Frank Buckland
1826 – 1880

A PIONEER of FISHERY RESEARCH

H.M. Inspector of Salmon Fisheries for England and Wales 1867-80
Tagging of Salmon on the Tweed at Heughshiel by the Experimental Committee of the River Tweed Commissioners. *The Daily Graphic* 6th Dec 1873
The life-cycle of the Salmon as we know it today. All very obvious and simple – but it took centuries to work it out.
But what did the first writings about Salmon say?

Hector Boece, 1527, *Historia Gentis Scotorum*,
translated 1536 by John Bellenden

JOHN BELLENDEN,
Archdeacon of Moray

At the request of James V he translated Hecor Boece’s *Historia Gentis Scotorum*

This translation, the *Croniklis of Scotland* has both additions to and omissions from Boece’s work and the two need to be considered together to show what the early 16th century knew about salmon

HECTOR BOECE: First Principal of what was later called King’s College, Aberdeen
### What was known in the 16th century?

<table>
<thead>
<tr>
<th>BOECE 1527</th>
</tr>
</thead>
<tbody>
<tr>
<td>Go upstream and into small channels to spawn</td>
</tr>
<tr>
<td>Male &amp; Female spawn together</td>
</tr>
<tr>
<td>Cover their eggs with &quot;sand&quot;</td>
</tr>
<tr>
<td>Become emaciated after spawning</td>
</tr>
<tr>
<td>If touch other salmon these immediately also become emaciated</td>
</tr>
<tr>
<td>Young hatch from under the &quot;sand&quot; in Spring. No larger than a man's finger</td>
</tr>
</tbody>
</table>

| + at harvest time (Aug / Sept) |
| + male has milt, females Roe |
| ditto |
| ditto |
| omitted |
| no larger than a man's thumb |

**Incorrect & so omitted by Bellenden**
**What was known in the early 16th century?**

**BOECE 1527**

<table>
<thead>
<tr>
<th>Action</th>
<th>Details</th>
</tr>
</thead>
<tbody>
<tr>
<td>Go quickly to the sea</td>
<td>Grow very large in 20 days</td>
</tr>
<tr>
<td>Swim back upstream to where they were born</td>
<td>Leap at waterfalls</td>
</tr>
<tr>
<td>Those that fall onto land taken and cooked in cauldrons set beside the waterfalls</td>
<td>Go back to where they came from and wait till spawning time</td>
</tr>
<tr>
<td>Illegal to catch them at this time - 10th Sept to 1st Nov</td>
<td>No food ever found in them</td>
</tr>
</tbody>
</table>

**BELLENDEN 1536**

(3) .. fact or fiction?

- At the first rise in water go to the sea
ditto
ditto

- Some injure themselves leaping and develop fungus
ditto
ditto - but illegal 8th Sept to 15th Nov
ditto

(2) .. but how did they know this in the 16th century?

He didn’t actually say fungus, he said “measal” meaning leprous, but this is clearly referring to the white *Saprolegia* fungus that infects sick and injured Salmon. A very acute observation.
When King James VI & I returned to Scotland in 1617, he said it was due to his *salmon-like instinct to see the place of his breeding*.

*Because it was thought that every river had its own distinctive race of Salmon*

“for example, there are three or four salmon rivers flow in to the Frith of Moray in Scotland, .... they all associate and live together for some months in the sea ..... each class of fish returns to its own river..... from there being distinguishing features in the shape of each class of fish known to inhabit these different rivers.” (Ashworth 1868)

Just one example of many historic statements of something that is true to some extent physically and is largely the case genetically
(2) Cooking in cauldrons by waterfalls?  **Fact or Fiction?**

This sounds more like a description of a Basket Fishery. Iron baskets were fixed beside waterfalls and every now and again a fish would fall into it. There are stories that in some places lines were run from the basket to a bell in the kitchen of a nearby house, so when a fish fell in and shook the basket the bell would ring and the cauldron would be put on the fire. More practical than keeping a fire going right beside a waterfall.

This photograph of the basket at the Linn of Tummel (Pitlochry) was taken by George Washington Wilson (G.W.W.) an early Aberdeen photographer whose archive is now held in Aberdeen University library. However the negative there with the number of this photograph, 2869 is of a different scene. Bonskeid Estate has some catch records of this fishery.
The basic knowledge: (1) Salmon come up rivers, (2) spawn and (3) their young go back down to the sea

The Arms of the Royal Burgh of Peebles – one salmon going upstream, two coming down. The motto stands for:

“I swim against the current and increase”

The first record of these Arms was in 1473

The Province of Angermanland, northern Sweden has similar Arms.

