Subordinate legislation - The Sea Fish (Prohibition on Fishing) (Firth of Clyde) Order 2024

Correspondence from Professor Michael Heath, 12 March 2024

Dear Deputy Convener,

I am writing to you as one of the co-supervisors from the University of Strathclyde of the PhD research on Clyde cod that was repeatedly mentioned in the Rural Affairs and Islands Committee meeting on 28 February 2024 (Sea Fish (Prohibition on Fishing) (Firth of Clyde) Order 2024 (SSI 2024/6)). My colleague Dr Robin Cook (who was the lead supervisor) and I would like to draw your attention to accuracies in the evidence provided to the Committee by the representatives from the Marine Directorate.

We outline below the three main issues that, from our perspective, we consider to be of concernregarding the Marine Directorate evidence. Our perspective is the conservation of the population of Clyde cod. In their evidence, the Marine Directorate maintained that there is no such thing as Clyde cod. However, a 2022 examination by the International Council for the Exploration of the Sea (ICES)of the scientific evidence (see accompanying document) says exactly the opposite – there is a distinct population of cod in the Clyde which is separate from the west of Scotland. We believe that the Scottish Government has a responsibility to protect and conserve this iconic aspect of Scotland's marine biodiversity. The issues are wider than the spawning closure SSI. While the closure may be a reasonable precaution, our research shows it is unlikely, on its own, to be sufficient to achieve the goal of recovering the population.

Given the inaccuracies in the evidence provided to the Committee by the Marine Directorate, we believed there is a case for further inquiry by the Committee extending beyond the issue of the spawning closure SSI. The Government has the right to decide that other priorities dictate the Clyde cod should be allowed to decline to an extremely low level, but not without explaining why this should be allowed to happen. In this case the issue is why they are apparently unwilling to consider all possible measures that would eliminate the incidental by-catch of cod by all means of fishing for prawns.

Concerns regarding the accuracy of evidence provided to the Committee.

1. Availability of PhD research from the University of Strathclyde

First, we would like to comment on the availability and validity of the frequently mentioned PhD research for advising policy on conserving cod in the Clyde.

Funding for this project was provided partly by the University of Strathclyde, and partly by UKRI and the Marine Directorate through the UK Natural Environment Research Council SUPER Doctoral Training Programme. The funding was awarded through a peer reviewed competitive process. We sought supervisory participation from two Marine Directorate staff due to their expertise, and the fact that they hold all of the raw data required for the project. As mentioned by Dr Needle, the student (Ms Ana Adao) has recently submitted her thesis for examination, and the exam date has been set for 21st May 2024.

Dr Needle stated that there has been no external or internal peer review of the work, and argued that “we therefore remain in a position of not having a Clyde-specific stock assessment for cod”. The evidence from Ana Adao’s research is highly relevant in providing the only analysis of the state of cod in the Clyde and the likelihood to any recovery. Contrary to Dr Needle’s assertion, UK Government guidelines on the use of scientific advice make it clear that while peer review is desirable it is not a pre-requisite to using evidence (page 10, paragraphs 25-26 in accompanying document). Any review needs to be proportionate while allowing new and emerging findings to be used. The fundamental principle is openness and transparency about the quality of information used. Furthermore, the UK guidelines stress the need to seek evidence beyond internal government sources (paragraphs 12-17 in the accompanying document).

Both of the Marine Directorate supervisors have been highly engaged throughout the 3.5 year project, and have reviewed the thesis prior to submission. So it is incorrect to say that the work has not been subject to internal review. Dr Needle has been aware of the work. Ms Adao gave presentations at the Marine Directorate Laboratory in Aberdeen, the MASTS annual science conference, and a Marine Directorate/MASTS policy-science workshop at Heriot Watt University. The research is therefore in the public domain and has been discussed with both Marine Directorate scientists and policy officials. If they disagree with the findings, these concerns have not hitherto been raised with us – Certainly, this work represents a substantial body of evidence on the state of the Clyde cod that should have been summarised for the Committee. Ms Adao, Dr Cook, or myself would also have been happy to appear before the Committee to explain the results.

Briefly, the findings of the PhD research show that the cod stock is at a very low level and that there is no sign of recovery over a 20 year period, despite having previously supported a significant fishery. Since around 2011 there have been zero or only very minimal landings of cod from the Clyde for human consumption. Almost all the catch has been taken incidentally as by-catch by the prawn trawlers and discarded at sea. The quantities caught, although small in absolute terms (around 100 tonnes per year), represent a high proportion of the remaining stock. At these high rates of fishing mortality it is almost impossible for the stock to recover.

From our perspective, the Clyde spawning closure covered by the SSI is a sensible precautionary measure under the circumstances, though there are many concerns

about its equity and effectiveness. However, for the reasons outlined above, it is most certainly not sufficient to secure the recovery of the stock. In his evidence, Mr Gibb outlined some technical measures regarding mesh sizes of nets that have been implemented to reduce by-catch of juvenile fish by the prawn trawl fishery. However, no evidence was provided of their effectiveness at reducing fishing mortality for cod, and indeed, we see from the Marine Directorate observer programme that cod by-catch in the Clyde has continued. If there is a desire to facilitate cod recovery then additional measures are required, such as spatial restrictions on fishing for prawns so as to avoid known high concentrations of juvenile cod. We know that these occur in certain locations in the Clyde.

2. Is there a separate stock of cod in the Clyde?

Our second area of concern regards the conflicting and confusing messages provided by Dr Needle and Mr Gibb regarding the distinctiveness of Clyde cod relative to cod in neighbouring regions, and the practicality of carrying out separate assessments for the Clyde.

The International Council for the Exploration of the Sea (ICES) has recently reconfigured their view of the spatial extent of cod stocks and the assessments thereof. The west of Scotland is no longer considered to be a separate stock, but part of a unit that also encompasses the north-western North Sea. This decision was based on a thorough and careful consideration of a wealth of peer-reviewed evidence on genetics, tagging, chemical, abundance trends and biological data. The ICES working group that conducted this evaluation in 2022 (see accompanying document) concluded that:

- The scientific evidence points most strongly to North Sea and west of Scotland cod being made up of multiple over-lapping subpopulations spanning ICES Divisions 4.a and 6.a, plus a separate subpopulation of Clyde cod.
- However, treating the Clyde as a separate population is currently problematic with respect to reconstructing historical catches and undertaking assessments.
- As a short-term measure, data on Clyde cod could be included in the north-western cod assessment while investigations continue into the possibility of a separate assessment of the Clyde cod and the improvement of data availability.

This explains why data from the Clyde have been included in the ICES assessment for the north-western cod stock that Dr Needle and Mr Gibb refer to. However, this is not because ICES consider the Clyde to be part of the north-western assemblage of sub-populations. It is clearly stated that the Clyde is considered to be distinct and separate. Consequently, there is no basis to assume, as Dr Needle does in his evidence, that:

- “it is possible that the Clyde area is recovering in a similar way to what we see in the north□western sub-stock of the northern shelf cod stock”.

The ICES working group shows that the Clyde cod have not followed the same trends in abundance over time as the other sub-populations making up the north-western stock. Indeed, if the Clyde followed the north-western stock, the current ICES assessment implies that the stock recovered as early as 2008 for which there is certainly no evidence.

The commentary on Clyde cod provided by Mr Gibb is also at odds with the ICES advice. He said:

- “There is no stand-alone Clyde set of stocks and species; they are part of the broader west of Scotland stock. They come and go: pelagic fish will migrate in and out of the Clyde; saithe will stay there when they are small but go offshore when they are bigger. Therefore, the idea of managing Clyde stocks in the Clyde is not right. There are fish stocks, and some of those stocks are found in the Clyde. It is important that we recognise the difference.“
- “It is likely that some of the cod in the Clyde—I will not describe them as Clyde cod—are actually part of the Irish Sea genetic stock, but, as we do not have the definitive data to enable us to say that that is the case, the international scientific community assesses all those fish as the broad west of Scotland stock. However, I think that that is irrelevant. It does not matter whether the stock is genetically linked to the Irish Sea or to the west of Scotland, because, either way, it is equally important to give it an element of protection, because the Irish Sea stock is in a perilous condition compared with the northern stocks.”

He is likely correct to say there is no stand-alone Clyde stock of saithe and some other species, but ICES is absolutely clear that there is strong scientific evidence for a Clyde-specific population of cod. He says that in any case, the issue is irrelevant, but we profoundly disagree. The issue is absolutely fundamental to how one proceeds in relation to a strategy for recovering cod in the Clyde.

3. Availability of data on Clyde cod

The challenge of reconstructing historical catches and undertaking an assessment for the Clyde which is identified by the ICES working group was precisely the justification for the PhD project undertaken by our student Ana Adao. Hence the significance of her research for consideration by the Committee.

Regarding the availability of data, Dr Needle says:

- “the Clyde and other inshore areas around Scotland cannot currently be assessed as separate stocks, due to lack of data”.

This assertion is simply wrong. Ms Adao has accomplished this for the Clyde, using Marine Directorate data, as part of her PhD. The data consist of records from trawl surveys by the Marine Directorate and its predecessors, which have systematically visited the Clyde at least once a year, every year, since 1984; quarterly sampling of cod landed at the fish markets in the Clyde, especially at Ayr, since the 1980s until commercial scale landings ceased; and data from quarterly sampling of the discarded by-catch collected by observers on commercial vessels in the Clyde since

the early 1980's. This represents a very significant investment of public funds in data collection, and represents typical data used in most ICES assessments. The lower level of sampling in the Clyde means that there is higher uncertainty in the assessment. However, this uncertainty has been quantified by the PhD project and it is clear that robust conclusions can be drawn from the analysis.

4. Summary

In summary,

- There is no reason that we can see why the findings of Ms Adao's PhD project, which are known to the Marine Directorate, could not have been presented to the Committee in line with UK Government guidelines, subject to the understanding that they have yet to be approved by her external examiner.
- The Marine Directorate evidence provided to the Committee on whether or not cod in the Clyde are a separate stock from the west of Scotland clearly contradicted the advice from ICES. The ICES advice is clear –Clyde cod are a distinct population separate from the west of Scotland. This issue is fundamental to how one proceeds with developing a strategy to recover Clyde cod and it is disturbing that the Marine Directorate are denying this advice.
- The assertion that there is a lack of data to support a separate assessment of cod in the Clyde is clearly not borne out by Ms Adao's PhD research. We find that there is a substantial legacy of data available collected over several decades at considerable public expense, and this should all be bought to bear on the problem.
- Given these inaccuracies in the evidence, we believed there is a case for further inquiry by Committee Members extending beyond the issue of the spawning closure SSI. The Marine Directorate need to explain why they are apparently unwilling to consider all possible measures, in addition to the spawning closure, that might facilitate the recovery of Scotland's iconic population of Clyde cod. These might include spatial and technical measures to eliminate incidental fishing mortality on cod by all means of fishing for prawns, and protection of the essential habitat for juvenile cod.

Yours sincerely,

Professor Michael Heath

WORKSHOP ON STOCK IDENTIFICATION OF WEST OF SCOTLAND SEA COD (WK6aCodID; outputs from 2021 meeting)

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ICES International Council for the Exploration of the Sea
CIEM Conseil International pour l'Exploration de la Mer

Contents

i Executive summary

The Workshop on stock identification of West of Scotland cod (WK6aCodID) convened to recommend the most plausible scenario of population structure for stock assessment and fishery management advice. The review considered geographic variation and movements of cod life-stages inferred from genetic analyses, scientific surveys, fishery data, tagging, and otolith microchemistry and shape. Based on the review, several population structure scenarios were hypothesized (including the scenario assumed in the current advisory unit), and the plausibility of each scenario was evaluated. Practical implications of the most plausible scenario, including the derivation of a catch time-series, were considered to form recommendations for benchmark stock assessment workshops.

The workshop considered three hypotheses - hypothesis 1: closed homogenous population; hypothesis 2: a metapopulation with overlapping subpopulations (but not necessarily with areas within Division 6.a) (Clyde, Dogger inshore, Dogger offshore) and hypothesis 3: multiple overlapping subpopulations related to Dogger stocks (between Division 4.a and Division 6.a) and a separate subpopulation of Clyde.

