The Convener: We will explore that subject in greater detail as we move along.

Finlay Carson (Galloway and West Dumfries) (Con): We mentioned maerl beds earlier. Are there any areas of environmental impact that the report does not address? There may be impacts that you are not aware of, but are there any that you are aware of that are not covered in the report?

Professor Tett: We began with a process of trying to identify all possible environmental effects by drawing up a matrix of pressures caused by the human activities that are involved in fish farming. Against that, we tabulated areas of ecosystem function from the marine strategy framework directive. I would say that we picked up all the major issues, with the exception of plastic, which is of current concern but on which there is very little literature relating to its effects in Scottish waters.

Finlay Carson: The report is quite comprehensive and it takes some time to get through. What are the top three environmental impacts of salmon farming in Scotland and, on the back of that, what are the likely outcomes of an increase in salmon farming in relation to those three top concerns?

Professor Tett: I refer back to my distinction between effects and impacts. The effects have been established from reviewing the scientific evidence, whereas the impacts, to some extent, depend on judgment. You might get a different answer about impacts even from the different experts who are here today, so I hope that I am not the only person to reply to your question.

I am a systems ecologist, so I am interested in the health of ecosystems as a whole rather than individual populations. One of the top two issues for me is the global impact of getting the ingredients for fish feed. Going to 300,000 tonnes of production will clearly increase the demand for ingredients. Scotland will be in competition for that with Norway, which is talking about going from 1.5

million tonnes to 5 million tonnes; there is also Chile and other world industries. That means that there are global issues around the impact of demand for fish feed on land use if most of the protein comes from terrestrial sources. There will also be an impact on fish stocks if we still need to get fish oil from marine sources. That is my top issue, because of the scale. Of course, Scotland is playing only a part in that global demand.

The second issue, for me, is the low-level and long-term effects of chemicals on the environment. That is of concern because we do not know enough about the long-term effects. We have a good system of regulation, which involves environmental quality standards that set maximum tolerable levels, but in recent years the long-term protection of those standards has been questioned. We do not know enough about this area, and it could affect ecosystems as a whole through harming their essential components—from the small animals that live in the sea bed and bring oxygen to the sediment by burrowing through it, to those that live in the water column and are an essential part of the food web.

I have given you only two issues. I understand concerns about the impacts of farming on wild salmon—both the impacts of sea lice and those of the effects of escapes and genetic transfer. I do not see those as a threat to ecosystems as a whole, but my colleagues might differ.

Professor Eric Verspoor (University of the Highlands and Islands): Whether something is a concern depends on which sector people are in: some will see certain things as a concern and other people will see others. As a scientist, in trying to answer such questions my main concern is the lack of the information that one needs in order to do so. In my area, which is Atlantic salmon, farm-wild interaction relates primarily to genetics. In the period from 2002 until now, specific knowledge about the level of interbreeding between farmed salmon that have escaped and wild salmon has progressed very little.

We might ask why that is. I think that it is because investment in gathering such information has not happened. We are very far behind Norway. If you are asking what levels of funding are required, I suggest that members go to Norway, where they will see them; I have had indications from colleagues that their spend on sea lice research alone is larger than the entire budget for all research on farm-wild interactions here. As a scientist, that is my concern. The literature is incredibly sparse, particularly with regard to Scotland and Ireland and anywhere else outside Norway.

The Convener: Who funds the scientific research in Norway? Is it the Government or is the sector required to fund it?

Professor Verspoor: I am not 100 per cent sure of who funds the total spend, but the industry contributes and the Government puts in a great deal of money through various departments. One example is that, a few years ago, there was a budget of £23 million just for sea lice research.

The Convener: Okay. Mark Ruskell has a question.

Mark Ruskell: I want to return to the issue of environmental impacts that are perhaps not covered by the report. There have been very well-publicised incidents in which dead salmon have been transported on the roads and there have been biosecurity issues, with waste leaking out of trucks and potentially getting into watercourses. To what extent do you see that as a problem? Do you see the increasing expansion of the industry causing any issues for the welfare of the fish?

Professor Owens: Perhaps Adam Hughes could talk about the welfare aspect, at least.

Dr Hughes: Where there are large numbers of fish deaths, a robust system of disposal needs to be in place. That is really difficult, because a lot of the locations are remote and the events might occur only once in five or 10 years. Planning for them will therefore be difficult and expensive, and it will need to be proportionate to the risk. At the moment, work is being done on the process of dealing with large-scale fish kills, but I do not know what stage it has reached as regards evidence.

I am sorry—what was the second question? It was about welfare.

Mark Ruskell: I asked whether you see specific biosecurity issues with regard to leaking fish waste getting into watercourses.

Dr Hughes: All salmon producers take biosecurity very seriously, and I suggest that the committee talks to them about the plans that they have in place. I cannot comment on individual cases that have happened up on Lewis recently.

On fish welfare, there will always be a proportion of society who are uncomfortable with the farming of animals and fish. I believe that the welfare standards are very high at the moment, but that is a personal opinion. As the industry expands, there is no reason for those welfare standards to degrade. The expansion is based on current best practice. It is for society to decide what it is acceptable in terms of its food production and animal welfare.

10:15

Mark Ruskell: Is it acceptable that we see 25 per cent higher mortality rate within the livestock? Only 75 per cent of farmed salmon actually make it to market and 25 per cent are dying. Is that

comparable with other production systems, such as chickens or pigs?

Dr Hughes: I have no idea whether that rate is comparable to that of other production systems. I do not know whether those figures are across the board for the industry and whether it is acceptable. As I said, that is for society or yourselves to decide.

The Convener: How does that mortality rate compare to those of other countries?

Dr Hughes: I do not have those figures, I am afraid. Compared to places such as Chile, which has had big problems with disease for the past three or four years, I think that Scotland probably has a lower mortality rate, but I do not have the figures.

The Convener: If you were able to source those figures in due course, it would be useful for the committee to have them. Norway would be a particularly interesting comparison.

Kate Forbes: I have a supplementary question on the earlier point about the Norwegian research. The SAMS report says that there is no specific data for Scotland but you have looked at studies from elsewhere. What are the restrictions or limits on applying the Norwegian research to the Scottish environment?

Professor Verspoor: On sea lice or genetic interactions, the research is accessible and relevant in that it informs the potential for impacts and often shows the degree of impact. However, it also shows that the impact can be very local, unpredictable and dependent on local circumstances such as the sea loch environment, the direction of wind and that type of thing. It is therefore difficult to say whether we could predict what the situation will be in a given location. That is very much where you have to have local information and that is generally what is lacking, at least in the public domain.

The review is based upon what is in the literature and what is accessible, and not just on raw data but what has been analysed. There is very little out there. There have been studies but they are not systematic and, in most cases, they are not up to date. Transferring from Norway to here gives only a general idea of the potential for a problem. We need to collect information that shows what is actually happening.

The Convener: Given the lack of information and available science that we have discussed today and which is touched upon in your report, I am struggling to see where the precautionary principle has been applied in allowing this sector to expand in the way that it has. Is that harsh?

Professor Verspoor: There have been attempts to find a way to work together on this. I recommend that you contact your counterparts in Iceland and look at what they are doing. Iceland is expanding its fish farming industry and it has introduced a new regulatory framework that takes a learn-as-we-go approach. It is a neutral framework, in that if you have evidence that there is no impact—in contrast to there being no evidence for impact—the industry will be allowed to grow. If there is evidence of impacts, the industry may have to contract. That is a flexible and adaptive system. However, it is contingent on the information being collected and in that respect the onus will be on the industry to contribute to the monitoring of the environmental parameters, such as sea lice levels and genetic introgression.

John Scott: How important is the difference in the sea temperatures in considering the research from Norway and Iceland? My very limited knowledge of chemistry leads me to believe that, as a rule, warmer temperatures make things happen quicker. Although we are not measuring those impacts, might the problems be worse in our waters, given that they are warmer than those farther north in Norway and Iceland?

Professor Tett: I can try to answer that. What you say is true: the rate of biological reactions roughly doubles with every 10° increase in water temperature. However, the Norwegian coast is extremely long and fish are farmed all the way up it. In the southern part of Norway, water temperatures are not very dissimilar to those in the west of Scotland. The water is colder in the north of Norway, but it also benefits from flows of warmer water from across the north Atlantic—northern Norway is not as cold as one might expect.

There are differences. For example, in terms of lice control, the Norwegians seem to have a preference for using lumpsuckers, which are cold water fish, to eat the lice, rather than wrasse, which are warm water fish that are used for preference in Britain.

John Scott: Would the water temperature affect the breeding of the sea lice? Would they breed more quickly and readily in our warmer waters than they would in Iceland?

Professor Verspoor: Yes, the lifecycle would be shortened.

Professor Tett: Typically, a salmon farm has a two-year cycle, with maximum stock held in the summer of the second year. That is the time when the fish are growing the fastest because the water is warmest and their metabolic activity is greatest, so it is in summer that they would have the greatest local environmental impact, through excretion.

As water temperatures increase, it is likely that metabolic activity will increase. I am now talking

about climate change. We have seen an increase in temperature of about 1° over the period that I have been working. That will have a small effect on metabolic rates. The same things will apply to the sediments.

That issue is coupled with the solubility of oxygen in seawater, which decreases as the water gets warmer. Cold water is better for salmon, because it is higher in oxygen than warm water. That is one of the factors that favour the growing of sea bass and sea bream under Mediterranean conditions.

Finlay Carson: Given the projected increases in farmed salmon and your answers on the top two or three environmental impacts, can you tell us what role alternative approaches and technologies could have on those impacts?

Dr Hughes: I guess that you are referring to recirculation systems, which are closed containment systems that take the production out of the environment, giving producers much greater control over such things as biosecurity and where the effluents go and how they are treated. There has been interest in recirculation systems for a long time and we are beginning to see one or two commercial salmon recirculation systems here in Scotland and in Norway. The technology is coming online. It is a question of economics and the cost of production; it is about the cost of capital expenditure—it is much more capital intensive to build an onshore facility, although they are now moving to offshore closed containment systems in Norway—versus the running costs and the environmental benefit.

Recirculation systems are a technology that has been coming for the past 10 or 15 years and it is still on the cusp. It will have environmental benefits. No food production system is without environmental impact, and there are other environmental impacts associated with it. It is just a question of economics and of whether it is cost effective to produce the salmon in closed containment systems.