This basic knowledge is reflected in English, Irish & Scottish legislation which protected the fish in all these three stages
<table>
<thead>
<tr>
<th>(1) Upstream migration</th>
<th>(2) Spawning fish</th>
<th>(3) Downstream migration</th>
</tr>
</thead>
<tbody>
<tr>
<td>1424 <strong>Saturday slap</strong> to be kept</td>
<td>1424 Close time 15th Aug - 30th Nov</td>
<td>1469 Millers forbidden to catch smolts with creels or in any other way</td>
</tr>
<tr>
<td>1469 <strong>Cowpes</strong>, Narrow Masses, nets and Prynes &quot;set in to&quot; rivers or estuaries abolished for three years</td>
<td></td>
<td>1503 Penalties for the killing of red fish. Anyone claiming to have rights to kill in forbidden times to prove them</td>
</tr>
<tr>
<td>1489 <strong>Cruives</strong> to have hecks 5&quot; wide, a 5' midstream slap and not to be operated in forbidden times</td>
<td></td>
<td>1489 Laws on cruives &amp; <strong>yairs</strong> that destroy fry repeated / Millers not to use creels or nets to catch fry in mill lades / hecks (grids) on cruives to be 5&quot; wide</td>
</tr>
</tbody>
</table>

Acts in 1318, 1424, 1457, 1469, 1477, 1489, 1503, 1525, 1563, 1579, 1685, 1696, 1705

The “Saturday Slap” was the ban on operating fish traps from late on Saturday night to early Monday morning, so there was no work on the Sunday.

**What were Cowpes, Cruives & Yairs?**
Coops & Yairs – What were they?

The replica mediaeval fish trap (earliest mention 1388) at the Kjaerra Waterfall on the R. Numedalslågen, Lardal in Vestfold, Norway

Open, wicker, “pots” are mounted in the gaps

There is still an early mediaeval Coop Trap at Castle Corby on the Cumberland Eden

While similar in structure, the Yair or Zair, caught the fish in wicker baskets, the Coop trapped them in a box, or coop, after they had gone through an inscale. Both relied on the fish being confused in white water.
A cruive is a barrier across a river with gaps in which fish traps (Corffs) are set.
### ENGLISH LEGISLATION (& WELSH after 1536) – a pre-1800 selection

<table>
<thead>
<tr>
<th>(1) Upstream migration</th>
<th>(2) Spawning fish</th>
<th>(3) Downstream migration</th>
</tr>
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<tbody>
<tr>
<td><strong>1473</strong> Any weirs, mill-dams, mill-stanks, locks, ebbing-wears, stakes, <strong>kiddels</strong>,hecks or flood-gates that are made or enlarged to be broken down within three months</td>
<td><strong>1285</strong> Rivers to be “in defence” for salmon (=close time): Nativity of Our Lady [8th Sept] to St. Martin's Day [11th Nov] (=1st Sept to 3rd Nov Gregorian calendar)</td>
<td><strong>1285</strong> Young salmon not to be destroyed by nets or other engines at mill pools from the midst of April to the Nativity of St. John Baptist [24th June] (=16th Gregorian)</td>
</tr>
<tr>
<td><strong>What’s a Kiddel?</strong></td>
<td><strong>1705</strong> Close time 1st July to 12th Nov for taking Salmon or Salmon peale with nets or other engines in rivers in Wiltshire &amp; Southampton</td>
<td><strong>1558</strong> No-one to use a net, device or engine to take young salmon or other fish at weirs, mill-tails or other places. No salmon under 15'' to be taken or killed.</td>
</tr>
</tbody>
</table>

Acts in: 1225, 1285, 1389, 1390, 1394, 1403’ 1424, 1473, 1538, 1705,1760 + many local Acts

---

Elizabeth I: “In divers parts of the realme, they fed swine and dogs with the fry and spawn of fish and otherwise lamentable and horrible to be reported destroyed the same to the great hindrance and decay of the Commonwealth”
On the Severn, where Kiddels (Eel weirs) blocked the rivers, so side-channels ("Gutters") were made around them so boats could pass.

Not surprisingly, there was a long history of conflict between weir fishers and boat users, with commissions appointed at various times over the centuries to resolved conflicts and either improve passage at weirs or have them pulled down.

