

Atlantic Cod (*Gadus morhua*)

Stock identification in ICES Division 6a

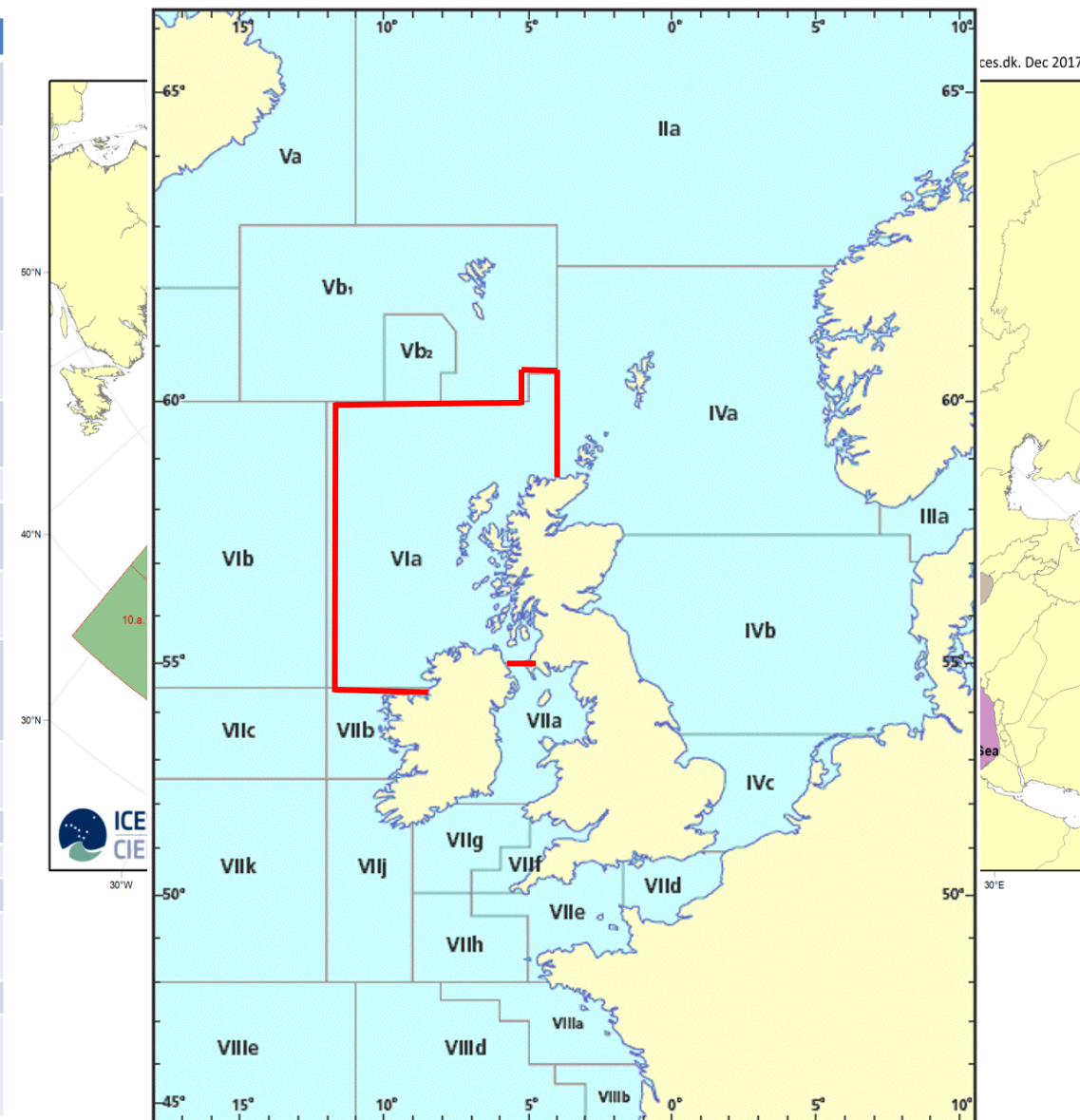


NWWAC, Dublin Castle
13th September 2018

Edward Farrell, EDF Scientific Ltd.
Peter Wright, Marine Scotland Science

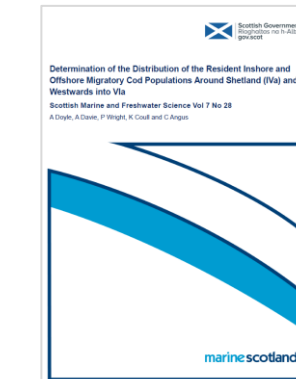
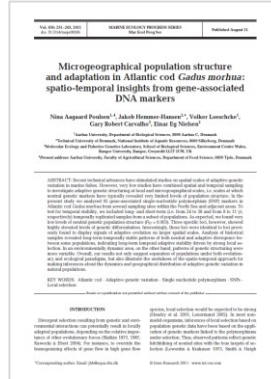
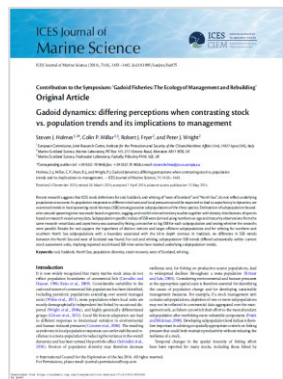
ICES Cod stocks

Stock Key Label	Stock Key Description	Eco Region	EG
cod.21.1	NAFO Subarea 1, inshore (West Greenland cod)	Arctic Ocean Ecoregion, Greenland Sea Ecoregion	NWWG
cod.21.1a-e	NAFO divisions 1.A-E, offshore (West Greenland)	Arctic Ocean Ecoregion, Greenland Sea Ecoregion	NWWG
cod.2127.1f14	ICES Subarea 14 and NAFO Division 1.F (East Greenland, South Greenland)	Arctic Ocean Ecoregion, Greenland Sea Ecoregion, Iceland Sea Ecoregion, Norwegian Sea Ecoregion, Oceanic Northeast Atlantic Ecoregion	NWWG
cod.27.1-2	subareas 1 and 2 (Northeast Arctic)	Arctic Ocean Ecoregion, Barents Sea Ecoregion, Norwegian Sea Ecoregion	AFWG
cod.27.1-2coast	subareas 1 and 2 (Norwegian coastal waters cod)	Arctic Ocean Ecoregion, Barents Sea Ecoregion, Norwegian Sea Ecoregion	AFWG