Societal perception is also an issue. Work has been done to ask consumers whether they think that fish farmed in a closed containment system are more environmentally friendly than fish farmed in an open-water system, and the consumers believe that the open-water system is better because it is more natural, so there is greater consumer acceptance for cage farming than there is for recirculation systems.

Finlay Carson: What is driving the change towards more containment? Is it driven by economics—in terms of increased production, because of fewer losses—or is it driven by regulations relating to environmental protection?

Dr Hughes: My personal opinion is that the main driver is that it allows better control of the production cycle through biosecurity, with fewer losses and a better prediction of what the end product will be. It makes it much easier to control the environment, so producers can have a better idea of the product that they will get at the end of the production cycle.

Kate Forbes: I would like to ask briefly about the capex and the economic costs. How does Government support in Scotland or the lack of incentives compare with the situation in Norway?

Dr Hughes: I am afraid that I do not have the answer to that.

Kate Forbes: That is fine.

The Convener: We will look at the sea lice issue in more detail.

Claudia Beamish (South Scotland) (Lab): I was involved, as a complete layperson and with some trepidation, in consideration of the Aquaculture and Fisheries (Scotland) Bill, so rather than dipping into the areas on which the committee may want to make recommendations, I want to start with the science, which is what you are here for, and with where the science has got to and what would be useful for the science in the future, to inform us further. However, I am tempted to highlight a quotation from your report, which states at section 2.1:

> "Sea lice ... are ectoparasites and a key impediment to the expansion of the Scottish salmon farming industry in the marine environment."

You know that, of course, but I wanted to read it out for the record. Perhaps I should have held back on that, but there is concern about that issue not only among the public but among scientific communities globally as well as in Scotland. Let us start with the science, please.

Professor Verspoor: What is your specific question about the science? What aspect of it do you want us to address?

Claudia Beamish: Each of you could cover whatever it is appropriate to cover—for example, the effect on wild fish; any views highlighted in the literature about welfare effects on farmed salmon; the trigger levels of sea lice on smolts, post-smolts and adults that might be appropriate for action in view of the science; or transparency and whether it is appropriate for the scientific analysis to be more publicly available. I lodged an amendment in 2013 that addressed that issue on a farm-by-farm basis, but it was rejected. I also invite comments on any other aspects of the science that it is appropriate to comment on. I am simply trying to open up the discussion, because I and other members have questions on this important issue.

10:30

Professor Owens: Professor Verspoor can answer the questions about the impact and levels of sea lice. I will follow up on that by providing some information about and thoughts on ecological modelling and how we might make a step-change in improving that.

The Convener: I would also like to ask whether there are any figures for the volume of salmon that is being lost specifically to sea lice annually.

Professor Owens: I do not know the answer to that. Professor Verspoor might.

Professor Verspoor: I believe that there are estimates of that number. However, this review focused on the impact on the wild populations of sea lice from farms—that is the literature that we reviewed—and we did not cover exactly what is going on in the fish farms, so you will have to forgive us if we do not have those particular figures. The science tells us that an excessive sea lice burden on wild salmon can have a negative impact on their survival.

Claudia Beamish: You say "can", but the research literature that you highlight in your report says that more than 11 sea lice on a smolt or post-smolt would lead to mortality, so there is scientific evidence on that specific point. Perhaps you are coming to that.

Professor Verspoor: I am somewhat hesitant to say that mortality will result from two sea lice per 10.3g of fish. It will depend very much on circumstances and will vary with the various factors affecting the fish, such as its size. The science would probably suggest that, if you increase sea lice burden on a wild fish for a significant amount of time, you will increase the likelihood of there being a negative impact on its growth or survival. Sea lice do not benefit salmon.

The extent to which sea lice are attached to salmon will depend on the local circumstances, such as the time of the year and the environmental conditions. You can say that there is a risk and a potential problem. However, whether it is a concern in a given location is another question. In Scotland, a location that I am familiar with but whose identity is not in the public domain has had historically high numbers of salmon even though those salmon have to go past a very large salmon farming operation. It would be difficult to say that sea lice are having a negative impact, given that the numbers of salmon in that location are at historical highs. However, there is a large number of confounding factors. For example, the river is stocked; does that account for the historical highs? Is it perhaps the case that the marine conditions where those salmon happen to go have been particularly good? Not all salmon go to the same place in the ocean—they do not all have the same journey. It is difficult to take information from one controlled study in one location, under a certain set of environmental conditions to do with temperature, feeding regimes and so on, and extrapolate that in a way that would allow us to say how many sea lice per gram of fish would be critical or would be an indication of how big the problem is.

Claudia Beamish: I would think that there is also a significant issue about the amount of sea lice that are on the salmon in the farm that the wild salmon pass.

Professor Verspoor: Absolutely, and you did ask about access to data. If we are going to do good science on these questions, we need access to data. As far as I know, that data is being collected to some degree, but it is not generally accessible. It is not universally in the public domain for scientists to analyse and say what it tells us. Is it sufficient data to answer the questions? If it is not, how should the data collection be altered to improve the data so that we can say more about, for example, what the impact might be or how the sea lice might be controlled? We were asked to review the literature, but that information is not in the literature, so we cannot comment on it.

Claudia Beamish: Can you comment on how transparency and the public openness of real-time data on a farm-by-farm basis could help develop the science as we go forward?

Professor Verspoor: It would help advance the science, but I understand equally that such information is misused on both sides of the fence in the debate. The science takes a long time to crunch the numbers and assess the implications, but when data is made public there are often knee-jerk reactions over what it means or does not mean, which is an obstacle. However, I accept that, in principle, if we want the best science to inform the debate, we need transparency about the available information.

Claudia Beamish: But surely how that information would be used by anybody beyond the scientists would be the same as when, on land, if there was a discharge into a burn, the Scottish Environment Protection Agency will release information publicly. What is the difference?

Professor Verspoor: I am talking about the misuse of the data by certain sectors.

Claudia Beamish: But is that a reason not to have the science made public?

Professor Verspoor: No, but I am just saying why that is not happening.

Claudia Beamish: Okay. I am misunderstanding what you are saying.

Professor Verspoor: I am saying that the science should be made public because if we want science to inform the debate, we need everything to be accessible ultimately for analysis.

Claudia Beamish: Thank you. That is helpful. Can we go to Professor Owens, please?

Professor Owens: Certainly. That is a pertinent point on which to come in. One of the things that we are in the business of doing is modelling the distributions of sea lice. We combine a biological model with an ecosystem—

Claudia Beamish: Is that the same as biophysical modelling?

Professor Owens: Yes. One of the limitations that we have in getting a predictive model as to where sea lice will be transported to from fish farms and so on is the availability of live, real-time data. If we had farm-by-farm data on the distribution and numbers of sea lice in the cages, we would have a considerable improvement in our predictive capabilities, certainly of the distribution of the sea lice. We then move into a biological question as to what might happen to those sea lice and the impact that they might have on the salmon.

To take the example that we have just heard about, one of the possible explanations for the apparently high levels of wild salmon in an area where there are cages is the very fine-scale variations in the distribution of the sea lice coming from the cages versus where the wild salmon are travelling. We do not have that information because we do not have the real-time data.

The Convener: Thank you.

Alex Rowley (Mid Scotland and Fife) (Lab): The science of the impact of sea lice on salmon is perhaps something that we do not hear being discussed in the pub on a Friday night. However, when "The One Show" ran its two evenings of programmes on salmon fishing in Scotland, I think that people were horrified to see the amount of dead salmon that was being put into lorries and shipped halfway across Scotland. There is therefore a genuine need for the public to know about the issues.

As has been said, the report does not highlight the disease in salmon farms and does not go into the detail of why so many fish are being slaughtered. I know a local farmer who has a dairy herd; if 25 per cent of his cattle were being slaughtered every year because of disease, that would mean that there was a serious problem across the industry. As Mark Ruskell said, the dead fish are being transported around Scotland.

Regardless of whether data can be misused depending on who has it, is there a lack of farm-by-farm data on the amount of disease that is in the fish stock, of which 20 to 25 per cent is being slaughtered? If fish production has doubled since 2002, what has happened to the number of fish that are slaughtered as a result of disease? Do we just keep compensating for that? Do we double production over the next 10 to 15 years to compensate, or should we do something to tackle the reason why the disease is there?

Professor Verspoor: That is outwith the remit that we were given. The people who can answer your questions and who have whatever information is available on the issue are Marine Scotland science, the fish health inspectorate and those who are associated with them. I would direct those questions to them.

We dealt specifically with the impacts on wild stocks and not with what you referred to. We have no access to those organisations' databases, so I cannot say what information they have.

Alex Rowley: If you are to look at the disease interaction between farmed salmon and the wild population, should you have access to such data? If the level of disease continues to increase and is compensated for by producing more, does that create more risk for wild salmon in our rivers up and down Scotland?

Professor Verspoor: Yes—that is potentially the case. However, that area of work involves Marine Scotland science and the fish health inspectorate team. Information on the subject has been published—scientific studies are referred to in the report—but the level of information that you ask for is not in the public domain. You would have to check on that with those organisations.

The Convener: We will have the opportunity to do that with the witnesses who appear before us next week.

John Scott: I return to sea lice burdens—given the lack of published information, we are in the realms of conjecture, so I will invite you to speculate. Am I right in deducing from what you have said that there are a number of key variables for the likely sea lice burden? They include the genetics of the salmon, whose ability to fend off or absorb sea lice varies; the feeding regimes, as what the salmon are fed might attract sea lice; temperatures; and the water conditions in which the fish find themselves. Am I right in deducing that, given those variables, if we were dealing with a differential equation, there would be so many variables that it would be almost impossible to solve? Do you have to contend with those variables in arriving at a conclusion?

Professor Verspoor: Yes. The Norwegian research programme perhaps gives the best understanding of the effect of a lot of the variables that you mentioned. That research has also considered whether there is an association across

Norway between the health of salmon populations and the levels of sea lice. In general, it has found that there is an association, in that the higher the sea lice levels in an area, the larger the effect on the wild populations. It is correlative, although there are exceptions, which are probably because of the sort of local circumstances that we have discussed.

10:45

The Convener: I have one final question on this issue. The report says that

"sea lice populations ... appear to be developing"

widespread and serious

"resistance to many existing treatment medicines".

Is there any Scotland-specific evidence of that, or are we talking about global evidence?

Professor Tett: It is global evidence.

The Convener: So that is another gap in our understanding at a Scottish level.

