PINK SALMON WORKSHOP

NOVOTEL, EDINBURGH

21 SEPTEMBER 2017

MINUTE OF MEETING

This is a brief minute of the Pink salmon workshop held in Edinburgh on 21 September 2017.

The agenda for this meeting is provided in Annex 1 of this note. The names and affiliations of workshop attendees are provided at Annex 2.

1. INTRODUCTIONS AND AIMS OF THE MEETING

The meeting was opened by Colin Bean, who introduced the broad aims of the workshop. These were to ensure that we:

1) understood the history of Pink salmon introductions within northern Russia and western Europe, the scale of historical catches around this area and the nature of catches made in 2017. These may help to inform our views as to what might be expected in future (possibly odd) years;

2) had a common understanding of Pink salmon ecology, species plasticity, invasiveness and implications of phenological change. This type of basic information has been used to develop the existing Risk Assessments for this species in UK and Europe;

3) were aware of current surveillance and management measures in use across Europe. The workshop would examine their efficacy and explore the potential use of new monitoring tools (such as. eDNA); and

4) would, at the end of the workshop, be in a position where we can Identify knowledge gaps, and identify how these can be addressed – and by whom.

2. SETTING THE SCENE

2.1 Overview

By way of an introduction to this item Colin Bean [CB] outlined a brief history of Pink salmon introductions in northern Russia and the probable source of fish captured in western Europe over the last sixty years. Pink salmon were first introduced into the White Sea basin in 1956 with annual egg transfers of ‘even-year’ fish from Far east of Russia (Sakhalin Island and northern Kamchatka) over a period of 20 years.

These early introductions utilised ‘even year’ Pink salmon spawn which, because they spawn relatively late in the year were not adapted to the low temperatures experienced in northern Russia and introductions failed. The stocking of ‘even year’ Pink salmon ceased there in 1979.

‘Odd year’ Pink salmon, which spawn earlier and are able to withstand colder water temperatures, were introduced into the White Sea basin from the River Ola stock in 1985. Self-sustaining populations were quickly established in rivers around Murmansk and Arkangelsk, and adult Pink salmon have been recorded in at least 40 northern Norwegian rivers and two Finnish systems since 1960.

CB added that occasional Pink salmon have also been recorded in Scottish waters since that date, but in very low numbers – 17 fish over 65 years. It is suggested that this may be a significant underestimate of the actual numbers of Pink salmon which have entered Scottish waters.

2.2 Country Reports

Prior to attending the workshop, participants from each country were asked by CB to come prepared to present data under four headings. These were:
1) An overview of historical catches until 2016;
2) A review of the situation in 2017;
3) A description of the management measures in place within that country; and
4) A statement about the availability of data and biological material for those organisations which may need it for research/management purposes (such as genetics, SIA analyses etc.).

Country-by-country presentations, following this structure, were presented and these have been made available to workshop attendees and the wider email discussion group by Dropbox. The key messages from each talk are recorded below:

2.2.1 SCOTLAND: (Alan Wells - Fisheries Management Scotland and John Armstrong - Marine Scotland Science)

a) Historic catches.
Pink salmon catches extend as far back as the 1960's, though numbers have been low during the period 1960 – 2016. Most catches occurred in odd years, (1960 (1fish); 1965 (1 fish); 1967 (2 fish); 1973 (5 fish); 2003 (1 fish); 2007 (1 fish); 2009 (1 fish); 2011 (2 fish); 2012 (1fish) and 2015 (1 fish)).

b) A review of the situation in 2017.
A total of 139 Pink salmon were recorded in 2017 - 75 rod and line; 24 commercial nets; 26 targeted netting; 8 observed. And a further six dead fish have been reported. There is some evidence of fish moving as far as 50 km upstream in the River Dee (Aberdeenshire).

c) A description of the management measures in place.
Spatial records collated by Salmon Fishery District and collated by Fishery management Scotland (an umbrella body for District Salmon Fishery Boards in Scotland). FMS has, in consultation with others, developed advice on Pink salmon identification and retention and provided this to the network of DSFBs and Fisheries Trusts. This has been disseminated onwards to anglers.

Members have taken samples from captured fish and stored scales, tissue samples and whole carcasses.

In addition to this local biologists have monitored the distribution of fish within their catchments – mostly visually and by collating the records of others. One DSFB (Ness) has carried out detailed monitoring of spawning behaviour. Redd marking has been carried out in three significant river systems by at least three DSFBs (Ness, Dee and Thurso).

Attempts have been made to excavate eggs and manually disrupt marked redds. Some of these eggs have been removed and are being monitored by Marine Scotland Science at various temperatures to assess hatching success. Others have been held *in situ* in egg boxes to monitor hatching success in the wild.

In the laboratory, eggs which were believed to have been laid on 14 August 2017 were excavated on 7 September 2017, are being held in groups of 100 at approximately 14, 16, 18, 20, 22, 24 ^{o}C. High mortalities were observed at the highest temperatures (24 ^{o}C (100%; 22^{o}C (67%) with less than 5% at other temperatures within the series. Hatching was recorded at three temperatures (as at 20 September 2017) – 18 ^{o}C (three eggs); 20 ^{o}C (two

eggs) and 22 ^{o}C (two eggs). It was suggested that survival rates could be related to modelled temperature data to assess likelihood of successful spawning. A visual assessment against temperature maxima suggests that viable hatching may occur over large areas of Scotland. Estimated mergence dates calculated from literature values across a plausible temperature range for Scotland suggest that this is likely to occur in autumn/early winter. It was suggested that sea entry, which typically occurs soon after emergence, may therefore be poorly matched to optimum seasons for survival. Key questions were posed: First, are there any successful populations of pink salmon emerging in autumn/winter? Second, can the colonisation risk zone be modelled using data on spawning date and ambient temperatures to predict emergence/emigration date in relation to season? (It was subsequently reported that such an approach was in development by Norwegian colleagues). .