cod.27.21	Subdivision 21 (Kattegat)	Greater North Sea Ecoregion	WGBFAS
cod.27.22-24	subdivisions 22–24, western Baltic stock (western Baltic Sea)	Baltic Sea Ecoregion	WGBFAS
cod.27.24-32	subdivisions 24–32, eastern Baltic stock (eastern Baltic Sea)	Baltic Sea Ecoregion	WGBFAS
cod.27.47d20	Subarea 4, Division 7.d, and Subdivision 20 (North Sea, eastern English Channel, Skagerrak)	Greater North Sea Ecoregion	WGNSSK
cod.27.5a	Division 5.a (Iceland grounds)	Greenland Sea Ecoregion, Iceland Sea Ecoregion	NWWG
cod.27.5b1	Subdivision 5.b.1 (Faroe Plateau)	Faroes Ecoregion	NWWG
cod.27.5b2	Subdivision 5.b.2 (Faroe Bank)	Faroes Ecoregion	NWWG
cod.27.6a	Division 6.a (West of Scotland)	Celtic Seas Ecoregion	WGCE
cod.27.6b	Division 6.b (Rockall)	Celtic Seas Ecoregion, Oceanic Northeast Atlantic Ecoregion	WGCE
cod.27.7a	Division 7.a (Irish Sea)	Celtic Seas Ecoregion	WGCE
cod.27.7e-k	Divisions 7.e-k (eastern English Channel and southern Celtic Seas)	Celtic Seas Ecoregion, Greater North Sea Ecoregion, Oceanic Northeast Atlantic Ecoregion	WGCE