Claudia Beamish: It appears to relate to Scotland as well. Section 2.1.4 of the report states that the treatment methods

"appear neither to be succeeding in controlling sea lice, nor capable of addressing the environmental effects of the lice."

Professor Tett: Sorry, I was addressing the question whether the evidence for the developing resistance of sea lice to chemicals is gained from Scottish work.

Claudia Beamish: Okay.

The Convener: Let us look at the discharge of waste nutrients.

John Scott: Information is provided on what the literature says about environmental quality standards for emamectin benzoate. What does the review suggest in relation to possible changes to EQSs for EMB in Scotland?

Professor Tett: I will start by explaining a little bit about emamectin and how it is used. It is an in-feed treatment that is supplied in salmon food. It is carried in the blood of salmon and gets to the sea lice in that way, and it certainly damages their growth—think of it as a systemic insecticide. It reaches the sediment in the faeces of the salmon and can then penetrate into the food chain if animals on the sea bed eat salmon faeces or eat the bacteria that have eaten the salmon faeces.

Environmental quality standards to ensure a minimum safe level of the chemical emamectin are set by the regulators in several different respects. One is in respect of anything that is to be eaten by humans—for example, an EQS is set for mussels that are intended for human consumption, in order to avoid emamectin getting into the human diet. Lower concentration levels are also set for the material in sediment, in order to protect animals that live in the sediment. In that case, the EQS is based on laboratory experiments with a number of test animals—the marine equivalent of white mice. The test animals are things that can be grown under laboratory conditions and are therefore pretty robust. Basically, the experiments involve determining the minimum dose of the chemical that is necessary to have a harmful effect on the test animal and then working out what concentration has no effect on the test animal. That gives us the NOEC—the no observed effect concentration. It is then necessary to introduce a precautionary factor, because the test animals are very robust. The precautionary factor might be 10, 100 or 1,000. The aim is to introduce sufficient precaution so that we can rely on the EQS to provide adequate protection of the animal community that lives on the sea bed.

That is now seen to raise two issues. The first is whether we are introducing enough precaution into the EQS and whether we know how sensitive certain animals are. Secondly, when we are developing the EQSs, we talk about the direct effects on particular animals, but are there more general, diffuse and long-term effects on ecosystems, such as on the behaviour and reproductive capacity of animals, that will not show up as mortality but will interfere? It has proven difficult to get evidence on that other level.

The reasons for that include the necessity of relating sediment concentration of emamectin to the state of the animal community in the sea bed, with which there are two particular difficulties. One is that most of the monitoring surveys of emamectin are not sensitive enough to measure the levels that might be causing harm, although recent improvements in techniques have begun to remedy that. The second issue is that samples for chemical pollutants in the sediment are taken in different places and at different times from the samples for the biological content of the sediment. Therefore, it is difficult to do a reliable statistical analysis of the relationship between the emamectin content of the sediment and the biological content.

One of my colleagues has attempted such an analysis, which is published in a report by the Scottish agricultural research forum. It suggests that there are lochs where levels of emamectin are being detected some way away from the fish farms and that that correlates with changes in the community of animals in the sea bed. From a scientific point of view, the confidence that we have in those conclusions is only moderately strong. The statistical analysis is the best that can be done but it is limited by the available data.

This is one of the research areas in which there is a need to do a specific, probably long-term investigation of a few sea lochs, including research studies of the level of these chemicals in the sediment and of changes in the communities of animals, including the effects of those potential changes.

Another factor that compounds the medicines' effects is the organic input from the farm. A big farm will have a lot of organic input and will use a lot of medicines, and it is difficult to distinguish between the two.

John Scott: The two might interact.

Professor Tett: Yes. I suppose this is an area—

John Scott: This is an area that requires further research. From what I read in your report, it appears that the breakdown of evidence shows that the distribution of emamectin is almost linear in distance from the cage. That might be obvious, but I am more concerned about the effect on other species of the breakdown of ivermectins in the sea—the impact that it might have on other sea life. You are really saying that it needs more research to even begin to measure that.

Is the breakdown of ivermectin, or whatever it is properly called—

Professor Tett: It is called emamectin.

John Scott: I should declare an interest as a land-based farmer. Is the breakdown process clear and well-defined? Does it break down into components that are not dangerous?

Professor Tett: It eventually breaks down into non-dangerous components. I do not know of research on the breakdown products, but there is research into the breakdown time, which is typically approximately half a year, although it seems to vary between sediment type and condition.

John Scott: The sediment type can have an effect on the breakdown process, and the sediment type is a function of what the fish are fed on in the first place as well as what the sea bed is composed of.

Professor Tett: Exactly. One of the conclusions that I have come to from looking at all the papers that have been published is that there is no standard sea loch. There is a wide variety of physical types with a wide variety of sediment types. It is clearly desirable for each farmer to understand the local conditions, which might favour rapid breakdown of the chemicals in some cases, or their retention in others. There is little published information about the spread of conditions.

John Scott: Nevertheless, it would be an area hugely worthy of further investigation to enable guidelines to be provided on suitable locations for future fish farms in respect of the composition of the sea bed and its sludges, rather than just species.

Professor Tett: I agree strongly. We have a precedent in the locational guidelines that Marine Scotland brought out in 2002—and updates regularly—which consider effects on the sea bed and the water column. They could be expanded to take into account variations in sediment quality.

John Scott: I may have already asked this question, but are there any data and analysis gaps relating to the discharge of medicines and chemicals into the environment? If so, how might those gaps be filled and what would the benefits be?

I had not read that question. It appears that you may already have answered it.

Professor Tett: I answered in relation to emamectin, the sea-lice treatment medicine, but there are two other categories of chemicals, the first of which is antibiotics. Our evidence is that antibiotics are little used in Scotland.

John Scott: I am very pleased to hear it.

Professor Tett: The reason for that seems to be the vaccination of fish against disease. The other category of chemicals is those used in anti-fouling—the paints that are applied to farm structures and the steeps for nets that are used to prevent seaweeds and barnacles from growing on them. They are used not only on fish farms, but on any moored structures, such as sailing boats.

As you may be aware, over the past 20 or 30 years, there has been a big change in the nature of anti-fouling compounds. In the late 1980s, it was discovered that tributyltin had very harmful effects on molluscs—it caused them to change sex, which had an unfortunate effect on shellfish farms. That discovery, along with other evidence, led to a major change in the kind of anti-fouling chemicals that are used.

We now use compounds based on copper and zinc, with some organic ingredients, and, as far as we know, those are less harmful. However, there are some indications that we do not know the adequate environmental quality standards for some of those chemicals in respect of ecosystem function. That has not been raised as an area of concern so far, but we need to keep it under review if the industry expands—particularly if it expands in large, off-shore floating structures, which will need anti-fouling treatment.

John Scott: Of those three issues, which is the key one towards which Government money for research should be directed?

Professor Tett: At the moment the key issue is the direct impact of anti-lice chemicals.

The Convener: We are told in the report that the DEPOMOD model is now thought only to be accurate to 63 to 85 per cent, which is somewhat at odds with an original accuracy estimate of 13 to 20 per cent. I ask the question as a layman, but from a scientific perspective, with how much concern should we view that difference?

Professor Owens: Are you talking about the fact that it has been considerably improved?

The Convener: Yes.

Professor Owens: We should be pleased that it has improved. We are still working on the models to make them even more accurate and useful.

The Convener: That was my clumsy attempt to get that point clear. I read that part of the report three times and two different ways. I now understand that it is an improvement.

Professor Owens: Yes, it is an improvement.

The Convener: I am glad that I asked that question on the committee's behalf.

Finlay Carson: My question comes from my experience of using ivermectin in cattle and the resulting very slow breakdown of animal dung. When the fish equivalent is used, is the impact of withdrawal on breakdown of the sediment considered? Has any work been done on how quickly the sediment breaks down the use of the pesticide? Should there be?

11:00

Professor Tett: I will try to answer that. In general terms, the rate at which fish faeces, or any organic inputs, break down depends on bacterial activity. That in turn depends on the rate at which seawater containing oxygen can get into the sediments.

One of the key roles for the larger animals that live in the sea bed—the worms and the prawns and so forth—is to burrow into the sediment to rework it and to let a flow of water in. If those animals are harmed and their activity slows down, the rate of reaeration of the sediment will slow down. The rate at which the waste material breaks down will slow and the fallowing period will have to be longer.

Finlay Carson: So should we bear it in mind that if those chemicals stop being used, the sediment is likely to break down far quicker and there will be an environmental impact?

Professor Tett: We cannot say that we know that. It is possible to turn it around to say that, if those chemicals are widely affecting the macrobenthic organisms—the reworkers, such as the worms—over the base of a loch, the general rate of breakdown of organic material will slow down.

The Convener: We will now cover the discharge of waste nutrients and their interaction with the wider marine environment.

Mark Ruskell: I want to linger a bit longer on the chemicals and ask about cocktail effects. Is that an area where there is a research gap? Are there proposals from the Scottish aquaculture research forum or elsewhere to study the interactions of some of those chemicals?

Professor Tett: The simple answer is that it is a research gap. I do not know whether there are any new proposals for research.

Mark Ruskell: On nutrients, my understanding is that SEPA is feeding into a sector review that will look at revised environmental quality standards for emamectin. The review will look at introducing a new depositional zone regulation—or DZR—that, on the face of it, could allow the industry to expand but could also increase environmental compliance.

What are your thoughts, particularly on SEPA's DZR proposal? It is something that we have known about for some time, but it has not come to the committee yet. How does it reflect on the research base that you have been looking at?

Dr Hughes: The changeover to DZR has allowed a review of the current way that the fish biomass is consented for a site, and that is to be welcomed.

The prescribed maximum limit of 2,500 tonnes of salmon per site had no real basis in evidence; it was an arbitrary figure. The DZR will allow a more adaptive and responsive management of the biomass, which will be allowed to increase or decrease depending on the impacts on the benthos.

Scientists do not have any clear understanding of the detail of the mechanisms behind the DZR. The proposal has gone out for consultation and we do not have the results. It is difficult to say whether the scientific evidence supports a move to DZR, because we do not know what such a move would mean.

Mark Ruskell: Do any other members of the panel have views on that?

Professor Owens: I do not have anything to add.

Mark Ruskell: Perhaps I could pitch it in a slightly different way. You have already mentioned the regulatory regimes in Norway and Iceland, which are very much focused on achieving environmental objectives. There has been a consultation on DZR, so you are aware of what is

coming, in broad terms. How does DZR compare to regulatory regimes that are focused on delivering environmental objectives first and foremost?

