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Report of the Stock Identification Methods Working Group (SIMWG)

By correspondence

International Council for the Exploration of the Sea

Conseil International pour l'Exploration de la Mer

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Contents

Executive summary

Over the past three years, the Stock Identification Methods Working Group (SIMWG) has made significant progress toward addressing our multi-year terms of reference and has contributed to ICES Science Plan priorities. The working group was chaired by Lisa Kerr (USA) during this period and SIMWG organized and held a physical meeting in Portland, Maine, 10–12 June 2015, and worked by correspondence in 2014 and 2016.

During this period, a 2nd edition of the book Stock Identification Methods: Applications in Fishery Science was published. SIMWG members S. Cadrin, L. Kerr and S. Mariani edited the edition and several SIMWG members contributed chapters to this book. In addition, SIMWG developed a glossary of terms for consistent usage of terminology relevant to stock identification that was included in the 2014 ICES SIMWG report. SIMWG has continued to provide annual updates on recent applications of stock identification methods to ICES species and on advances in stock identification methods. Furthermore, we have increased the documentation and accessibility of our past work through sharing summary materials documenting past SIMWG stock identity reviews (1998–2014) and providing a link to archived SIMWG reports through the SIMWG website. A key activity of SIMWG is to address requests by ICES working groups for technical advice on issues of stock identity. Over the past three years, we have provided advice on ICES blue whiting, Atlantic cod, haddock, megrim, anchovy, greater silver smelt, plaice, and mackerel stocks. These requests came from a range of ICES working groups including WGWIDE, WGBIE, WGHANSA, and NWWG; benchmark workshops including WKPLE and WKHAD, and advice drafting groups such as ADGDEEP. SIMWG's advice has been well received by these groups and there are a growing number of requests from different groups which speaks to the service that SIMWG provides to the ICES community. SIMWG has also made progress on reviewing and reporting on advances in mixed stock analysis. This work will continue through our next three year to and is relevant to resolving mixed stock composition issues in assessment and management.

SIMWG contributes to the general understanding of the biological features of the north Atlantic ecosystem through its work to describe fish population structure. Additionally, SIMWG's annual reviews on advances in stock identification methods keeps ICES members abreast of best practices in this field of study. SIMWG expert reviews on questions of stock structure for particular ICES species are directly relevant to the appropriate definition of stock and contribute to the accuracy of stock assessment and effectiveness of management actions. We see an important role for SIMWG in the future as ICES copes with the shifting distributions of fishery resources and questions regarding the appropriate definition of fish stocks. Understanding stock structure is a fundamental requirement before any assessment or modelling on a stock can be contemplated and SIMWG will continue to work with ICES expert groups to address pressing stock identification issues.

1 Administrative details

Working Group name
Stock Identification Methods Working Group (SIMWG)
Year of Appointment
2014
Reporting year within current cycle (1, 2 or 3)
3
Chair(s)
Lisa Kerr, USA
Meeting venue(s) and dates
SIMWG met by correspondence in 2016

2 Terms of Reference a) – z)

SIMWGs multiannual ToRs are as follows:

a) Review advances in stock identification methods;
b) Build a reference database with updated information on known biological stocks for ICES species of interest;
c) Provide technical reviews and expert opinions on matters of stock identification, as requested by specific Working Groups and SCICOM;
d) Review and report on advances in mixed stock analysis, and assess their potential role in improving precision of stock assessment.

3 Summary of Work plan

Year 1	Organise a physical meeting for SIMWG for summer 2015, trying to identify a period of the year that would allow best coordination with benchmarking processes. Establish working agreement with ICES web designers for delivery of ToR b.
Year 2	Focus primarily on ToR b and assess personnel commitment and feasibility of ToR c.
Year 3	Complete the first version of ToRc.

4 Summary of Achievements of the WG during 3-year term

- SIMWG organized and held a physical meeting in Portland, Maine, June 10–12 2015. SIMWG worked by correspondence in 2014 and 2016.
- SIMWG developed a glossary of terms for consistent usage of terminology relevant to stock identification.

- SIMWG provided annual updates on recent applications of stock identification methods to ICES species and on recent advances in stock identification methods.
- A 2nd edition of the book Stock Identification Methods: Applications in Fishery Science was published in 2014. SIMWG members S. Cadrin, L. Kerr and S. Mariani edited the edition and several SIMWG members contributed chapters to this book.
- SIMWG developed summary materials of past SIMWG reviews on issues of stock identity for ICES species (1998–2014).
- SIMWG provided expert advice on the following species over the past three years:
    1) Blue whiting (*Micromesistius poutassou*) in Subareas 1–9, 12, and 14 as requested by WGWIDE;
    2) Atlantic cod (*Gadus morhua*) in: 1) inshore waters of NAFO Subarea 1, and 2) offshore waters of ICES Subarea 14 and NAFO Subarea 1 as requested by NGWG;
    3) Haddock (*Melanogrammus aeglefinus*) in ICES Subareas 4 and 6a (North Sea and West of Scotland) as requested by WKHAD;
    4) Megrim (*Lepidorhombus whiffiagonis*) in ICES Subareas 8c and 9a as requested by WGBIE;
    5) Anchovy (*Engraulis encrasicolus*) in ICES Division 9a as requested by WGHANSA;
    6) Greater silver smelt (*Argentina silus*) in ICES Subareas 1, 2, 4, 6, 7, 8, 9, 10, 12 and 14 and Divisions 3a and 5b as requested by ADGDEEP;
    7) Plaice (*Pleuronectes platessa*) in ICES sub-area 3a and Adjacent Areas as requested by WKPLE;
    8) Mackerel (*Scomber scombrus*) in ICES Subareas 1–7 and 14 and Divisions 8a-e and 9a as requested by WGWIDE;
- SIMWG provided an annual review of advances in mixed stock analysis.

5 ToR a) Review recent advances in stock identification methods

In the last year, there have been several notable advances in stock identification methods and a proliferation of applications, with many results relevant to ICES science and advice. Here, we summarize advances and results accounting for research in genetics, life history parameters, morphometrics, tagging, otoliths, early life history stages, parasites, and interdisciplinary approaches.

In the past year, a special volume of Fisheries Research was dedicated to stock identification methods (Pita *et al.* 2016). Additionally, a theme Set entitled ”Beyond ocean connectivity: new frontiers in early life stages and adult connectivity to meet assessment and management challenges” is in progress and to be published in the ICES Journal of Marine Science. This theme set follows up a session by the same name at ICES ASC 2015 (Conveners: Manuel Hidalgo, Lisa Kerr, and Claire Paris).

5.1 Genetic Analysis

(Stefano Mariani)

Since the analysis carried out in Mariani and Bekkevold (2014), we are continuing to monitor changes in the usage of genetic methods in fisheries stock identification on an annual basis. Here we report data on the most recent five years of scientific output (Fig. 1). Through 2015 microsatellites continued to be the most widely applied genetic method, however in 2016 (for which full citation metrics will not be available until 2017) the relative importance of SNPs appears to become more substantial. SIMWG will continue to track and summarize trends in genetic methods, in order to monitor the short-term changes in molecular marker usage in fisheries science.

