

Geographical distribution of SAV subtypes in marine farmed Atlantic salmon in Scotland & Ireland

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Outline of the talk

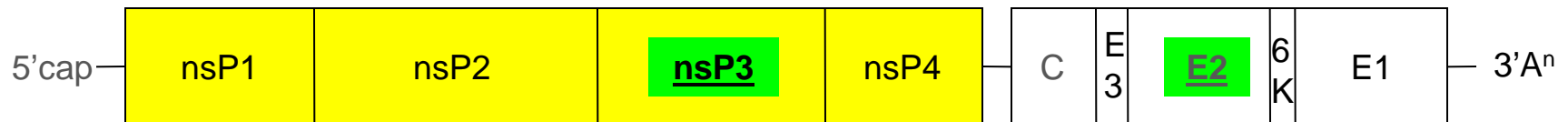
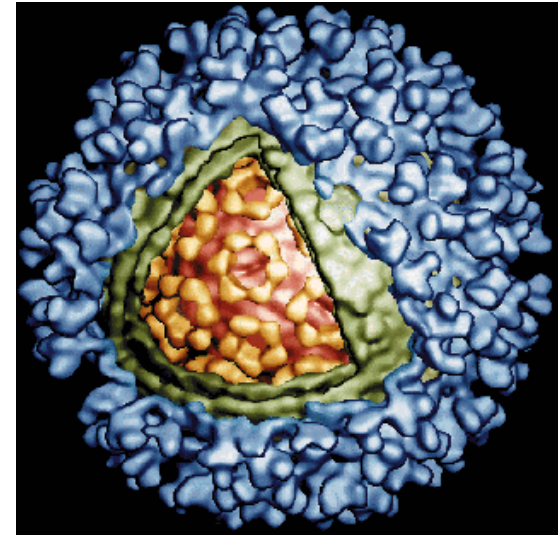
- Background
- What did we do?
- Summary of results
- Significant findings
- Practical implications
- Gaps in our knowledge & how you can help.

Salmonid Alphaviruses (SAV)

- Salmon Pancreas Disease Virus (SPDV)
- 1st fish alphavirus isolated in 1993 (Togaviridae family)
- Causes pancreas disease (PD) in marine salmonids (AS RT)
- Sleeping disease virus (SDV) freshwater rainbow trout (1997)
- SPDV & SDV were shown to be genetically closely related, produce similar pathology & are serologically cross reactive.
- Considered closely related strains of the same virus (*Powers et al 2001*)