Professor Tett: Could I return us to the topic of adaptive management versus the precautionary principle? Adaptive management is learning by doing. It allows development to go ahead without there being absolutely clarity on what the environmental effects will be. It assumes that the environmental effects will be monitored and that knowledge of those effects will change management practice as necessary.

One can see the change to DZR in that framework. If it allows or encourages the industry, particularly farms, to monitor the condition of the sea bed in such a way that management practice changes, it will be successful. My understanding is that that is what is meant when people say that it is preferable to set the standard and then allow a fish farm to find its own way of achieving that standard, rather than trying to regulate by setting the maximum stock that can be held at a site.

If I am heading in the right direction, I would like to go on a little more with my answer.

Mark Ruskell: Yes.

Professor Tett: The important question is: what are the circumstances in which adaptive management can be properly implemented and will succeed? That clearly requires some changes in the way in which we all think about it, including changes in the way in which the public think about what the regulator is required to do. If the regulator is seen as being in a policing role—there to enforce specific regulations for that stock—that will set up a confrontational situation.

There is a degree of adaptive management at the moment because, in my experience, regulators talk with farmers and, in many cases, are able to guide them in how they might change their practice or stock without the need for a confrontational court case. Nonetheless, I have been associated with the European research programme, which has done research into public attitudes, and what I have just described leads to some public concern about whether the regulators are doing their job properly.

An improvement to adaptive management would include bringing in two additional groups of people. One would be research scientists, and the other would be those whom I think of as citizen scientists. Citizen scientists are members of the community who are sufficiently interested in the issues, from either the pro-industry side or the anti-industry side, and are willing to contribute some time to take part in some aspects of the monitoring process. SAMS has a good example of citizen scientists who are looking at seashore communities.

Mark Ruskell: That would require full transparency from the industry.

Professor Tett: It would require full transparency, and there are clearly issues around that. This is not something that I would recommend as a panacea, but it could be usefully introduced under experimental conditions to see how well it works. I am sure that there are some farms and farming organisations that would welcome such an approach and be willing to go along with it.

Mark Ruskell: Do you believe that the DZR approach should be applied to every fish farm, including the existing inshore sites, or should it be restricted to expansions or new sites in more exposed locations? If it is a good thing, where do you draw the line?

Professor Tett: I am saying that adaptive management is a good thing. I do not have strong views on the change from the allowable zone of effects to DZR.

I would like to see some of what we might call environmental social science—some monitoring not only of the environmental conditions at farms that have switched to the new system, but of the way that management works and interacts as part of an adaptive management process and of how the local community feels about it—whether they are engaged and whether it is changing their views of the impacts of the industry.

Mark Ruskell: I have another question, which relates to nutrients, the issue of efficiency and the prospects of multi-trophic aquaculture systems, which produce multiple products. What is the potential for those systems? If we accelerate to 2030, given the industry's anticipated growth, where do you see multi-trophic aquaculture sitting?

Professor Tett: I will pass that on to Adam Hughes.

Dr Hughes: The concept of integrated multi-trophic aquaculture involves using the waste products from one production level in another. In the case of salmon, those products can be utilised by seaweed or mussels. It reduces the environmental impact and increases the growth of the species that is being co-cultured.

The idea is really attractive, but the practicalities are difficult at farm scale. We really need to go back to the question of what we are trying to achieve by implementing a multi-trophic system. It is quite difficult to balance out nutrient budgets at the farm scale, because there is a spatial mismatch between the amount of space that it takes to produce 1,000 tonnes of salmon and the

amount of space that it takes to produce 1,000 tonnes of mussels. Roughly, a 1,000-tonne fish farm might be a hectare. Taking up 10 per cent of those nutrients through IMTA will require about 10 hectares of mussels or seaweed. It is really difficult to imagine that happening at farm scale, because it would mean a huge increase in production at a site.

If we start thinking about it at an ecosystem level, in which we are trying to balance the nutrient inputs from aquaculture and the nutrient reductions from activities such as mussel or seaweed farming, we might get a more viable model—one that works better when we move away from the farm scale to the ecosystem scale.

The benefits of IMTA might be greater than just the impact on nutrient budgets. There is the diversification of aquaculture; the development of new business, more businesses and rural economies; and the social acceptance of aquaculture. If you are looking into IMTA solely to balance nutrient budgets at the farm scale, there are a lot of logistical problems with it. If you are looking at it as a more holistic tool—taking the ecosystem approach to aquaculture, balancing social need and so on—there is more value in it.

The Convener: Let us move on to the impact of escapes from fish farms.

Angus MacDonald (Falkirk East) (SNP): Good morning. Eric Verspoor has already touched on the issue of escapes. However, we see in the report that, in Scotland, between October 2002 and October 2017, approximately 2.2 million Atlantic salmon were reported to have escaped. We also see references to "drip escapes", which

"are difficult to identify and quantify and not encompassed by reported escape events, but"

which have

"been estimated in Norway to be substantial".

We know that the causes of the escapes are human error, holes in the nets, predators and, of course, the weather.

How concerned should be we about escapes? The report says that

"the majority of salmon that escape from farms will not survive to interact with wild fisheries populations".

How can we be sure of that?

Professor Verspoor: The research that has been done in Norway and, in part, in Ireland indicates that even moderate and low levels of introgression of farm genes into wild populations can affect the normal life history characteristics of the populations in the rivers where that takes place. Once we disturb those characteristics, we will most likely increase mortality rates—it will compound the rates of mortality caused by other factors. In general, such populations also show declines, on average. Therefore the genetic mixing of farmed stocks with wild stocks will almost inevitably have negative consequences if it occurs.

11:15

Norway has found levels of mixing to be highly variable—from about 5 to 10 per cent up to about 50 to 60 per cent. Those levels are generally associated with rivers that are in farming areas. Equally, there are some rivers in farming areas that are not impacted and others that are outside farming areas that are impacted, so it is difficult to predict. Norway has a system of monitoring and has developed genetic markers with which to estimate levels of introgression to get an indication of the extent to which populations have been impacted.

On the assumption—which is quite well supported by the science—that introgression will have negative impacts, we can then look at managing such situations in the knowledge that we have to reduce the levels of escapes in those areas in order to bring the levels of genetic mixing down. That is the adaptive management approach that the Icelandic Government will be putting in place. It has been approved, and will guide the industry in future. If there is no evidence of introgression, the industry will be allowed to expand, on that criterion. If there is such evidence, the industry will have to take measures to reduce those levels before it will be allowed to expand, or it will be asked to decrease production levels to a point where introgression is no longer a problem. That is the principle of adaptive management.

In Scotland, we have very little information on levels of introgression. We have historical evidence, going back to the early 1990s, from which we know that escaped farmed fish ascend rivers and reproduce. We also have some evidence of subsequent introgression, but it is imperfect. We had to use the Norwegian molecular markers—which are designed specifically for Norway—in Scotland. That did not allow us to get an accurate assessment of introgression, but it was suggestive of it.

On the other hand, I studied a very small river in the middle of a farming area on the west coast. We did not even know that there was a wild salmon population there. There was no evidence of introgression despite the population probably being composed of a few tens of breeding individuals.

The situation can be highly variable, and the only answer is that we need to monitor levels of introgression in Scottish wild stocks regularly and then manage them according to their actual effects, as we know that, if introgression occurs, it

is extremely likely that there will be negative impacts to some degree, which will probably scale with the level of introgression.

Angus MacDonald: Are you aware of any molecular or genetic marking that is going on in Scotland?

Professor Verspoor: There are different ways of addressing the issue. The Norwegians have markers that will indicate the level of introgression. They also have markers that allow them to associate farm escapes with particular cages. If there is a farm escape, they can go to local farms, get samples of fish from them and see where the escaped farmed fish might have come from. They do that either by using genetic markers or by profiling the lipids in the fish, because the feed that the fish are given can be quite unique. That approach has been quite successful.

In Scotland, I and my co-author Mark Coulson tried to apply those Norwegian markers, but they were not accurate enough in terms of distinguishing farmed and wild fish. We have just completed a UK research council grant. We are identifying genes for domestication, which should give us better markers that will allow us to go into any river and identify farmed fish and hybrids between farmed and wild fish, and measure the extent of introgression—not fully, but we should be able to do what the Norwegians are doing. We now have a European structural and investment funds studentship that will enable us to look at historical samples and contemporary samples to identify evidence of introgression.

Angus MacDonald: That is good to hear.

Convener, I have a couple of questions on wrasse. Do you want me to wait before asking them?

The Convener: Yes, we will come to that in a moment.

I would like to wrap up this section by seeking clarity on the statement in section 5.8.3 of the report that

"experiments to develop triploid strains have so far not proven commercially successful."

Does that mean that it can be done but that it is just too costly, or is there a bigger issue than that?

Professor Verspoor: It is fairly inexpensive to produce triploids. The question about triploids concerns their performance and the economics—are they more susceptible to disease, and do they grow as well? Since the early 1990s, people have been playing with triploids to see whether they would be suitable, but they find that sometimes the performance is equivalent, sometimes it is superior and sometimes it is inferior. The fact that the industry has not taken up triploids suggests that, for some reason, they do not work for it. It may be public perception. Do people perceive triploids as being genetically modified? It depends on the definition of genetic modification.

John Scott: Is there any other way to physically inhibit the breeding characteristics of fish, were they to escape into the wild?

Professor Verspoor: Potentially there is. Farmed strains are currently selected for the traits that are of economic value, such as growth rate, delayed maturation or disease resistance, but they are also inadvertently selected for domestication—fish that are happy to live in cages tend to survive and are more docile. There are other traits that are not of relevance to production that could be selected in breeding programmes—for example, the tendency to migrate and the ability to reproduce successfully. There is a whole behavioural repertoire that is associated with successful reproduction in the wild. Those traits are not needed in a farm setting because the fish are spawned artificially. There are also stress-related traits that are important in the wild, because you have to be a little bit nervous in the wild in case you get predated upon, and in a farm context those traits can be changed, because stress-related traits are not advantageous.

There are indeed other traits that could be brought in. The immediate economic gain in terms of production is not there, but there could be a longer-term environmental gain in making the fish less able to breed in the wild—so that they do not run up rivers to spawn, for example.

John Scott: Fish that want to stay at home, near their cage and their source of food, are likely to be the ones that do best anyway.

Professor Verspoor: Exactly. There is some potential that has not been explored yet, but there is some hope that, in the coming years, we might explore those possibilities.