(Diagram from Pannett, 1987: Fish Weirs of the River Severn)
<table>
<thead>
<tr>
<th>(1) Upstream migration</th>
<th>(2) Spawning fish</th>
<th>(3) Downstream migration</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>1783</strong> Only fishery owners allowed to make stages on rivers to spear salmon; fix hoop-nets, baskets or bushes in sluices to stop salmon getting upstream or put nets across river mouths. Fishing weirs to be left open after their legal season ends. A &quot;Kings Share&quot; of 21ft to be left open in the deepest part of a river at any obstruction. Anyone affected by an illegal weir can serve notice on its owner for its removal.</td>
<td><strong>1757</strong> No-one to take salmon by any method or carry gear for taking salmon on a river bank. <strong>12th August to 1st Feb.</strong> EXCEPT: Rivers Rathmalton, Lachagh, Donnegall &amp; Bundrouse (Co. Donegal): R. Sligo, R. Shannon from the sea to St. Thomas' Isle: R. Boyne: L. Lean, rivers Lanne &amp; Carragh (Co. Kerry): R. Lee to Cork city: R. Busk (Antrim): R. Newport (Mayo). Fishing allowed 1st Feb to 20th Oct. R. Seal (Kerry)</td>
<td><strong>1569</strong> No pigs to graze on estuary shores as destroy Salmon &amp; Eel fry. <strong>1634</strong> No Salmon fry to be taken by any means other than angling. <strong>1715</strong> No nets or other engines to be used at mills to take salmon fry. <strong>1569</strong> No processing of Flax &amp; hides in rivers as poisons the water. <strong>1634</strong> Processing of Flax &amp; hides in rivers forbidden,</td>
</tr>
</tbody>
</table>

English Acts + 1537, 1569, 1635, 1715, 1721, 1725
<table>
<thead>
<tr>
<th><strong>IRISH (BREHON) LEGISLATION: law texts of 7th &amp; 8th centuries</strong></th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>(1) Upstream migration</strong></td>
</tr>
<tr>
<td>Fishing weirs not to extend more than 1/3rd across a river, if one bank owned. If both, then could be 1/6th of channel width from both banks</td>
</tr>
<tr>
<td>No general right to salmon fish, but &quot;public&quot; fish weirs for the &quot;tuath&quot; (tribe) as well as private (owned by a lord or a &quot;fine&quot; (extended family)</td>
</tr>
<tr>
<td>Riparian farmers limited in number of salmon could take - one swift dip of the net allowed, from their own farmland</td>
</tr>
<tr>
<td>The sea belonged to the local king, who had a share in all salmon, seals and porpoises caught</td>
</tr>
<tr>
<td><strong>SECULAR LAWS</strong></td>
</tr>
<tr>
<td><strong>CHURC H LAW</strong></td>
</tr>
<tr>
<td>No fishing from Vespers on Saturday to Tierce on Monday (approx. 18.00 to 09.00 hrs)</td>
</tr>
<tr>
<td>A “Weekly Slap” for religious reasons</td>
</tr>
</tbody>
</table>
Nothing about fish passes in the pre-19th century legislation, and almost nothing about pollution

These issues come later with industrialisation, which was first based on water power

Note too, protection of stale and spawning fish – but not of spawned fish, kelts. That too came later

Mill dams that blocked salmon could lead to violence though!
Civil strife amongst the Campbells – Glendaruel vs Ormidale

Eskacmachan, August 7, 1755

To the Chief of Ormidale

Sir- I will have no more child’s play, but I and 100 men will appear on the eastern side of the river, at the dam, between ten and eleven o’clock forenoon, tomorrow, and you bring the same number of men, but no more, otherwise your are a coward and void of all honour. Have but the same number of men which I will have, and if I may feel inclined to do so, I will drown you and all your unspirited men in your own dam, and make all your bodies food for the fish of the river. At all events, I shall have the dam down to-morrow, and to confirm my words, I now kiss the sword.

Before anyone was actually killed however, the local minister arrived who with considerable difficulty, and some danger to himself, managed to separate the combatants. It all ended up in court in Dunoon, with Ormidale being required to erect “box-steps from the bed of the river to the top of the dam-breast, so that when a spate in the river would occur, fish could get over.” (Campbell, 1885)

The fish pass at Deanston Mill, on the Teith, built in the early 19th century is sometimes said to have been the first fish pass, but clearly the concept was well known earlier
19th century attitudes towards pollution are of interest.

The knowledge that it was deleterious was obvious and widespread, but attitudes towards it are of interest.

Today, we think that the link between clean rivers and fish and fisheries is inevitable and obvious and go together naturally –

*but this is not necessarily so!*

One suggested solution to the problem of polluted rivers in the 1860s was to dose them with “Chloride of Lime” –

- *nice, clean, hygienic (& dead) rivers!*
The 19\textsuperscript{th} century had a very strong belief in the inevitability and value, both moral and financial, of progress.

\textit{We regret to perceive that the Commissioners} (1860 Commission on Salmon in England & Wales) \textit{deem the extinction of the Cornwall fisheries inevitable.}

\textit{They are fortunately not of the highest value, and to prefer them to the great mining interests which form the staple industry of a wealthy county, would no doubt be to preserve salmon at a preposterous cost} (Easdail, 1865)
19th century utilitarian attitudes to rivers carried on well into the 20th: in 1953, this image would not have been seen as a hideous scene of pollution but as signifying industry and prosperity. The same image has changed its meaning entirely with changes in social attitudes.
The 19th century saw some detailed inquiries & new legislation