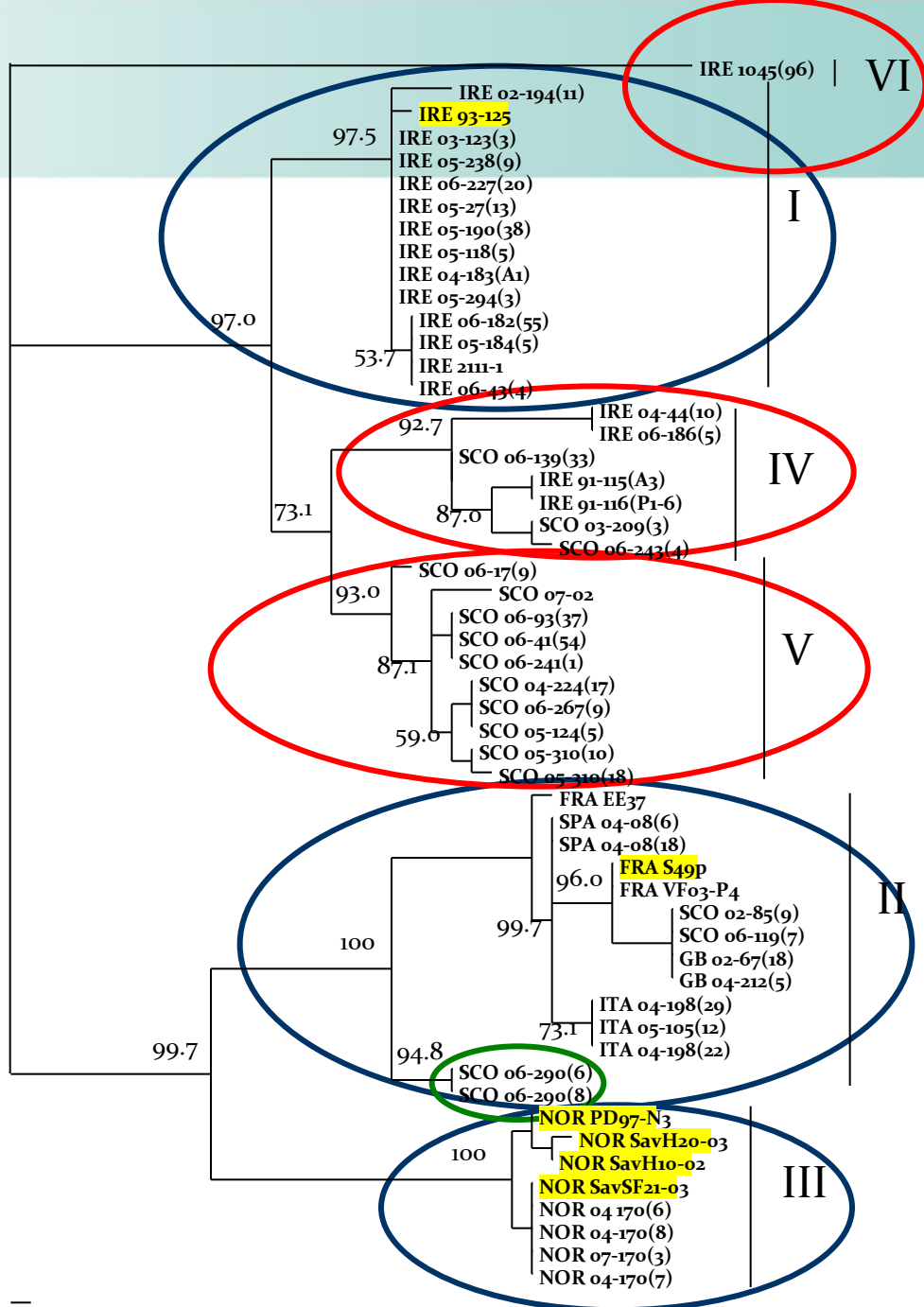
Properties of SAV

- Enveloped RNA virus
 - Family *Togaviridae*
 - Genus *Alphavirus*
(Six subtypes identified)
- 65.5 ± 4.3 nm
- ≈ 11.9 kb genome



SAV Subtypes

- Genetic analysis of viral sequences has shown there are at least 6 genetic clusters of SAV and these are referred to as subtypes (Fringuelli et al 2008)
- Subtypes are virtual groups of SAV isolates
- The original SPDV isolate (93-125) is founder member of SAV and referred to as subtype 1 for that reason
- SDV (S49p) is the earliest member of the SAV 2 subtype (RT)
- First Scottish isolate from FRS PD material (P42p) SAV 2.
- SAV was isolated in Norway in 1997 & later typed as SAV3 (2005)
- SAV 4, 5 & 6 identified in 2008 (Fringuelli 2008)
- SAV 2 has recently been isolated in marine Atlantic salmon in Norway (Hjortaas M.J. et al. 2012)



E2 gene-based phylogenetic analysis

(Fringuelli 2008)