John Scott: Fascinating. Thank you.

The Convener: Let us move on to feed supplies.

Richard Lyle (Uddingston and Bellshill) (SNP): Good morning. Paul Tett touched on my question earlier. The report states that the sustainability of feed supplies is one of the main issues, and section 6 is headed "Sustainability of feed supplies including substitution with plant-derived ingredients". Farmed salmon production has been between 130,000 tonnes and 160,000 tonnes, but the intention is to almost double the higher figure to 300,000 tonnes. How can those farmed salmon be fed? Can the feeding be sustained, particularly if Norway is also increasing salmon production? Your report states:

"Increasing salmon production in Scotland and elsewhere (e.g. Norway) will necessarily increase the demand for the raw materials for feed ... required additional, sustainable, source of 'omega-3' could be obtained from—"

wait for it—

"transgenic oilseed crops",

which are commonly known as genetically modified crops—oops! Nobody wants them in Scotland and we banned them, so what do we do?

Professor Tett: I will pass that on to my colleague to answer.

Dr Hughes: The inclusion of marine ingredients in salmon feed is mainly an issue driven by the consumer. The marine ingredients in fish feed are down to about 20 per cent in Norway, but the figure is 25 per cent in Scotland. That is because the United Kingdom consumer prefers a product higher in marine ingredients, which is seen as more natural because it is fed on fish.

There has been complete substitution of marine oils by vegetable oils in salmon feed that has shown very little difference in growth rates. However, the product at the end of that process is not full of omega 3 oils, which are good for public health. The substitution of marine ingredients by terrestrial ingredients can continue as far as we want, but that will mean losing a lot of health benefits and a lot of consumer acceptance of the product.

Richard Lyle: So, with the greatest of respect, what is the answer? Is it to allow GM crops? A colleague pointed out earlier that 2 million salmon have been lost to escape and 25 per cent have been culled, but they still had to be fed. Does the industry need to get better at being sustainable in order to grow? Or do we just let rip and let everything come back in? I do not think that a lot of people would agree with doing that.

Dr Hughes: The issue of GM is something for society to decide. As I understand it, Scotland has made a very clear statement that it does not want GM products to be farmed in Scotland. That is a societal decision, but it does not necessarily have anything to do with the science.

On other options, a large proportion of the marine ingredients is sourced from the anchoveta fishery on the Peruvian coast in South America. That fishery is at the limit of its sustainable exploitation; although most of it is well managed, there is no real room for expansion there. There is also increasing use of discards and fish by-products to create fish oil, which in some respect has met demand. However, there are developing technologies, such as microalgal oils and bacterially produced oils, that might produce the oils that are required to go into the fish feed in order to get the public health benefit that comes from eating salmon. That should not be underestimated, because salmon is a major source of omega 3s to the Scottish population and it has huge health benefits.

Richard Lyle: So, my last question is: do you honestly think that the industry's desire to double production in the next number of years is achievable? Or would you like to pass on that question?

Dr Hughes: In terms of feed?

Richard Lyle: In terms of feed.

Dr Hughes: I think that it is achievable because no matter what the Scottish industry does, the Norwegian industry is going to be larger than the Scottish industry by an order of magnitude of 10 and it will have to come up with solutions for exactly the same problem. So, there are technological and societal solutions out there, and it is about what we choose to adopt.

11:30

Mark Ruskell: You mentioned the South American anchoveta fishery. At what point in the next 10 to 15 years will that fishery start to tip over its total allowable catch? At what point will it exceed maximum sustainable yield and therefore be in a state of collapse?

Dr Hughes: I do not have that information. It is outside my area of expertise, as it is a fisheries management issue.

Professor Tett: As I understand it, the fishery is sustainably managed at the moment, which means that it is managed at maximum sustainable yield and is giving us as much as it can. There is much fluctuation from year to year, depending on the El Niño cycle, but it seems unlikely that we can expect a much greater yield from that fishery. If it is not managed sustainably, we might get more fish from it for a few years, but after that we will have exhausted it.

There do not seem to be any other major sources of fish oil available from the natural world at the moment.

Mark Ruskell: So we are at the limit.

Professor Tett: Yes.

I could add just one more thing. As Adam Hughes mentioned, one of the possible technologies involves growing what the industry calls microalgae to produce omega 3. They are not what I would call algae, because they do not photosynthesise. The promising method seems to involve a sort of fermentation technology, so it is more like brewing. Scotland is pretty good at

brewing, so perhaps that is an industry that we could develop.

The Convener: I have a brief question about acoustic deterrent devices. Paragraph 7.1.5 in the report says that most ADDs are left to operate continuously. What evidence is there for that? I seem to recall that, in the previous session of Parliament, the Rural Affairs, Climate Change and Environment Committee was told that those devices should and would only be used in short bursts because, otherwise, they would be harmful to occupants of the wider marine environment. Therefore, the assertion in the report is quite concerning. Can you flesh that out?

Professor Tett: I confess that I do not know the precise answer to that. I am aware that there is limited documentation available on what sort of devices are used, the conditions that they are used under, the length of time that they operate and the length of time that they do not operate.

The Convener: So how have you backed up that assertion?

Professor Tett: I cannot answer that directly. We will find out.

Dr Lindsay Vare (Scottish Association for Marine Science): That paragraph was written by one of the other experts at SAMS. We can look into that and get back to you.

The Convener: That would be helpful. At face value, the paragraph is concerning, because it raises the question of the need for consistent ADD monitoring and perhaps a licensing regime. That is quite an important point, so it would be good if you could come back to us on that.

Angus MacDonald will ask about wrasse.

Angus MacDonald: During the course of the Aquaculture and Fisheries (Scotland) Bill, the Rural Affairs, Climate Change and Environment Committee went on a fact-finding visit to Lochaber. At that time, Marine Harvest was already using wrasse to control sea lice infestations. I am not sure when that policy was introduced, but there now seems to be more widespread use of wrasse. According to the report, official statistics show that 1.7 million lumpsuckers and 1 million wrasse were bought by the Scottish farming industry in 2016.

Overall, does the evidence show that the commercial rearing of wrasse and lumpsuckers is a sustainable approach to controlling lice the Scottish salmon industry? Do you have any concerns about future increased demand for cleaner fish, particularly given that salmon production is set to increase significantly in Scotland and in Norway? Presumably, there are only so many wrasse available to be bought, so demand will be pretty excessive.

Professor Tett: The information that we have is that the cultivation of lumpsuckers seems to be capable of satisfying the demand.

The situation with wrasse is not so clear cut. Information from the industry suggests that by 2019 it would like to be able to cultivate all the wrasse that it uses, but it is not clear whether that is an achievable target. If it is not achievable, clearly the demand for wild wrasse will continue. In that case, there will be a need for fisheries management of the wrasse fishery, following the example that has begun to be developed in south-west England, where a local fisheries management board has successfully managed the wrasse fishery in such a way that it provides a sustainable source of employment for people in that part of the country. Many of those wrasse exports come to Scotland.

Angus MacDonald: The killer question is this: if the use of cleaner fish is so widespread, why are lice still a problem?

Professor Tett: That is where we need more research. The industry probably needs a portfolio of different lice control methods: some biological, some chemical and some physical. I have not seen published information as to what is the optimum mixture of the different methods. It might vary from site to site, depending on the cultivation conditions for the salmon and the hydrographic conditions in which the farm is situated.

Temperature certainly plays a part as well. Wrasse are warm-water fish and lumpsuckers are cold-water fish. The northern Norwegians prefer lumpsuckers because they grow more quickly when they are reared and they are more active in the cold temperatures in northern Norway.

The issue is still to be decided in the Scottish fishery. We hear a lot about wrasse but, looking at the numbers, we see that lumpsuckers are also important. If I remember rightly, lumpsuckers can be reared in a few months, whereas wrasse take more than a year to rear in a hatchery, so there are clearly economic aspects to the issue.

The Convener: Before we wrap up, let us turn to mitigation.

Alex Rowley: I must confess that, when I saw the BBC programme, I thought that wrasse or lumpsuckers were the solution, but in the report you talk about recirculation aquaculture systems and enclosed systems, which seem to be the solution. What are the main environmental concerns about enclosed systems? Could they become the main means of salmon production in the future? If not, why not?

Dr Hughes: On the environmental side, the main concern with recirculation systems is in dealing with solid waste: the same amount of solid

waste is generated, but it is generated inland or in an enclosed system at sea. That waste needs to be dealt with in some way. It is saline waste, so it might not be suitable for standard means of waste disposal, such as the biodigesters that might be used on a farm. A biodigester can be used for saline waste, but it needs to be dedicated to that purpose. There might be other ways of reusing that material.

There is obviously much better disease control, including lice control, as the water that goes in and what goes out are controlled. That system is an option for development of the industry; reduction in the number of sea lice is one of the reasons why the industry is so interested in it. I reiterate my comments about developing a system that is economically viable for the industry.

As I said, we also have societal concerns and perceptions of what is natural versus perceptions of what is unnatural. To make the economics for recirculation systems work, we would increase the stocking density well beyond the level at which an open-water system would operate. That would have animal welfare implications and societal implications in respect of where we judge those standards to be.

Alex Rowley: I suppose that it will depend on what we define as "natural", given the amount of salmon that we see packed in to cages. As John Scott said earlier, you are really looking for an engineering solution. Will you say a bit more about the economics of that? Would the salmon-producing companies have to invest much more in the enclosed systems that are much safer environmentally?

Dr Hughes: The capital expenditure that is required to set up recirculation plant is much more than what is required for an open-water cage system, and the same is true of the running costs, to a degree. However, that cost could be offset by better control of the life cycle and lower disease impact. I cannot make an economic analysis—that is for the salmon-producing companies to do—but at the moment the economic balance is obviously not tipping towards recirculation systems, or else there would have been more widespread adoption of the technology.

Alex Rowley: Throughout this evidence session, we have heard that there is a lack of data and research in many areas. The Norwegians seem to be much further ahead than we are on investment and research. Is that a fair conclusion to draw?

Dr Hughes: In my opinion, that is an absolutely fair conclusion. The level of investment in research in Norway is much higher than that in Scotland, and technology development in the Norwegian aquaculture industry is much more advanced than it is in Scotland.

John Scott: Finally, you have spoken at length about adaptive management systems, and you have pretty well said that it would be a good idea to pursue that direction of travel. Would you like to agree that that is the case?