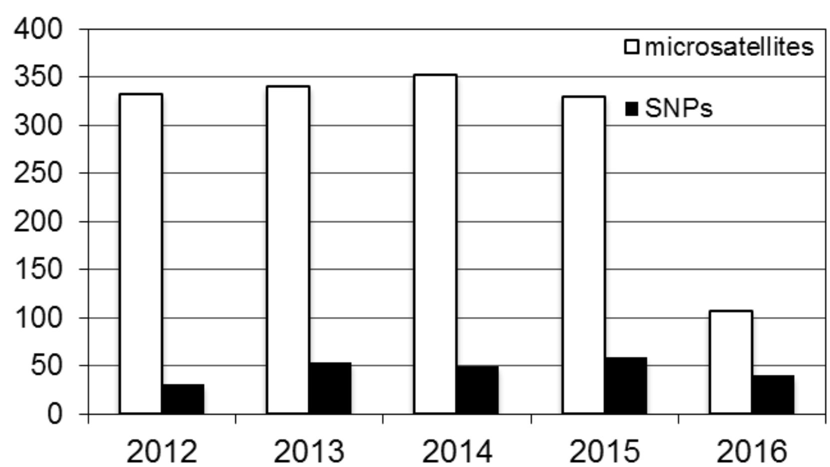

Figure 1. Scientific publishing trend since 2012, comparing outputs of studies using microsatellites (white bars) and SNPs (black bars), as listed in the ISI Thompson-Reuters Web-of-Science. The search criteria were: "fish* AND gene* AND (population OR stock) AND 'molecular marker*'," where 'molecular marker*' means "Microsatellite*" or "SNP*". Only papers in the following disciplinary areas were considered: 'Fisheries', 'Environmental Sciences & Ecology', 'Biodiversity Conservation', 'Marine & Freshwater Biology' and 'Oceanography'.

Additionally, there were a few new applications of genetic methods over the past year that are of direct relevance to ICES advice. An important study shed light on the stock structure of saithe (*Pollachius virens*), using 131 SNPs and nearly 600 individuals sampled across the species' distribution range (Saha *et al.* 2015). The authors detected four main stock groups: Barents Sea, Central Northeast Atlantic, Rockall, and Canada, and provided an improved understanding of stock structure for the redefinition of management boundaries. More insights into European anchovy (*Engraulis encrasicolus*) in the Bay of Biscay were offered by a study by Montes *et al.* (2016), using 349 SNP markers. This study showed that despite recent stock reductions, the Bay of Biscay anchovy population does not appear to have reduced its effective size, with negligible effect on its underpinning genetic diversity. On the contrary, Mirimin *et al.* (2016) documented how over-exploitation appears to have caused a severe bottleneck and effective size reduction in South-African dusky kob (*Argyrosomus japonicas*). Laconcha *et al.* (2015) used >1300 individuals worldwide and 75 SNPs to discriminate populations of albacore tuna (*Thunnus alalunga*) between Atlantic and Mediterranean (as well as Indian and Pacific Ocean) and found that current management perceptions and stable effective population size are conducive of sustainable fisheries. Meanwhile, a review by Kumar *et al.* (2015) synthesized genetic population structure of eleven tuna species (albacore, bigeye, yellowfin, Pacific bluefin, Atlantic bluefin, southern bluefin, blackfin, longtail, skipjack, frigate, and little tuna). This study suggested there are up to 50 distinct populations of tuna species worldwide, and in some cases the authors' conclusions conflicted with other studies; for instance, they report up to 12 genetic units in albacore (as opposed the four in Laconcha *et al.* 2015).

Despite over 100 articles published in the last 18 months on fisheries stock identification using genetic markers, no significant advancements were recorded in terms of resolving long-standing mismatches between biological and management boundaries for species of ICES relevance. Most of the studies conducted in the North Atlantic were focused on salmonids and cod, delving deeper into biological processes and using high-coverage genomic tools to explore adaptation in the best known species. In other parts of the world, including the USA, South Africa, South America, the Red Sea, and the Mediterranean, genetic studies continue to increase our knowledge of stock structure, providing information that is relevant to improved management practices. It is important to note that, alongside an increased power in our understanding of functional genomics in keystone species, fisheries management continues to require basic spatio-temporal definition of stock boundaries in a wider array of exploited species.

5.2 Life history parameters

(Richard McBride)

Recent research of South African hakes (*Merluccius spp.*) highlighted the value of length-based monitoring programs when operating at the appropriate spatial scale. Jansen *et al.* (2016) collected shallow-water hake (*M. capensis*) throughout its range, with multiple demersal-trawl surveys. They presented a length-based geostatistical model to describe age-specific distributions and movements. This approach revealed three primary population components which they recommended should be accounted for in future stock assessments and management policies. Additionally, Strømme *et al.* (2016) collected deep-water hake (*M. paradoxus*) throughout its range with synoptic, demersal-trawl surveys. They concluded that this species was a unit stock with extensive migrations throughout its range. The scale of connectivity of this species not been captured previously because monitoring, assessment and management had occured within national jurisdictions.

5.3 Body Morphometrics

(Steve Cadrin)

A special volume of Fisheries Research was dedicated to stock identification methods (Pita *et al.* 2016), and the volume includes a case study in geometric morphometrics (Miyan *et al.* 2016). However, the volume's preface considers morphometric analysis to be a traditional approach, does not recognize advances in image analysis or geometric methods, and does not include morphometrics in their 'global logistics approach' (Pita *et al.* 2016). Contrary to the perspectives of Pita *et al.* (2016), a review of publications in the last year by SIMWG indicates that analysis of body morphometrics continues to be an active approach to stock identification. Several studies were published in the last year on methods and applications to a diverse array of finfish and crustaceans. A continuing trend is to include body morphometrics in interdisciplinary studies of stock identity. Unfortunately, best practices in morphometric analysis are not being applied in many case studies.

An important methods paper was published by Takács *et al.* (2016) that investigated the scientific rigor of morphometric analysis. They compared repeatability, reproducibility, discrimination power and subjectivity of "traditional" linear distances, truss networks, and geometric methods (Figure 2). They reported that all methods were able to differentiate source populations, but geometric methods and truss networks performed best for repeatability and measurer effect and traditional distances had poor repeatability and reproducibility. Their review is similar to previous conclusions that geometric and truss network methods are more sensitive to differences in form than traditional distances (Strauss and Bookstein 1982, Winans 1987, Schweigert 1990, Roby *et al.* 1991, Cadrin and Friedland 1999). A new review by Mojekwu and Anumudu (2015) supports the conclusion that geometric approaches have greater discriminating power (Bronte and Moore 2007, Shao *et al.* 2007).

ICES SIMWG has promoted geometric methods for decades. Therefore this review is organized according to method.

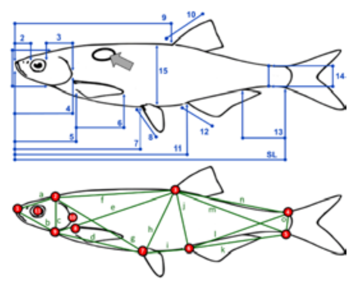

Figure 2. Traditional morphometric distances (above) and geometric landmarks with truss network (below) analyzed for repeatability, reproducibility, discriminating power and subjectivity (modified from Takács *et al.* 2016).

Traditional Linear Distances

Fourteen recent case studies (10 finfish and four crustaceans) were reviewed that investigated stock identity by measuring linear distances (Figure 3).