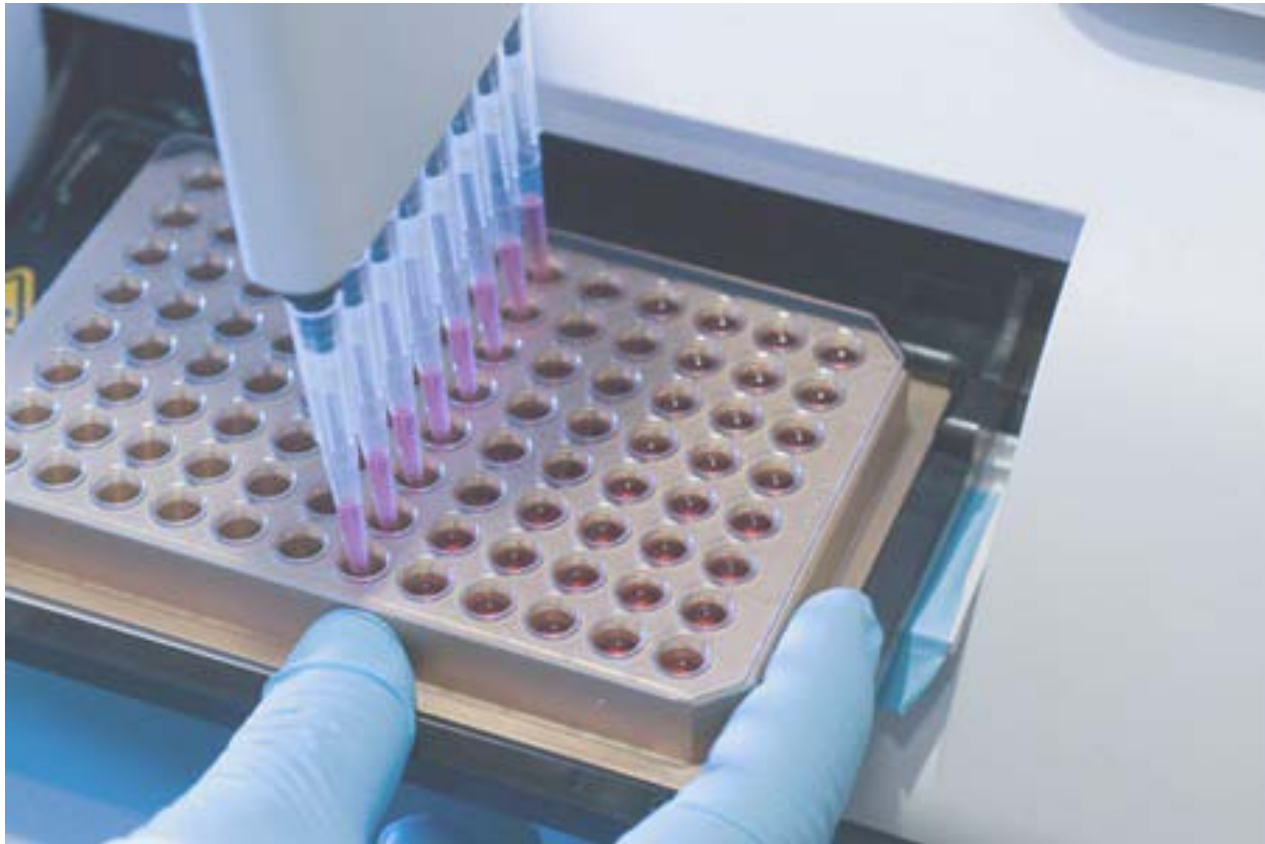
Salmonid alphavirus subtypes

SAV Subtype	Species	Country
SAV 1 (PD)	AS (SW) RT# (FW)	Ire, Scot#
SAV 2 (FW) SAV 2 (SW)	RT AS*ϕ	Fr, Eng, Scot, Italy, Sp, Ger, Croatia Scot* NORWAYϕ
SAV 3(PD)	AS & RT in sea	NORWAY only
SAV 4 (PD)	AS	Ire, Scot
SAV 5 (PD)	AS	Scotland
SAV 6 (PD)	AS	Ireland only