Professor Owens: I would like to agree to that.

John Scott: I just wanted to have that very definitely on the record.

Professor Verspoor: Adaptive management is essentially evidence-based management being done in an adaptive way. As evidence accumulates, management gets better because it is based on that expanding body of information and understanding of the system.

John Scott: You also said that that happens on a real-time basis, which relates to the ability that we now have, and that we probably did not have 10 years ago, to understand in real-time populations of lice, for example.

Professor Owens: Indeed. Paul Tett also made an important point about including communities, individuals and society in ways in which they have not previously been included, in order to minimise conflicts.

John Scott: Yes. We take that on board.

The Convener: Finally, we will hear two brief supplementaries from Mark Ruskell and Claudia Beamish.

Mark Ruskell: On that last point, you spoke earlier about adaptive management versus the precautionary approach. Do we need a kind of hybrid? We have talked about the cocktail effect of chemicals, which is an issue on which the precautionary approach may be needed, but there are other elements of which we have some understanding, but there is a lack of monitoring and research. Is that a fair way to characterise the situation, or do we just have either the precautionary approach or the adaptive approach?

Professor Tett: I think that what Mark Ruskell says is apt: we need a mixture of precaution and adaptive management. Of course, there is a judgment to be made about how much precaution is needed, and that judgment goes back to the risks from any particular issue and whether they are likely to be unmitigable in the long term or to be risks from which we can recover.

Professor Verspoor: Research has to be done to monitor the levels and to look at compliance with standards, but there also has to be research on the standards, because we often do not understand enough to know whether a standard is appropriate. Adaptive management involves monitoring as well as researching the standards.

Claudia Beamish: Do any of the witnesses wish to comment from a scientific perspective on the relationship between fish farms and marine protected areas and other marine protections?

Dr Hughes: I was one author of a paper last year that dealt with that issue across Europe. The working group that put the paper together concluded that, given that an MPA is usually designated for a specific purpose—maerl beds or transient cetacean populations, for example—if aquaculture is to be sited within MPAs, as much aquaculture in Scotland already is, we need to understand the impact of the industry on the specific objective of the protection.

If there is an MPA for maerl beds, for example, you would not put a fin-fish farm on top of it, but if the MPA was for wading birds or a shoreline feature it might be possible to have a farm off the coast, so long as the appropriate processes were gone through. Scotland has a robust system: if the risk assessment says that there would be no impact on the conservation feature that the MPA is there to protect, there is no reason why the MPA and aquaculture cannot coexist in the same space.

The Convener: Thank you for your time. The discussion has been useful in teasing out some of the detail of the report.

11:46

Meeting suspended.

11:51

On resuming—

Draft Climate Change Plan (RPP3)

The Convener: We will now take evidence on the Scottish Government's draft climate change plan, the third report on policies and proposals. I welcome, from the Scottish Government, Chris Stark, the director of energy and climate change, Clare Hamilton, the deputy director and head of decarbonisation, and Michael King, the head of the energy and climate change unit. I apologise for the delay.

What specific changes might be made to the plan as a result of stakeholder engagement since the publication of the draft plan?

Chris Stark (Scottish Government): I am happy to answer that question but, first, I would like to make a short detour by explaining what has happened since January 2017.

Since the draft plan was published in January 2017, we have done an awful lot of work. Indeed, I came before the committee to talk about that work previously. In February, the committee will see the product of all that work—I hope that you like it. There are four aspects to that work, of which stakeholder involvement is one.

We have been through an extraordinary amount of scrutiny. On top of that, we have done a lot of work with stakeholders in each of the sectors and on the plan itself, which I will talk about in a moment. In addition, we have developed our model—Mike King is the architect of that—and have made several revisions to the data so that we are more accurate in the way that we view the future. We have also introduced some new measures, and that is where there is the biggest interaction with stakeholders.

There is a good story about how much we have done, over the past 12 months, to amend, consider and respond. That has included our work with stakeholders. A heck of a lot has been done both by my team and by the sector teams that work with each sector in the climate change plan.

I can give the committee a few highlights. We have worked extensively with the public sector—I know that the committee has been interested in that. The cabinet secretary and I have done various things to work with several parts of the public sector to understand their views. We can also draw in a couple of examples of where we have done some deeper stakeholder work. I am sure that, many times in today's meeting, we will refer to the plan on energy efficiency that we are

bringing together this year. That plan has been informed by several stakeholder sessions that we have held. We are in the midst of putting in the final details of what I hope will be a 20-year plan to improve the energy efficiency of the building stock in Scotland. That plan has been greatly influenced by industry stakeholders, in particular.

I also draw members' attention to the transport work. That is an area in which we have responded to the views of the committee, in particular, in setting new policies in the programme for Government around ultra-low-emission vehicles—ULEVs—active travel and low-emission zones.

All those things are the product of deep stakeholder engagement, of which I am personally quite proud.

The Convener: What specific examples can you give us of changes? Let us go beyond the stakeholders and look at the criticisms that the parliamentary committees made of the original draft plan. What changes have been made directly as a consequence of that commentary?

Chris Stark: I should probably preface my comments by saying that I cannot reveal the final plan, as you would expect. That is coming in February. However, I will do my best to tell you as much as I can about it.

There were two areas where we felt that it was particularly important to respond. One was carbon capture and storage—I might add biofuels to that—and the other was the criticism that we received of what can be described as a highly ambitious projection for decarbonised heat. We have worked really hard to amend that in the final plan, and my team feels that the work that we have done, especially with transport, helps us to address the legitimate criticism of that decarbonised heat run. I might also agree that our projections for CCS—particularly for negative emissions—were highly ambitious. We have been able to amend those things, and you will see in the final plan that those changes are a direct product of the scrutiny and criticism that we received at the time.

Without giving the committee details about how we have responded, I can say that those are areas in which you can look forward to seeing quite a different plan in the future.

The Convener: Okay. Let us move on to the monitoring and evaluation framework.

Kate Forbes: You spoke about the impact that stakeholder engagement has had on the draft plan. How has the Scottish Government engaged with stakeholders, including the UK Committee on Climate Change, to develop the monitoring and evaluation framework?

Chris Stark: I do not mind saying that, when we published the draft plan in January 2017, that area was not as fully fleshed out as I had hoped it would be. We have done a lot of work on monitoring and evaluation, and we will continue to do that work.

We have done some advance work to show the UKCCC how we are planning to develop the framework for monitoring and evaluation. We did that by going to that committee early and demonstrating, particularly with the electricity sector, how we might set some metrics and, crucially, how we would properly embed them in the plan and in the policies that sit in the plan for each of the sectors.

In February, when we produce the final plan, I hope that you will see a well-embedded set of metrics that will allow you to monitor and evaluate how we are doing in the future. That is very much an on-going process. I have mentioned the energy efficiency plan that we are bringing together, and the current assumption is that, when we produce the final plan, we will do something in May to launch the final energy efficiency plan.

Alongside developing a policy, we will consider how we will measure it. In each sector, there is a live process of considering ways in which we can track progress against the things that we say are important. In the future, we will do that by producing an annual report, which we plan to do in October this year.

It is difficult to talk about how each of those things will look until the committee sees the plan itself. However, we have a good set of metrics and they are timely, so the committee will be able to see, on most occasions and in most sectors, when we are off track and when we are on track. You will be able to track that annually, at least, and I am sure that the committee will be interested in doing that in the future.

The process is on-going and, in that sense, there is a role for the committee in defining how members want to scrutinise those measures. I am sure that you will want to return to that once you have seen the final plan.

Again, there has been a stakeholder process alongside these things; therefore, we think that the metrics and forms of evaluation will mean something to each of the key stakeholders in each of the sectors. I hope that the process is live in the sense that we do not set these metrics and then let them go. As the proposals and policies in those sectors develop, we will develop the monitoring and evaluation framework. The plan is a very live thing, but I think that you will be happier in February, when you see that the framework has improved since we spoke last year.

12:00

The Convener: You suggested that you would publish the annual report in October this year. Is that the intended timing for future years? That would sit relatively well with the timing of the budget.

Chris Stark: That is our intention, but, if you would prefer a different arrangement, I am sure that we could accommodate that.

The Convener: The committee can reflect on that.

John Scott will now ask about emission envelopes and ambitions.

John Scott: I am pleased to hear that you have been interacting with stakeholders in developing the draft plan. I again declare my interest as a farmer. What progress have you made on the level of ambition for emission reductions in the transport and agriculture sectors? I would be grateful if you could tell us a little about that, although I appreciate that what you can tell us might be limited.

Chris Stark: I mentioned the four ways in which we have been amending the plan. You have picked out two of the sectors in which the product of that work is probably evident. When it comes to transport, I do not mind saying that we will have greater ambition—that is written into the programme for government—and a great deal of that is climate led. Our programme on transport has responded to the criticism that we received on the draft plan, and I hope that, once the plan is published, you will see greater ambition in the transport sector.

John Scott: Are there any specific areas that you want to comment on?

Chris Stark: I do not mind drawing out the measures that have been published. I will deal with the three issues on transport as I see them. There is the active travel package, which I think is one of the biggest things that we have done. The headline-grabbing item was the commitment on ULEVs, which is eight years in advance of a similar commitment by the United Kingdom Government. In addition, there are low-emission zones, which are probably one of our primary routes to achieving the goals that we want to achieve in transport.

That amounts to quite an ambitious package on transport, although it is worth saying that there was already quite an ambitious package on transport. It is not in any sense the case that what we published last year was weak; I just felt that there was more that we could do. I am pleased that we have done more, and you will see that reflected in the plan.

On agriculture, there is a more interesting story to tell. In each of the sectors, as we have refined our analysis, we have come to understand better how we need to approach the climate objectives that we have set for ourselves. We have obtained a greater understanding of how difficult it is to make progress in agriculture and land use. I am keen not to leave the committee with the impression that we have stepped back in our ambition on agriculture, but we have understood that it is harder to make progress there. Without revealing exactly what is in the plan, I can say that you will see that in the plan, too.

John Scott: We have discovered, through our budget scrutiny, that there is a need for greater dissemination of information from our esteemed science community, which has some of the solutions. The dissemination of such knowledge to rural communities needs to be better developed. I am a great believer in the use of the carrot rather than the stick, but I think that there is a lack of awareness in rural communities that the Government is immensely keen on the use of such information. That message needs to be conveyed more effectively than it has been thus far.