While hypothesis 3 provides the strongest scientific evidence, treating the Clyde as a separate population is problematic with respect to reconstructing historical catches and undertaking assessments. Over the last two decades of local management with the Clyde cod closure, incorporating minimal catches into subpopulations is unlikely to impact assessments at the present time.

Given the current weak state of Clyde cod, hypotheses 2 and 3 would be practically indistinguishable in terms of assessment outcome and the workshop considers hypothesis 2 amenable to stock assessment in the short- to medium-term, while investigations continue into the assessment of the Clyde cod and the improvement of data availability. Given linkages of the inshore and offshore subpopulations to cod in Division 4.a, it is recommended to combine the North Sea and West of Scotland cod assessments in a future benchmark.

The workshop elaborated two scenarios with respect to a potential ICES data submission consistent with the modelling approaches being considered for the North Sea cod stock (cod in Subarea 4, Division 7.d and Subdivision 20); namely, either that data are submitted for the whole of Division 6.a as for the current ICES stock assessment, or that data are split into stock components as defined under hypothesis 2 (and hypothesis 3). In these cases, the workshop suggested that two approaches be considered based on data availability and a conversation between ICES national data submitters and ICES stock assessors.

ICES data submitters and ICES stock assessors should agree on a suitable time period for data splitting; considering the current assessment time-series for both West of Scotland and North Sea stocks and data quality back in time.

Having addressed its Terms of Reference, the workshop noted that there is potential for much reshaping of Atlantic cod stock assessments currently. With the four primary cod assessments (Celtic Sea, Irish Sea, West of Scotland and North Sea) presently exhibiting issues. Primarily these revolve around continued low catch tonnage, which translates into low catch numbers-at-age and resolves with heightened uncertainties in assessments. To investigate and review further, the workshop proposes that a planned approach be developed within ICES, through initial *roadmapping* for improving assessments and the basis for advice.

ii Expert group information

Expert group name	Workshop on stock identification of West of Scotland cod (WK6aCodID)
Expert group cycle	Annual
Year cycle started	2021
Reporting year in cycle	1/1
Chair(s)	Carl O'Brien, United Kingdom
Meeting venue(s) and dates	29 November – 1 December 2021, online meeting (16 participants)

1 Introduction

1.1 Terms of reference (ToRs)

A **Workshop on Stock Identification of West of Scotland Sea Cod (WK6aCodID)** chaired by Carl O'Brien, UK, will meet online from 29 November – 1 December 2021 to:

a) Review information on stock identification of West of Scotland cod and adjacent areas in the context of the Atlantic cod population structure, including critical evaluation of inferences from each source of information, to build up a picture of cod sub-stock structure in the West of Scotland and adjacent areas, based on the following:
   i) Distribution and movements of different life-stages of cod, including changes over time, inferred from:
      1) Tagging
      2) Scientific Surveys
      3) Commercial landings
      4) Dispersal models (e.g. of cod eggs and larva/juveniles)
   ii) Genetic analyses
   iii) Otolith microchemistry
   iv) Morphometrics and meristics
   v) Life-history and parasites
   vi) Other approaches not listed above

b) Based on the evidence from ToR a), formulate scenarios for cod stocks West of Scotland and adjacent areas, and assess the evidence-based plausibility of each of these scenarios (including current definitions).

c) Consider the practical implications, for data, particularly historical time-series of catch data, of each of the scenarios in ToR b), and how any difficulties might be dealt with. For example, considering spatial components with mixing in a single model has different implications for data compared to split stock units. Considerations should include how to deal with changes over time.

d) Make recommendations for which cod stock scenario(s) to take forward in the forthcoming cod benchmark, including in what format data should be requested and prepared.

The Workshop will report by 20 December 2021 for the attention of ACOM and FRSG.

1.2 Background

The 2020 benchmark stock assessment of cod West of Scotland (ICES, 2020a) was not primarily focused on stock identification but reported: *Stock structure remains an issue for cod in Division 6.a. The latest evidence […] suggests that there are at least three sub-stocks which remain largely geographically isolated throughout the year with the northern offshore component (currently responsible for the majority of the landings) more closely linked to cod in the northern North Sea than the rest of Division 6.a.*

WK6aCodID was established to reconsider the stock identification of West of Scotland cod and adjacent areas.

1.3 Conduct of the meeting

The list of participants and agenda for the workshop are presented in Annex 1 and Annex 2, respectively.

Intersessional work had taken place ahead of the WK6aCodID meeting by its participants, and this was presented during the first day and the morning of the second day. The presentations were used to define the work programme for the remainder of the workshop and to address the ToRs.

Given ICES role as a knowledge provider, it is essential that experts contributing to ICES science and advice maintain scientific independence, integrity and impartiality. It is also essential that their behaviours and actions minimise any risk of actual, potential or perceived Conflicts of Interest (CoI).

To ensure credibility, salience, legitimacy, transparency and accountability in ICES work, to avoid CoI and to safeguard the reputation of ICES as an impartial knowledge provider, all contributors to ICES work are required to abide by the ICES Code of Conduct. The ICES Code of Conduct document dated October 2018 was brought to the attention of participants at the workshop and no CoI was reported.

1.4 Plenary presentations

Seven presentations were given during the plenary sessions of WK6aCodID; presenter and title below.

Thomas Regnier:

Otoliths, microchemistry and tagging

- Presentation summarising studies involving otolith shape and microchemistry, tagging studies (those led my MSS and an historic one with key results), a reanalysis of tagging data for NScod in 2020 and a proposed population structure in 6.a based on a review of evidence from different sources at MSS, following a similar approach used in Holmes *et al*. 2014).

Mathieu Lundy:
Review of Celtic Seas and West of Scotland tagging records

- Background figures produced during an EASME-funded cod tagging project in the Irish Sea; compiled by Victoria Bendall (Cefas, UK) as a review of tagging records in ICES Divisions 6.a, 7.a and 7.g).

David Murray:

Summary of genetic data from previous studies on West of Scotland cod and adjacent areas

- Presentation on research involving the genetic structure of Atlantic cod within ICES Division 6.a, as well as adjacent ICES areas including Divisions 4.a and 7.a.

Helen Dobby:

Sub-stock survey biomass and recruitment trends

- Trends with an assumed sub-stock definition, not about determining sub-stock definition/stock identification.

Jakob Hemmer Hansen:

Figures 2.13 and 2.14 – heatmap (ICES, 2020b)

Nicola Walker:

North Sea cod mixing with 6.a cod

- A description of survey analyses combining data from the North Sea and Division 6.a, explored at the recent benchmark of North Sea cod (WKNSEA, 2021) and explanation of the ad hoc adjustment currently used in the North Sea cod assessment to account for connectivity with 6.a cod.

Helen Dobby:

West of Scotland cod - catch data and misreporting

1.5 Structure of the report

The structure of the report is as follows:

- Section 2 focuses on a review of information on stock identification of West of Scotland cod and adjacent areas – ToR a);
- Section 3 focuses on plausible scenarios for cod stocks West of Scotland and adjacent areas – ToR b);
- Section 4 focuses on practical implications of cod stock scenarios – ToR c); and
- Section 5 focuses on recommendations for West of Scotland cod stock scenario(s) to progress within ICES – ToR d).

Instead of providing conclusions from the workshop at the end of the report as is customary with ICES reports, each of the Sections 2–5 provides a synthesis of the material presented within each Section in either a summary or future work Section.

Initial compilation of the draft report was agreed to be completed by 13 December 2021; with final comments and review by the participants of the workshop to be completed by 17 December 2021 to ensure completion by the 20 December 2021.

1.6 References

ICES. 2020a. Benchmark Workshop for Demersal Species (WKDEM). ICES Scientific Reports. 2:31. 135 pp. http://doi.org/10.17895/ices.pub.5548

ICES. 2020b. Workshop on Stock Identification of North Sea Cod (WKNSCodID). ICES Scientific Reports. 2:89. 82 pp. http://doi.org/10.17895/ices.pub.7499

2 Review information on stock identification of West of Scotland cod and adjacent areas

2.1 Introduction

This section focusses on ToR a).

2.2 Otoliths, microchemistry and tagging

Otolith shape analyses

A single study used otolith shape analyses to identify spawning groups in ICES Divisions 6.a, 7.a and 4.a. Galley *et al*. (2006) sampled cod aged 2 to 4 years old on known spawning grounds in the Irish Sea, the Firth of Clyde, the South Minch, Papa Bank, Shetland, Viking Bank and the Moray Firth and analysed differences in general shape descriptors (e.g. rectangularity, circularity etcetera) and harmonics produced by Cartesian Fourier analysis. The produced otolith shape descriptors were analysed by two methods: (i) a randomization analysis of Fourier descriptors and (ii) a discriminant analysis of both general and Fourier descriptors. Results indicate significant differences in the otolith shape of fish collected at different spawning sites including neighbouring sites. In particular, the shape of otoliths of Clyde cod was different from the one of fish sampled in the Irish Sea or the South Minch, indicating the presence of distinct spawning groups. The otolith shape of fish spawning in the South Minch was also found to be different from the one of fish spawning on the East coast of Scotland in the Moray Firth. The population structure of cod in 6a appears to be complex with coastal spawning grounds associated with distinct spawning groups over a relatively small spatial scale.

Otolith microchemistry

Two studies used otolith microchemistry to investigate population structure in cod around the Scottish coast with at least a sample originating from Division 6.a (Wright *et al*. 2006a, Gibb *et al*. 2007). Gibb *et al*. (2007) used whole solution Inductively Coupled Plasma Mass Spectrometry (ICPMS) analyses to investigate the difference in otolith chemistry between nursery areas in the Firth of Clyde, Shetland, the Moray Firth and Buchan. Results indicate significant differences between areas and the potential for otolith chemistry to discriminate between fish from distinct geographical origins. As only young of the year (age 0) cod sampled on nursery grounds and a single nursery ground from 6.a was sampled (Firth of Clyde), the results are of limited significance to the objective of this workshop (i.e. at best no exchange of juvenile fish between the Firth of Clyde nursery and nurseries to the East of Scotland and Shetland).

Wright *et al*. (2006a) considered connectivity between nursery and spawning areas. In this study, sampling targeted 0-group cod from the 2001 year-class on nursery grounds and then the same year-class at age 2 when they first spawned. Based on solution ICPMS of whole 0-group otoliths, samples from the Scottish west coast could be distinguished into three regions; the Minch, Inner Hebrides and Clyde. The 0-group component of adult cod were micro-milled from the otoliths for comparison with the regional 0-group chemistry. Adult cod in the Inner Hebrides and the Clyde had a chemistry consistent with local origin as 91% and 100% of adult fish were assigned to the local 0-group respectively (Wright *et al*., 2006a). The lack of a chemistry signal from Minch 0-group would suggest there is little exchange between the Minch and cod further south. Up to 9% of Inner Hebrides adult were assigned to the Firth of Clyde nursery. While this result can be largely due to classification error arising from overlapping chemical signatures, it is possible that

a small fraction of Clyde fish spawn in the Inner Hebrides. As such this might suggest that the northern part of the Celtic unit may extend to the Inner Hebrides but not further north.

Tagging

The tagging evidence reviewed in this section originates from four peer-reviewed articles (Easey 1987, Wright *et al*. 2006a,b, Neat *et al*. 2014) as well as a re-analysis of the tagging data realised at the Workshop on Stock Identification of North Sea Cod (WKNSCodID 2020).

Easey (1987) examined the extent of mixing between the North Sea and the West of Scotland using tag-recapture data from adult cod released at 4 locations, Papa Bank (limit 6.a/4.a), Sumburgh (SE Shetland), North Shetland (4.a) and the West Hebrides (6.a). The release locations in Division 6.a considered in this study are situated more offshore than in more recent studies (Wright *et al*. 2006a,b, Neat *et al*. 2014). 82% of fish released on Papa Bank were recaptured in an area between Northern Ireland and North Orkney and 14% near Shetland with a larger extent of movement observed in fish recaptured in Q1 and Q2. The fish released near Shetland (Sumburgh, North Shetland) were mostly recaptured around Shetland. While movements toward Papa Bank (6a limit) were observed for North Shetland individuals, the low sample size limits its significance. Individuals released at the West of the Hebrides were recaptured in majority near the Hebrides but a significant proportion (32%) was recaptured in Papa Bank and another 8% recaptured further East. The results indicate extensive movement across the 6.a/4.a limit, for fish released in offshore sites along the shelf edge to the North/Northwest of Scotland.