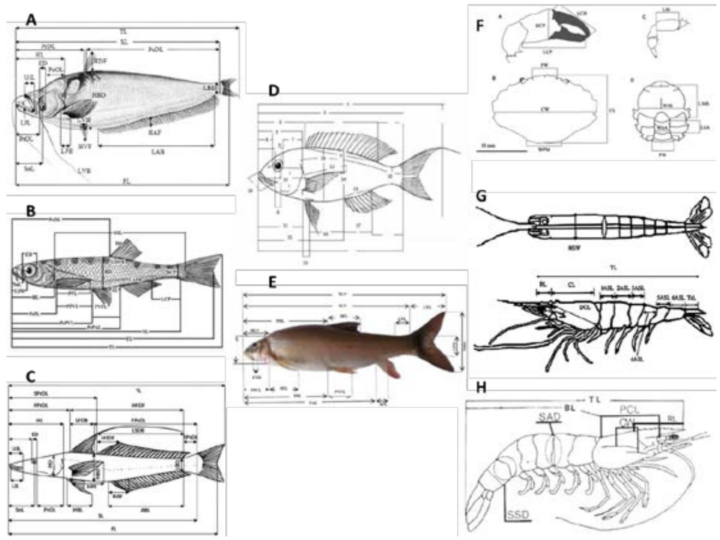

Figure 3. Traditional morphometric distances (from A: Chaklader *et al.* 2016; B: Saxena *et al.* 2015; C: Siddik *et al.* 2016b; D: Sreekanth *et al.* 2015; E: Wagle *et al.* 2016; F: Afkhami *et al.* 2016; G: Chen *et al.* 2015; H: Rebello *et al.* 2016).

1) Cuttitta *et al.* (2015) found population structure of European anchovy in the Strait of Sicily using larval morphometrics and genetics. Mouth length and body diameter were more powerful for separating groups than the genetic characters.

2) Chaklader *et al.* (2016) found differences in 25 distances and five meristic characters from 80 specimens of catfish among southern coastal rivers of Bangladesh (Figure 3a).

3) Saxena *et al.* (2015) found differences between two river populations of the cyprinid *Barilius bendelisis* in India, with differences in body depth, length of pectoral fin, dorsal fin base length, sub orbital width, head length and snout length, measuring 24 distances from 134 specimens, and a cross-validated classification accuracy of 83% (Figure 3b).

4) Siddik *et al.* (2016b) found distinct river stocks of Gangetic whiting, as indicated by differences in 27 distances sampled from 194 specimens, with 71% classification accuracy (Figure 3c).

5) Sreekanth *et al.* (2015) measured 21 morphometric distances Japanese thread fin bream from four locations off India, and discriminated the four areas based on body depth, length and head, with 80% classification accuracy (Figure 3d).

6) Wagle *et al.* (2016) found morphometric divergence of snow trout among three river systems using multivariate analysis of 17 measured morphometric characters of 207 specimens, with most of the variation in the head, body depth and fin length (Figure 3e).

7) Jalbani *et al.* (2016) found homogeneous morphological variation among 190 specimens of catfish from the Indus River.

8) Mwakitiac *et al.* (2016) measured 16 morphometric distances of cutlassfish and found distinct differences north and south of the Kenyan coast.

9) Myoung and Kim (2016) found distinct eastern and western morphotypes of Korean gizzard shad, with a mixing zone the Korean Strait, using discriminant analysis of 17 morphometric and 5 meristic characters of 173 individuals.

10) Siddik *et al.* (2016a) found two distinct river groups of olive barb from morphometric distances measured from 110 specimens, with 55 % classification accuracy.

11) Afkhami *et al.* (2016) found differences in fifteen morphometric characters of the crab *Leptodius exaratus* between the Persian Gulf and the Gulf of Oman. Males and females were analysed separately because of sexual dimorphism (Figure 3f).

12) Chen *et al.* (2015) found morphometric differences in river prawn between estuaries and reservoirs, using 12 traditional distances (Figure 3g).

13) Rebello *et al.* (2016) analysed four morphometric distances and biochemical characters of Penaeid shrimp and found no significant differences among areas of the Kerala Coast (Figure 3h).

14) Jónsdóttir *et al.* (2016) found differences in ten morphometric distances of northern shrimp sampled from four areas in two adjacent Icelandic fjords, with 41-79% classification accuracy.

Truss Analyses

Five case studies were reviewed that investigated stock identity using truss analysis methods (Figure 4).

1) Azrita (2015) found morphological variation among five strains of giant gourami using a truss network of sixteen distances, finding differences in dorsal fin, anal fin, pelvic fin, and head dimensions.

2) Hossain *et al.* (2015) measured 25 truss distances and 14 meristic characters from 125 specimens of mullet off Bangladesh and found three distinct geographic groups.

3) Remya *et al.* (2015) measured 21 truss distances between 10 morphometric landmarks from 200 specimens of oil sardine, and found no morphometric differences between the southeast and southwest coasts of India.

4) Zhang *et al.* (2016) found a latitudinal gradient and subpopulations of yellow croaker off the Chinese coast using a truss network in a sample of 431 specimens from the main spawning grounds. Primary differences were in head measurements, body length and tail size.

5) Munasinghe (2015) investigated morphological and genetic variations of three shrimp populations in Sri Lanka using a truss network of 37 distances and the mitochondrial control region and found significant differences among eastern, western and southern regions.

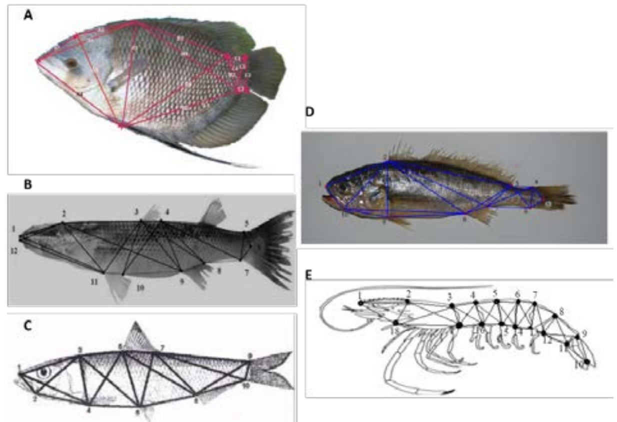

Figure 4. Truss network distances (from A: Azrita 2015; B: Hossain *et al.* 2015; C: Zhang *et al.* 2016; D: Remya *et al.* 2015; E: Munasinghe 2015).

Geometric Analysis

Three case studies were reviewed that investigated stock identity using geometric analyses (Figure 5).

1) Porrini *et al.* (2015) identified two phenotypic stocks of common sea bream based on differences in landmark morphometrics, primarily body depth and caudal peduncle length, between two spawning areas north and south of Buenos Aires, despite genetic homogeneity.

2) Kashyap *et al.* (2016) investigated morphometric landmarks to identify subpopulations of freshwater murrel in different habitats, with 97% cross-validated classification accuracy based on variation in dorsal fin length, snout length, inter-orbital length, pre-anal length, head length, pre-dorsal length and pre pectoral length.

3) Vatandoust *et al.* (2015) found morphometric variation between two river stocks of Caspian lamprey. Stocks were discriminated based on predorsal length, interdorsal, interorbital distance, tail length, and first dorsal fin length.

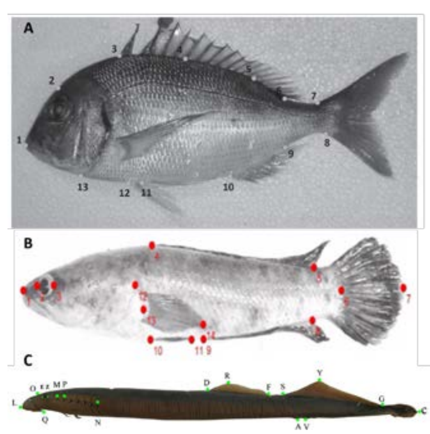

Figure 5. Geometric landmarks (from A: Porrini *et al.* 2015; B: Kashyap *et al.* 2016; Vatandoust *et al.* 2015).