By way of a postscript – eggs successfully hatched in the River Ness on 23 September 2017.

d) Data and material availability.
In terms of material available for further work, 23 scale samples, 28 frozen samples are available. A further 12 fish have been passed to the Marine Scotland Fish Health Inspectorate from Fishery Trusts and District Salmon Fishery Boards.

2.2.2 ENGLAND: (Jon Shelley and Gareth Davies - Environment Agency)

a) Historic catches.
Historic records of Pink salmon captures in England extend back to 1960 and anecdotal reports exist from the 1990's onwards. Many the most recent reports have come in odd years (e.g. one fish from the River camel in 2007, and small numbers in coastal nets in 2009 and from both nets and fisheries in 2015).

b) A review of the situation in 2017.
During 2017 there have been fairly widespread reports of Pink salmon catches in Yorkshire and the North East England coastal net fishery. No exact figures are available of the numbers of fish captured by these fisheries, although the estimated number of fish captured between the Scottish border and the East Yorkshire coast is c. 200 fish. No fish were captured after mid-August.

Rod caught Pink salmon records have been come from North West England (River Cocker), Southern England (River Frome (Dorset) and the River Avon (Hampshire)), Yorkshire and the Yorkshire & North East (rivers Tyne, Coquet, Wear and Hull). Other observations (of dead or pre-spawning fish) have come from the River Duddon estuary (North West England) and lower Hampshire Avon respectively.

c) A description of the management measures in place.
An internal management group established by the Environment Agency and an advice note was issued which asked the public and netsmen to report any Pink salmon catches and retain any fish captured. The Pink salmon issue was widely publicised via traditional and social media outlets to alert anglers. A review of the legislative framework for managing the issue was also undertaken. Post-mortem examinations of Pink salmon carcasses were also undertaken. These yielded nothing of particular concern from a disease of parasite transmission perspective and virology samples have also been taken from a small number of animals. The Environment Agency has maintained a watching brief on the issue and continues liaison with wider interests.

d) Data and material availability.
The Environment Agency received nine Pink salmon carcasses and these have been retained in frozen storage. Samples of fins, muscle, scales, etc have been preserved from all fish for future work.

2.2.3 IRELAND: (Michael Millane – Inland Fisheries Ireland)

a) Historic catches.
The first record of Pink salmon caught in Ireland was from the River Moy in 1973. Since then, occasional and largely anecdotal reports of Pink salmon have been made. These have been restricted to the west (Moy and Corrib systems) and south west (Munster Blackwater) of Ireland.

b) A review of the situation in 2017.
A total of 32 Pink salmon have been captured from ten river systems in Ireland during 2017. All but one of these fish were captured by anglers between the months of June and September. Peak catches occurred in July. One fish was retrieved from an illegal net. All of these fish were captured in river systems which extend from the north (Crana and Lackagh), north west (Ballisodare, Drowes, Garavogue and Moy) and west (Corrib, Erriff, Owengarve and Owenmore). Pink salmon have been captured significant distances upstream – up to 34 km upstream in the case of the River Corrib.

An additional Pink salmon was captured in the River Mourne, part of the Foyle system which forms the border between much of Northern Ireland and the Republic of Ireland.

c) A description of the management measures in place.
Following the appearance of Pink salmon in Ireland, Inland Fisheries Ireland embarked on extensive public awareness campaign. The primary aim of this was to increase reporting rates and to encourage anglers to retain any specimens caught for verification and subsequent scientific assessment.

IFI are also leading on the development of a Pink salmon risk assessment, in an attempt to to evaluate the potential impacts of the species in Ireland.

d) Data and material availability.
A total of 13 Pink salmon carcasses have been retained and stored by IFI and a range of biological samples (e.g. scales and tissue) will be removed. Carcasses will also be assessed for the presence of parasites and pathogens. IFI intend that these materials will be used for life history, genetic and genetic analyses, and some material may be used to develop eDNA assays. No decision has been made as to how the samples will be distributed for scientific assessments that IFI cannot conduct in-house. However, pathogen and parasitic analyses will be conducted by the Fish Health Unit of the Marine Institute.