The study by Wright *et al*. (2006a) considers the level of residency and reproductive isolation in Scottish waters using tag recapture data collected between 1960 and 1984. The release locations comprised two sites in 4.a (St Andrews Bay and the Moray Firth) and three sites in 6.a (Clyde, Minch and Northern Coast). Contrary to the earlier study (Easey 1987) all release sites were coastal. Fish tagged in the Clyde and the Minch were recaptured locally during the spawning season. While most fish released on the Northern coast and the Moray Firth were recaptured locally, a significant overlap in the extent of movements was found between these two groups. The result indicate that cod recaptured on inshore spawning grounds on the West coast of Scotland were resident groups and that some mixing was apparent between cod spawning on the Northern coast (6.a) and the Moray Firth (4.a).

Site fidelity of spawning aggregations was investigated by Wright *et al*. (2006b) using tag-recapture data of cod released in spawning areas during the spawning season. The tag-recapture data was composed of conventional tag data collected between 1962 and 1981 and Data Storage Tag (DST) of cod released between 2002 and 2004. The release sites included three sites in 4.a (Viking Bank, East Shetland and the Moray Firth) and two sites in 6.a (Minch and Clyde) for the conventional tags and two additional 4.a sites for the DST data, however the very low recapture rate of DST tagged fish in 6.a provides no useful information for this type of tag. Average displacement distance between release and recapture was <100 km on average and lower in coastal sites (Minch, Clyde and Moray Firth) compared to offshore sites (Viking Bank and East Shetland) suggesting limited movements and residency. The reconstructed extent of movement of DST tagged individuals released to the West of Shetland indicated an overlap with 6.a near Papa Bank. The study therefore highlights differences between inshore and offshore spawning groups and possible mixing between offshore groups around the 4^0 limit between 6.a and 4.a, however offshore sites in 6.a were not considered in this study.

The study by Neat *et al*. (2014) aimed at describing the home ranges of cod released in nine geographic areas including the West of Scotland, North East Scotland and the Irish Sea. In this study, geolocations estimated from DST data were used to reconstruct home ranges and mixing between areas. As the data used for the West of Scotland originated only from inshore locations in the Clyde, Inner Hebrides and the Minch (no offshore groups) and the number of DST tags

recovered was low, limited conclusions could be drawn from this study regarding exchange with adjacent areas (4.a and 7.a). Despite the limited data, overlap between the home ranges of the Irish Sea and West Scotland cod was evident in the North Channel and the North of the Irish Sea.

At the recent Workshop on Stock Identification of North Sea Cod (2020) data from the English and Scottish conventional tagging experiments were reanalysed considering the three proposed North Sea units (Northwestern, Viking and Southern units, WKNSCodID 2020) and data for cod released in 6.a to the North of Scotland and West of the Hebrides (6.a group). Kernel Density Estimation (KDE) was used to estimate the extent of movements of fish released in these 4 areas.

2.3 Genetic data from previous studies on West of Scotland cod and adjacent areas

The genetic population structures of Atlantic cod on the west coast of Scotland have been relatively poorly investigated. Existing studies have mainly focused on the connectivity of ICES Division 6.a to adjacent advisory units such as the North and Irish Seas (Nielsen *et al*. 2009; Heath *et al*. 2014; ICES 2020; Wright *et al*. 2021). Arguably, Health *et al*. (2014) provided the most informative analysis of ICES Division 6.a cod population, using 96 single nucleotide polymorphisms (SNPs) to delimit populations around the UK. Both adult cod and eggs from adjacent spawning areas were tested with analysis revealing three distinct, spatially separated groups referred to as, i) Viking, ii) Dogger and iii) Celtic units (Heath *et al*. 2014). Both Dogger and Celtic units occupied areas within ICES Division 6.a, with Celtic units including cod from the Firth of Clyde inhabiting the southern region of the division, while Dogger units remained isolated from Celtic units at the northern extent of ICES Division 6.a, encompassing inshore and offshore areas of the Outer Hebrides (Heath *et al*. 2014). The observed population units identified within this study do not conform to current ICES advisory units with adult cod found around the Outer Hebrides sharing a genetic affinity with cod found across a broad swathe of the North Sea (ICES Subarea 4), while fish in the Firth of Clyde were clearly part of the Irish Sea cod (ICES Division 7.a) (Heath *et al*. 2014). Despite robust analyses with multiple discriminatory genetic markers, the lack of within site temporal replicates does question the stability of these populations across time.

Wright *et al*. (2021) used a limited marker set (13 SNPs) to describe the genetic structure within the northern extent of ICES 6a cod. Investigating areas from as far east as the Viking Bank to offshore of the Outer Hebrides between two time points (2002/3 and 2013/14) and seasons (spring and autumn), the authors observed clear and consistent genetic differentiation between cod from the Viking Bank (ICES Division 4.a) and those found inshore of the west of Scotland (ICES Division 6.a) (Wright *et al*. 2021). There was evidence of population substructures within ICES Division 6.a, with inshore and offshore cod being weakly differentiated within 2002/3 samples (Wright *et al*. 2021). However, as well as being temporally dependent, they were not significant when corrected for multiple testing (Wright *et al*. 2021). Conversely, the lack of significant genetic differences among samples to the west of Shetland (ICES 4a) out to offshore areas of the Outer Hebrides may suggest a greater exchange of genetic material (Wright *et al*. 2021). Similar to Health *et al*. (2014), genetic analysis indicates that the North Sea and west of Scotland do not correspond to the current advisor units, with the divergence between the two divisions being more complex than the current 4°W boundary currently separating ICES Divisions 6.a and 4.a (Wright *et al*. 2021).

Although there is evidence of genetic differentiation between cod within multiple regions of ICES Division 6.a, these studies do not suggest fixed structures produced by reproductive isolation (Heath *et al*. 2014; Wright *et al*. 2021). Using 10 microsatellites, Nielson *et al*. (2009)

investigated potential microgeographical population structures among cod at two sites within ICES Division 6.a, Firth of Clyde and Butt of Lewis. There was no evidence of genetic differentiation between these sites, suggesting significant levels of genetic exchange between the two areas (Nielsen *et al*. 2009). Consequently, the limited genetic evidence provided by these studies points towards a single metapopulation with multiple subpopulations, specifically inshore, offshore and Clyde subpopulations within ICES Division 6.a. These are not isolated populations, instead there appears to be gene flow between subpopulations, but importantly also between adjacent ICES Divisions 4.a and 7.a. Further studies will be required to confirm genetic subpopulation structures within these areas, ideally with multiple temporal replicates to confirm the consistency of these structures across time.

2.4 Sub-stock survey biomass and recruitment trends

Introduction

While the presence of cod sub-populations within the west of Scotland has been acknowledged for a number of years (Wright *et al*, 2006a, 2006b), exploration of trends in sub-population SSB and/or recruitment have not been routinely carried out. This has been due, in part, to uncertainty over the population boundaries and also due to changes to the design and gear used in the Scottish surveys, making analysis more difficult. The most recent study was presented in Holmes *et al*. (2014) who defined three putative sub-populations in Division 6.a and based on an analysis of Scottish quarter 1 survey data up to 2010 concluded that the subpopulations exhibited different trends in SSB. In the Southwest area, SSB had essentially collapsed while the declines in the Clyde and Minch were less severe and more in line with the overall decline in the west of Scotland assessment area. The aim of the work presented here was to update the sub-population trends in biomass presented in Holmes *et al*. (2014) using more recently defined sub-populations (Figure 6 in Wright *et al*., 2020) and additional survey data, including data from quarter 4 and from 2011 onwards, and furthermore, to explore the trends in recruitment in different sub populations.

Data and Methods

Survey data

Five different survey data series (two of which are discontinued) cover the area to the west of Scotland (See Table 2.5.1 below). Prior to 2011, the two annual Scottish surveys (SWC-IBTS) were conducted using GOV trawl with ground-gear 'C', using a design based on fixed stations within ICES rectangles and one or two hauls per rectangle (to cover the depth range) (ICES, 2010). In 2011, a new random stratified survey design was implemented and the ground-gear was modified (to GOV 'D') (SCOWCGFS). The changes to the ground-gear are considered likely to have had an impact on catchability and hence the surveys are treated as separate time series with different identifiers within DATRAS. In addition to the two annual Scottish surveys, an Irish survey is conducted in quarter 4 which covers the southern part of Division 6.a (south of approx. 56.5˚N).

Table 2.5.1 Summary of bottom trawl surveys covering Division 6a.

Quarter	Survey	Acronym	Gear	Spatial coverage	Years	Source
Quarter 1	Scottish West Coast Groundfish Survey	SWC-IBTS	GOV	6.a, 4.a (limited)	1985 - 2010	DATRAS
		SCOWCGFS	GOV	6.a	2011 - 2020	DATRAS
	Scottish West Coast Groundfish Survey	SWC-IBTS	GOV	6.a, 7.a (limited) & 7.b (limited)	2003 - 2009	DATRAS
		SCOWCGFS	GOV	6.a, 7.b (limited)	2011 - 2019	DATRAS
Quarter 4	Irish Groundfish Survey	IE-IGFS	GOV	6.a (South), 7.a, 7.b, 7.g, 7.j	2003 - 2019	DATRAS

SSB trends

SSB at the sub-population level was calculated following a broadly similar approach to that described in Holmes *et al*. (2014), with the exception that the haul-based catch rates at age were derived from the raw exchange format data (downloaded from the DATRAS database) by applying a modelled ALK (Berg and Kristensen, 2012) to the numbers-at-length (rather than using the relevant DATRAS data product). Numbers-at-age were averaged over all hauls within an ICES statistical rectangle and then summed over all rectangles within each subarea. SSB was calculated as the sum of products of the numbers-at-age index for each subarea, weights-at-age and maturity-at-age. Weights-at-age which are common across subareas were taken from the assessment WG report (ICES, 2021) and are assumed equal to the smoothed catch weights-at-age. Maturity-at-age has been demonstrated to vary between subareas (Baudron *et al*., 2020), but was kept constant over time. In order to identify potentially asynchrony in SSB trends across subareas, a GAM allowing for separate trends for each area in addition to a common trend was fitted to the log-transformed indices:

log SSB ~ A + s (Y) + s (Y, by=A),

where A denotes a categorical variable allowing a different level for each subarea, s (Y) a smooth function of year describing a common trend, and s (Y, by=A) are subarea specific smooth functions of year that describe smooth deviations from the common trend.

Given the changes in survey ground-gear, the analysis was carried out for each of the four Scottish surveys separately.

Recruitment

To explore trends in recruitment, an alternative approach was taken in which recruitment at age 1 was modelled using the 'surveyIndex' R package (Berg, *et al*. 2014) which implements a GAM modelling framework using data in the DATRAS format and allowing for a variety of different model assumptions. The general form of the model was as follows:

$$g(\mu_i) = Year_i + Gear_i + U(Ship_i) + f_1\left(\mathrm{lon}_i, \mathrm{lat}_i, Year\right) + f_2(\mathrm{depth}_i) + f_3(\mathrm{timeofday}_i) + \log(\mathrm{HaulDur}_i)$$

where g is the link function and μ_i is the expected numbers-at-age one in the ith haul (or probability of non-zero catch for the presence-absence part), $Year_i$ is a categorical effect, f_2 a thin-plate spline, f_3 a cyclic cubic regression spline, $Gear_i$ is a categorical effect of the gear (including

groundgear effect, see above) and U is a random vessel effect. A number of different formulations for the spatio-temporal interaction term were fitted and compared (f_1):

1. Moderate resolution 3-d tensor product smooth using cubic regression/thin plate regression spline
2. As above, but using duchon spline.
3. Fixed moderate resolution spatial effect with independent annual spatial deviances (low resolution).
4. Fixed moderate resolution spatial effect with time varying spatial deviances defined using 3-d tensor product smooth.
5. Independent annual low resolution spatial effects

The model diagnostics were compared and AIC was used to evaluate which model gave the best fit to the data. In addition, all models were tested using delta-lognormal, delta-gamma and Tweedie distributions.