1824/25 Report, H. of Commons Select Comm. on the Salmon Fisheries of the UK
1827 Comm. on the Bill for the more Effectual Preservation and Increase of the Breed of Salmon and for Regulation of the Salmon Fisheries throughout Great Britain & Ireland
1836 Rep. from the Select Comm. on the Salmon Fisheries of Scotland
1836 Royal Commission on the Salmon Fisheries of Ireland
1860 Rep. from the Select Comm. of the H. of Lords (*coastal net fishing property rights*)
1860 Royal Commission on the Salmon Fisheries of England and Wales
1898 Royal Commission on the Salmon Fisheries of the Tweed and the Solway
1902 Royal Commission on Salmon Fisheries. *(UK)*

So frequent and annoying were these attempts to disturb the Fishery Laws of Scotland, that the late Sir Robert Peel deprecated “the continual paltering and pottering with the Fisheries question,” wasting the time of the House, and keeping so important a branch of national industry in a state of continual uneasiness. *Russell, 1864*
Still the same three basics in the 19th century

In 1863, the then Lord Chancellor (Westbury) stated, in a judicial decision that the leading principles in all Statutes were:

...mon law, were these:—“The first was the object of securing to the salmon a free access from the lower to the upper fresh waters of the rivers, which are the natural spawning-grounds of the fish; the second was to secure the means of return to the young salmon or smolt down to the sea; the third was the prohibiting the taking of unclean fish during certain periods of the year when it was out of season as an article of food.”

But what if there was more to the life-cycle of Salmon than these 3 features?
THE GREAT PARR CONTROVERSY

Salmon or not salmon?
Salmon were thought to grow from hatching in March / April to smolt size in June and then to migrate, *hence references* to “smolts” as “fry”

But what then were the Parr or Samlets also seen in salmon rivers?

*They were there all year round, and mature males could be found*
## The Great Salmon Parr Controversy

<table>
<thead>
<tr>
<th>Reference</th>
<th>Species</th>
<th>Young Salmon</th>
<th>Comment</th>
</tr>
</thead>
<tbody>
<tr>
<td>Walton</td>
<td>1653</td>
<td>*</td>
<td>some say</td>
</tr>
<tr>
<td>Francks</td>
<td>1658</td>
<td>*</td>
<td>*</td>
</tr>
<tr>
<td>Willoughby</td>
<td>1686</td>
<td>*</td>
<td>All males, interbreed with Salmon</td>
</tr>
<tr>
<td>Williamson</td>
<td>1711</td>
<td>*</td>
<td></td>
</tr>
<tr>
<td>Ray</td>
<td>1713</td>
<td>*</td>
<td>All males</td>
</tr>
<tr>
<td>Burt</td>
<td>1730</td>
<td>*</td>
<td>A trout, but very like salmon fry</td>
</tr>
<tr>
<td>Pennant</td>
<td>1776</td>
<td>*</td>
<td></td>
</tr>
<tr>
<td>Turton</td>
<td>1807</td>
<td>*</td>
<td></td>
</tr>
<tr>
<td>Hogg</td>
<td>1830s</td>
<td>*</td>
<td>Observed parr in transition to smolt</td>
</tr>
<tr>
<td>Stoddart</td>
<td>1831</td>
<td>*</td>
<td></td>
</tr>
<tr>
<td>Davy</td>
<td>1832</td>
<td>-</td>
<td>Hybrids between Salmon &amp; Trout</td>
</tr>
<tr>
<td>Buist (1)</td>
<td>1832</td>
<td>*</td>
<td></td>
</tr>
<tr>
<td>Jardine</td>
<td>1835</td>
<td>*</td>
<td>A trout</td>
</tr>
<tr>
<td>Jenyns</td>
<td>1835</td>
<td>*</td>
<td>&quot;now pretty well ascertained to be a distinct species&quot;</td>
</tr>
<tr>
<td>Yarrell 1st Ed.</td>
<td>1836</td>
<td>*</td>
<td></td>
</tr>
<tr>
<td>Shaw</td>
<td>1837</td>
<td>*</td>
<td>Hatched eggs and recorded how they turned into Parr and then Smolts</td>
</tr>
<tr>
<td>Parnell</td>
<td>1838</td>
<td>*</td>
<td></td>
</tr>
<tr>
<td>Yarrell 2nd Ed.</td>
<td>1841</td>
<td>*</td>
<td></td>
</tr>
<tr>
<td>Knox</td>
<td>1854</td>
<td>-</td>
<td>A hybrid</td>
</tr>
<tr>
<td>Young</td>
<td>1854</td>
<td>*</td>
<td>A trout that looks very like a young Salmon</td>
</tr>
<tr>
<td>Russell</td>
<td>1864</td>
<td>*</td>
<td></td>
</tr>
<tr>
<td>Couch</td>
<td>1865</td>
<td>*</td>
<td>Could be a species looking very like young salmon</td>
</tr>
<tr>
<td>Bertram</td>
<td>1865</td>
<td>*</td>
<td></td>
</tr>
<tr>
<td>Buist (2)</td>
<td>1867</td>
<td>*</td>
<td></td>
</tr>
<tr>
<td>Gunther</td>
<td>1880</td>
<td>*</td>
<td></td>
</tr>
</tbody>
</table>

Data from Day (1887)
The Great Salmon Parr Controversy: Bitter and protracted

Prof. Gunther, Keeper of Zoology at the British Museum

“Some advocates for the opinion of the specific distinctiveness of the parr pretend indeed to have found female parrs.