Chris Stark: I agree with that. I return to the point that we now have a better understanding of the challenges that are faced in agriculture. As a sector, agriculture is doing very well from the point of view of its carbon absorption and, indeed, its emissions. The 2015 statistics show that agriculture emissions have come down by more than 25 per cent from baseline levels. There is a nice trend there, which we would like to continue. However, it is a more difficult sector to decarbonise, and attitudes in the agriculture sector matter immensely to that. I agree that there is more that we can do with the sector to make Government priorities known.

John Scott: There is an enormous level of ingenuity in that sector. If It becomes the mindset of practising farmers and those involved in the industry that that is something that everyone wants to achieve, subconsciously that will have an effect over the long term.

Chris Stark: We occasionally talk about co-benefits, which is not a very accessible term. There are benefits in every sector to addressing climate change, and they vary. For example, developing a low-carbon agricultural sector is also a means to seeing that sector continue to thrive in the future. Those are the arguments that we need to make more strongly.

John Scott: You do not believe that the two are incompatible.

Chris Stark: No.

Mark Ruskell: I want to ask about transport. The original plan was predicated on an increase of

about 27 per cent in the number of vehicle miles. That obviously makes a big difference to the plan. On 5 December, when Humza Yousaf was in front of the committee, giving evidence on air quality, he said:

"we do not predicate our approach on increasing traffic".

He went on to say:

"It would certainly give me concern if local transport strategies were predicated on increasing the number of car journeys."—[*Official Report, Environment, Climate Change and Land Reform Committee,* 5 December 2017; c 15.]

What will the final climate plan be predicated on?

Chris Stark: We draw on the work of my colleagues in transport, who have a well-developed—probably the most developed—method of appraising projects that involves using what is called the transport model. It has within it a set of assumptions. We have not tried to change those assumptions, although, if we are successful in implementing the active travel package, I would expect the assumptions to change in the future. You will see that.

Mark Ruskell: The transport minister has said that you do not predicate your approach to air quality on increasing traffic, but you are saying that the approach in the climate plan is still predicated on increasing levels of traffic. Do you see that as a bit of a mismatch?

Chris Stark: No. There is a set of assumptions contained within the modelling that is done by transport colleagues, which we are happy to adopt, and they are not predictive.

Mark Ruskell: Which set of assumptions—assumptions that there is going to be an increase in traffic or assumptions that there is not?

Chris Stark: I do not know the specifics. I am sorry.

We do not have a separate climate model for transport; we fall in behind how transport colleagues view the future. The assumptions are not designed to be self-fulfilling prophecies, however. I expect that, if we are successful in some of the things that we are trying to do in transport, the assumptions will change. They are exogenous to the model that we use.

Mark Ruskell: Just to be clear, is the minister wrong?

Chris Stark: I make no statement about whether the minister is right or wrong. I do not have the data in front of me.

Mark Ruskell: His statement may contradict the data that is received by your Transport Scotland colleagues in producing the climate plan.

Chris Stark: I would not want you to infer that I am making any judgment about Mr Yousaf's view of the future. I am explaining how we adopt the transport model for the climate model.

Claudia Beamish: Good morning to you all. I have one brief question on transport and one that is a supplementary to John Scott's on agriculture.

The committee recommended that, as the transport sector is one of the heaviest emitters, the model should be rerun with more of a focus on active travel. Is it the case that the model was not rerun? I respect the fact that active travel funding has been increased, but I ask for clarification on that point.

Chris Stark: I ask my colleague Mike King to answer that and to explain to the committee how we have approached the transport work over the past twelve months.

Michael King (Scottish Government): As Chris Stark set out, the transport analysis focuses on a report that was commissioned by Transport Scotland and produced by Element Energy, which set out a pathway for the transport sector. That analysis has been updated since then to take account of the programme for government commitments, and that is the transport analysis that now informs the development of the final plan. That analysis is deemed to be the most up-to-date evidence for how emissions will evolve in the transport sector. We have adopted it into the wider TIMES framework to understand what the impacts are for all the sectors in the TIMES model and framework. That is the approach that we have taken to transport modelling.

Claudia Beamish: In layperson's terms—I am sure that I will never understand the TIMES model—does that mean that the Government's active travel commitments and the budget increase in the programme for government have now been included in your deliberations?

Chris Stark: Yes.

Claudia Beamish: I want to follow on from John Scott's earlier question. I respect his views as a farmer, but I highlight that agriculture, along with transport and housing, are the heaviest emitters. Is there a place for some compulsory focus as well as voluntary support, which is—I agree with my colleague on this—very important? That might be difficult in agriculture, which is more diffuse, but a number of compulsory arrangements are being developed in transport. They are in part to do with pollution, but they are also to do with climate change, congestion and other issues. Can we have a comment on that, please?

Chris Stark: I do not feel that I am equipped to make a judgment on the most appropriate policy measures, but I am content with what is in the plan.

Claudia Beamish: You have already made a comment on agriculture, and there is some agreement between you and John Scott. I am asking for your comment on the other side of the coin—on compulsion.

Chris Stark: I acknowledge that it is important that we take food producers and farmers with us in the process. We have discussed the many reasons why that is a good idea. I would love to have said exactly what is in the plan, but I think that you will know a great deal of it.

Claudia Beamish: I am not asking about that.

Chris Stark: Exactly. I suppose that the right way to answer your question is to say that we will monitor progress against the goals that we have set in the plan. Again, that is when the monitoring and evaluation framework will come in. If we are not on track, we will re-evaluate our approach.

You are right to raise the transport example. That is where we have built a good evidence base to do the things that we are doing.

I think that the agricultural work is good and that, in the future, we will see the extent to which the trend that we have already seen is maintained. If an element of greater compulsion is required and the evidence supports that, we can return to that and re-evaluate our approach.

Claudia Beamish: Are you aware that our predecessor committee in the previous session was concerned that it was perhaps time for more compulsion? I highlight that point.

Chris Stark: Yes. That is noted.

The Convener: I want to clarify something; I hope that you will be able to answer this. The elements of the programme for government that address transport have the potential to facilitate considerable improvement in the performance of that sector. Does that take the overall plan to a more ambitious place, or has there been rollback in any other sectors that would mean that, in effect, the plan is neutral in terms of performance?

Chris Stark: Those are certainly not terms that I recognise. I would not use them.

We have readjusted between the sectors. For example, to address the legitimate criticism that our projections on heat decarbonisation were very ambitious, we have made the plan more realistic. One way that we can do that is by being more ambitious in some sectors than we were in January 2017. Transport is one of those sectors.

We will need to be incredibly successful in rolling out the plan if we are to meet our targets—even those that we have now. I believe that we will be, but the harder that we make this by having a harder headline target, the more we will need to focus on making it a success. That requires us to be conscious of how much ambition we have in every sector.

My ambition is that we overshoot wherever possible, and you will see that in the plan.

12:15

The Convener: To be clear, you are saying that there will be changes that might bring about a raised eyebrow, but they are based on an outbreak of realism, as opposed to just deciding that something would probably be too difficult to do.

Chris Stark: Definitely. That is a very good way of characterising it.

The Convener: Let us move on to policies, proposals and assumptions.

Angus MacDonald: This has partly been covered. It is clear that everyone needs a plan B. Our committee report last March recommended the inclusion of a plan B when particular assumptions have been made that might prove to be unfounded, particularly in the case of CCS, which you mentioned. For clarification, have you produced any plan B time scenarios should any of the significant assumptions that are made in the plan—such as, for example, on the reliance on CCS—fail to be deliverable?

Chris Stark: It might be worth saying a bit more about CCS, as I know that it has been of interest to the committee. That is another area in which the committee will see a change. I have already referred to that.

Without saying specifically what is in the plan, I do not mind telling you that we are not projecting CCS before 2030, so the plan that we will publish is in effect without CCS. However, it remains essential to the future. The effort that we have made during the past 12 years to maintain CCS as an option with the funds and resources available to us in the Scottish Government is to ensure that we have that option available to us. We are very pro CCS.

You will not be surprised to hear me say that I am unhappy with referring to a plan B. The plan still has CCS in it, albeit that there is a set of projections that do not rely on it. That is the best way to describe it.

There are other areas in which we are changing the plan. However, it is a plan: I want to be clear on that. It is the Government's plan. We have thought a lot about scenarios and presenting them in different ways, and we think that the best way of going about it is to make a single plan and to open ourselves up to scrutiny. As I have said to the committee previously, one of the ways in which we will do that is by putting the model out, allowing

others to do the inquisition that allows them to produce some of the scenarios that the committee has asked for in the past, and using that as a basis for discussing future iterations of the plan.

The committee will see a single plan, which will be a plan A, albeit an amended version of the one that was published in January last year.

Finlay Carson: We have already touched on agriculture. Does the plan refer to any specific requirements regarding soil testing?

The lack of information on blue carbon was commented on earlier. Is there any mention of the potential of blue carbon in the plan?

Chris Stark: I am happy to report that blue carbon will be a part of the plan. That is a really good story of the scrutiny that the process has put us under. I am quite excited by some of the things that are happening in blue carbon.

Although you will find blue carbon in the plan, it is not yet part of the greenhouse gas emissions inventory. You will see a plan for that to be the case in future, and Scotland should be in the lead on that, given all the advantages that might come from having blue carbon as part of our inventory.

On soil testing and how compulsory it is, I am afraid that you will have to wait until February to read the plan. I go back to the story about the agriculture sector more generally. The elements of compulsion have been subject to a great deal of scrutiny in this committee and in others, and there has been an active internal process that has led to the set of policies that you will see in the final plan.

The Convener: We will look at that with interest.

Let us develop the theme of realism. Given that the funding that is available in the draft Scottish budget for peatland restoration is considerably less than that in the current budget, has the draft plan target to double planned peatland restoration been reduced?

Chris Stark: You will, of course, have to wait until we publish the plan, but the—

The Convener: God loves a trier.

Chris Stark: Indeed.

The other thing to say is that we are still actively discussing some of those things. I do not want to be too dismissive of the question, because on some issues we are still doing our best to resolve the final plan. I therefore feel comfortable in saying to you that February is the appropriate point at which to talk about those things. It might be enough simply to say that we know that peatland restoration is very important, and we have done the analysis to show how important it is. We have, of course, noted the draft budget and its impact. It is important to say that I am hopeful that peatland restoration will continue to be funded in the way that I am sure the committee would like it to be. The budget is part of that planning, and I am sure that there will be future iterations of budgets.

The Convener: We would also like it to be funded in a way that is capable of delivering on a doubling of the target.