Indices were calculated by first predicting abundance on a spatial grid (at haul positions nearest to the centroid of each grid cell) with other effects such as gear and ship held fixed at each prediction (i.e. the prediction is made for a standard gear/ship) and then summing over the grid points. Sub-population recruitment indices were then calculated by summing over the appropriate sub-set of grid points.

A single quarter 4 model was developed using data from the two Scottish surveys and the Irish survey while data from the two Scottish quarter 1 surveys were analysed separately due to a lack of overlap in the two surveys with different ground gear. Estimated sub-population indices were mean standardised and compared, and additionally comparisons were made with recruitment in the neighbouring Irish Sea using the age 1 index from the N. Irish Q1 groundfish survey taken from the most recent assessment WG report (ICES, 2021). Correlation between detrended (lag-1 differenced) sub-population log recruitment.

Results

SSB trends

The analysis of the early Scottish Q1 survey (SWC-IBTS Q1) shows a decline over the full time series (1986 to 2010). All subareas exhibit a relatively linear decline, although with some evidence of a steeper decline in the Northern Offshore area compared to the other areas. (Note that these results differ somewhat to those of Holmes *et al*. (2014) who showed – this appears to be due to the modified sub-population definitions rather than the use of a modified data set.) Evidence of declining SSB is less apparent in the early Q4 survey (SWC-IBTS Q4) with the trends in Clyde and N. Inshore estimated to be increasing.

The two current Scottish surveys (Q1 and Q4) show a consistent picture. In both surveys, SSB in the N. Offshore area shows a clear increase to around 2016 with a decline since then. This is in contrast to the continued declining trend observed in the S. Inshore area and the relatively stable SSB in the Clyde over the past 10 years (again consistent across both surveys).

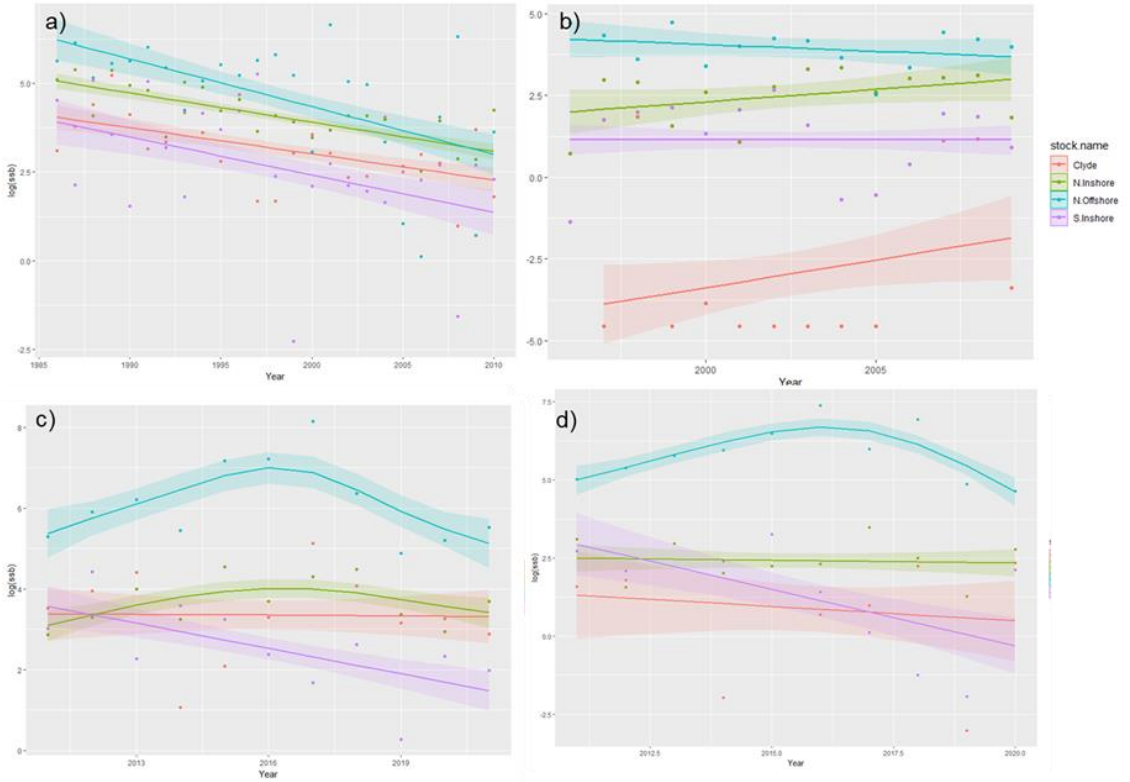

Figure 2.5.1 Log SSB indices and fitted smoothers for each putative sub-population using data from a) SWC-IBTS Q1, b) SWC-IBTS Q4, c) SCOWCGFS Q1, and d) SCOWCGFS Q4.

Recruitment

The most parsimonious model in terms of AIC varied across input data sets. However, the choice of final model made little difference to the conclusions and in all models/data sets there was a high degree of synchrony between estimated sub-population recruitment indices (Figure 2.5.3). Correlations are significant between all sub-populations for all models/quarters (example in Figure 2.5.4 for SWC-IBTS Q1).

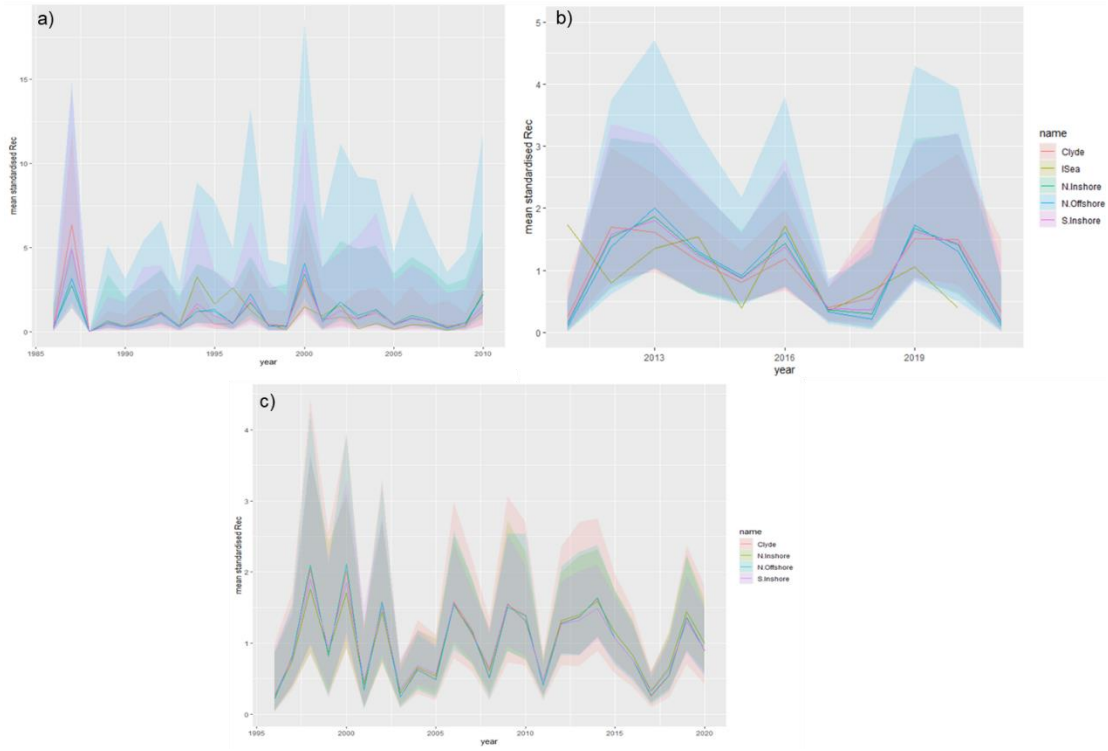

Figure 2.5.2. Mean standardised recruitment indices for each putative sub-population from delta-GAM models using data from a) SWC-IBTS Q1 (Model 3 with delta-logN), b) SCOWCGFS Q1 (Model 2 with delta-logN), and c) all Q4 data: SWC-IBTS, SCOWCGFS & IE-GFS (Model 2 with delta-logN). Irish Sea data (not modelled) are also shown for comparison in a) and b).

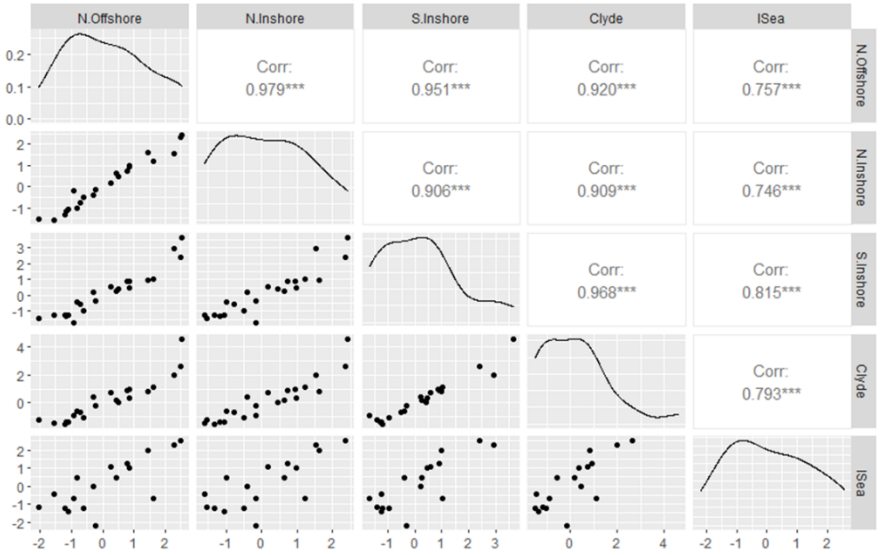

Figure 2.5.3. Correlations between lag-1 year differenced log recruitment indices by putative sub-population from SWC-IBTS Q1. Scatterplots show differenced log recruitment for each pair of sub-populations, the top right (numbers) are the Pearson correlation coefficient and the diagonal plots show the distribution of differenced log index values by sub area.

Summary

While the historical survey data (Q1) show a similar declining picture for SSB across all four sub-populations, there appears to have been a clear divergence in trends in the most recent 10-year

period. The most recent survey data show a recovery in biomass levels in the northern part of Division 6.a with declining/stable trends in the south of the region. The 'windsock' closure (in place since the early 2000s) in the northern part of Division 6.a may have contributed to the increase in SSB in this subarea.

In contrast to the recent differing trends in SSB, the estimated recruitment indices show very little asynchrony and are highly correlated across all subareas. This is also true, although to a slightly lesser degree, for the Irish Sea recruitment data which are not derived as part of the GAM modelling process and are based on data from the Northern Irish Q1 groundfish survey (i.e derived completely independently to the other indices). One explanation for the high correlation in recruitment given differing SSB trends could be that common environmental factors are affecting recruitment across all sub-populations

2.5 Summary and conclusions

Evidence from studies using otolith analyses (shape and microchemistry) and tag-recapture data indicated a complex cod population structure in 6.a. All studies pointed towards differences between inshore and offshore spawning groups in 6.a. Most inshore spawning groups were characterised by a high level of residency, relied on local recruitment and showed little to no mixing with neighbouring areas, even at a small spatial scale (e.g. Minch, Inner Hebrides and Clyde), however, the inshore group to the North of Scotland showed mixing with the Moray Firth in 4.a. Offshore groups to the West of the Hebrides and on Papa Bank showed a larger extent of movement with fish being recaptured from the South West of 6.a to Shetland in the North East (4.a) but did not show much mixing with the inshore groups. Mixing with across the 6.a/4.a limit was evident along the shelf edge with fish moving in both directions but also in inshore waters with also reciprocal movements found between the North of Scotland and the Moray Firth. While otolith shape and otolith chemistry show a strong level of residency for Clyde fish, tagging data suggest possible mixing with Irish Sea cod (7.a) in the Northern Channel and the Northern Irish Sea. Little evidence is available for the South West part of 6.a and while the distinction between inshore and offshore groups is assumed to follow the shelf edge contour (100m contour), uncertainty remains regarding where the limit should be placed in this part of Division 6.a.