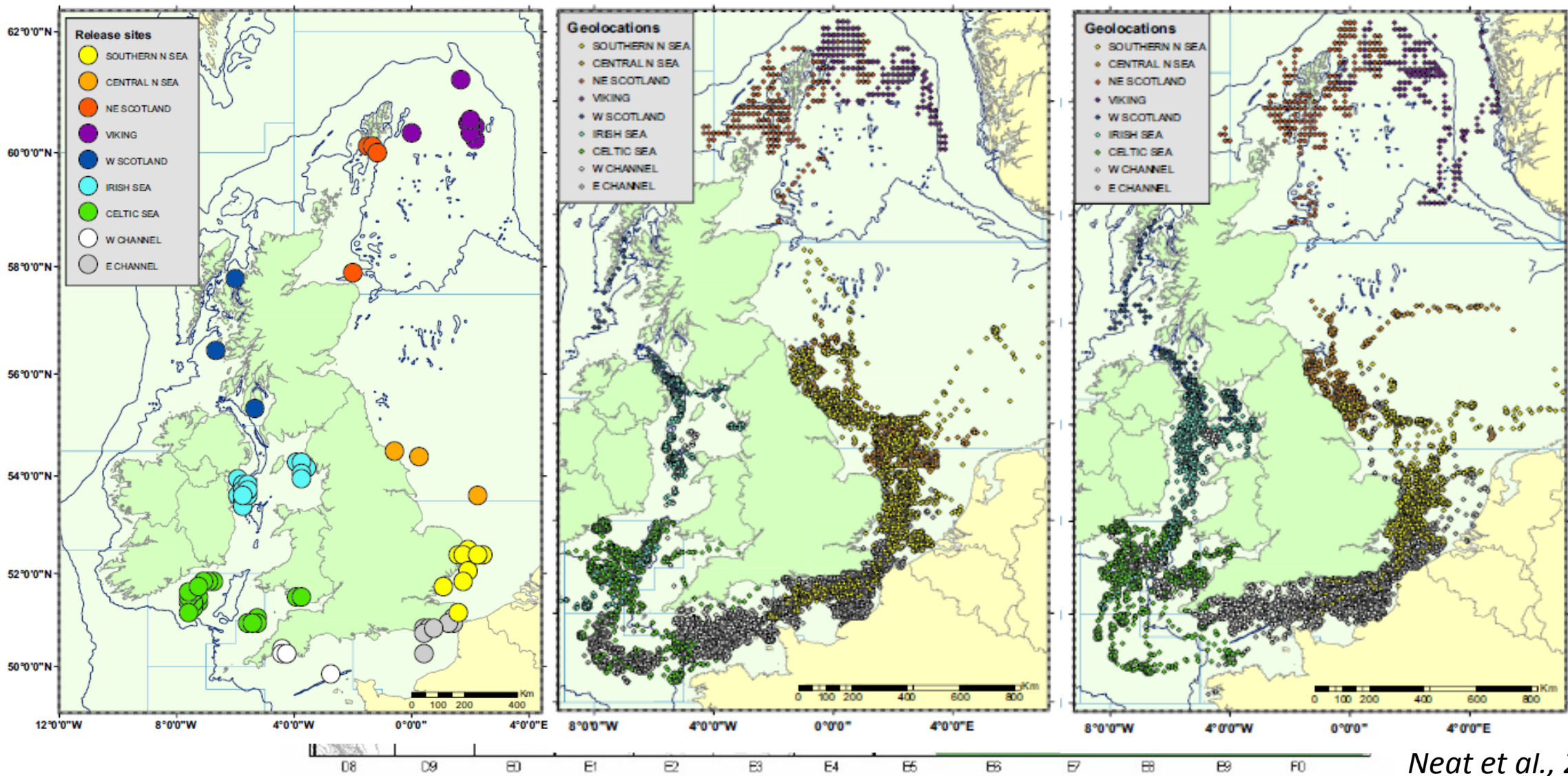


Cod populations

- Numerous studies
- Multiple methods
 - Tagging, otolith morphometrics, otolith microchemistry, life-history analyses, genetics.
- Population structure more complex than assessed stocks
- Stock boundaries do not align with biological populations
- Multiple populations with stock areas