Some persons were so anxious to convince me of the correctness of this opinion that they sent me specimens with ova in the abdominal cavity.

On closer examination these fishes turned out to be immature male specimens, the ova having been introduced by a cut in to the abdomen, said to have been made to admit the spirit”

Gunter, quoted in Houghton 1879:
The Great Salmon Parr Controversy: Major implications for both legislation & management. An important advance in knowledge.

The determination that Parr were young salmon – and therefore that there was a freshwater phase of 1 to 3 years in the salmon life-cycle had important legislative and management repercussions.

For a start, Parr had to be protected as well as smolts and spawning fish – but none of the old Acts mentioned Parr, only Smolts and the “Fry of Salmon”.
When prosecutions were made for killing Parr on the grounds that they were the Fry (Young) of Salmon, Scottish judges said they were not mentioned in the Acts – and would not convict.

The Tay Fishery Board vs Miller, 1869

8th October: The Sheriff found that "The defendant had in his possession certain fish commonly known as pars, but which are not named in the prohibitory and penal clauses libelled [cited]; but finding it not proved that he then had any fish known as smolts, the only fish named in the same section of the statute libelled, and declines to inquire and decide the question in natural science whether par be, or be not, salmon fry".

deserves consideration. If there is a distinct species of fish called pars, (which seemingly there is no doubt of), then by the Acts of Parliament these are protected from capture from one end of the year to the other. They never become smolts or salmon. They will
I remember two things; every local railway station displayed coloured posters showing the differences between parr and trout, and every local angler displayed wrath and indignation.

McCaskie, 1950:

Confusion continued into the 20th century
A NEW HOPE - HATCHERIES
1850s: A new option for management—artificial reproduction in hatcheries

Until the discoveries of the late 18th and early 19th century on how to spawn and rear salmon artificially were made, management was negative & reactive, controlling adverse impacts on wild fish.

Artificial rearing offered the prospect of positive, proactive management — and even a possible substitute for wild stocks and any need for their preservation.
1850s: A new option for management – artificial propagation in hatcheries

Though there was an old tradition of “stew ponds” keeping carps, Pike and Trout – the rearing and release of migratory fish in the expectation of their return was a major innovation.

The rest of this talk is about the history of hatcheries as it is of relevance today.

Hatcheries and stocking have been the most contentious issue in salmon management history and are still today
Hatcheries were seen as coming at just the right time

“It is scarcely possible”, observes the Morning Post, “to overrate the importance of these experiments”

“...this valuable fish has, for the purposes of commerce entirely, and for the objects of sport almost entirely disappeared from the western and midland rivers of England in which it once abounded, and has been subjected latterly to continuous and alarming decrease in the streams of Scotland, Ireland and Wales” (Ashworth, 1853)
1850s: The Salmon context when hatcheries started

The Causes of this decline, as given by Russell, 1864:-

Land drainage: reducing the time but increasing the ferocity of floods

Obstructions and pollutions

Killing of spawning fish in close time

Shortness or mis-timing of close seasons in Scotland

Over-fishing:
(1) Old, by sweep netting
(2) New, by coastal bag and stake nets
The decline that was giving so much concern in the mid 19th century can be quantified by these catch figures (1842-1920) from the Sandstell netting station at the mouth of the Tweed.

Only towards the end of the 19th century was it understood that the decline had been in one-sea-winter Grilse and not in multi-sea-winter Salmon.
1850s: What was also going on!
Grilse & Salmon ratios in net catches, 1740s – 2000s:

Cycles!

TWEED ESTUARY: Salmon/Grilse ratios in net catches

More Salmon than Grilse 1740-1790

More Grilse than Salmon 1790-1860

More Grilse than Salmon 1860-1910

1:1 1860-1910

More Salmon than Grilse 1910-1970

More Grilse than Salmon 1970-?2010

1 to 1: Equal proportions

Grilse per Salmon | Salmon per Grilse

From 1985 onwards early season netting declines, so Grilse over-represented
A.M.O.: Atlantic multi-decadal oscillation: cycles in sea temperatures that change the ratios of Salmon and Grilse

### Diagram

**Sea warmer than average**

- More Salmon than Grilse 1910-1960
- More Grilse than Salmon 1970-2005
- More Salmon than Grilse

**Sea colder than average**

- Sea warmer than average

**RAI**

- Grilse per Salmon
- Salmon per Grilse

### Lesson

**LESSON:** It’s not only human impacts that can affect fisheries, but the 19th century had no way of knowing about these cycles and thought hatcheries could be the answer to the “problem”.