Current Study

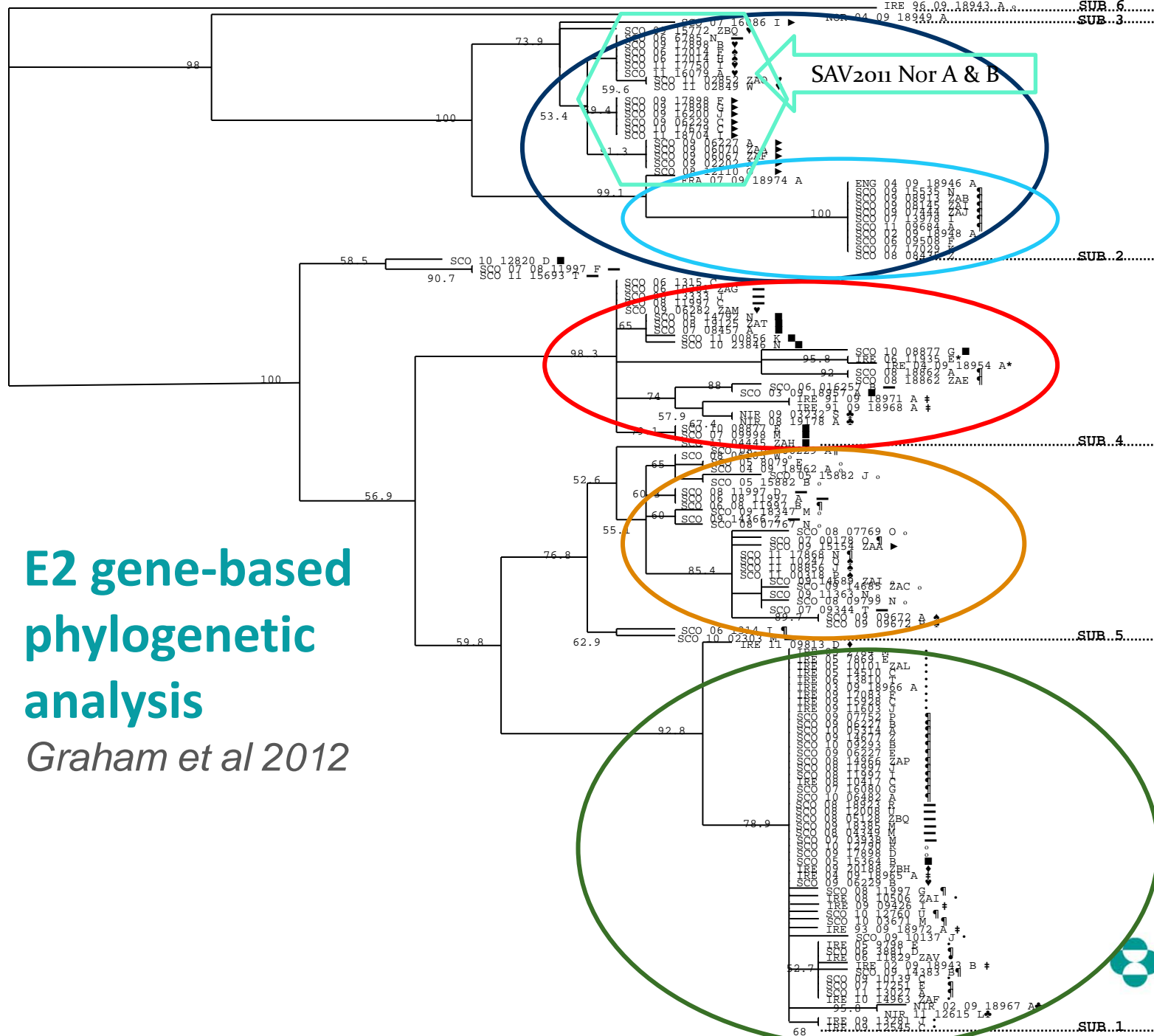
- E2 Sequence data from Scotland & Ireland (1991-2011)
 - (Majority from 2005-2011)
- Database of all SAV sub-typing at AFBI FDU, Belfast
- 160 strains (Culture or tissue PCR)
- 20 fish farming companies
- 110 different sites
- Geographical distribution
- Molecular epidemiological observations