The limited genetic evidence provided by these studies points towards a single metapopulation with multiple subpopulations, specifically inshore, offshore and Clyde subpopulations within ICES Division 6.a. These are not isolated populations, instead there appears to be gene flow between subpopulations, but importantly also between adjacent ICES Divisions 4.a and 7.a. Further studies will be required to confirm genetic subpopulation structures within these areas, ideally with multiple temporal replicates to confirm the consistency of these structures across time.

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3 Plausible scenarios for cod stocks West of Scotland and adjacent areas

3.1 Introduction

This section focusses on ToR b).

Using the data provided, WK6aCodID generated hypotheses related to cod population structuring within the west of Scotland (ICES Division 6.a);

- Hypothesis 1: Cod are a closed, homogenous population.
- Hypothesis 2: Cod exist as a metapopulation with overlapping subpopulations (Inshore, Offshore and Clyde units), but not necessarily with areas within ICES Division 6.a.
- Hypothesis 3: Cod exist as multiple overlapping subpopulations related to dogger stocks (between ICES Divisions 4.a and 6.a) and a separate Clyde subpopulation.

The evidence provided to WK6aCodID indicates that cod in the west of Scotland (ICES Division 6.a) are not a closed, homogenous population but exist as distinct subpopulations with connectivity to adjacent ICES cod units. Genetic, otolith and tagging data have highlighted patterns of differentiation among inshore, offshore and Clyde cod (Galley *et al*. 2006; Neat *et al*. 2014; Wright *et al*. 2021). These subpopulations generally inhabit different portions of the west of Scotland, with WK6aCodID proposing boundaries, as well as linkages to adjacent ICES Divisions, for each unit (see Figure 3.1.1) based on the available evidence.

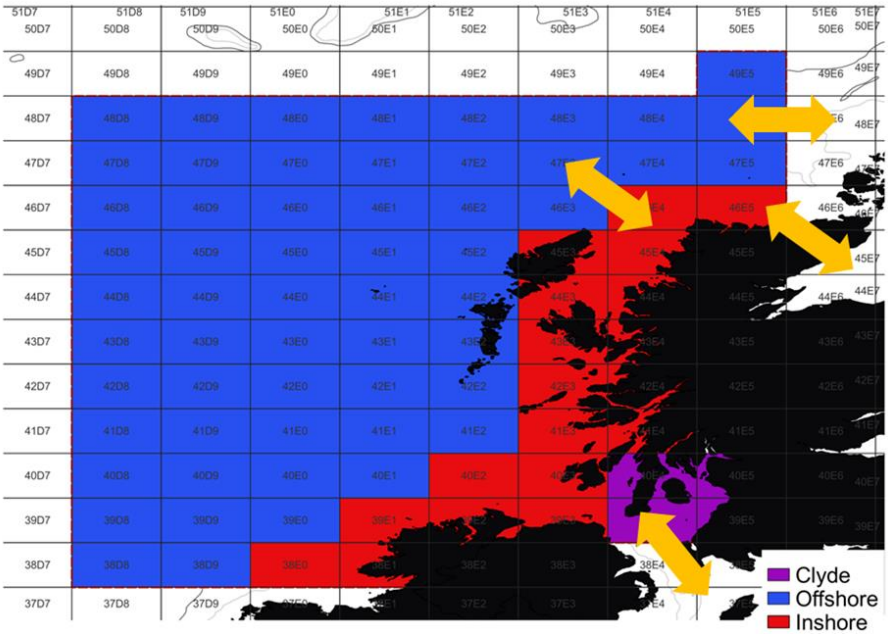

Figure 3.1.1. Putative subpopulations of cod within the West of Scotland ICES Division 6.a. Arrows represent potential mixing between subpopulations and between adjacent ICES Divisions.

3.2 Summary and conclusions

Heath *et al*. (2014) revealed two distinct spatio-genetic cod groups referred to as the "Dogger" (ICES Divisions 4.a, 4.b, 4.c, 6.a and 7.d) and "Celtic" (ICES Divisions 6.a, 7.a, 7.d, 7.e-k) units. Loci for the Celtic cod were found in the western channel, Celtic Sea, Irish Sea and Firth of Clyde, while the Dogger unit centred broadly on cod in the Dogger bank but also encompassing southern and western North Sea, and around the Outer Hebrides. These results highlighted the genetic differentiation between the Clyde and Inshore/Offshore (described by Health *et al*. 2014, as Dogger unit) subpopulations within ICES Division 6.a, but also their connectivity with adjacent advisory units (i.e. Firth of Clyde cod with ICES Division 7.a and Inshore/Offshore cod with ICES Division 4.a). Genetic analysis of north and west Scotland populations also revealed admixture between Dogger cod (ICES Division 4.a) and those inshore and offshore of the Outer Hebrides (ICES Division 6.a) (Wright *et al*. 2021). However, the same study revealed genetic evidence of separate Inshore and Offshore cod subpopulations within ICES Division 6.a (Wright *et al*. 2021). Finally, despite some separation, genetic evidence did not support the idea that Inshore, Offshore and Clyde cod are reproductively isolated populations. Instead, the evidence is suggestive of a metapopulation, whereby migration from one subpopulation to another occurs producing some degree of admixture (Nielsen *et al*. 2009; Heath *et al*. 2014; Wright *et al*. 2021).

Results revealed distinct otolith microchemical signatures related to specific nursery grounds in Buchan, Moray Firth and Shetland (all ICES Division 4.a), and the Minch, Inner Hebrides and Firth of Clyde (all ICES Division 6.a) (Wright *et al*. 2006; Gibb *et al*. 2007). Otolith signatures suggested there was little to no exchange of juveniles between ICES Division 6.a and ICES Division 4.a (Gibb *et al*. 2007). However, based on otolith microchemistry of age-2 cod, possible movement of cod from Shetland to the Inshore subpopulation and from this area to the Firth of Clyde subpopulation was observed. Similarly, Galley *et al*. (2006) used otolith shape to investigate spawning area fidelity of cod occupying multiple areas within ICES Division 6.a. Results from this study observed possible fine-scale stock structures within ICES Division 6.a, with differences in otolith shape between adult cod from Inshore and Firth of Clyde subpopulations (Galley *et al*. 2006).

Several studies have used conventional tag-recapture and digital storage tag (DST) experiments to discern cod movements within ICES Division 6.a, and between adjacent ICES Divisions (Easey 1987; Wright *et al*. 2006; Wright *et al*. 2006; Neat *et al*. 2014; ICES 2020). Easey *et al*. (1987) conventional tagging experiment observed cod released at the boundary between ICES 4.a and 6.a were recaptured in areas consistent with the offshore cod units proposed by WK6aCodID. Summaries from multiple tagging studies suggested reciprocated movement, with cod captured at the Outer Hebrides, associated with the offshore unit, being recaptured in ICES Division 4.a (Easey 1987; Wright *et al*. 2006; ICES 2020). Combining traditional tagging methods with digital storage tags, Wright *et al*. (2006) found cod from inshore and Clyde subpopulations travelled shorter distances suggesting more residential behaviour of these subpopulations. Likewise, a complementary conventional tagging study observed similar results with cod collected from inshore areas of the west of Scotland mainly remaining in these areas or being recaptured relatively short distances within the offshore component of ICES Division 6.a (Wright *et al*. 2006). Alternatively, cod released in offshore areas dispersed longer distances, moving to inshore regions of ICES Division 6.a, as well as sites such as the Moray Firth and Shetland within ICES Division 4.a (Wright *et al*. 2006). Cod from the Firth of Clyde were again observed displaying mainly residential behaviour with little or no migration to inshore or offshore regions recorded (Wright *et al*. 2006), but there was some limited evidence from Neat *et al*. 2017 to suggest that Clyde and Irish Sea cod were mixing between ICES Divisions 6.a and 7.a.

Holmes *et al*., 2014 examined trends in spawning stock biomass (SBB) between ICES 6.a subpopulation boundaries derived from genetic, tagging and otolith microchemistry studies. Trends in SBB suggest the presence of distinct inshore and larger offshore subpopulations within the west of Scotland (Holmes *et al*. 2014). Analysis of more recent survey data (Section 2.4) also suggests asynchrony is SSB trends across subpopulations.

In conclusion, hypotheses 2 and 3 are both supported by the available evidence. However, while scenario 3 is supported by the strongest scientific evidence, treating the Clyde as a separate population is problematic with respect to reconstructing historical catches and undertaking assessments. Over the last two decades of local management with Clyde cod closures, incorporating minimal catches into subpopulations are unlikely to impact assessments at the present time. Given the current weak state of Clyde cod, hypotheses 2 and 3 would be practically indistinguishable in terms of assessment in the short to medium term while investigators continue into the assessment of the Clyde cod and improvement of data availability.

3.3 Future work

Data pertaining to cod population structuring within the West of Scotland was relatively limited. Considerably more data will be required to test our hypothesis for accurate long-term cod stock assessments within ICES Division 6.a. From a genetic perspective, future work applying full genome sequencing with full site and temporal replicates would provide in-depth information regarding subpopulations at finer geographical scales and the stability of these structures across time.

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Wright, Peter J, Alice Doyle, John B Taggart, and Andrew Davie (2021). Linking Scales of Life-History Variation With Population Structure in Atlantic Cod. *Frontiers in Marine Science* . https://www.frontiersin.org/article/10.3389/fmars.2021.630515.

4 Practical implications of cod stock scenarios

4.1 Introduction

This Section of the report focusses on the ToRs c) and d).

Practical implications for data are considered and recommendations made for a potential data submission.

4.2 Catch data

There are two scenarios with respect to a potential data submission consistent with modelling approaches being considered for the North Sea cod stock (cod in Subarea 4, Division 7.d and Subdivision 20): that data are submitted for the whole of Division 6.a as for the current stock assessment, or data are split into stock components.

In the case of the latter, the workshop suggests two approaches be considered based on data availability and a conversation between data submitters and stock assessors:

a) The preferred option is to separate catches based on rectangles representing inshore and offshore subpopulations (Figure 4.2.1). Due to uncertainty, there are several rectangles that are considered flexible (hatched rectangles in Figure 4.2.1) and could be assigned as either inshore (red) or offshore (blue) based on practical considerations and data availability.

b) If (a) is not possible, to separate catches at a fleet level making the approximation that OTB_CRU represents inshore catches and OTB_DEF offshore catches.

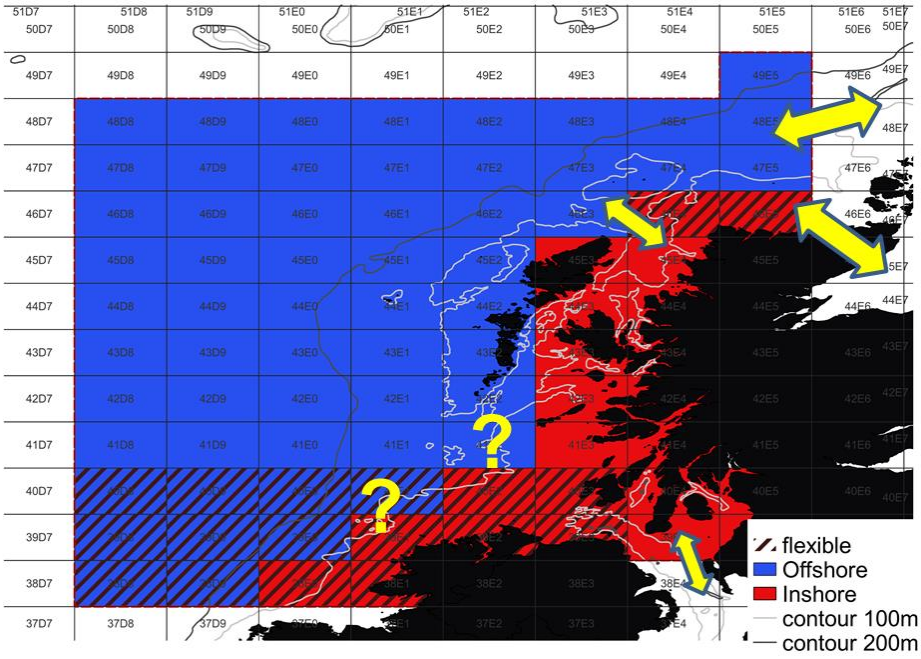

Figure 4.2.1. Rectangles considered inshore of offshore for the purposes compiling fishery and survey data. Flexible rectangles are more uncertain and can therefore be assigned as either inshore or offshore based on practical considerations. Question marks represent uncertainty about the border between the inshore and offshore subpopulations while arrows represent potential mixing both within and outside of Division 6.a.