A.M.O. Diagram: By Giorgiogp2 - Own work, CC BY-SA 3.0, https://commons.wikimedia.org/w/index.php?curid=18733673
1850s: Catching the public imagination – artificial hatching & Frank Buckland

He arranged for London zoo to have a demonstration of fish hatching in its aquarium

And for a display in the street window of the offices of “The Field” magazine, which excited “general public interest”

(Buckland, Fish Hatching, 1863)
Early hatcheries / rearing ponds

The first salmon hatchery in the British Isles was at Oughterard in Galway, Ireland, set up by the Ashworth brothers in 1852.

The first in Scotland was at Stormontfield on the R. Tay, in 1852-53, with which Thomas Ashworth was also involved.

The first efforts in England were in Yorkshire, also in 1853, on the R. Swale.
A great future for salmon fishing, based on hatcheries, was forecast.

In those anticipated days, when fish shall be reared by millions, how many a keen angler, who now only gets "glorious nibbles," shall experience the frequent joy of slaying a plump five-and-twenty pound salmon fresh from the sea, with the sea-louse yet clinging to his silvery sides!

Easdail, 1865

FAST FORWARD: 2014 Natural Resources Wales recommends all its salmon stocking should end.

How did we get from then to now, and why?
1850s & 1860s – the knowledge base for hatcheries. Why was it thought they were a good idea?

It was well known that Salmon females had large numbers of eggs and so that many millions must be spawned in rivers

Knowing that a single salmon produces, it may be, twenty-five thousand ova, and that, according to a very moderate computation, one hundred million are annually deposited in the Tay, we are apt to be surprised at the complaints as to the decrease of salmon, not in this country only, but also in Norway, Holland, and the United States of America.

(Easdail, 1865)

Why therefore, were there not also millions of salmon returning to rivers in the mid-19th century?

Why were salmon numbers were declining?
1850s & 1860s – the knowledge base for hatcheries

Predation by insects, fish & birds on eggs was thought to be the explanation

Frank Buckland (1863) however, by actually examining the gizzards of Water Ouzels (Dippers) shot from around salmon spawning beds in Wales was able to declare them innocent!

He also “acquitted” the Dabchick of eating eggs, but found they ate small fish
As well as predation on eggs, the idea that natural fertilisation was not very efficient started to gain ground.

This is the first mention, in Brown (1862) but no example was given. I can’t yet place exactly where the idea came from, but it steadily gained ground till by the end of the 19th century it was “received wisdom”.

One witness to the 1902 Royal Commission claimed only 200 out of every 10,000 eggs were fertilised in natural reproduction.
Why was natural fertilisation thought to be so poor?

Experimental evidence was one source

In hatcheries the “Dry Process” [mixing eggs & milt without water] was found to be more efficient than the original “Wet Process” [mixing eggs & milt in water].

It was thought therefore that water was an adverse ingredient for fish spawning as both eggs and milt remained active longer without it.

This “dry” process was first devised by a Russian, Vrassky, in the 1850s, but only became general knowledge after a translation of his work was published in New York in 1871.
Salmonids came to be regarded as we regard Giant Pandas now – just not very good at reproducing themselves and in need of human help.

The writer has never but once seen the two sexes together performing the functions necessary to fertilize the eggs ........... I have never met a man who had seen the two sexes together at this time, ....... (Downing, 1900)

.... and for this reason it is safe to say that not one egg in one thousand is fertilized when the fish spawn on the reefs naturally

The conclusion drawn from this idea was that spawning fish in hatcheries saved a huge number of eggs from “waste” and that humans could reproduce fish better than the fish themselves.
The strange thing is that there was good evidence that natural fertilisation was very efficient, from at least the 1870s.

Some early American trout hatcheries had artificial streams running in to their holding ponds that fish could run up, spawn “naturally” and from which the eggs could be then be collected after they fell through screens placed under surface gravel. (Stone, 1872)

and all, or nearly all, of the spawn will be found perfectly impregnated and fully matured, so that they will all hatch, if taken out every three days, or once a week,
There was even an automated version!

Gravel is put on top of a metal screen, the fish excavate redds in this, the eggs then fall through the screen and on to the “endless apron” below, which is moved by winding the handle, the eggs are carried forward to the roller, where they fall off into a channel from which they can be collected.
“Although I was the first to try the experiment of breeding salmon artificially in the United Kingdom. Time and experience have convinced me that the increase in the produce has not arisen from the adoption of any artificial means of hatching. But in consequence of increased care principally by protecting the parent fish.” — Ashworth, 1856

However some thought that if rivers were managed better, obstacles opened up and enough fish allowed to escape to breed, hatcheries would not be needed.