Results

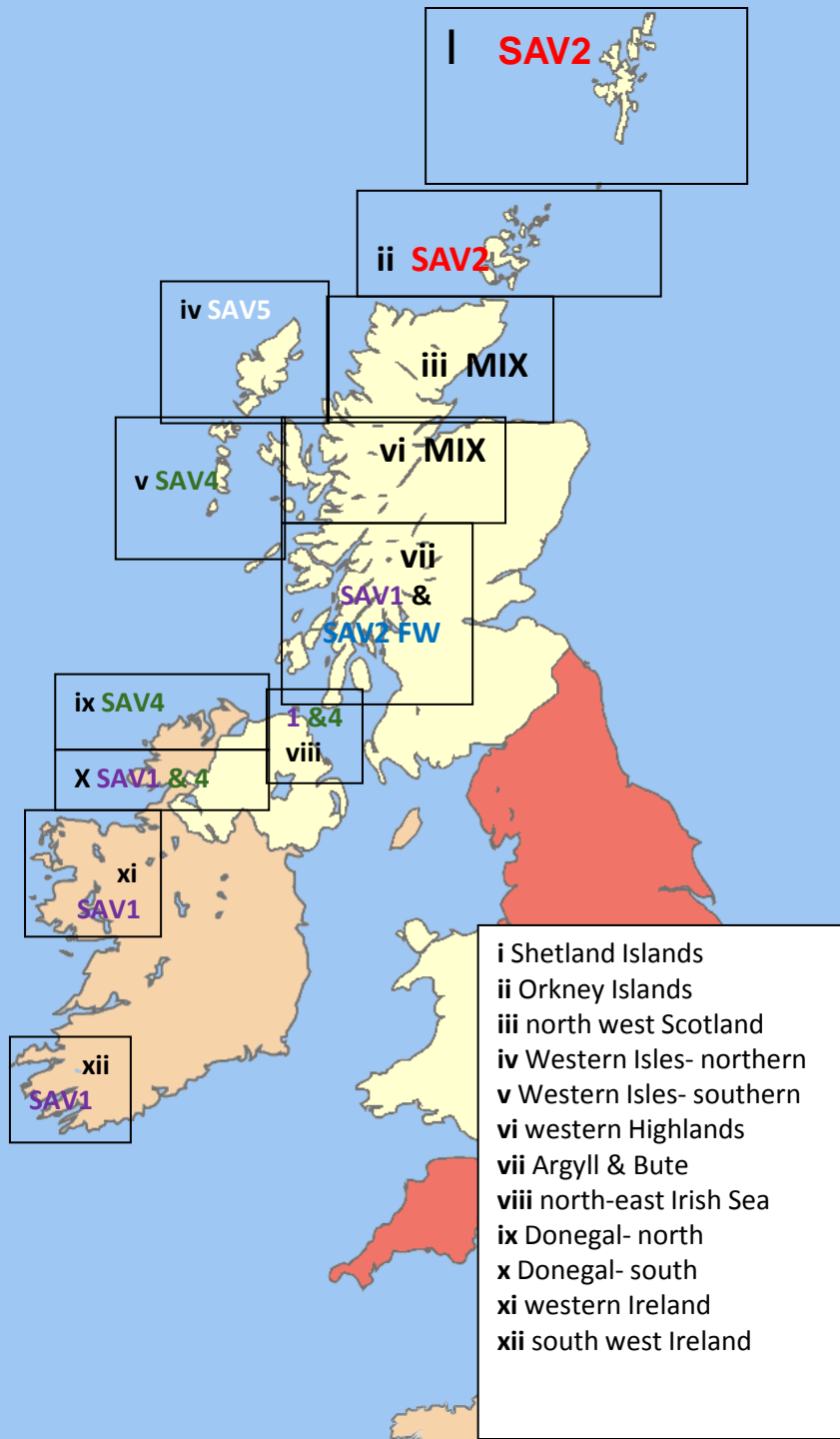


E2 gene-based phylogenetic analysis

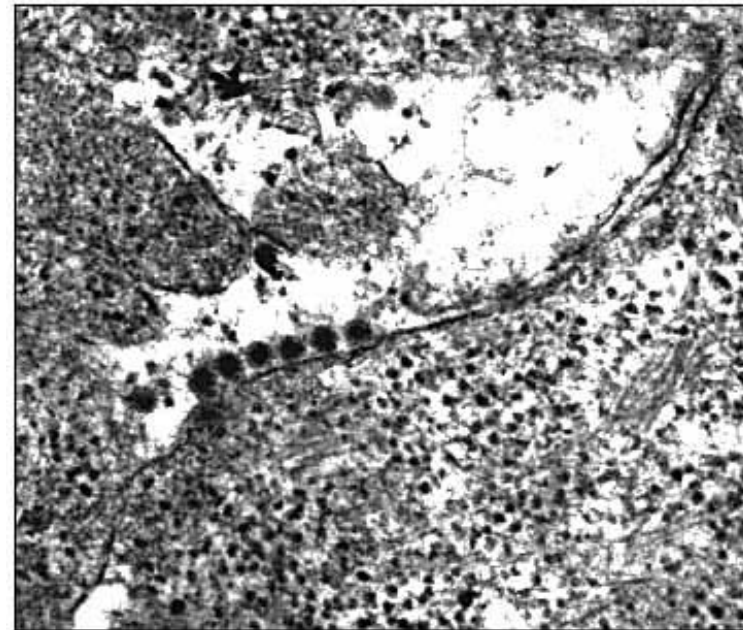
Graham et al 2012



Geographical regions of Scotland & Ireland



Predominant subtype shown



Scottish SAV Subtype Distribution

Subtype	Argyll & Bute	West High	N.W Scotland	Orkney	Shetland	Harris & Lewis	Uist
SAV 1	20	6	0	2	0	2	1
SAV 2	6 FW	1SW	2SW	7SW	12SW	0	0
SAV 4	3	6	1	0	0	1	13
SAV 5	6	7	6	1	1	16	1
SAV 6							
Total	35	20	9	10	13	19	15