Assuming a split of the catch data can be achieved, comparisons should be made with the catch data for the whole 6.a stock, as currently used in the stock assessment, to check for quality and consistency. Furthermore, data submitters and stock assessors should agree on a suitable time period for splitting the catch data, considering the current assessment time-series for both West of Scotland and North Sea cod stocks and data quality back in time.

4.3 Survey and biological data

The workshop suggests separating survey and biological data into inshore and offshore components using the rectangles in Figure 4.2.1. The hatched rectangles in Figure 4.2.1 are flexible, as described above, but their assignment should match that used for the catch data if a split of the catch data can be achieved following option (a) above. Subpopulation survey indices could be developed in collaboration with the Working Group on Improving use of Survey Data for Assessment and Advice (WGISDAA).

5 Recommendations for West of Scotland cod

5.1 Introduction

In this Section, WK6aCodID collates their main recommendations which addresses the four ToRs a), b), c) and d).

5.2 Recommendation 1 – population structure

WK6aCodID considered three hypotheses - hypothesis 1: closed homogenous population; hypothesis 2: a metapopulation with overlapping subpopulations (but not necessarily with areas within Division 6.a) (Clyde, Dogger inshore, Dogger offshore) and hypothesis 3: multiple overlapping subpopulations related to Dogger stocks (between Division 4.a and Division 6.a) and a separate subpopulation of Clyde.

While hypothesis 3 provides the strongest scientific evidence, treating the Clyde as a separate population is problematic with respect to reconstructing historical catches and undertaking assessments. Over the last two decades of local management with the Clyde cod closure, incorporating minimal catches into subpopulations is unlikely to impact assessments at the present time.

5.3 Recommendation 2 – stock assessment

Given the current weak state of Clyde cod, hypotheses 2 and 3 would be practically indistinguishable in terms of assessment outcome and the workshop considers hypothesis 2 amenable to stock assessment in the short- to medium-term, while investigations continue into the assessment of the Clyde cod and the improvement of data availability. Given linkages of the inshore and offshore subpopulations to cod in Division 4.a, it is recommended to combine the North Sea and West of Scotland cod assessments in a future benchmark.

5.4 Recommendation 3 – data submission

The workshop elaborated two scenarios with respect to a potential ICES data submission consistent with the modelling approaches being considered for the North Sea cod stock (cod in Subarea 4, Division 7.d and Subdivision 20); namely, either that data are submitted for the whole of Division 6.a as for the current ICES stock assessment, or that data are split into stock components as defined under hypothesis 2 (and hypothesis 3). In the latter case, WK6aCodID suggests that two approaches be considered based on data availability and a conversation between ICES national data submitters and ICES stock assessors.

ICES data submitters and ICES stock assessors should agree on a suitable time period for data splitting; considering the current assessment time-series for both West of Scotland and North Sea stocks and data quality back in time.

5.5 Recommendation 4 – future road-map

WK6aCodID noted that there is potential for much reshaping of Atlantic cod stock assessments currently with the four principal cod assessments (Celtic Sea, Irish Sea, West of Scotland and North Sea) presently exhibiting issues. Primarily these revolve around continued low catch

tonnage, which translates into low catch numbers-at-age resulting in increased uncertainties in assessments. To investigate and review further, the workshop proposes that a planned approach be developed within ICES, through initial road-mapping for improving assessments and the basis for advice; based on these principal assessments and then more widely within the North-east Atlantic; e.g. cod stocks in Norwegian waters, and including those under the jurisdiction of Canada and the United States of America.

Annex 1: List of participants

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Annex 2: Workshop agenda

Workshop on stock identification of West of Scotland cod
WK6aCodID

29 November – 1 December 2021 (MS Teams - online)

PLEASE NOTE: time table = Copenhagen time

Agenda

29 November (Monday)

11:00-11:30

- Introductions & meeting Terms of Reference (ToRs)
- ICES Code of Conduct and Conflict of Interest (CoI) [All participants to read and inform meeting of CoI]
- Draft agenda

11:30-13:00 [no break]

ToR a:

- Presentation & plenary discussion:

  Thomas Regnier: Otoliths, microchemistry and tagging
  - presentation summarising studies involving otolith shape and microchemistry, tagging studies (those led my MSS and an historic one with key results), a reanalysis of tagging data for NS cod in 2020 and a proposed population structure in Division 6.a based on a review of evidence from different sources at MSS, following a similar approach used in Holmes *et al*. 2014)

  Mathieu Lundy: Review of Celtic Seas and West of Scotland tagging records
  - Background figures produced during an EAMSE-funded cod tagging project in the Irish Sea; compiled by Victoria Bendall as a review of tagging records in ICES Divisions 6.a, 7.a and 7.g.

13:00-14:00 Lunch break

14:00-17:00 [Comfort break 15:30-15:45]

ToR a (continued):

- Presentation & plenary discussion

  David Murray: Summary of genetic data from previous studies on West of Scotland cod and adjacent areas

  Helen Dobby: Sub-stock survey biomass and recruitment trends
  - Trends with an assumed sub-stock definition, not about determining sub-stock definition/stock identification

  Jakob Hemmer Hansen: Figures 2.13 and 2.14 WKNSCodID 2020 report

30 November (Tuesday)

11:00-13:10 [Comfort break 12:00-12:15]

ToR a (continued):
Nicola Walker: North Sea cod mixing with 6.a cod
Helen Dobby: West of Scotland cod - catch data and misreporting
ToR b:

- Plenary discussion

13:00-14:00 Lunch break

14:10-18:00 [Comfort break 16:00-16:15]

ToR b (continued):

- Plenary discussion and drafting

1 December (Wednesday)

11:00-13:00 [Comfort break 12:20-12:30]

ToRs b & c:

- Plenary discussion

13:00-14:00 Lunch break

14:00-16:30 [Comfort break 15:50-16:05]

ToRs c & d:

- Plenary discussion
- Report structure and assignment of tasks
- Next steps

Government Office for Science

The Government Chief Scientific Adviser's Guidelines on the Use of Scientific and Engineering Advice in Policy Making

Contents

Introduction by the Government Chief Scientific Adviser

Climate change, security, pressures on the supply of energy, food and water, health and migration pose unprecedented and inter-connected challenges to the world. Science and engineering are central to identifying, understanding and addressing these challenges. In fact it is difficult to think of a policy area, or a government department, where science cannot make an important contribution. While some of these are obvious such as climate change, others may be not so apparent, for example, the science of demography and ageing needed to inform the funding of future pensions and benefits or the volcanic eruption in Iceland which demonstrates the role science and engineering advice can play in civil contingency planning.

It is essential that policy-makers across government are able to draw on high quality, wide-ranging and robust evidence to enable informed decision-making. Together with an effective advisory process, this allows government to ensure that all opportunities are explored to their full potential and deal capably with emergencies.

A key element of my role as the Government's Chief Scientific Adviser is to work across government to embed an evidence-based approach to policy-making. These Guidelines support this process. The Guidelines were originally introduced in 1997 and were last revised in October 2005. It is important that they remain relevant. I have therefore decided to update them to reflect recent developments in policy making best practice.

While these guidelines are primarily targeted at those within government, I hope that they will also help reassure the wider scientific community that relevant science and engineering is considered seriously and methodically by policy makers.

The guidelines

1. These guidelines address how scientific and engineering advice should be sought and applied to enhance the ability of government policy makers to make better informed decisions. The key messages are that departments, and policy makers within them, should:

   - **identify early** the issues which need scientific and engineering advice and where **public engagement** is appropriate;
   - draw on a **wide range of expert advice** sources, particularly when there is uncertainty;
   - adopt an **open and transparent approach** to the scientific advisory process and publish the evidence and analysis as soon as possible;
   - **explain publicly the reasons for policy decisions**, particularly when the decision appears to be inconsistent with scientific advice; and

- **work collectively** to ensure a joined-up approach throughout government to integrating scientific and engineering evidence and advice into policy making.

2. Departments should ensure that they have the capacity and capability to recognise where there is a need for scientific and engineering advice and to deliver that advice sustainably and effectively.

3. This updated version of the Guidelines replaces the third edition issued in October 2005. It builds on policy making experience gained inside government and input from a wide range of partner organisations and individuals who responded to the public consultation held between November 2009 and February 2010.

4. We encourage departments to ensure these Guidelines are woven into departmental guidance on better policy making. Chief Scientific Advisers should work in partnership with policy makers to ensure these Guidelines are fully embedded into departmental policy procedures and to ensure appropriate scientific input to policy decisions.

Which areas of evidence do the guidelines cover?

5. The Guidelines focus on the use of scientific and engineering advice in government. They are complementary to that provided by the other analytical professions in government; economists, social researchers, statisticians, and operational researchers. Collectively, this guidance provides a framework to help departments deliver an integrated approach.

The advisory process

Identify early the issues which need scientific and engineering advice and where public engagement is appropriate, and draw on a wide range of expert advice sources, particularly when there is uncertainty.

6. There are a number of stages within the policy making process that require scientific and engineering advice, from policy development through to implementation, monitoring and evaluation.

7. Departments should ensure their procedures for obtaining advice are consistent with the steps outlined below. The various stages in the process may have to be applied iteratively.

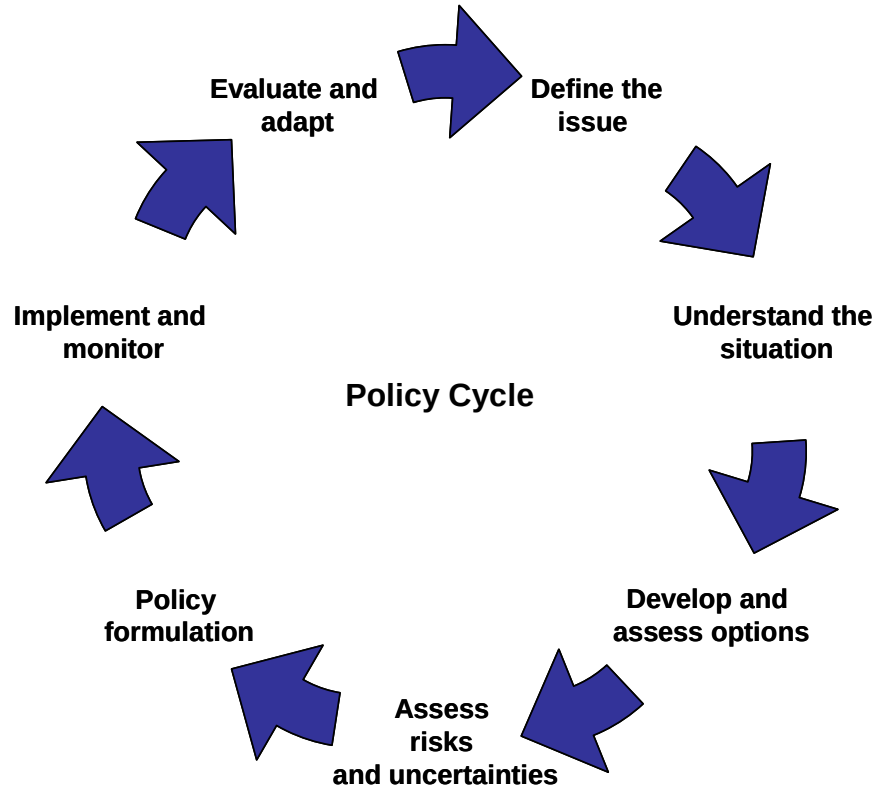

Figure 1: The policy cycle adapted from reference 1.[1]

Identification of issues

8. In order to provide well informed advice and underpin policy it may be necessary to undertake or commission research. The need to anticipate future research and policy needs is as important as shorter term reactive

[1] Adapted from Defra E&I Strategy http://www.defra.gov.uk/evidence/science/how/documents/eis-100126.pdf and Clayton, H. and Culshaw, F. (2009) 'Science into policy: taking part in the process' Natural Environment Research Council: http://www.nerc.ac.uk/publications/corporate/policy.asp

research requirements. Individual departments should ensure that their procedures anticipate as early as possible issues that require scientific and engineering advice. Where research is needed to answer key questions important to policy formulation and/or its implementation a significant lead time may be necessary. Departments should regularly review their horizon scanning[2] procedures, ensuring that horizon scanning evidence is appropriately considered and, where necessary, acted upon. Horizon scanning should look broadly, beyond departments' current areas of interest, and should address opportunities as well as risks.