2.2.4 NORWAY: (Ingebrigt Uglem and Kjetil Hindar - The Norwegian Institute for Nature Research, NINA)

a) Historic catches.
Even-year Pink salmon released in Russia from 1956 – 1978 did not establish successfully, but later introductions from 1985 – 2001 using odd-year fish did establish self-sustaining populations. Pink salmon have been recorded in northern Norway since 1958 and large numbers (25-50 tonnes) were captured along Norwegian coast during the 1960s and 70s. catches have been limited until 2017.

b) A review of the situation in 2017.
A total 2773 Pink salmon have, up until 21 September 2017, been caught in the sea and in riverine sport fisheries. It is thought that more fish will be reported over the course of the year, and numbers will be refined once reports are received from individual rivers and bag nets. So far, reports of Pink salmon catches have been reported from sport fisheries in 236 Norwegian rivers, extending over 15 counties and covering the length of the country. Recent rod catches for 2015 and 2016 were 162 Pink salmon from 21 rivers and 159 Pink salmon from 30 rivers respectively. The numbers observed in 2017 are, therefore, a significant increase on previous years.

c) A description of the management measures in place.
In Norway Pink salmon have been subjected to increased 'catch and kill' angling pressure in rivers where they are present. In 22 rivers (in counties Finnmark, Troms, Nordland and Møre og Romsal), measures such as removal by harpoon and netting have been used in addition to the use of sports fishing gear. Whilst 1639 fish had been removed in this way at the time of writing, the actual number of fish killed is not yet available and may be higher than reported here.

In addition to the removal of fish, Pink salmon redds have also been disrupted through raking of the river substrate. The efficacy of this measure has not been assessed.

d) Data and material availability.
Small numbers of Pink salmon scales are available from 1999, although samples are available from more than 300 fish captured in 2017. Samples of whole fish (frozen) or fish tissue are also available from 80-100 individuals

2.2.5 ICELAND: (Guðni Guðbergsson - Marine and Freshwater Research Institute, Iceland)

a) Historic catches.
The first Pink salmon reported in Iceland was captured in 1960. Since that date Pink salmon have been captured in most years, and most abundantly in odd years. The actual number of Pink salmon captured in Iceland may have been under-reported because female fish have been misidentified as Arctic charr.

b) A review of the situation in 2017.
Approximately 60 fish have been reported from Iceland during 2017.

c) A description of the management measures in place.
There are no specific management measures in place to protect native fish from Pink salmon in Iceland, and there has been no systematic research carried out to assess recruitment or recruitment potential.

d) Data and material availability.
Scale samples and DNA are available from *c.*20 fish which were captured in 2017.

2.2.6 DENMARK: (info supplied by Finn Sivebæk - Danmarks Tekniske Universitet)

a) Historic catches.
Only two historical records of Pink salmon are available for Denmark. One fish was captured from Vejle Fjord on the coast in 1976 and one fish was recovered from the River Ribe Å in 2007.

b) A review of the situation in 2017.
A total of nine Pink salmon have been caught in different rivers (Storå, Varde Å, Sneum Å, Kongeå, Ribe Å, Vidå samt i Sæby Å and Uggerby) in 2017. A further two were captured in coastal areas (Kattegat and Skagerrak).

c) A description of the management measures in place.
Action has so far been limited to observing the situation, compiling records and taking general samples (including tissue) from the catches.

d.) Data and material availability.
Scale and tissue samples are available from five Pink salmon.

2.2.7 FINLAND: (info supplied by Panu Orell, Jaako Erkinaro, Eero Niemelä - Natural Resources Institute Finland)

a) Historic catches.
Pink salmon have been caught almost annually in Tana and Neidenelva rivers since the 1970s.

b) A review of the situation in 2017.
There has been a significant increase in the numbers of Pink season entering the Tana and Neidenelva rivers during 2017. The final catch data is not available yet.

c) A description of the management measures in place.
There is no specific management in place within these river systems as yet. However, all Pink salmon captured are being killed.

d) Data and material availability.
The Natural Resources Institute Finland (Luke) has collected scale samples over the years and are keen to participate in future monitoring and research. From the Norwegian side (mostly on the lower River Tana, 0-70 km from the sea) 108 pink salmon scales have been collected in 2017. This has been supplemented by the collection of an additional 30 pink salmon scales from the Finnish side (middle-upper River Tana plus tributaries).

2.2.8 FRANCE: (info supplied by Jean-Luc Bagliniere, Quentin Josset and Laurent Beaulaton - French National Institute for Agricultural Research, INRA)

a) Historic catches.
Pink salmon have not been recorded from French rivers prior to 2017.

b) A review of the situation in 2017.
Two fish have been captured in France. One in the Canche River in northern France on 25 August. It was released. The second was observed in early September during video counting in the Elorn River in North Brittany.

c) A description of the management measures in place.
No specific management measures are in place at the moment.

d) Data and material availability.
No scale or tissue samples are available.

2.2.9 GERMANY (info supplied by Marko Freese - Thuenen-Institute of Fisheries Ecology)

a) Historic catches.
No Pink salmon had been recorded in German waters prior to 2017.

b) A review of the situation in 2017.
A total of three Pink salmon have so far been captured or seen in German waters. One individual was captured by angling in the Weser/Ems system and another was captured during an electrofishing survey in a small stream close to the Danish border. Another fish was observed during this survey by was not captured.

c) A description of the management measures in place.
No management measures have been put in place, although regional authorities have been informed of the presence of these fish and they will maintain vigilance during future surveys.

d) Data and material availability.
No samples were kept during 2017, but regional authorities have been asked to retain suitable samples in future.