The continued application of traditional morphometric distances (e.g., Figure 3) despite the previous and newly published advantages of truss and geometric methods (e.g., Takács *et al.* 2016), the consideration of morphometrics as a traditional approach, and its exclusion from the 'global logistics approach' (Pita *et al.* 2016), suggest that SIMWG should continue to advocate for the application of best practices within each stock identification approach as well as an interdisciplinary approach that includes all approaches.

5.4 Tagging (conventional, acoustic, satellite)

(Steve Cadrin)

Several reviews and studies in the last year contributed to the advancement of tagging methods for stock identification. SIMWG member David Hallock Secor published a book titled "Migration Ecology of Marine Fishes", which has a chapter devoted to population structure (Figure 6). Dave presented a related plenary lecture at the 2015 ICES Annual Science conference titled "Mapping migrations onto dynamic seascapes: The most essential things are invisible to the eye." He explained how the digital age has produced millions of telemetered paths and a new focus on individual behaviour and movement motivations which contribute to complex population processes.

Figure 6. David Hallock Secor presenting his plenary address at the 2015 ICES Annual Science Conference.

Hussey *et al.* (2015) reviewed aquatic animal telemetry and concluded that advances in and expanding applications of telemetry during the last decade have transformed our study of fish movement (Figure 7). New ecological understanding is facilitated by observing animal movements in the context of physiological and environmental observations. These new insights are redefining how we view and conserve aquatic populations. A related review of advances in telemetry methods by Kays *et al.* (2015) suggested that we are in a golden age of animal tracking science, and discoveries in a wide range of scientific disciplines including population structure should be expected.

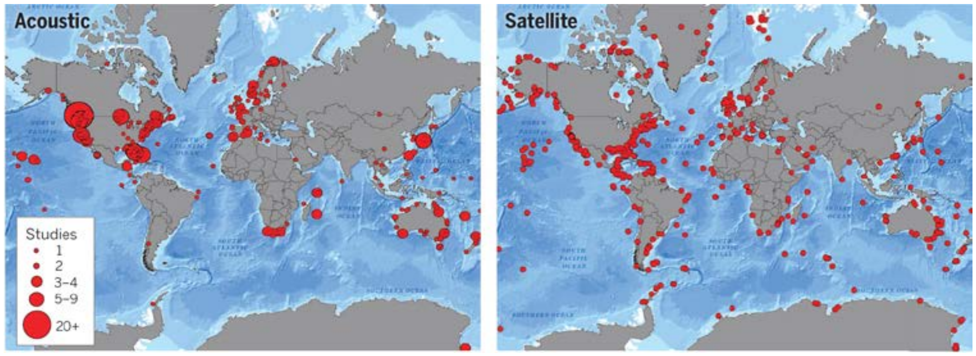

Figure 7. Global distribution of acoustic and satellite tagging studies (from Hussey *et al.* 2015).

A review by Sippel *et al.* (2015) demonstrated how electronic tags can be used to inform movement and stock mixing. In particular, electronic tags offer new opportunities to quantify movement rates of large pelagic species as discrete movements among management areas or continuous connectivity processes.

Recent tagging applications in the ICES area demonstrate the expanded use of tagging technology, insights on individual behaviour, and population inferences. Amilhat *et al.* (2016) used pop-up satellite tags to provide evidence of European eels exiting the Mediterranean Sea during their spawning migration. Witt *et al.* (2014) used satellite tags on basking sharks and found high levels of site fidelity to waters around the Hebrides Islands. Woillez *et al.* (2016) deployed data storage tags on European sea bass to infer migration tracks. Freitas *et al.* (2016) used acoustic tagging to study the effect of temperature on habitat selection and habitat use of Atlantic cod off the Norwegian Skagerrak coast.

5.5 Growth marks in calcified structures

(Richard McBride)

Two examples from 2016 demonstrate best practices when examining growth marks in calcified structures. Using back-calculated size-at-otolith-age data, Kuparinen *et al.* (2016) reported differences in growth trajectories of Atlantic cod (*Gadus morhua*) inhabiting inner and outer fjord habitats in the Norwegian Skagerrak. These phenotypic differences are also associated with genetic stock structure data, demonstrating that small scales of diversity can contribute to productivity and resilience within widely ranging species. Morrongiello and Thresher (2015) examined a particularly large dataset of otolith ages of tiger flathead (*Platycephalus richardsoni*) (i.e., 25 000 growth marks measured from 6000 fish collected during four decades from seven fishing areas). Their presentation of a hierarchical model – one that addresses sources of variation from the individual to the species level – should be of interest to all those dealing with data-rich situations.

5.6 Otolith Shape

(Christoph Stransky and Kelig Mahe)

From June 2015 to July 2016, there were nine new papers concerning the otolith shape as tool of stock identification that were published. There were two categories: critical study on otolith shape analysis (Vignon, 2015) and several case studies (*Atherina boyeri*, Boudinar *et al.* 2015; *Odontesthes nigricans*, Lattuca *et al.* 2015; *Pseudanthias rubrizonatus*, Fowler *et al.* 2015; *Diplodus annularis*, Trojette *et al.* 2015; *Gadus morhua*, Hüssy *et al.* 2016a & 2016b; *Micromesistius poutassou*, Mahé *et al.* 2016; *Scomberomorus niphonius*, Zhang *et al.* 2016).

Vignon (2015) identified sources of otolith shape variation across spatial and taxonomic scales (8 coral reef species) using a new hierarchical partitioning method embedded in a geometric morphometric framework. Various environmental, taxonomic, and endogenic factors which affect otolith shape were quantitatively investigated in 2077 individuals. Allometry accounted for a considerable degree of otolith shape variation at all scales and contributed more variation to regional differences than did habitats or islands. While large-scale variations are expected to be associated with significant shape variation, the study provides quantitative evidence that both local environmental variables and large-scale patterns contribute equally to otolith shape variation. Vignon (2015) showed that the importance of local environmental variables may therefore act as an important confounding effect into the predictive models of discriminating stocks.

Boudinar *et al.* (2015) showed that for big-scale sand smelt (*Atherina boyeri*) along the Algerian coasts, from the analysis of somatic morphology and otolith shape (Fourier descriptors), there were three distinct groups: (1) a marine punctuated, (2) lagoon and marine unpunctuated, and (3) an estuarine group. The visual difference (unpunctuated vs. punctuated) of marine individuals is in accordance with differences found in otolith shape.

Lattuca *et al.* (2015) used age and growth, otolith shape, and diet to discriminate silverside (*Odontesthes nigricans*) populations from the South Atlantic Ocean (Punta María) and Beagle Channel waters (Varela Bay). Otolith shape variation using elliptical Fourier analysis showed significant differences between Varela Bay and Punta María populations.

Fowler *et al.* (2015) tested the role of oil structures as habitats for reef fishes (*Pseudanthias rubrizonatus*) on Australia's North West Shelf from otolith microchemistry and shape. This study indicated that reef fish can develop unique otolith properties during their residency on oil production structures which may be useful for assessing the habitat value of individual structures. According to the authors, otolith shape should be considered in future investigations of residency on oil structures, because it provides a measure of population separation over longer time scales than most other methods (e.g., edge microchemistry, tagging).