Chris Stark: Well, you will have to wait to see the target, will you not? However, I note your interest.

The Convener: It is a very strong interest. I of course recognise the issues around the budget. Last year, some of the sums were drawn down from other sources.

Chris Stark: They were.

The Convener: There is a legitimate issue here. Obviously, peatland restoration is an important contributor to our performance.

Chris Stark: I am desperate not to be slippery. Peatland restoration is very important, and it is remarkable how big the impact will be in future years. Far be it from me to try to direct the committee, but that is one area in which co-benefits are really important. There are a number of reasons for pursuing a policy of peatland restoration, and we will, of course, make that argument internally, as you would expect us to.

The Convener: That is about issues such as water quality.

Chris Stark: Indeed. Building an industry around those things is another argument.

The Convener: There are certainly employment opportunities.

Chris Stark: Absolutely.

The Convener: Let us explore behavioural change.

Richard Lyle: Basically, the plan will work only if the public buy into it. Do you agree that changes in behaviour will be needed? In particular, do we propose—you might want to say yes or no on this one—to have a policy of installing solar panels on new build to encourage people to use those, or a policy of installing electric car charging points on new build, so that people can plug in their car, just as they can currently plug in their phone or wi-fi? Alternatively, we could change street furniture to have charging points on it. What are we going to do to encourage the public to change their behaviour?

Chris Stark: I introduce the committee to the concepts of carrots, sticks and tambourines, which are the ways in which we have been considering the future approach.

The Convener: You have been saving that one up.

Chris Stark: Yes, I have—it is a rhetorical flourish.

Richard Lyle: I have heard of carrots and sticks, but not along with tambourines.

Chris Stark: In the past—although certainly not on our watch—policy development has been littered with policies that have not met the third of those elements, which is about feeling compelled or wanting to do something. For example, a great deal of work has been done on the green deal, which was a UK policy that did not work as well as intended when it was introduced. I believe passionately that the reason why that policy did not work is that it was principally a financial instrument and it did not have the tambourine element, or the feeling of wishing to do something.

I could not agree more with how Richard Lyle summarised the issue. We will not be successful unless there is a change in behaviour. That requires a deep consideration of the appropriate way in which to change behaviour.

We have been thinking about the concepts of carrots, sticks and tambourines particularly in relation to the energy efficiency programme that I mentioned. That programme will last for at least two decades in order to realise an overall improvement in the quality of the building stock in Scotland as well as the other things that we have included in it. To be successful, we probably need a programme that, for the first ten years, looks more at incentives and, for the second part, looks more at the harder-edge stuff. It is the foresight that will build the industry—knowing that that will come.

You are right to raise those issues, which will be enormously important. How we plan the built environment around us is an area in which we need to be much clearer about the way in which things must change. We must give suitable foresight to allow industry and consumer behaviour to respond.

I am keen on having a better regional or local plan around such things. Written into the DNA of the energy strategy that we published just before Christmas is the idea that we will need better localised planning around the whole energy system—heat, power, transport and the built environment. We need a well-integrated set of localised plans for those things that will cover the issues that you referred to in your question, such as charging points, solar panels on roofs, recovery of waste heat and so on.

There is a grand endeavour over the next two decades that will require everyone to better understand how they fit into the plan. It will require us to have a plan in the central belt that is different from the plan in the Highlands and Islands, for example. Behind all that is the harder-edge set of things, including building standards, regulatory tools and the legislation that we will need to put in place to make it work. However, we cannot do it through those things alone—we will need some tambourines along the way, too.

The Convener: You will have found the recent announcements by certain house builders that they will voluntarily take a positive approach to electric charging points, and, to a lesser extent, solar panels, encouraging.

Chris Stark: That is exactly what I am talking about. Just the promise of a harder-edge approach is often enough to catalyse change in the market. Do not forget that we are talking about infrastructure, so decades is the correct time horizon. Unless we are planning well now, we cannot expect the industry to respond and nor can we expect consumers to respond in the right way.

Richard Lyle: Many years ago, people never considered having a telephone plug-in point in their house, but now it is standard, as is wi-fi.

When was the last time that you advertised on television to suggest that people should not go out in their cars, but should have a wee walk to the local shop?

Chris Stark: I do not know. It is a perfectly good question. We pursue a set of policies and marketing strategies, including under the banner of greener Scotland. I will go away and find that out forthwith.

Richard Lyle: You should put it in the plan, alongside the tambourine.

Chris Stark: I agree—we should have tambourines.

Alex Rowley: You talked about the built environment. Has there been clear discussion about the draft planning bill in relation to the climate change plan and will we be able to see where those fit together?

Chris Stark: In my time in the job, I have learned that, for very good reasons, planning does not move quickly. It is right that it does not move quickly because in making any change to planning, it is important to have a good strategy in place for what you are trying to achieve. We now have that for energy and climate issues. I hope that the planning regime will follow that. That is the right way to do it.

Alex Rowley: Given the legislation that is under way, will the committee be able to see where there is opportunity under the planning bill to drive such initiatives and developments?

Chris Stark: You will.

Alex Rowley: Have you been working at that?

Chris Stark: Yes. The planning bill is an important process for us all, but particularly for my department, given the issues that I have just talked about.

I draw your attention to a couple of things. First, there is a second stage consultation around local heat and energy efficiency planning. That is the blueprint for what I have just described. It is a local authority-led approach to local plans around energy efficiency and heat. It is not a great leap to think that we might add transport planning to that, which means that you have an almost full picture of a local plan for all those things. The committee will be able to see that.

I draw your attention to the future revision of the national planning framework, which will be cognisant of the climate change plan and also the energy strategy, which has the right long-term horizon to demonstrate how we can decarbonise our energy system.

12:30

The NPF and associated Scottish planning policy, alongside the plans for localised heat and energy efficiency and transport, will allow you to see what you want; local and regional plans will be well-integrated in the future, which is the right way to go about it.

Alex Rowley: I look forward to seeing whether that is the case. You spoke about carrot and stick approaches. It is interesting that McDonald's recently announced its plan to do X, Y and Z in 2030. By then, most of its executives will have moved on. Is there a danger in company after company making big announcements about what they will do in a couple of decades ahead, while they are not doing very much now?

Chris Stark: I recognise that there is definitely a risk, although I regularly see corporate practice change quite dramatically. In recent years, outlooks about investment holdings by organisations such as universities have changed quite dramatically.

I suppose that the right answer to your question is that we need to be active rather than passive about such things. We need long-term plans that every corporate in the Scottish economy wants to follow. The plans need to be developed with the individuals who are in those corporates, as a corporate is not a thing. The right long-term targets and objectives in each sector will give a platform to discuss with the industries in those sectors how to develop the right plans together. I hope that we will overshoot the targets that we have said that we will achieve. That will need a mixture of carrots and sticks; the tambourine is for the corporates that want to do this plan because it is in their commercial interest—in that area, we have not been as strong as we might have been in the past.

For corporates that operate in the Scottish economy, I want to work harder so that they do this plan because it is in their corporate interest and will grow the business, not because it is a corporate social responsibility measure. Our impact on global patterns of climate change is small, but we are doing this plan for an economic reason. If we turn around and decarbonise the Scottish economy, our products and services will sell to the global market as other countries do the same. That principle cannot just sit in a document; we need to work hard to establish corporate attention, daily and weekly. I ask you to hold us to account on that approach.

Mark Ruskell: The climate change bill will bring in new targets for 2020 and 2030. How does the plan address those new targets? Is it sufficient to meet the new targets?

Chris Stark: We put the plans together to meet the current legislation, but we have had the 90 per cent trajectory in mind all along—the people who consider the issues are the same—and there will be a process for the new bill. The bill process has been separate to the formation of this plan, and we will have to bring those two things together later this year when the bill goes through Parliament. We wait to see the targets, which are a central issue. I cannot say here today the extent to which we may need to amend the current plan.

The UKCCC has been through the 90 per cent target with us so that we understand it. It says that 90 per cent is in line with the objectives that were set in Paris, although that target will be extremely challenging, and that the current plan will be just about sufficient if everything goes well. We are looking at that analysis, and I hope that we can do better than that. We may need to revise the plans, but it will depend on the trajectory of future climate emissions.

Mark Ruskell: The First Minister said in Bonn that a net zero carbon target was still being considered, whether that would be set at 2040 or 2050. Various countries are moving down that line, including Germany, Finland and Sweden. Do you see there being a radically different approach if we were to set a net zero carbon target? Would it make a difference to the traffic growth of 27 per cent, for example, or would more fundamental changes be required?

Chris Stark: I will give you my personal view, because I do not think that we have set out the analysis of that. I do see a difference between net zero and a 90 per cent reduction—the plan will need to be on a pretty steep trajectory to get to net

zero. Other countries have set that target—people often talk about Sweden, for example—but they have done that in the knowledge that it might mean that they buy international credits. The hallmark of the Scottish plan is that it has been a domestic effort, and that is what I want to keep.

Mark Ruskell: Are you saying that you want to get rid of the provision of carbon credits within Scottish legislation?

Chris Stark: No, I am not saying that. I am saying that I am keen to maintain the hallmark of the Scottish plan, which has been a domestic effort. We are not relying on some of those international mechanisms.

The Convener: I thank the panel for their evidence and take this opportunity to wish Chris Stark well in his new role at the UKCCC. The committee looks forward to engaging with you in that capacity in future. I am sure that you are looking forward to offering the Scottish Government advice on the development of policies that you have brought forward.

Chris Stark: Well, they are a good bunch.

The Convener: On a point of information, my colleague Claudia Beamish has just asked whether you will still be in your post here until the end of February.

Chris Stark: I will; indeed, my start date has not been arranged yet. It is good to have that on the record. I do not want there to be any implication that I am conflicted in that role. We will work that out, but I wanted the committee to know about it, although the appointment process has not formally completed yet. We will be very careful about the way in which we manage the roles in the coming period.

The Convener: It is a very good choice on the part of the UKCCC.

Chris Stark: Thank you.

The Convener: At its next meeting on 6 February, the committee will take oral evidence from stakeholders on the Scottish Association for Marine Science Research Services Ltd's report, "Review of the Environmental Impacts of Salmon Farming in Scotland". The committee also expects to consider its proposed approach to consideration of the Scottish Crown Estate Bill and a draft report on its inquiry into air quality in Scotland. As agreed earlier, we will now move into private session.

12:37

Meeting continued in private until 12:57.

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