3. The ecology of Pink salmon

CB opened the session by giving a very brief overview of the types of life history information which are available for Pink salmon from the literature and how these might compare with Atlantic salmon (e.g. Table 1)

Life stage	Pacific salmon	Atlantic salmon
Lifespan	2 years	Can be >10 years
Time spent in freshwater (adult)	~ 3 months	Up to 12 months
Spawning period	July-October	November-January (UK) Oct-Nov (north Norway)
Spawning strategy	Semelparous	Can be iteroparous
Egg to hatch	610 degree-days	440 degree-days
Time of emergence	December-March	April - June
Time spent in freshwater	<2 months - 3cm, 0.2g and 5°C	Up to 5 years – 12 cm, 20g and 10°C
Time spent in estuary/coast	3-6 months	<5 days?
Time spent at sea	1.5 years	Up to 4 years

Table 1. Basic life-history characteristics of Pink and Atlantic salmon taken from the literature.

The question of origin was also posed. It has, perhaps reasonably, been assumed that all of these fish have originated from northern Russia, but this is unconfirmed.

Eric Verspoor (EV) facilitated a wide ranging discussion relating to how this type of information may be used to determine whether Pink salmon may establish within the UK, Ireland and other parts of western Europe.

Plasticity: Much of this discussion related to plasticity within Pink salmon and Pacific salmonids as a whole. Gordon Copp (GC), using the example of Pumpkinseed, suggested that invasive species may be less plastic than we assume. EV used the example of Pink salmon establishment in the North American Great Lakes to explain how this species may adapt its ecology and lifecycle to new or novel environments. CB made the point that there is a body of literature available from Russian sources which may help determine the ability of Pink salmon to colonise new areas naturally and reveal how variable the ecology of this

species can be. It was suggested that the even-year Pink salmon population may not have succeeded because it didn't have the adaptive potential that the odd year population may have.

EV stated that we should focus our attention on those elements of Pink salmon ecology which we need to know in order to form as accurate a risk assessment as possible.

Recent spread: Conversation then turned to 2017 and why large numbers of Pink salmon are now being captured this year. Various views were put forward but attention focussed on climatic conditions. Carlos de Leaniz Garcia (CG) asked to what extent this may be seen as a one-off event or could we consider whether Pink salmon are simply adapting? CG went further and asked whether the 2017 cohort particularly adaptive, or was there something happening at sea that facilitated or permitted them to move larger distances? This provoked a short discussion re the development of expansion models and whether this is a direction that we should investigate. Phil McGinnity (PM) spoke about the nature of recipient habitats and asked whether these have now become more suitable for Pink salmon? It was agreed that this was a complex issue with little solid information to support any hypothesis, but was worthy of greater consideration.

CG suggested that the current invasion phase is the 'easy bit'. Fish are straying and eggs may be hatching, but to establish there needs to be more if populations are to become established. GC went on to say that modelling the expansion would be really informative and that is more likely to be a stochastic spawning expansion than a stepping stone process.

EV stated that there may be some genetic explanation that is selecting for straying and KH suggested that whilst Pink salmon are present in Norwegian rivers they may not be - sustaining at all.

Pink salmon versus Atlantic salmon: There appeared to be remarkable consistency in the timing of observed spawning activity throughout the geographical range of Pink salmon in 2017, with most fish initiating this activity at the beginning of August. Given that spawning may take place between July – October and that emergence could occur anywhere between November to March (based on scenarios put forward by Marine Scotland Science and NINA earlier in the workshop), discussion turned to the potential interaction between Pink and Atlantic salmon. Whilst accepting that most fishery managers will focus on the interaction between these two species, Kjetil Hindar (KH) also cautioned against this narrow focus and urged the group to think about the potential impact that Pink salmon may have on trout populations. CB added that there was also the need to consider impacts on non-salmonids, and Sea lamprey in particular. Any impacts on native juvenile salmonids may also impact non-fish species, such as Freshwater Pearl Mussel. Ingebrigt Uglem (IU) stated that Atlantic salmon within the Kola Peninsula appear to have been unaffected by the presence of Pink salmon and discussion within the group suggested that in rivers where complexes of Pacific salmonid species co-exist within their native range (such as Pink and Coho in the same river), there appears to be little negative overlap.

Ecosystem impacts: Jens Carlson (JC) asked what impact large numbers of Pink salmon will affect the ecosystem. It was agreed that large influxes of additional nutrients may have a significant impact on nutrient budgets in affected areas, and if numbers were significantly large and regular.

Feeding: JC asked what Pink salmon were feeding on. Gareth Davies (GD) and Chris Conroy (CC) confirmed that all of the Pink salmon stomachs examined during 2017 were empty. GD added that some fish captured in England were hosts to sea lice. Michael Millane (MM) queries what species of sea louse were found on pink salmon. GD confirmed that they were *Lepeophtheirus salmonis*. This is consistent with published accounts of Pink salmon as

host of this species within its native range. CC suggested that we could use scale samples to help inform the movements and diet of fish captured in our rivers.

Moving forward: EV suggested that we may be limited in what we can say at the moment, but that we should consider putting together a framework for moving forward. CB added that we need to focus on pooling the limited resources at our disposal – both financial and the biological material which has been collected so far. It was important to avoid any unnecessary duplication of effort across Europe and within the UK.

4. Pink salmon Rapid Risk Assessment

GC led the discussion on the risk assessment process and took the group through a brief presentation. Access to this has been provided to all workshop members and the email group by Dropbox.