Trojette *et al.* (2015) looked at population structure of annular seabream (*Diplodus annularis*) from two islands off the Tunisian coast and found significant differences in asymmetry between right and left otoliths from the different islands.

Hüssy *et al.* (2016a & 2016b) analysed the spatio-temporal dynamics of stock mixing composed by two distinct cod stocks "Eastern Baltic cod" and "Western Baltic cod" using otolith shape analysis for classification of individuals caught in the mixed stock cod fishery. The first study (Hüssy *et al.* 2015a) used SNPs for genetic assignment of otolith shape baselines. The inclusion of genotyped individuals balanced the baseline size composition and to large extent removed a strong size related bias in classification success. These results demonstrated the interplay of environmental, ontogenetic, and genetic influences on otolith shape, which complicates the application of otolith shape for stock discrimination in mixed-stock scenarios. The second study (Hüssy *et al.* 2016b) focused on the impact of eastern cod immigration on recruitment in the western Baltic Sea, which was investigated using hydrographic drift modelling and otolith shape. This study has shown that eastern Baltic cod immigrating into the Arkona Basin may contribute to recruitment in the western Baltic.

Mahé *et al.* (2016) examined blue whiting (*Micromesistius poutassou*) stock structure at a large geographical scale (Norway to Portugal) in the Northeast Atlantic using otolith shape analysis. The results indicated two stocks located north and south of ICES Divisions 6a and 6b (54°5N to 60°5N, 4°W to 11°W). The central area corresponds to the spawning area west of Scotland. Sampling year effects and misclassification in the linear discriminant analysis suggested exchanges between the northern and southern stocks. The results corroborate previous studies indicating structuring of the blue whiting stock into two stocks, with some degree of mixing in the central overlap area.

Zhang *et al.* (2016) studied the population structure of Japanese Spanish mackerel (*Scomberomorus niphonius*) from eight main spawning grounds using commercial gill nets, covering the distribution range along the coast of China. The contour reconstruction suggested differences in the posterior–ventral zone of otoliths between geographical regions, being slighter with a latitude increase.

5.7 Otolith Chemistry

(Lisa Kerr)

In the past year, otolith chemistry was broadly applied as a stock identification tool to discern stock structure of fish species around the world. Below is a summary of recent applications of otolith chemistry to fish stock identification on ICES species of interest and advances in the field.

Marriot *et al.* (2016) compared otolith chemical signatures of juvenile European plaice (*Pleuronectes platessa*) sampled from known nursery habitats in the south-eastern Irish Sea. Their analysis of a suite of elements (Li, Na, Mg, K, Mn, Zn, Rb, Sr, Sn, Ba) revealed significant differences in otolith elemental composition across eight nursery grounds that were used for discrimination of juveniles within the south-eastern Irish Sea. This provides a means for understanding the supply of juveniles from specific nursery grounds and adult plaice in the region.

Otolith microchemistry of the small sandeel (*Ammodytes tobianus*) was compared across three different sites along the coast of the south-western English Channel in France (Laugier *et al.* 2015). Of the thirteen trace element ratios examined, Mn/Ca, Zn/Ca, and Cu/Ca ratios enabled significant discrimination among sampling sites. Furthermore, chemical fingerprints of each life stage varied significantly among sampling sites but not within them, suggesting limited exchange across sites. The fingerprints of life stages found in coastal sites were significantly different from those of the dispersive phases (larval and metamorphosis stages). The analysis of trace element fingerprints in sandeel otoliths appears to be a valuable method to further studies on population mixing and sandeel life history.

Cambie *et al.* (2016) used stable isotope ($\delta^{13}C$ and $\delta^{15}N$) composition of European sea bass (*Dicentrarchus labrax*) scales to evaluate stock mixing on coastal feeding grounds. The classification model showed that 75% of the fish could be correctly assigned to their collection region (north, mid, and south Wales) based on the isotope composition of scales. The work suggests that 2 sub-populations of sea bass in Welsh waters use separate feeding grounds (south vs. mid/north Wales), and may need separate management. This information has the potential to inform a more accurate definition of the stock boundaries for sea bass in the NE Atlantic.

Otolith elemental analysis (Ca, Ba, Sr, Zn, Mn, Fe) was used to evaluate whether European whitefish (*Coregonus lavaretus*) groups in the brackish Gulf of Bothnia (Baltic Sea) express specific otolith chemistry (Hägerstrand *et al.* 2015). Otoliths from six sites, four in the sea and two in rivers along the west coast of Finland, and from a fresh water lake were compared. The results showed considerable variation in the otolith elemental composition of whitefish across sites, suggesting the high potential for population identification using elemental fingerprints.

Reis-Santos (2015) examined the combined use of muscle stable isotopes ($\delta^{13}C$, $\delta^{15}N$) and otolith elemental composition (Li:Ca, Mg:Ca, Mn:Ca, Cu:Ca, Sr:Ca, Ba:Ca, and Pb:Ca) to evaluate connectivity between two estuarine nursery areas for juvenile European seabass (*Dicentrarchus labrax*) and common goby (*Pomatoschistus microps*). Distinct muscle isotopic ratios and otolith elemental signatures were found between areas for these species. The combined analysis using both muscle stable isotopes and otolith chemistry resulted in increased accuracy with no classification errors and shows great promise for discerning intra-estuarine connectivity patterns.

There were also many applications of otolith chemistry outside of the ICES geographic region. A notable example is Siskey *et al.* (2016), which summarized a forty year record of mixed stock composition information for Atlantic bluefin tuna in the northwest Atlantic. Otolith stable isotope analysis was used to discriminate stock of origin (i.e., Mediterranean or Gulf of Mexico). The study indicated fluctuating stock composition, with a substantially higher contribution of Mediterranean-origin fish in the 1990s (48% eastern stock contribution) than in the 1970s (0% contribution), and the most recent sample (4% contribution). Higher mixing and severe age truncation in the 1990s indicated that the northwestern Atlantic population was at a depressed state, whereas current reduced mixing and a slightly expanded age structure may indicate a recovery. Another example is research by Stanley *et al.* (2016) which examined spatial variation in otolith chemistry of juvenile Atlantic cod (*Gadus morhua*) from 54 inshore sites spanned five embayments in eastern Newfoundland. Otolith composition differed at all spatial scales and related inversely to spatial scale. Classification analysis revealed increasing discrimination at coarser spatial scales: site (26%–58%), bay (49%), and coast (76%). These results demonstrate environmental influence on otolith chemistry and illustrate the importance of resolving baseline variability in otolith chemistry when conducting assignment tests.

In the special volume entitled *Advances in Fish Stock Delineation* in Fisheries Research Tanner *et al.* (2016) provided a review of the major achievements in stock identification using otolith chemistry. This overview also detailed the evolution in methodological and analytical approaches over the last decades and provided insights on combining multiple stock identity techniques (e.g., otolith chemistry and genetic markers) to resolve stock structure. Current and future challenges and research gaps were outlined focusing on the need to provide accurate stock structure estimates for management purposes. Izzo *et al.* (2016) tested the long held assumptions that elements substitute for calcium within the $CaCO_3$ otolith structure. They examined where elements bind within the otolith (i.e., the proteinaceous and mineral components). Of the 12 elements investigated, most were found in both the proteinaceous and mineral components, but always in greater concentrations in the latter. Elements considered 'non-essential' to fish physiology were present in the mineral component in relatively high concentrations whereas elements essential to fish physiology were distributed throughout the protein and mineral components of the otolith. These findings enhance our understanding of element incorporation in the otolith and will improve interpretations of otolith-based environmental reconstructions.