9. The Government Office for Science[3] houses Foresight[4] and its Horizon Scanning Centre.[5] Foresight conducts in-depth studies looking at strategic issues up to 50 years in the future, usually with a strong science focus. New projects can be proposed, and past projects contain a wealth of scientific analysis by leading experts. The Horizon Scanning Centre provides guidance and training on techniques and can be approached by government departments to undertake focused futures projects across the spectrum of public policy drawing on a broad evidence base.

Framing the question

10. Early engagement with experts and partner organisations is key to framing appropriate and relevant questions on scientific and engineering issues. Departments must ensure that questions are framed to cover the interests and concerns of all relevant partners, including consumers and citizens. Where possible, there should be public involvement in framing the questions that experts and policy makers need to address. The proposed questions should also be discussed with the experts themselves. Effective public dialogue should begin as early as possible and key partners should be engaged throughout the policy cycle.

11. The role of public dialogue in the policy process will be specific to each department and each issue under consideration. Departments should consider their own consultative arrangements and working practices to ensure public engagement is effective. [6] Sciencewise-ERC[7] is the UK's national centre of expertise on public dialogue and engagement on science and technology issues. Sciencewise-ERC is currently working with government departments to provide advice and guidance to policy makers on the benefits and the implementation of public dialogue.

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[2] Horizon scanning is the systematic examination of potential threats, opportunities and likely developments including but not restricted to those at the margins of current thinking and planning. Horizon scanning may explore novel and unexpected issues as well as persistent problems or trends.

[3] http://www.bis.gov.uk/go-science

[4] http://www.foresight.gov.uk/index.asp

[5] http://www.foresight.gov.uk/Horizon%20Scanning%20Centre/index.asp

[6] http://interactive.bis.gov.uk/scienceandsociety/site/trust/files/2010/03/BIS-R9201-URN10-699-WEB.pdf

[7] http://www.sciencewise-erc.org.uk/

Sources of research and advice

12. Departments should ensure they have sufficient in-house scientific and engineering capability to act as an intelligent customer of research and advice. While advice from external sources should be sought whenever necessary, departments should particularly ensure that such advice is sought when:

    - the issue raises questions that are outside the expertise of in-house staff;
    - responsibility for a particular issue cuts across government departments;
    - a wide range of expert opinion exists and/or there is considerable uncertainty;
    - new findings are emerging rapidly;
    - there are potentially significant implications for areas of public policy; and/or
    - public confidence in scientific advice from government could be strengthened.

13. Departments should draw on a range of appropriate expert sources, both within and outside government. The selection of advisers should match the nature of the issue and should be sufficiently wide to reflect the diversity of opinion amongst experts in the appropriate field(s) in a balanced way.

14. A number of government departments have established Science Advisory Councils to provide independent overview and challenge of their management and use of science. Complementing the work of Science Advisory Councils, Scientific Advisory Committees provide scientific advice to one or more departments on a specific issue, for example, nutrition or air quality.

15. Science Advisory Councils and Scientific Advisory Committees provide an important resource, for example, to identify emerging issues, provide advice on how to frame the questions, and at the evaluation stage. Published in 2010, 'The Principles of Scientific Advice to Government'[8] provide a foundation on which independent scientific advisers and government departments should base their operations and interactions (Annex A). 'The Code of Practice for Scientific Advisory Committees'[9] offers more detailed advice focused on the working of these bodies.

16. When deciding which external sources to consult, departments should encourage those responsible for individual issues to establish new networks continually in order to capture the full diversity of good evidence-based advice.

[8] http://www.bis.gov.uk/go-science/principles-of-scientific-advice-to-government
[9] http://www.bis.gov.uk/goscience-copsac

17. Sources of research and advice may include:

- departments' own experts and analysts, and programmes of internal and externally commissioned research;
- departments' existing expert advisory systems; such as Science Advisory Councils and Scientific Advisory Committees;
- other departments' research programmes;
- Research and Funding Councils;
- research from non-departmental-sources, including international bodies (for example, the European Commission and non-departmental public bodies such as the Council for Science and Technology);
- National Academies,[10] professional institutions and the other learned societies; and
- the broad science and engineering community. For example, universities, private and charity sector research and development funders.

An international perspective

18. Where appropriate, consideration should also be given to consulting experts from outside the UK, for example those from European or international advisory mechanisms. International advice is particularly important in cases where the other countries have experience of, or are likely to be affected by, the issue under consideration. For example, the European Academies Science Advisory Council[11] (EASAC) enables the national academies of Europe to work together to provide high quality advice to European Union policy makers. The European Commission's Joint Research Centre functions as a reference centre of science and technology for the Union.[12]

19. The UK Government's Science and Innovation Network[13] of officials in key UK Embassies and Consulates undertake a wide variety of work (promoting scientific expertise, strengthening UK innovation, informing effective policy making and leadership and using science and innovation as an influencing tool) and can provide a useful network for identifying and making use of international expertise.

Roles and responsibilities

20. There should be a clear understanding between scientists, advisers and policy makers on what advice is being sought, by whom and for what purpose. It should be made clear to the experts what role(s) they are being

[10] The Royal Society, the Royal Academy of Engineering, the Academy of Medical Sciences and the British Academy
[11] http://www.easac.eu/
[12] http://ec.europa.eu/dgs/jrc/index.cfm
[13] http://www.fco.gov.uk/en/about-us/publications-and-documents/publications1/annual-reports/science-and-innovation1

asked to perform and the boundary of their role(s). Boundaries should be reasonable and agreed at the start with external advisers to avoid any misunderstanding later in the advisory process. These roles can include:

- review of existing data and research sources;
- collection and analysis of new scientific data;
- interpretation of research from different sources;
- application of expert judgement where data is lacking or inconclusive;
- identification of policy options based on data and research evidence; and
- providing expert scientific and engineering advice on policy options.

21. When asking experts to identify policy options or to comment on policy options prepared by others, those involved should respect the line between the responsibility of experts to provide advice, and the responsibility of departments for any subsequent policy decisions based on that advice. 'The Principles of Scientific Advice to Government' (Annex A) are a useful tool for ensuring the respective roles are clear.

22. Departmental guidance should consider how advice is provided in an emergency,[14] including clear designation of responsibility, the processes to be employed and the sources of advice.

Risks and uncertainties

23. When assessing the levels of risk or establishing risk management strategies in relation to a specific policy, it is vital to take into account all known sources of uncertainty. The use of evidence is essential and scientists, engineers and policy makers must also ensure that they include evidence of any differing perspectives of risk as part of any decision making process.[15] Early public engagement is often vital to ensure this happens.

24. Evidence in public policy making contains varying levels of uncertainty that must be assessed, communicated and managed. Departments should not press experts to come to firm conclusions that cannot be justified by the evidence available. The levels of uncertainty should be explicitly identified and communicated directly in plain language to decision makers. There will inevitably be occasions where advice is required within a few days, or even within hours. Decision makers should therefore also be made aware

[14] Cabinet Office advice on emergencies http://www.cabinetoffice.gov.uk/ukresilience.aspx, includes the Concept of Operations (CONOPS).

[15] HM Treasury's 'Managing risks to the public: appraisal guidance' for further details on risk management: http://www.hm-treasury.gov.uk/d/managingrisks_appraisal220705.pdf The Better Regulation Commission's report 'Public Risk – the Next Frontier for Better Regulation' http://archive.cabinetoffice.gov.uk/brc/upload/assets/www.brc.gov.uk/public_risk_report_070108.pdf RRAC reports 'Response with Responsibility: Policy-making for Public Risk in the 21st Century' http://www.berr.gov.uk/files/file51459.pdf 'A Practical Guide to Public Risk and Communication' http://www.berr.gov.uk/files/file51458.pdf

of the period of notice which policy makers and specialists have had to prepare advice. The level of confidence and appropriate caveats should be stated where analysis and advice has been time limited.

Quality assurance and peer review

25. Quality assurance provides confidence in the evidence gathering process whilst peer review provides expert evaluation of the evidence itself. Both are vital tools in ensuring that advice is as up-to-date and robust as possible. All evidence should be subject to critical evaluation; however, this can take different forms and needs to be proportionate to the nature of the evidence and its use. Departments should ensure appropriate quality assurance and peer review processes are carried out. Scientific Advisory Committees, learned societies, academics and other experts can assist in the peer review process.

26. When responding to public concerns over emerging findings, it is important that departments state clearly the level of quality assurance and peer review which has been carried out, whether they intend to subject the work to any further assessment or peer review and when the outcome of this is likely to be available. It is important that departments revisit issues and policy decisions in the light of new or changing evidence.

Openness and transparency

Adopt an open and transparent approach to the scientific advisory process, publish the evidence and analysis as soon as possible and explain publicly the reasons for policy decisions, particularly when the decision appears to be inconsistent with scientific advice.

27. Scientific advice is only one consideration which may need to be taken into account by government decision makers. Others might include social, political, economic, or ethical concerns.

28. Openness of the scientific advisory process is vital to ensure that all relevant streams of evidence are considered, and that the process has the confidence of experts and the public.[16] The evidence for a particular policy should be published as early as possible, unless there are over-riding reasons for not doing so, for example, national security, or requirements to protect personal or commercial confidentiality. The evidence should be published in a way that is meaningful to the non-expert. The analysis and judgement that went into it, and any important omissions in the data, should be clearly identified.

[16] This is covered in Section 35/6 of the Freedom of information Act. Full guidance on the Act can be found at: http://www.dca.gov.uk/foi/guidance/index.htm.

29. It is important to ensure that working practices are transparent. Departments should ask prospective experts to follow the seven principles of public life[17] as set out by the Committee on Standards in Public Life, which include the obligation to declare any private interests relating to their public duties. As called for in 'The Universal Ethical Code for Scientists'[18], a declaration of conflicts of interest should be made available to anyone who might rely on that advice and made more widely available as appropriate. Departments should judge whether these interests could undermine the credibility or independence of the advice. It is important to recognise that advisers are rarely totally independent as, by the nature of their expertise they will often have an interest in the sector on which they advise. Gathering evidence from a range of experts or from an expert committee ensures a more independent view as, for example, lobbying will become apparent.

Communicating the advice

30. The effective and efficient handling of scientific advice is essential. Those responsible for communication with the public should ensure that the evidence on which any decisions are based is included as part of any press release or communication strategy. The reasons for policy decisions should be explained publicly, particularly when the decision appears to be inconsistent with scientific advice.

31. In public presentations, departments should wherever possible consider giving experts (internal or external) a leading role in explaining their advice on a particular issue. Independent scientific advisory bodies should have the ability to communicate relevant advice freely, subject to normal confidentiality restrictions, including when it has not been accepted. Scientific advisers should make clear in what capacity they are communicating, for example as Committee Chair or in an academic capacity.[19] Further guidance can be found in the 'The Code of Practice for Scientific Advisory Committees'.[20]

32. Departments and committees should consider the potential benefits that consumer or lay representatives can bring to the clear communication and transparency of the scientific advice that is provided by committees. Policy makers should state clearly what precautionary approaches are being taken in response to uncertainties identified during the advisory process. Ministers or policy officials have the responsibility to describe how the government's policies have been informed by the advice received.

33. Consideration should also be given to early communication with key partners, including consumers and citizens, and to providing early warning of significant policy announcements to other government departments and

[17] http://www.public-standards.gov.uk/Library/Seven_principles.doc
[18] http://www.bis.gov.uk/goscience-code
[19] http://www.bis.gov.uk/go-science/principles-of-scientific-advice-to-government
[20] http://www.bis.gov.uk/goscience-copsac

international organisations, where there are likely to be implications for other countries.[21]

Capacity and capability

It is important for departments and policy makers to work collectively to ensure a joined-up approach throughout government to integrating scientific and engineering evidence and advice into policy making.