By way of an introduction GC explained the origin of the risk assessment process – via the nuclear industry. He also explained that: 1) risk analysis should be a dynamic process which allows re-assessment as new data becomes available; 2) risk assessments should be used to inform decision makers and are not a decision-making tool; 3) risk assessments deal with adverse impacts only; and 4) they are based on current information and climatic conditions – not future scenarios. The current Rapid Risk Assessment for Pink salmon suggested that:

Entry – very likely – high confidence
Establishment – very likely – high confidence
Dispersal – rapid spread – high confidence
    Natural – rapid – high confidence
    Human assisted – intermediate – high confidence
Impact overall – Moderate – low confidence
    Environmental – moderate – low confidence
    Economic – moderate – low confidence
    Social – moderate – low confidence
Overall – high risk

GC added that there was a view that numbers were increasing from 2007 onwards and that most record follow the odd-year pattern that might be expected from fish originating for the Russian stockings.

He added that there was evidence of successful spawning but not of recruitment. Following this meeting (23 September 2017), Chris Conroy of the Ness and Beauly District Salmon Fishery Board confirmed that eggs held in egg boxes *in situ* within the River Ness had successfully hatched to the alevin stage.

There remains an absence of evidence of adverse impacts and there was a need to address this through the delivery of an appropriate R&D programme.

Initial discussion following the introductory talk focussed on establishment. More specifically how many reproductive cycles were required to confirm that a population is sustainable. A conservative view, put forward by GC, was that this might be 20 reproductive cycles, but could extend to 50.

Going forward, the workshop attendees were informed that the GB Non Native Species Secretariat (GBNNSS) would be commissioning a full Risk Assessment for Pink salmon. This process will be co-ordinated by the GBNNSS and they were in the process of identifying a lead to take this task on. Some financial resource are available for this, but this is relatively

small (~ £1K). Following receipt of a draft Risk Assessment, the document will be peer-reviewed and the final document has to be signed off by the GBNNSS Board.

CB asked if any other countries represented either had, or were planning to develop, a Pink salmon Risk Assessment. MM indicated that IFI were in the process of putting such a document together. IU stated that all INNS are assessed every five years within the Norwegian Black List Assessment process and Pink salmon should form part of that.

5. Drivers for Management – Themed breakout sessions

CB ensured that everyone at the workshop had signed up to contribute to one of the four themed breakout sessions. These were:

a) Data gathering and evidence;
b) Genetics;
c) Interactions; and
d) Management.

A list of participants in each of the four themes is provided at Annex 3.

Theme 1: Data gathering and evidence (Rapporteur – Colin Bean)

This group reported that there is a need for a coordinated approach to collecting and recording data relating to Pink salmon at an individual country level, at a UK level and that there should be some mechanism for data collected from Europe (as a whole) to be made available to all. For this to be of wider use, there is a need to identify the key data needs and, if possible, standardise the ways in which these data are obtained.

Much of the data obtained (based on the presentations provided during the workshop and historical records) is provided by recreational anglers and netsmen, rather than by specialised or targeted survey. There is a requirement, therefore, to provide the requisite training and materials to those individuals which will enable them to identify Pink salmon at all stages of development, and provide both data (such as location and time of capture) and physical samples (such as scales, tissue or whole fish, for laboratory analyses).

Within the laboratory, any samples received, should go through a standard post-mortem procedure, which should be standardised throughout Europe as much possible. Beyond identifying, what should be, basic data needs (e.g. morphometric data, parasitology, bacteria/viruses, age, sex, etc.) there appears to be little published material with regard to standard post mortem procedures which would allow comparisons to be made and for standards to be developed. The issue of sample storage also needs to be addressed, and it would be useful to identify minimum requirements and standard preservation protocols which would enable all those with a need to access these to obtain good quality material.

A range of potential survey techniques were explored by the group. These are summarised in Table 2 below and included a number of passive and active survey approaches.

There was a feeling that reliance on public reports (from anglers and netsmen) or on ad hoc surveys to identify the distribution of Pink salmon may result in significant under-reporting of Pink salmon distribution and numbers. Ways of increasing efficiency of data gathering, such as the use of geotagged mobile telephone ‘apps’ were also discussed.

Discussion then turned to alternative monitoring approaches, including the use of environmental DNA. Pink salmon eDNA assays have already been developed by JC at

University College Dublin and John Finarelli (JF) led a short exchange on survey designs which may reduce effort and maximise detection. Such an approach would require careful survey design to ensure that the upstream limit of migration was identified, and some consideration would have to be given to survey timing given that Pink salmon may only be present within the river for 6-7 months of the year as spawning adults and juvenile fish. There may be a possibility of sampling estuarine and near coastal environments to identify the presence of post-smolt fish in the months following their emigration from rivers. It was suggested that water sampling may form part of the routine surveys carried out by agencies such as SEPA, EA etc. who are responsible for water quality monitoring, and in the case of Scotland, SEPA also have lead responsibility for aquatic non-natives.