Tagging

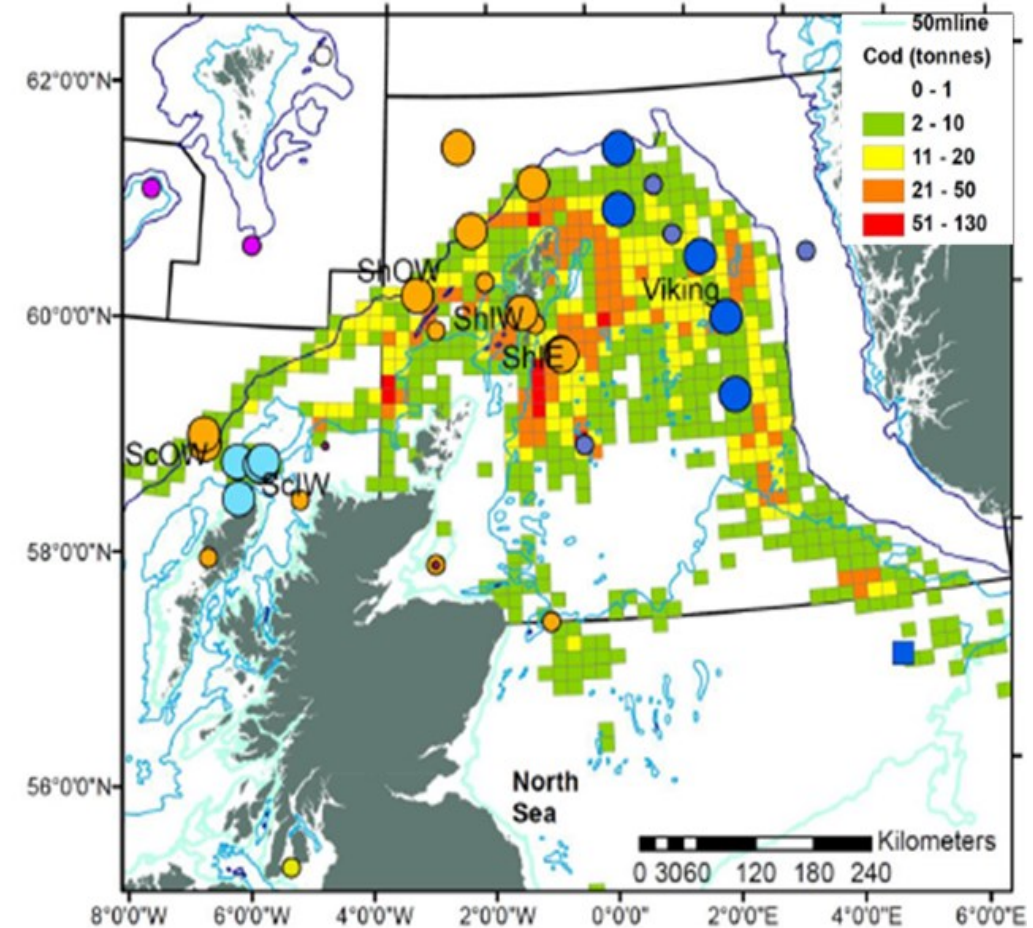


Ó Cuaig and Officer, 2007

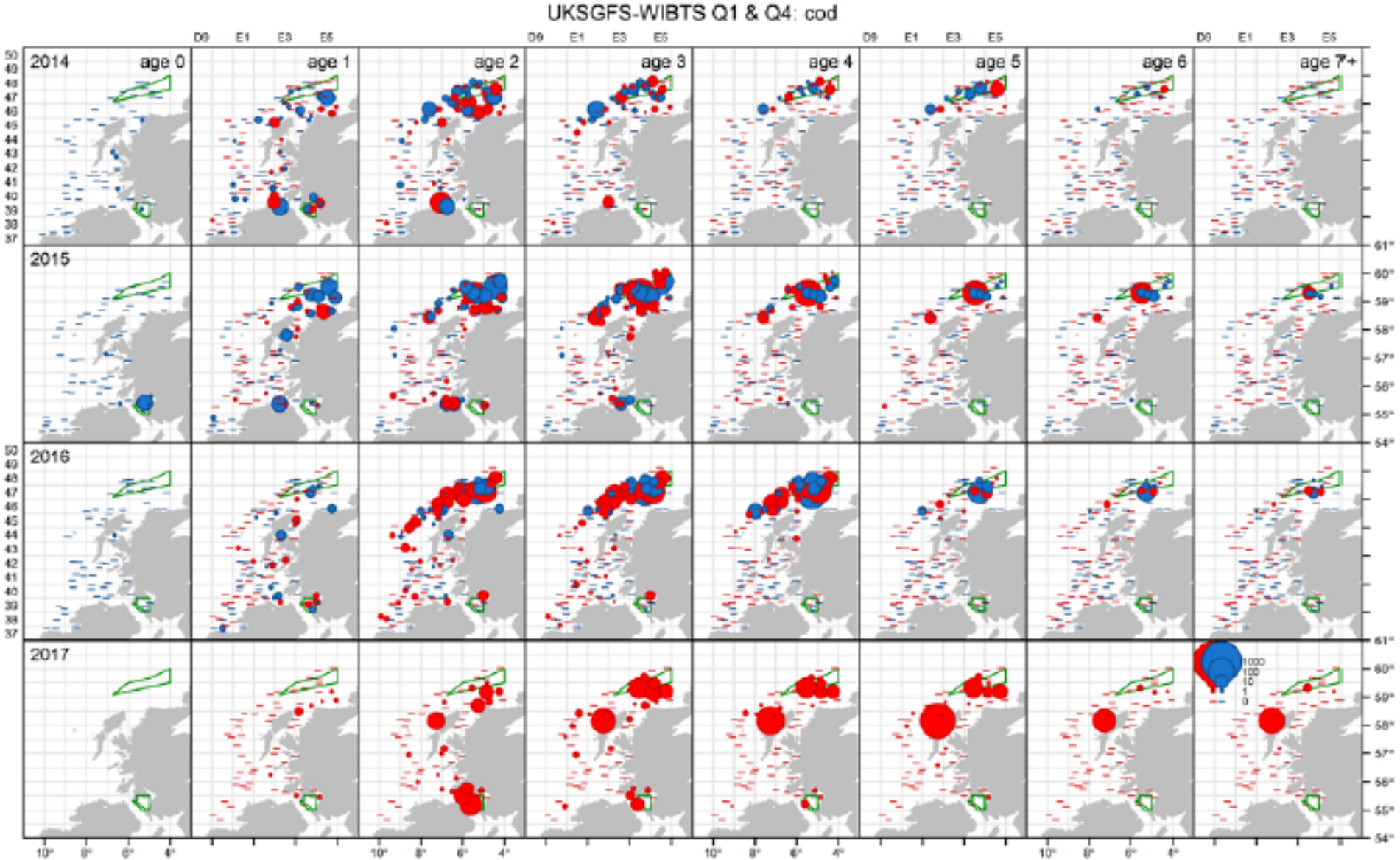
Neat et al., 2014

Genetics

- Multiple studies
- Microsatellites and SNPs
- Mainly focussed on NS-WoS
- Two populations in Northern NS
- Mixing across the 4° of migratory cod
- Structure between WoS and south
- 6a sampling and resolution low