*Give us Nature’s laws and abundance of breeders and we ask no more. We shall then have no need of artificial production*  — Young, 1854
Others thought it would be better to give up on natural production and environmental protection and simply produce all salmon artificially.

The opinion is gaining ground that, as it is to artificial causes that the deterioration of our salmon fisheries is due, so purely artificial measures should be resorted to in order to revive them;

that instead of devoting all our energies to the restoration of our rivers .... by remedying the obstructiveness of weirs, removing pollutions and preserving the breeding fish ....

… we should altogether supplant nature, and take the hatching and rearing of fish entirely into our own hands (in Fryer 1883)
And as time went on, the lack of success of hatcheries started to become apparent & it was seen that the early promises were not being fulfilled.

There was very conflicting evidence – reports of great successes from abroad, but little sign of success at home.

“It may be said of all British rivers that there has been a serious shortage of salmon which began to show itself in the last half century and has gone on ever since at an accelerated pace. Attempts at artificial replenishment have not made any perceptible difference”

(“Corrigeen”, Salmon & Trout Magazine #4, 1912)

The first (of many!) reports on the value of hatcheries and stocking made in the UK was by a Royal Commission set up in 1901.
Exhaustive inquiries made in America, Canada and Europe to test reports of great stocking successes there, but found that on detailed examination these were not valid & that other approaches, such as restricting fisheries or extending close seasons were also being applied to the rivers at the same time that stocking was being undertaken.

In the present state of our knowledge, therefore, it would seem that it is to facilitating the passage of fish to the upper waters, their protection whilst there, the removal of pollutions and obstructions and the regulation of netting that we must look for the improvement of the fisheries.

This did not end the debate though!
Calderwood, 1931, looked at North America for his Buckland Fellowship

... the very great amount of hatching which is carried on in Canada and the United States, ... on scale quite unknown in this country may accompany a steady continuance of decline in the fisheries.

(U.S. hatcheries – over a thousand million eggs & fry annually)

.. The general policy in the States of Washington, Oregon and California was to attempt to overcome any decline in the fisheries by increasing hatchery output.

It was a policy that rather suited everyone, because when over-fishing was complained about, there was no argument to stop the fishing. The position could be met by still further hatching.

If the cannery people wanted to get the close season cut down, the argument was the same.
A lesson from history - Politicians like hatcheries!

It lets them promise both Salmon and development!

This is why hatcheries were built as part of the Hydro-electric schemes of the 1950s – to have both salmon and electricity from Scottish rivers.

In the present rush for “renewable” energy we must remember that it is Water that is a renewable resource – Rivers are not
INTRODUCTION

The possibility of increasing the stock of salmon by means of artificial propagation has been a subject of much controversy for many years.

(The report lists investigations made in 1924 & 1930 as well as the Royal Commission of 1902 and recommended a large scale field experiment, later cancelled due to government cutbacks)

This is 80 years after the first hatcheries – still no evidence that stocking was of any value, despite million egg capacity hatcheries on the Spey and the Helmsdale.
Why could no-one find any evidence for the benefits of stocking?

The problem was that no-one could find what they were looking for from hatcheries – *a clear increase in adult returns due to no other reason* than stocking.

It was assumed that huge “wastage” of eggs through poor natural fertilisation and predation, and heavy predation on the surviving fry meant that spawning areas were under-stocked or even “empty” and therefore needed stocked.

These assumptions went unchallenged as there was no way of actually surveying and counting the juveniles in nursery areas.
“What amounts to a complete reversal of existing ideas on the efficiency of natural spawning in salmon and trout comes to us from New Zealand”.

“Hitherto, it has always been tacitly assumed that fertilisation of fish eggs was a very inefficient affair.

Some writers have put fertilisation of eggs as low as five per cent others have suggested ten per cent as a good average and very few have put fertile results as high as fifty per cent…..”

This is what the sensation was about:-
Hobbs marked out and then dug up redds to find out how well the eggs had been fertilised – and found that well over 90% had been fertilised.

He wasn’t actually the first to do this – W. H. Armisted did in 1908, in Galloway, but got a completely different result:

In one stream, only 1 batch of eggs in 17 redds was alive, making a “fertilisation rate” of 8%.

He assumed this death rate was due to poor natural fertilisation.

But was it? He reported other things going on in his area at the same time -
What no-one knew till much later was that Galloway was the part of the British Isles most affected by Acid Rain – and it was this that was having the effects on fish that he found as is clear from the “symptoms” listed above.

His hatchery once wiped out by toxic water he linked to heavy *Sphagnum* moss growth in the water supply.

- Of 500 eyed eggs from the wild, put in a hatchery, 98% hatched, but only 150 were not deformed.

- Trapping a trout spawning burn found only a small number of mainly large, old, spawners.