5.8 Parasites

(Lisa Kerr)

In the past year, we found that this technique was applied to one stock within in the ICES area. Klapper *et al.* (2016) used parasites as a biological tag for discrimination of beaked redfish (*Sebastes mentella*) in the Barents Sea and Norwegian Sea. The study compared two methods, metazoan parasite assemblage and *A. simplex* haplotype structure, to examine whether stocks of *S. mentella* can be separated in the North East Atlantic region. The metazoan parasite fauna of beaked redfish from East Greenland differed from Tampen, northern North Sea, and Bear Island, Barents Sea. However, the present study suggests that *S. mentella* in the northern North Sea and Barents Sea is not sub-structured. These results align with previous studies.

In the special volume entitled *Advances in Fish Stock Delineation* in Fisheries Research Abollo and González (2016) describe the data gaps and challenges in using marine parasites as biological tags in fish stock studies. They focus on the utility of biobanking and molecular markers as relevant tools for the use of parasites as tags. The authors suggest that biobanking and molecular markers are promising technical solutions which could play a key role in stock discrimination of marine fish populations based on parasite data.

5.9 Early life stages

(Zach Whitener)

The dispersal patterns of larvae must be considered when conducting stock discrimination studies. A few studies were published in the past year that look at the role of early life history its application to stock structure related questions and considerations.

Huwer *et al.* (2016) used transport patterns of particles based on drift models to assess the interconnectivity of Atlantic cod (*Gadus morhua*) larvae within and between the North and Baltic Seas, including trends in variability, degree of exchange between management areas, and in comparison to distribution of juvenile cod. With particle exchange rates between management areas of up to 70%, the researchers determined cod populations to be demographically correlated and the authors believe that larval dispersal is responsible for the lack of genetic differentiation between the North Sea and Western Baltic Sea. These results demonstrate that information on larval dispersal can be an important considered in stock discrimination studies.

Fraker *et al.* (2015) used particle backtracking modelling to determine that river- and wind-driven circulation in Lake Erie may have influenced the larval drift to the extent that not all yellow perch (*Perca flavescens*) larvae collected at a presumed hatching location may have originated there. They used microsatellite DNA and otolith microchemistry as natural tags and re-assigned larvae to their most probable hatching site based on dispersal trajectories from the backtracking model, improving the estimated contributions of each breeding subpopulation (stock) to a mixed population of juvenile recruits.

5.10 Interdisciplinary analysis

(Steve Cadrin)

The special volume Fisheries Research dedicated to stock identification methods opens with a proposal for a 'global logistics approach' (Figure 8, Pita *et al.* 2016). They review the variety of new genetic and chemical markers, geographic information modelling, and 'traditional methods' (e.g., morphometrics, parasites, life history traits) as complementary approaches. They conclude that single technical approaches are often insufficient to delineate stocks, and although interdisciplinary approaches often perform better, they are underused. Their review supports the need for the maintenance of an interdisciplinary team to evaluate stock identity in the ICES system.

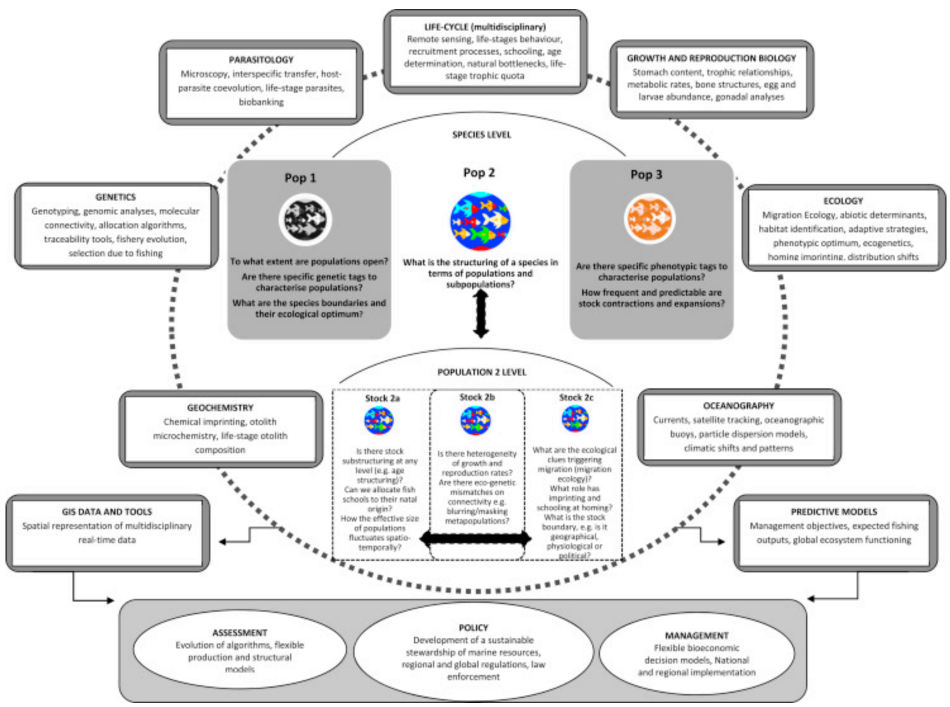

Figure 8. Global logistics approach matching research needs on population structure and stock delineation (inside the dashed circle) with current discipline-specific expertise (rectangles) to improve decision-making processes (ellipses) for fisheries sustainability (from Pita *et al.* 2016).

6 ToR b) Build a reference database with updated information on known biological stocks for species of ICES interest

In the past, SIMWG has discussed the challenge of communicating the existence of stock identity reviews for ICES species that reside within our annual reports. The members felt that producing a summary table of past reviews with reference to the source document would serve both the working group and the broader ICES community.

SIMWG has now established an online reference table (Table 1, Annex 5) that summarizes past reviews conducted by SIMWG scientists on issues of stock identity for ICES species. The table will be updated annually and includes reference to the annual report in which the species review is contained. Additionally, there is now a link to the past annual reports (1997–2015) on the SIMWG webpage via the ICES on-line library.

We have also produced a table summarizing the history and progress of SIMWG dating back to 1998. (Table 2, Annex 5) that will be updated annually in our report. The table provides a history of SIMWG activities, and provides details on previous chairs, meeting locations, terms of reference, as well as the species for which issues of stock identity were reviewed.

7 ToR c) Provide technical reviews and expert opinions on matters of stock identification, as requested by specific Working Groups and SCICOM

7.1 Evaluation of Northeast Mackerel Stock Identity in ICES Subareas 1–7 and 14 and Divisions 8a–e and 9a

ECOREGIONS: Widely distributed and migratory stocks

ICES STOCK(S):

1) Mackerel in the Northeast Atlantic (combined Southern, Western, and North Sea spawning components)

SIMWG FINDINGS: SIMWG concludes that the evidence of population structure within the NEA mackerel stock unit is equivocal. Existing genetic information indicates genetic differentiation of the Western spawning component from the North Sea and Adriatic components, suggesting that the Western spawning component may be reproductively isolated. However, there is no evidence that the North Sea spawning component is genetically distinct from other spawning components in the NEA. It is important to note, however, that the techniques used in this genetic study are no longer viewed as state-of-the–art for detecting differentiation in resources with large effective population size, such as mackerel. The distribution of early life stages, tagging data, parasites, and otolith growth supports connectivity between Southern, Western, and North Sea components.