34. The Government Chief Scientific Adviser (GCSA) and the Government Office for Science exist to ensure that the UK Government has access to, and uses, high quality scientific and engineering advice. [22]

35. There is now a Chief Scientific Adviser (CSA) in every major science using department. Led by the GCSA, departmental CSAs work collectively, with other analytical disciplines and with departmental boards and Ministers, to ensure that robust, joined-up evidence is at the core of decisions within departments and across government. The Chief Scientific Advisers Committee (CSAC) works to ensure that scientific advice vital to multidisciplinary cross government issues such as climate change or counter terrorism is provided effectively.

36. It is also important that scientific and engineering advice is integrated with evidence from the other analytical professions. Across government, the heads of the analytical professions, including the GCSA in his capacity as Head of Science and Engineering Profession, are brought together in the Heads of Analysis (HoA) group.[23] HoA encourages good practice on cross-disciplinary working to deliver an integrated evidence base and on cross-government issues. All analytical professions in government have codes of practice or adhere to wider guidance, including the Civil Service Code, the seven principles of public life and the ESRC research ethics code. [24]

[21] Please see http://www.nationalschool.gov.uk/policyhub/better_policy_making/ for further details.
[22] http://www.bis.gov.uk/goscience-seg
[23] The analytical streams represented in HoA are: economics, social research, statistics, operational research and science and engineering
[24] The GSR Code http://www.gsr.gov.uk/professional_guidance/gsr_code/index.asp; The Code of practice for official Statistics http://www.statisticsauthority.gov.uk/assessment/code-of-practice/code-of-practice-for-official-statistics.pdf ; Nolan principles: http://www.public-standards.gov.uk/Library/Seven_principles.doc; Civil service Code: http://www.civilservice.gov.uk/Assets/cs_code_tcm6-2444.pdf; ESRC Research Ethics Code: http://www.esrcsocietytoday.ac.uk/ESRCInfoCentre/Images/Framework%20for%20Research%20Ethics%202010_tcm6-35811.pdf

Cross–cutting issues

37. It is important that departments adopt a joined-up approach on cross-cutting research issues. The maintenance of a wide ranging knowledge base is vital to policy making and delivery and departments should adopt a proactive approach to identifying what existing research is available across government.

Scientific capacity

38. Government departments and agencies need sufficient in-house scientific and engineering capacity to recognise the full spectrum of relevant evidence and to know how to access it. They may be assisted in this by individuals and organisations adept at working in the 'knowledge brokering'[25] capacity.

39. Government Science & Engineering (GSE)[26] is the cross-government community for scientists and engineers. GSE supports and promotes the science and engineering profession across the Civil Service, raising understanding of the skills, values and expertise of its members and building links between the different analytical streams and policy makers. The expertise of the GSE community is available to be drawn upon by government departments.

Reviewing the management and use of science and engineering by departments

40. The Government Office for Science's 'Science and Engineering Assurance' Programme produces benchmarking reviews of how departments use and manage scientific and engineering evidence. Each department is being reviewed once and thereafter on-going scrutiny will be achieved through departmental self-assessment with external verification. The reviews assess the 'fitness for purpose' of departments' systems and approaches, taking a 'critical friend' approach. They provide both the Departmental Permanent Secretary and the GCSA with an assessment of the evidence used to develop and delivery policy is robust, relevant and of a high quality.

41. The Government has revised its analytical framework to monitor the management and use of science and engineering and now uses the following criteria:

    · Strategy, policy making and delivery should be effectively informed by science and engineering.

[25] http://www.rcuk.ac.uk/innovation/ktportal/default.htm
[26] http://www.civilservice.gov.uk/my-civil-service/networks/professional/science-engineering/index2.aspx

- Government as a whole, and individual government departments, should take a strategic approach to the prioritisation, accessing, resourcing and delivery of science and engineering.
- All science and engineering used by government should be robust, relevant and high quality.
- Science and engineering should be made publicly available unless there is a clear justification for not doing so.
- The implications of science and engineering for society should be fully considered, engaging the public whenever appropriate, using good practice.
- Government should ensure effective knowledge transfer, innovation and pull through of its research to the economic development of new technologies and services.
- Departments should ensure that they have the science and engineering capacity and capability to manage and deliver the above sustainably and effectively.

42. Departments are encouraged to ensure 'the Guidelines on the Use of Scientific and Engineering Advice in Policy Making' are woven into departmental guidance on better policy making. The integration and use of these, and other guidelines on effective use of analytical evidence, will be addressed in both Science and Engineering Assurance reviews and subsequent self-assessment exercises.

Useful information

Professional Guidance

- Principles of Scientific Advice to Government
  http://www.bis.gov.uk/go-science/principles-of-scientific-advice-to-government
- Civil Service Code
  http://www.civilservice.gov.uk/Assets/cs_code_tcm6-2444.pdf
- The GSR Code
  http://www.gsr.gov.uk/professional_guidance/gsr_code/index.asp
- The Code of practice for official Statistics
  http://www.statisticsauthority.gov.uk/assessment/code-of-practice/code-of-practice-for-official-statistics.pdf
- Research Councils UK: 'RCUK Policy and Code of Conduct on the Governance of good research conduct: Integrity, Clarity and Good Management'
  http://www.rcuk.ac.uk/review/grc/default.htm
- Cabinet Office's 1999 report 'Professional policy making for the twenty first century'
  http://www.nationalschool.gov.uk/policyhub/docs/profpolicymaking.pdf
- ESRC Research Ethics Code
  http://www.esrcsocietytoday.ac.uk/ESRCInfoCentre/Images/Framework%20for%20Research%20Ethics%202010_tcm6-35811.pdf

Identification of issues

- The Government Office for Science – Foresight
  http://www.foresight.gov.uk/index.asp
- The Government Office for Science – Foresight Horizon Scanning Centre
  http://www.foresight.gov.uk/Horizon%20Scanning%20Centre/index.asp

Framing the question

- Sciencewise ERC Guiding Principles
  http://www.sciencewise-erc.org.uk/cms/knowledge-hub/

Sources of advice

- The Code of Practice for Scientific Advisory Committees
  http://www.bis.gov.uk/goscience-copsac

- The European Academies Science Advisory Council
  http://www.easac.eu/
- The European Research Council
  http://erc.europa.eu/
- The Science and Innovation Network
  http://www.fco.gov.uk/en/about-us/publications-and-documents/publications1/annual-reports/science-and-innovation1

Risks and uncertainties

- HM Treasury's 'Managing risks to the public'
  http://www.hm-treasury.gov.uk/d/managingrisks_appraisal220705.pdf
- The Better Regulation Commission's report 'Public Risk – the Next Frontier for Better Regulation'
  http://archive.cabinetoffice.gov.uk/brc/upload/assets/www.brc.gov.uk/public_risk_report_070108.pdf
- RRAC report 'Response with Responsibility: Policy-making for Public Risk in the 21st Century'
  http://www.berr.gov.uk/files/file51459.pdf
- RRAC report 'A Practical Guide to Public Risk and Communication'
  http://www.berr.gov.uk/files/file51458.pdf
- House of Commons Science and Technology Committee Report 'Scientific Advice, Risk and Evidence Based Policy Making' (Seventh Report of Session 2005–06) HC 900-I (2006)
  http://www.publications.parliament.uk/pa/cm200506/cmselect/cmsctech/900/900-i.pdf
- 'Taking European Knowledge Society Seriously' includes a chapter on Risk, Uncertainty and Precaution
  http://ec.europa.eu/research/science-society/document_library/pdf_06/european-knowledge-society_en.pdf
- Cabinet Office advice on emergencies, includes the Concept of Operations (CONOPS)
  http://www.cabinetoffice.gov.uk/ukresilience.aspx

Openness and transparency

- Freedom of Information Act
  http://www.dca.gov.uk/foi/guidance/index.htm
- Seven Principles of Public Life
  http://www.public-standards.gov.uk/Library/Seven_principles.doc
- 'Rigour, Respect, Responsibility, A Universal Ethical Code for Scientists'
  http://www.bis.gov.uk/goscience-code
- The National School of Government's Policy hub has a useful list of 'key documents' accessible from the following page
  http://www.nationalschool.gov.uk/policyhub/better_policy_making/

- Science and Trust expert group report and action plan
  http://interactive.bis.gov.uk/scienceandsociety/site/trust/files/2010/03/BIS-R9201-URN10-699-WEB.pdf

Capacity and capability

- Science and Engineering in Government
  http://www.bis.gov.uk/goscience-seg
- RCUK Knowledge transfer portal
  http://www.rcuk.ac.uk/innovation/ktportal/default.htm
- Government Science and Engineering – the professional science and engineering community across Government
  http://www.civilservice.gov.uk/my-civil-service/networks/professional/science-engineering/index2.aspx
- 'Enhancing the Role of Science in the Decision-Making of the European Union'
  http://www.epc.eu/TEWN/pdf/668109152_EPC%20Working%20Paper%2017%20Enhancing%20the%20role%20of%20science%20in%20EU%20decision%20making%20(revised).pdf
- From Science and Society to Science in Society: Towards a Framework For 'co-operative research'
  http://ec.europa.eu/research/science-society/pdf/goverscience_final_report_en.pdf
- Government Office for Science: Annual Review 2009
  http://www.dius.gov.uk/assets/biscore/goscience/g/10-p95-goscience-annual-review.pdf

Annex A: Principles of Scientific Advice to Government

The Principles of Scientific Advice set out the rules of engagement between Government and those who provide independent scientific and engineering advice. They provide a foundation on which independent scientific advisers and government departments should base their operations and interactions.

The Principles apply to Ministers and Government departments, all members of Scientific Advisory Committees and Councils (the membership of which often includes statisticians, social researchers and lay members) and other independent scientific and engineering advice to Government. They do not apply to employed advisers, departmental Chief Scientific Advisers or other civil servants who provide scientific or analytical advice, as other codes of professional conduct apply.

Clear roles and responsibilities

- Government should respect and value the academic freedom, professional status and expertise of its independent scientific advisers.
- Scientific advisers should respect the democratic mandate of the Government to take decisions based on a wide range of factors and recognise that science is only part of the evidence that Government must consider in developing policy.
- Government and its scientific advisers should not act to undermine mutual trust.
- Chairs of Scientific Advisory Committees and Councils have a particular responsibility to maintain open lines of communication with their sponsor department and its Ministers.

Independence

- Scientific advisers should be free from political interference with their work.
- Scientific advisers are free to publish and present their research.
- Scientific advisers are free to communicate publicly their advice to Government, subject to normal confidentiality restrictions, including when it appears to be inconsistent with Government policy.
- Scientific advisers have the right to engage with the media and public independently of the Government and should seek independent media advice on substantive pieces of work.
- Scientific advisers should make clear in what capacity they are communicating.

Transparency and openness

- Scientific advice to Government should be made publicly available unless there are over-riding reasons, such as national security or the facilitation of a crime, for not doing so.
- Any requirement for independent advisers to sign non-disclosure agreements, for example for reasons of national security, should be publicly acknowledged and regularly reviewed.
- The timing of the publication of independent scientific advice is a matter for the advisory body but should be discussed with the Government beforehand.
- Government should not prejudge the advice of independent advisers, nor should it criticise advice or reject it before its publication.
- The timing of the Government's response to scientific advice should demonstrably allow for proper consideration of that advice.
- Government should publicly explain the reasons for policy decisions, particularly when the decision is not consistent with scientific advice and in doing so, should accurately represent the evidence.
- If Government is minded not to accept the advice of a Scientific Advisory Committee or Council the relevant minister should normally meet with the Chair to discuss the issue before a final decision is made, particularly on matters of significant public interest.

Applying the Principles

Scientific Advisory Committees, Councils and government departments should consider the extent to which the Principles in this document are reflected in their operation and to make changes as necessary. Issues relating to the function and working of scientific advisory bodies that are not reflected in these high-level Principles are discussed in more detailed guidance such as the *Code of practice for Scientific Advisory Committees* or the *Guidelines on scientific analysis in policy-making*.

Government departments and their independent scientific advisers should raise issues of concern over the application of the Principles, or other guidance, with the relevant departmental Chief Scientific Adviser (CSA). If the matter of concern cannot be effectively resolved or is especially serious CSAs should approach the Government Chief Scientific Adviser (GCSA) and Ministers should approach the GCSA and the Minister for Science. The matter will be examined against a clear set of criteria, which include a breach of the Principles or CoPSAC.

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