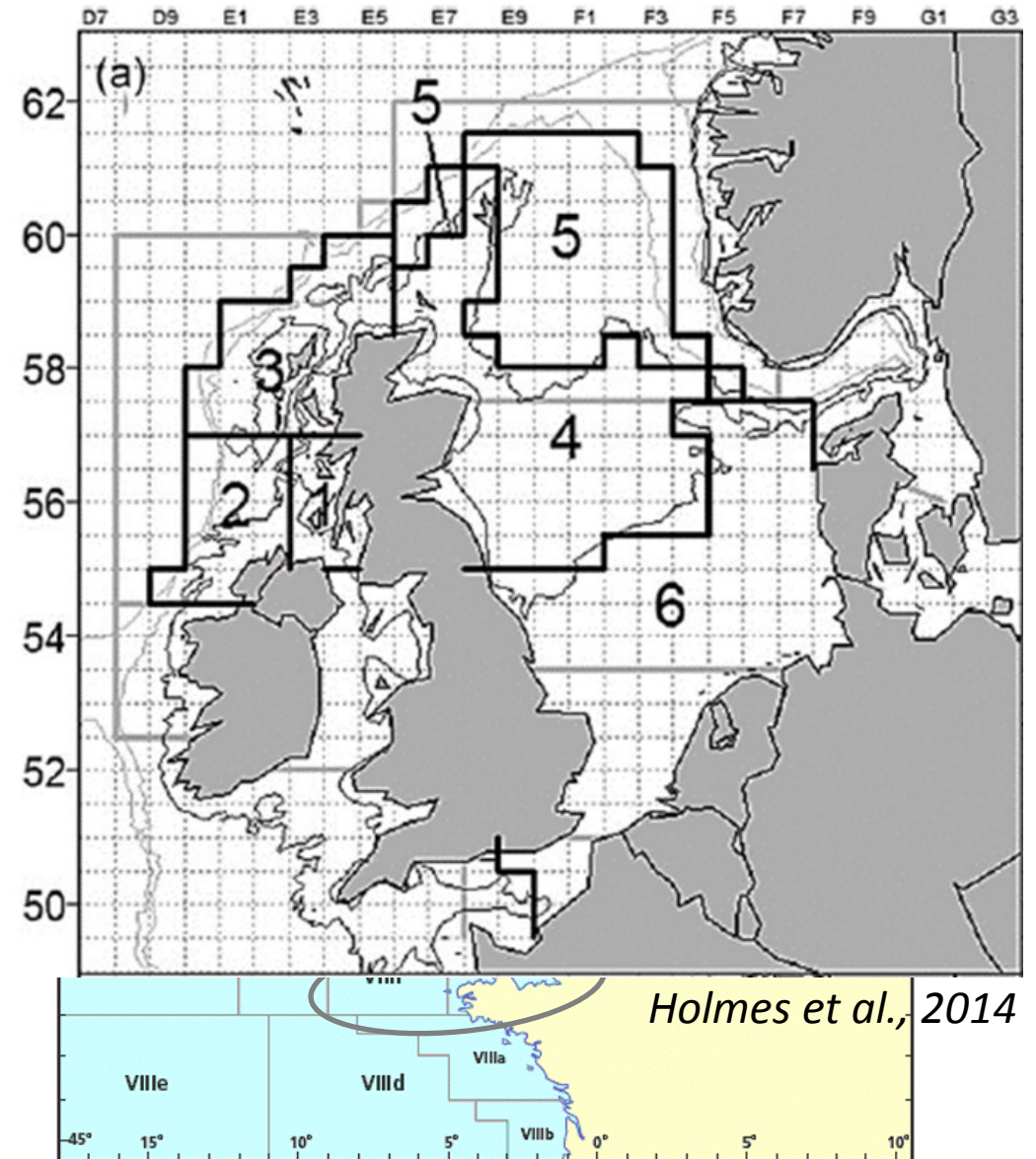


Survey data



Summary

- Multiple populations in NS
- At least one mixes with WoS
- Resident Coastal population WoS
- Divide between WoS and 6aS
- Mixing between 6aS, Clyde & 7a
- Migration from 7a to 7g and 7e to 7h