NEA mackerel have traditionally been viewed as three spawning components (Southern, Western, and North Sea). However, new studies suggest an alternative view of NEA mackerel as a population that exhibits a cline of different genetic and behavioural adaptations generated through spatial segregation of spawning migrations and straying. Additional genetic research is needed to resolve the degree of isolation of the Southern, Western, and North Sea spawning component and complement approaches utilized in recent studies. SIMWG recommends further work to resolve the genetic structure within the Northeast Atlantic using state-of-the art genetic techniques.

Background

Overview

SIMWG was requested by Working Group on Widely Distributed Stocks (WGWIDE) in 2015 to provide feedback on issues of stock structure of Northeast Atlantic mackerel (*Scomber scombrus*), with a particular focus on the North Sea component. Northeast Atlantic mackerel are assessed as one stock unit; however, the prevailing view has been that the stock consists of three spawning components: the Western Spawning Component (Divisions 6, 7, 8a,b,d,e), Southern Spawning Component (Divisions 8c and 9a), and the North Sea Spawning Component (Divisions 4 and 3a). The North Sea component is believed to have been at very low levels for decades (Jansen 2014). Regulations (including spatial and temporal closures and a higher minimum size limit for the North Sea component) designed to protect the North Sea spawning component have been in place for several decades and WGWIDE continues to advise that these protection measures should remain in place (ICES 2015). New research (Jansen and Gislason 2013) has called into question the view of the resource as three distinct spawning components and contends that the mackerel population in the NEA is best described as a dynamic cline. These recent studies question the uniqueness of North Sea mackerel and the appropriateness of distinct management measures aimed at protecting this spawning component (Jansen 2014, Pastoors 2015).

WGWIDE requested that SIMWG review the stock structure of Northeast Atlantic mackerel and provide their expert opinion on the degree of isolation/connectivity between components. This review is relevant to WGWIDE's intention to evaluate whether the current protection measures for North Sea mackerel are warranted.

Distribution

Mackerel are broadly distributed throughout the North Atlantic. In the Northeast Atlantic (NEA), mackerel spawn from the Mediterranean Sea in the south to the Faroe Islands in the North and from Hatton Bank in the West to Kattegat in the East (Jansen and Gislason 2013).

Spawning seems to form one large spatio-temporal continuum on a large scale (ICES WGWIDE 2014), however, lower levels of spawning in the English and Fair Isle Channels separates the spawning areas in the North Sea from the western areas along the continental shelf edge (Figure 1, ICES WGWIDE 2014). There is evidence to suggest that reproductive exchanges occur between regions, indicating that there is not complete spatial or temporal separation of spawning groups; however, NEA mackerel have traditionally been divided into three spawning components (Southern, Western, and North Sea; ICES WGWIDE 2014).

Environmental Influence

The largest observed change in mackerel abundance in the North Atlantic happened when the "North Sea mackerel" component collapsed (Jansen 2014). The traditional explanation of the decline of the North Sea spawning component has been overexploitation, which has led to recruitment failure since the 1970s. Jansen (2014) suggests an alternative explanation that this could be the combination of high fishing pressure, followed by decreasing temperatures that led to reduced spawning migration into the North Sea. Thus, rather than a local stock collapse, Jansen (2014) suggests this phenomenon could be attributed to a southwest shift in spawning distribution.

Catch and survey data from recent years indicate that the stock has expanded northwestwards during spawning and the summer feeding migration (ICES 2013). This distributional shift may be attributable to the combined impact of increased stock size with changes in the physical environment and in the concentration and distribution of zooplankton (ICES 2013).

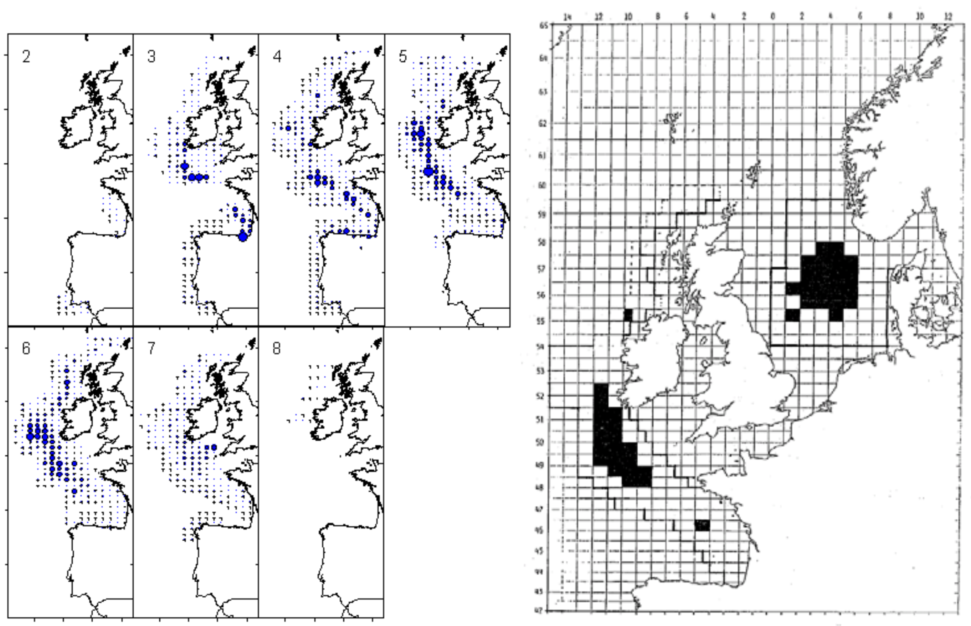

Figure 1 Left: Average distribution of mackerel eggs by ICES statistical rectangle in 1992–2007, each map represents a survey between February and August. Right: Shaded areas indicate 100 eggs/m² in at least two of the years in the period 1977–1988 (from ICES WGWIDE 2014).

Genetics

Nesbø *et al.* (2000) utilized the relatively slowly evolving mtDNA cytochrome b (cytb) gene and the rapidly evolving non-coding mtDNA D-loop to detect genetic differences in Atlantic mackerel. The study detected transatlantic genetic differentiation between mackerel on the eastern and western side of the Atlantic based on the mtDNA cytochrome b (cytb) gene. Based on the mtDNA D-loop sequences, they detected low levels of differentiation between stocks within the eastern Atlantic, with the western stock differentiated from other stocks (North Sea and Adriatic Sea). No genetic structuring was observed among shoals of individuals outside the spawning season (Nesbø *et al.* 2000). It is important to note that the techniques used in this genetic study are no longer viewed as state-of-the–art for detecting differentiation in resources with large effective population size, such as mackerel.

Additional recent studies have examined NEA mackerel genetics (Zandoya *et al.* 2004, Rodriguez-Ezpeleta *et al.* 2016); however, their sampling did not cover the three spawning components, including the North Sea, and thus their analysis does not explicitly address this question. There is ongoing genetic work to further resolve the degree of isolation between NEA mackerel spawning components that should be considered as soon as it is published (Pampoulie pers. comm.).