Method	Advantages	Disadvantages
Angling	Low cost; Effective reporting could be improved through the use of geotagged telephone apps which allow records to be verified if images are uploaded.	It is ad hoc; Pink salmon may vary in their catchability; Fish may be mis-identified as Atlantic salmon or sea trout as new river entrants or anadromous Arctic charr in areas above a latitude of 65^{o} N. Many anglers will not report their catch to relevant authorities, and many may not record morphological measurements or retain physical samples.
Netting	May provide large numbers of fish in coastal areas or as they enter river systems.	Netting effort is either absent or is being phased out in most areas; Coastal nets may capture fish at sea but this does not indicate which rivers they will attempt to enter.
Electrofishing	Can be used to capture fish in rivers and streams where they are known to be present, or to investigate presence in new areas.	Can be costly; Few areas can be sampled in a day if sampling sites are widely spread; May be ineffective in waters > 1m deep or in wide watercourses.
Visual Observations		
Direct observation	Can be very cheap if carried out from the bankside.	Water clarity may be an issue in many water bodies. Fish may be missed in areas which are highly coloured by dissolved organic material; Costs may increase if fish are observed *in situ* by snorkelling; Camera observations can yield good quality data but most are stationary and some post-processing of filmed material may be required.
Remote observation (Drones)	Can be used to monitor fish in clear waters (though these may need to be verified); can be used to identify and count spawning aggregations and redds.	Drones not widely used by many agencies; In some areas, there may be physical (e.g. canopy cover) or legal constraints which may limit their use.

Fish counters	Where installed many counters (particularly Vaki designs) now include cameras to allow quality assurance of count records; Counters provide data on presence and numbers of fish.	Cameras are not widely distributed in most countries; Some counters may be located in areas off of the main stem of rivers and in areas where maximum benefit is not realised for assessing Pink salmon numbers; Like static cameras, some post-processing of filmed material may be required.
Environmental DNA (eDNA)	Can be cheap if a reliable assay and bioinformatics are available.	A suitable survey approach has not yet been developed for Pink salmon in rivers; Water sample collection and filtering has to be carried out within a short timescale; Cross contamination of samples is concern in both the field and laboratory.
Telemetry	Increasingly affordable and tag efficiency is making use of this technology a routine tool in determining fish distribution, habitat use and migration behaviour. Data Storage Tags also provide the opportunity to determine the role of environmental parameters (such as temperature) in determining habitat preferences.	Fish have to be captured in order to insert the tags. Depending on the number of receivers used and the activity patterns of the fish, large volumes of data can be generated. This requires time for post-processing of data and interpretation.

Table 2. Advantages and disadvantages of surveillance and monitoring techniques discussed by the 'data gathering and evidence' Theme-group on 21 September 2017.

The use of standard DNA approaches to establish the source of Pink salmon in European rivers and to provide information on Effective Population Size were also discussed, though it was agreed that this would be covered within the Genetics Theme.

Theme 2: Genetics (Rapporteur – Eric Verspoor)

This group was well organised and it was clear that there were several programmes already established which could be used to support some new work on Pink salmon genetics.

There was a clear recommendation from the group that a technical steering group for Pink salmon should be established. This group, which could comprise the theme members as its core, should take the lead in coordinating genetics activities, identifying priorities and seeking out new funding opportunities. The possibility of applying for EU COST Action support was also discussed as a means of facilitating wider cooperation and information exchange between European partners. EV offered to lead or coordinate, what would be called, a 'European Pink Salmon Genetics Group'. One of the first tasks of the group will be to scope the range of genetics-based questions which need to be addressed.

One of the most obvious questions, which could be tackled relatively easily, relates to the origin of fish found around Europe. It is widely thought that all of the Pink salmon captured in Europe originated from established northern Russia. John Gilbey (JG) from Marine Scotland Science will coordinate a project which will use established contacts from across all of the European countries which collected samples during 2017 and compare these to baseline samples obtained from Russia to test whether this is true.

The genetics group will also, as part of its work, develop protocols and agree standards for eDNA monitoring protocols for Pink salmon and field sampling protocols for the collection of genetic material.

Theme 3: Interactions (Rapporteur – Alistair Duguid)

The interactions group examined spatial and temporal overlaps between Pink salmon and other species – particularly Atlantic salmon, but also trout, Arctic charr and anadromous lamprey species. Evidence from the River Ness in 2017, principally from the *in situ* camera work carried out by CC, showed that Pink salmon spawned in areas used by Atlantic salmon and trout.

It was agreed that several gaps exist in terms of our understanding of Pink salmon ecology and their environmental tolerances in waters outwith their native range. It was suggested that a modelling approach could be used, once their relationship with temperature was fully understood, to determine where fish might successfully spawn and predict timings for hatching and emergence as well as sea entry.

Whilst it was agreed that competition for food in freshwater may be limited, nothing is known about how large numbers of post-smolts may impact native fish in estuarine and near coastal waters. The behaviour of these fish in European rivers may adversely impact native fish. Aggressive behaviour may, for example, influence habitat use by Atlantic salmon and trout, and it was unclear whether precocious parr may, in particular, be adversely affected.

Initial examination of fish captured in 2017 suggested that disease and parasite transmission may not be as big issue as first thought, although relatively few fish have been analysed within the UK and in other parts of Europe. More work is required in this area. *Saprolognia* infections, picked up by fish which have entered freshwater may also be a cause of concern.

Newly arrived Pink salmon may attract piscivorous predators to new areas or to habitats which may not have been subject to significant predation pressure in the past. This can also be extended to human exploitation and it is possible that efforts to exploit Pink salmon illegally or legally may place additional pressure on native fish. Some concern exists over the efficacy of legal powers to limit human exploitation.