The cover photo of this report is of fish from L. Grennoch, Galloway, showing how fish populations die out due to lack of recruitment of young fish, eggs and fry being the most susceptible to acidification.
It was just bad luck that the only person who tried to check whether it was true natural fertilisation rates were low did so in an area affected by Acid Rain – and so apparently confirmed the general view.

Hobbs’s results were confirmed for the Atlantic Salmon by Prof. J.W. Jones in the 1940s and 1950s

Fortunately, he worked on the R. Alwen, a tributary of the Welsh Dee which was not affected by acid rain
a) Natural fertilisation is highly efficient, over 90%

b) The spawning areas are not therefore under-stocked

c) So stocking on top of naturally spawned fish is no advantage,

So why are there not millions of adults returning from millions of eggs?

The final piece in the jigsaw came with another new bit of technology
The first use of electric-fishing was in the 1930s in America, but it only started to be used to survey streams in the 1950s and 1960s.

Once spawning streams could be checked for juveniles, it was found that there were lots of them, except where there were obvious environmental or access problems.
This is the real reason why millions of eggs don’t produce millions of adults:

a) The number of eggs is vastly in excess of the food and space for fry in the nursery areas

b) Numbers “self-thin” down to the number that can be supported by the food and space, the Carrying Capacity.

This is what people in the 19th century didn’t know: The biggest killer of salmon fry is competition with other salmon fry and that it is Carrying Capacity that limits the output of smolts, not the number of eggs or fry.
CARRYING CAPACITY – WHY DID NO-ONE IN THE 19th CENTURY THINK OF IT? Every hill farmer grazing sheep knew of it!

Frank Buckland came near to this concept when he was asked to explain the differential growth of Parr in the Stormontfield rearing ponds – he said this was due to stronger fish gaining an advantage over the weaker.

He made a rather strange, analogy with humans:

In “human ponds” (cities) young children who live in “good air” and are fed on “butchers meat and beer” are much stronger and healthier than those in crowded areas and who are fed on “red herrings and tea”

He knew that animals with more food and space did better – he just needed to think about this in relation to the vast numbers of eggs spawned by Salmon – but he was an Intelligent Design creationist who disliked Darwin’s idea of the survival of the fittest.
CARRYING CAPACITY – the fry in the hatchery ointment

The first description of the concept of “Carrying Capacity” for streams found so far was in 1914:

Armistead, W.H.: *The fry bearing capacity of head waters.*
Salmon & Trout Magazine #7, April 1914

- There must be limits to the amount of food and space for juvenile salmonids in streams
- If no spare capacity left in a stream, then no amount of stocking could make any difference
- New capacity was necessary if stocking was to be useful
WHY SIXTY YEARS OF STOCKING HADN’T SHOWN ANY RESULTS

“I think it is safe to say that we cannot depend on hatcheries to increase the stock of migratory Salmonidae in a river unless the capacity of the existing fry-bearing ground is greater than is required for the normal, natural, output of fry. Armistead, 1914
A history of failure - could it have been different?

The early days of stocking reared smolts in ponds and released in estuaries, so were “smolt ranching” rather than “stocking” as we understand it

So no competition with naturally spawned fry and parr
A history of failure - *could it have been different?*

- But stocking eggs & fry into upland streams which were already fully stocked *could* never produce any results.

- *If smolt rearing had continued, on a large enough scale, or on a small enough river, then the sort of results looked for from hatcheries might have been found.* A technical problem though – rearing 1 year old smolts.
The history of hatcheries, a history of failure - could it have been different?

However, another assumption made in the 19th century was that the extra fish that survived in the safety of a hatchery were the same sorts of fish that survived in the wild in rivers.

This is not true. All salmon fry, even those in the same family, are genetically different from all others.

The ones that survive in the wild in rivers are the ones best suited to their local environment, the Winners in the struggle for survival, the best types of fish for that area.

The extra fish that survive in hatcheries are those that would have lost in the struggle for survival in the wild in the river, the Losers, the ones not best suited to their local areas.
The history of hatcheries, a history of failure - *could it have been different?*

But you don’t want it in a breeding population anyway – something the 19th century couldn’t think of.

A “loser” - dies in the wild, but would live in a hatchery.
The history of hatcheries, a history of failure - could it have been different?

A wild breeding population –
Every one a winner in **both** river and sea

Too much smolt-ranching, and losers will get into the breeding population
All winners in the sea, but only the wild winners in **both** the river and the sea

So it is just as well the 19th century didn’t carry on with smolt ranching
THE LESSONS OF THIS HISTORY:

1) Check your assumptions!
   Are they factually based or just “received wisdom”? Are they a disguise for ignorance?

2) Don’t try and do better than Nature – until you actually know what Nature does

3) Just because you can do something, does not mean you should do it – however technologically exciting it may be
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