ICES 6a Cod assessment and advice

- 'Tl
- 'In
- Sir
- Ca
- Lal
- Bic
- Lit

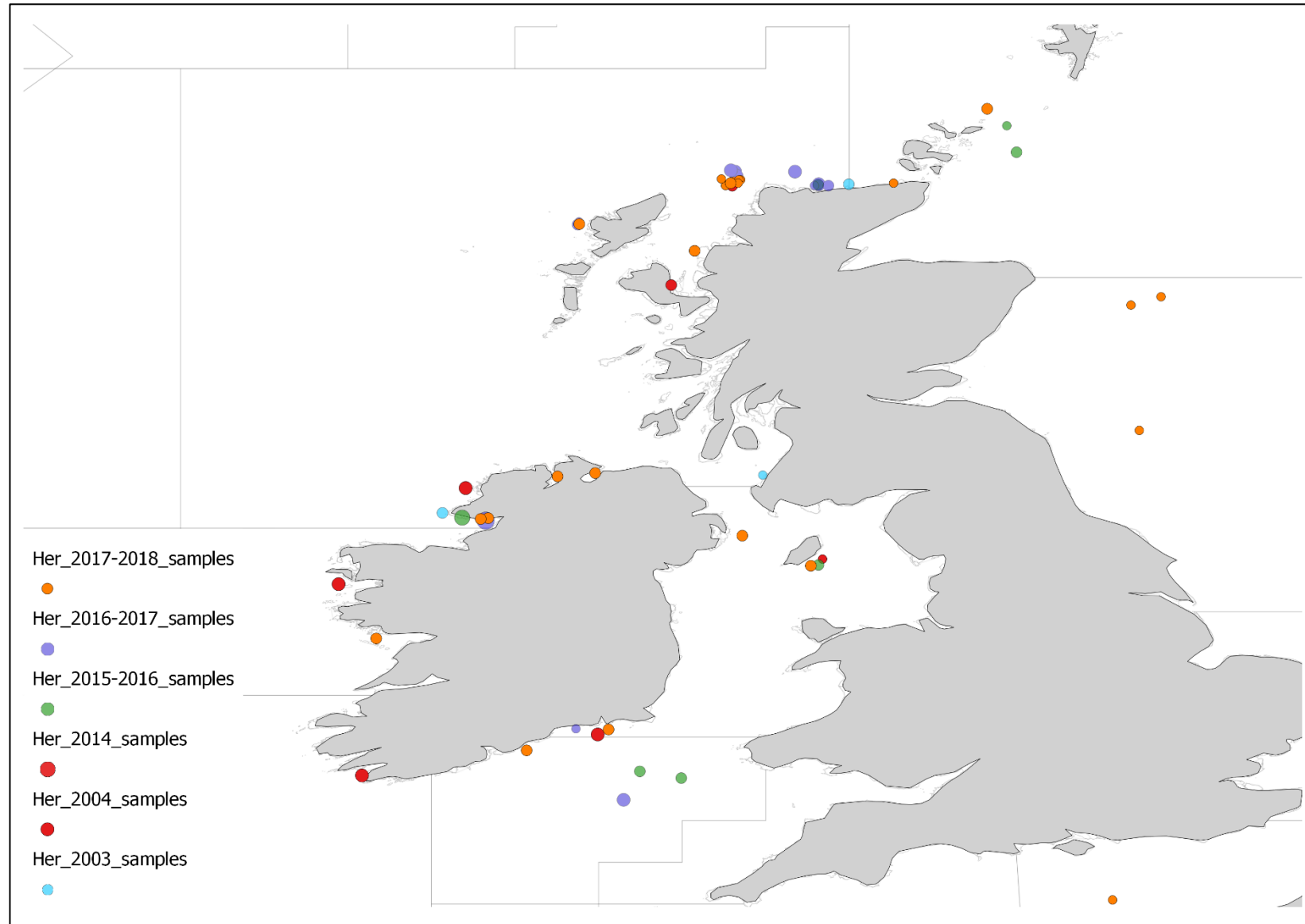


Figure 1 Cod in Division 6.a. Summary of the stock assessment. The shaded areas in the bottom panels correspond to one standard error for estimates of mortality and SSB.

How to resolve this?

- Scientifically
 - Robust and temporally stable genetic method to split 6a populations
 - Collect and analyse multiple years of baseline spawning samples
 - Define the geographic limits of the populations
 - Define the levels of mixing and be able to monitor annually
 - Discriminate 4a, 7a and other adjacent populations from 6a
- Practically
 - Close collaboration between industry, assessment scientists, survey scientists and biologists
 - Agreement from ICES on the level of structuring and need for a population level assessment within ICES

Herring Baseline samples



Cod genetic samples

Area	Date	N	Type	Source
Celtic Sea	March 2018	100	Fin and muscle in EtOH	MI Tagging
Irish Sea South	February 2018	100	Fin and muscle in EtOH	MI Tagging
Irish Sea North	March 2018	50	Fin in EtOH	AFBI Tagging
6aN	2014	388	Gill in EtOH	Doyle et al in prep
North Sea	2014	505	Gill in EtOH	Doyle et al in prep
Papa Bank	2003	47	DNA extract-80	Heath et al. 2014
Outer Hebrides	1998	44	DNA extract-80	Heath et al. 2014
North Minch	2003	50	DNA extract-80	Heath et al. 2014
Clyde	2003	77	DNA extract-80	Heath et al. 2014
Moray Firth	2003	49	DNA extract-80	Heath et al. 2014
Long Hole	2009	17	DNA extract-80	Heath et al. 2014
West of Shetland	2003	119	DNA extract-80	Heath et al. 2014
West of Shetland	2002	48	DNA extract-80	Heath et al. 2014
East of Shetland	2002	42	DNA extract-80	Heath et al. 2014
Viking Bank	2002	44	DNA extract-80	Heath et al. 2014
Viking Bank	2003	36	DNA extract-80	Heath et al. 2014
Viking Bank	2007	49	DNA extract-80	Heath et al. 2014

Draft Proposal

- Stage 1
 - Literature review
 - Sampling strategy
 - Existing resources
 - Sampling Programme
 - Starting 2019 spawning season
- Stage 2
 - Initial genetic Baseline
 - Existing samples and 2019 samples
 - c.2000 fish @100 markers
- Stage 3
 - 2020 baseline samples
 - Mixed samples

Item	Description	Timing	Cost €
Stage 1	Literature and marker review and 2019 Sampling programme coordination	Jan-April 2018	10,000
Stage 2	DNA Extraction, sample processing, laboratory preparation, sequencing, data analyses, reporting and all associated costs	May-Nov 2018	63,000
Subtotal ex VAT			73,000
VAT @ 23%			16,790
Total			89,790