The possibility of Pink salmon to influence catchments on a wider scale, through the addition of nutrients, was also discussed. The semelparous life history strategy of Pink salmon means that large numbers of fish can be left to decay within watercourses that they inhabit. Increases in nutrient levels could, for example, impact the quality of water available for species of high conservation value, such as Freshwater Pearl Mussel (*Margaritifera margaritifera*). From a human perspective the odours released from decaying carcasses may also impact the experience of recreational anglers. At its most extreme this may impact local economies.

Theme 4: Management (Rapporteur – Alan Wells)

The scale of the issue and the magnitude of the risks posed by Pink salmon were the primary consideration. So too was the powers available to fishery managers to deal with those risks once they have been identified. This requires a clear line of responsibility for dealing with the issue, and clarity with regard to the roles and responsibilities of others. Whilst it has been assumed that any new influx of Pink salmon will not happen before 2019 – in line with the odd year nature of the Pink salmon stock used to establish this species in northern Russia – it was noted that in Norway there had been observations of Pink salmon in

2016. It was therefore felt that the situation would need to be monitored closely in 2018 and that a full Risk Assessment, and a review of management measures should be developed in advance of that.

The group agreed that completion of the full Risk Assessment was a priority and that this should be used to get stakeholders into a state of readiness for 2019. From a Government perspective, the key drivers for management action will include the protection of sites designated for nature protection (such as SSSIs and SACs) the impact that Pink salmon may have on downgrading the status of WFD waterbodies. The impact on existing Atlantic salmon and trout fisheries may also be a significant driver for action and many European countries have a system of management targets (such as Conservation Limits, species management plans) which may influence their activity.

The group thought it important to understand why Pink salmon have appeared in larger numbers and explored the range of management measures which are currently being employed to deal with this. Most countries operated and 'catch & kill' policy, though early intervention may have resulted in more of these fish being retained for scientific analysis. Generally this has been limited to those fish captured by angling or in commercial nets. In Norway, however, this has extended to harpooning fish in the lower reaches of rivers. Additional effort, in Scotland and Norway, has gone into the physical disruption of redds. This activity may carry significant health and safety risks for those who carry this activity out in fast flowing and/or deep rivers, and IU added that its efficacy has yet to be assessed. Mark Bilsby (MB) added his experience from the River Dee, where this has been used as the primary management activity for dealing with Pink salmon. MB stated that this procedure is extremely labour intensive and that it appears to result in the loss of few ova. The causes of this are unknown and MB suggested that it may be due to the depth of the redds. He added that in many redds, no eggs were seen at all. There was some dialogue amongst workshop participants as to whether some of the areas identified as redds were actually redds at all, or whether they were areas tested by Pink salmon prior to attempting red excavation. CC confirmed that this accorded with behaviour observed in the River Ness. The re-suspension of fine material downstream was also discussed, as was the scale of such works. It was clear that such works, if they continue, should only only be carried out with hand tools at an individual redd level and that, in the early stages of such intervention, care should be taken to avoid the disturbance of Sea lamprey spawning areas, or Freshwater Pearl Mussels.

IU added that we need to have 'many tools in the toolbox' if we hope to manage pink salmon populations in addition to redd disruption. Discussion turned to the possible capture and removal of juvenile Pink salmon once they emerge from redds and initiate downstream migration. Various suggestions were made and these included the use of modified fine mesh drift nets, fyke nets and active fishing (using electrofishing) for juveniles/smolts. The small size of Pink salmon smolts (typically 30 mm in length and 0.2 g), and the possibility of large numbers, suggest that management intervention at this stage may be unsuccessful.

Regardless of which management activity is taken to tackle the Pink salmon issue, it is accepted that this will divert resources away from traditional fisheries management for native species at a time when the status some species, such as Atlantic salmon, is in decline.

Current work, which aims to understand the temperature requirements of Pink salmon, and the probability of successful recruitment in UK and Norwegian rivers, will help inform whether this species will establish. It will also determine what structures and materials should be in place prior to the expected return of these fish in 2019 and what management actions will be required.

6. Summary and outcomes

CB went back to the broad aims of the workshop identified at the start of the day. These were to:
- understand past, and current distribution and consider what we might expect in future years;
- have a common understanding of Pink salmon ecology, species plasticity, invasiveness and implications of phenological change;
- use this information to refine existing Risk Assessments in UK and Europe for this species;
- develop an awareness of current surveillance and management measures: examine their efficacy and explore the potential use of new tools (e.g. eDNA); and
- identify knowledge gaps and identify how these can be addressed – and by whom.

- **Workshop participants were provided with summary information from all of the areas known to have been affected by the invasion their rivers by Pink salmon in 2017. All participants were involved in discussions relating to Pink salmon ecology it was clear that our understanding of plasticity in this species is not well understood.**

- **The workshop identified similar workstreams relating to the role of temperature and hatching success in Pink salmon populations in both Scotland and Norway. This will form the basis of a better understanding of the environmental requirements of Pink salmon outwith their native range. In Scotland it may form the nucleus of a wider predictive approach, using newly developed water temperature models, to identify rivers most at risk. This work is being taken forward by Marine Scotland Science. Similar approaches may be used elsewhere.**

- **It is generally accepted that these fish originate from odd-year stock and that they have resulted in socking activities carried out in northern Russia. A project has originated from the workshop which will test whether this is true. This will be led by John Gilbey of Marine Scotland Science.**