Irish SAV Subtype Distribution

Subtype	North Donegal	South Donegal	West	South West
SAV 1	1	4	21	3
SAV 2				
SAV 4	3	2	0	0
SAV 5				
SAV 6	0	0	1	0
Total	4	6	22	3

Subtype	North Irish Sea
SAV 1	2
SAV 4	2
Total	4

New & Significant findings

Geographical clustering of SAV subtypes

- Shetland Islands and Orkney Isles- almost exclusively SAV 2
- Harris/Lewis-almost exclusively SAV5
- Uist-almost exclusively SAV 4
- Ireland West & South West- only SAV 1
- Ireland North-SAV1 & SAV 4

Practical implications

- Consistent with hypothesis that individual subtypes introduced from wild reservoirs, salmonids or otherwise on a limited number of occasions, but spread via water & aquaculture operations.

New & Significant findings

SAV 2 Subtypes

- **Two distinct SAV 2 strains** in Marine Atlantic salmon (MAS)
- SAV 2 strains found in Shetland and Orkney are distinguishable from Freshwater Rainbow trout [RT] SAV 2 strains
- SAV 2 strains found in (MAS), particularly in Argyll & Bute, are 100% similar to SAV 2 strains detected in Sleeping Disease in freshwater RT strains.
- **SAV 2 is infectious and pathogenic across salmonid species & environments.**
- Recently SAV 1 reported in freshwater RT (Lester 2011)
- **SAV2 isolated in Norway very similar to SAV 2 marine strains**

Practical implications of SAV 2

- Cross species horizontal transmission of SAV 2 subtypes and which is also seen with SAV 3 in Norway (AS & RT in the sea) has implications for disease spread & control.
- SAV can survive in both salt and freshwater and may be transmitted by movement of live fish, equipment and personnel
- SAV can survive for up to 60 days in seawater @ 4°C (Graham et al. 2007).
- Unvaccinated rainbow trout in FW or SW could undermine vaccinated Atlantic salmon populations in the same water catchment.
- Biosecurity measures have not worked in the past

Evidence of SAV Subtype switch

Site & Company	1 st SAV Subtype & year	Subsequent Subtype
24F	SAV4 (2006)	SAV 1 (2008)
48F	SAV 1 (2008)	SAV5 (2010)
8F	SAV 1 (2008)	SAV5 (2010)
64N	SAV5 (2009)	SAV 4 (2011)
70F	SAV 2 (2006)	SAV 5 (2011)
57F	SAV4 (2003)	SAV 1,4 (2005, 07)
94F	SAV 5 (2008)	SAV 1 (2010)
78L	SAV 4 (1991)	SAV 1,1,1, (1993, 2007, 09)
31J	SAV 1 (2002)	SAV4, 4 (2008,09)

Evidence of subtype switching on several individual sites which would allow for subtype comparisons of clinical disease and movement tracing

Other interesting observations

- In some regions there is a mix of subtypes which requires further investigation.
- No evidence of vertical transmission
- SAV 5 found in wild fish in Shetland (Snow et al 2010) but only one SAV 5 subtype found in Shetland
- Comparison of these SAV 5 sequences would be interesting.

Gaps in our knowledge

- Clinical impacts of SAV 1 ,2 , 4 & 5* in Farmed Atlantic salmon in Scotland under commercial farm conditions.
- The identity and role of wildlife reservoirs in SAV infections
- Subtype specific pathology and mortality
- Vaccine efficacy (Preliminary results indicate PD vaccine effective across subtypes)
- * Graham et al 2006 describes a subclinical outbreak of SAV 5 PD in Scotland

Conclusions

- Significant geographical clustering of SAV subtypes
- Evidence of transmission of freshwater SAV2 strains to marine phase Atlantic salmon
- Evidence of marine SAV 2 in Scotland from early 1990's
- Evidence of subtype switching on some sites?
- Gaps in our knowledge of wildlife reservoirs of infection, sub-type specific pathology & mortality and vaccine efficacy
- Geographical distribution of salmonid alphavirus subtypes in marine farmed Atlantic salmon, *Salmo salar* L., in Scotland and Ireland Graham et al 2012-
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Acknowledgements

- Salmon farms in Scotland & Ireland
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