- **The workshop has stimulated the formation of a 'European Pink Salmon Genetics Group' and this will be coordinated by EV of the University of the Highlands & Islands and will include input from Kjetil Hindat (NINA), Carlos Garcia de Leaniz (University of Swansea), Jens Carlsson (University College Dublin) and Phil McGinnity (University College Cork) as its core membership. This group will identify priorities and seeking out new funding opportunities.**

- **The rapid Risk Assessment has proved a useful basis for discussion and this will now progress to a full Risk Assessment. The lead for this will be the GB Non-Native Species Secretariat. Additional Risk Assessments will be carried out in Ireland and Norway. These should inform each other. Colin Bean (Scottish Natural Heritage) will inform GBNNSS of the Irish and Norwegian Risk Assessment work.**

- **There are significant gaps in our understanding of the interactions between Pink salmon and native biota. Low numbers of invading fish, and a lack of opportunity, has precluded properly organised scientific investigation. Should Pink salmon re-appear in 2019 arrangements for such work should be in place. This will also be informed by the outcome of the full Pink salmon Risk Assessment. Colin Bean indicated that he has already contacted colleagues**

who are interested in carrying out Stable Isotope Analyses on samples from across Europe. This work could take place in 2017/18 if material is made available.

- **The applicability of a range of surveillance tools for monitoring the distribution of Pink salmon were explored. The use of new and emerging technologies (such as the use of drones for spawning aggregation and red distribution) and eDNA, may allow greater geographical coverage and offer significant resource savings. The development of a Pink salmon eDNA assay is already underway through the work of Jens Carlsson (University College Dublin), and consideration must now go into the development of effective surveillance strategies using the methods available.**

- **Management options are limited once Pink salmon have invaded. A key concern in some areas (particularly Scotland) is the provision of legislative tools to prevent the mis-use of Pink salmon presence to facilitate the illegal exploitation of native salmonids. The development of methods for removing adult fish and for the removal of fertilised eggs is another priority. These may be informed by the full Risk Assessment, which will identify the critical life history stages where intervention may be most effective. An assessment of the efficacy of current removal techniques (angling, harpooning, redd disruption and juvenile capture) should be undertaken.**

CB ended the workshop by stating that this is a European issue and collaboration between States is essential if a solution is deemed necessary. The collection of material and its provision to others who wish to use it to achieve management aims and our wider scientific understanding of Pink salmon is essential.

No dates were agreed for a follow-up workshop, but there was a general feeling that this was a useful starting point for discussion and wider collaboration. Further dialogue is necessary if provisions are to be put in place in advance of any anticipated return of large numbers of Pink salmon in 2019.

Professor Colin Bean
Scotttish Natural Heritage
20 October 2017

ANNEX 1

Agenda

Location: Novotel, Edinburgh
Date: 21 September 2017

Start: 09:00/Finish 17:00

1. Introductions and aims of the meeting – Colin Bean

2. Setting the Scene

A quick (5-10 min max) description by a rep from each country:

Scotland – John Armstrong/Alan Wells
England - Jon Shelley
Ireland – Mike Millane
Norway – Kjetil Hindar/Ingebrigt Uglem
Iceland - Guðni Guðbergsson
France – Colin Bean (for Jean-Luc Bagliniere)
Germany – Colin Bean (for Marko Freese)
Finland – Colin Bean (for Jaakko Erkinaro)
Denmark – Colin Bean (for Finn Sivebæk)

3. The ecology of Pink salmon

4. Risk Assessment

5. Drivers for Management

6. Science to inform management

7. Next steps – All

ANNEX 2

Participants

Alistair Duguid	Scottish Environment Protection Agency
Alan Wells	Fisheries Management Scotland
Brian Davidson	Fisheries Management Scotland
Carlos Garcia de Leaniz	University of Swansea
Chris Conroy	Ness District Salmon Fishery Board
Colin Bean	Scottish Natural Heritage
Dave Ottewell	Natural England
Elvira de Eyto	Marine Institute, Ireland
Eric Verspoor	Rivers and Lochs Institute, UHI
Gareth Davies	Environment Agency
Gordon Copp	CEFAS
Guðni Guðbergsson	Marine and Freshwater Research Institute, Iceland
Ingebrigt Uglem	The Norwegian Institute for Nature Research
Jens Carlsson	University College Dublin
John Armstrong	Marine Scotland Science
John Finarelli	University College Dublin
John Gilbey	Marine Scotland Science
Jon Shelley	Environment Agency
Kjetil Hindar	The Norwegian Institute for Nature Research
Mark Bilsby	Dee District Salmon Fishery Board
Michael Millane	Inland Fisheries Ireland
Paddy Boylan	Loughs Agency, Ireland
Phil McGinnity	University College Cork
Simon Dryden	Marine Scotland

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ANNEX 3

Thematic discussion

All participants were invited to sign up to one of the four thematic discussions. These groups were:

Data gathering and evidence
Brian Davidson
Colin Bean*
Gareth Davies
John Finarelli
Michael Millane

Genetics
Carlos de Leaniz
Eric Verspoor*
Jens Carlsson
John Gilbey
Kjetil Hindar

Interactions
Alistair Duguid*
Elvira de Eyto
Gordon Copp
Guðni Guðbergsson
Ingebrigt Uglem
Paddy Boylan
Phil McGinnity

Management
Alan Wells*
Chris Conroy
Dave Ottewell
John Armstrong
Jon Shelley
Mark Bilsby
Simon Dryden

* denotes rapporteur