Tagging

An international tagging program started in 1997 on NEA mackerel from Portugal to the Shetland Islands (Uriarte *et al.* 2001). Tagging of mackerel has demonstrated that after spawning, fish from Southern and Western areas migrate to feed in the Norwegian Sea and the North Sea during the second half of the year. In the North Sea, fish tagged in the Southern and Western regions mix with the North Sea component. During wintertime those mackerel migrate southward towards the spawning grounds through the west of the British Isles. Uriarte *et al.* (2001) stated that the mixing of mackerel from the southern and western areas throughout most of the year and their cohabitation in the western spawning grounds (with the likely possibility of mixing) cast doubts on the reliability of the assumption of separate spawning components in these two areas. These observations do not, however, match the conclusions of genetic research (Nesbø *et al.* 2000) that supported the existence of separate spawning components.

Parasites

Prevalence rates of the tapeworm (*Grillotia smarisgora*) in mackerel provided a means of identifying mackerel which originate from nursery grounds to the southwest of the British Isles (MacKenzie 1990). Prevalence rates in mackerel caught in the Norwegian Sea, the North Sea (Subarea 4), and to the north and west of Scotland (Division 6a) indicate a high proportion of mackerel of southwestern origin in these areas at most times of the year. The results support the hypothesis of an overflow of Western stock mackerel into the North Sea. Somdal and Schram (1992) examined mackerel caught in the North Sea, Skagerrak, and southwest of Ireland for ectoparasites; however, they did not find any parasites were valuable as biological tags.

Early Life History Stage

Jansen *et al.* (2012) presented a time series of mackerel abundance in the North Sea based upon larvae caught by the Continuous Plankton Recorder (CPR) survey from 1948 to 2005. This time series includes the period of stock collapse through the 1970s and 1980s. The time series documents a significant decrease of spawning before 1970 to recent depleted levels. Additionally, spatial distribution of the larvae, and thus the spawning area, has shifted from early to recent decades, suggesting that the central North Sea is no longer as important as the areas further west and south.

Further analysis of the CPR larval index by Jansen and Gislason (2013) demonstrated a significant negative correlation between larval densities in the North Sea and in the Western spawning area. The combination of similar stock trends between regions and negatively correlated larval indices indicated that mackerel either switched spawning area preference from year to year or reacted oppositely to a common environmental factor. Jansen and Gislason (2013) contend that this information indicates that the North Sea and in the Western spawning components are connected by straying mackerel.

Life History Parameters

Jansen *et al.* (2013) examined juvenile growth patterns to understand the degree of spatial segregation in the spawning migration of NEA mackerel. The aim was to use otolith growth in adult fish during the first growth season as a proxy for somatic growth. Growth data of juveniles (derived from fish length) revealed that southern juvenile mackerel attain a greater length than those originating from further north. A similar relationship was found between the growth in the first year (derived from otoliths) and latitude for adult mackerel spawning between Bay of Biscay and west of Ireland. These findings suggest spatial segregation of the spawning migration (i.e., the further north that the fish were hatched, the further north they will tend to spawn). However, this analysis did not demonstrate separate growth patterns in the North Sea and in the areas west of Scotland.

Catch Information

Currently, mackerel catches cannot be allocated to a spawning area based on any biological discrimination technique. However, by convention catches from the Southern and Western components are separated according to the area where they are taken (ICES WGWIDE 2014).

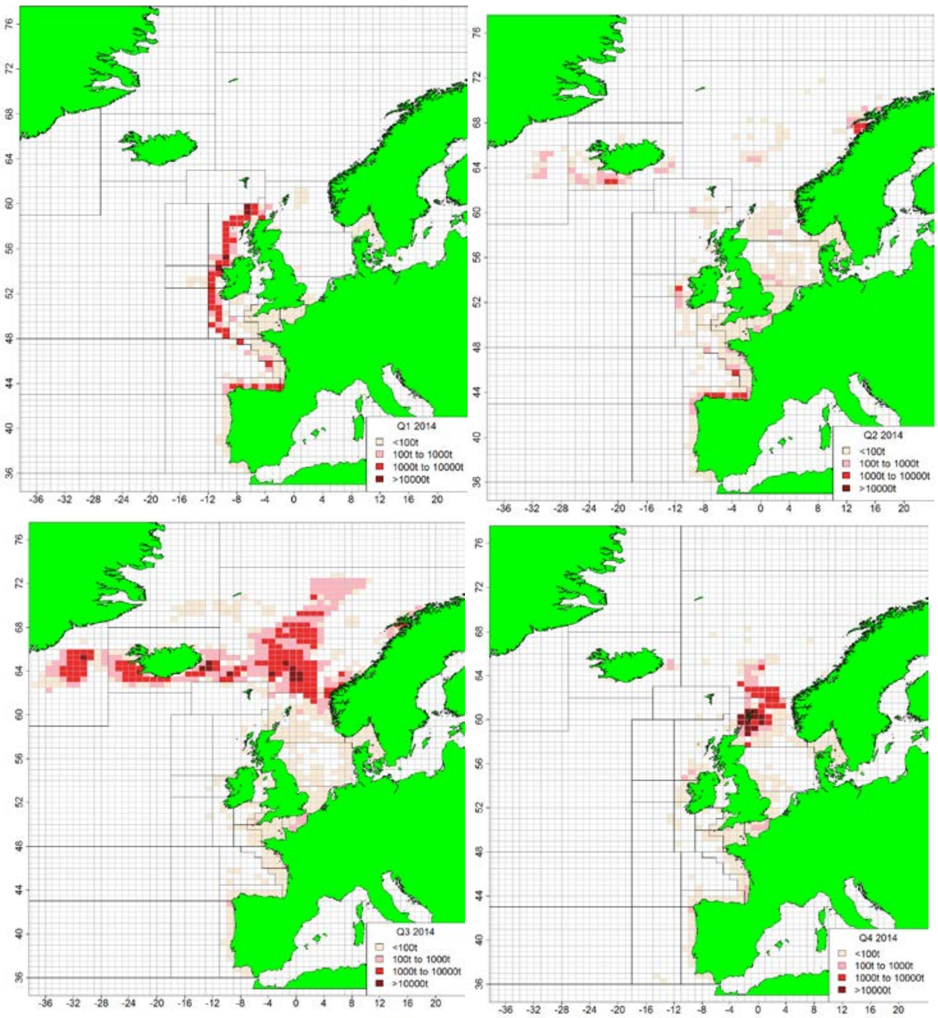

Figure 2. NE Atlantic Mackerel. Commercial catches in 2014, quarters1–4 (ICES WGWIDE 2014).

Otolith Growth and Shape

First year growth of otolith was examined as a tool for stock separation of North Sea and Western mackerel stocks when mixed (Dawson 1991). While the variation for both stocks follows the same trends, the difference in growth between Western and North Sea fish has not always been in the same direction. Otolith shape was found to differ between the Northwest Atlantic and North Sea, but this technique could not be used to determine finer population structure within the Northwest Atlantic (Castonguay *et al.* 1991). Jansen and Gislason (2013) reported that no difference was found between the North Sea and the Western components of mackerel in the Northeast Atlantic (Jansen unpubl. analysis of 652 mackerel otoliths). However, as these results were not published they should not be viewed as conclusive.

Interdisciplinary Analysis

Jansen and Gislason (2013) reviewed past stock identification studies on NEA mackerel. They concluded that despite numerous studies, there is very limited knowledge about the isolation and mixing between NEA mackerel spawning components and they remain weakly defined. They tested the hypothesis of mixing between the North Sea and Western spawning components by comparing stock trends and larval indices for coherence. They used strong and contrasting year classes as a means of tracking straying in the adult phase and used data from the Continuous Plankton Recorder (CPR) surveys as a larval mackerel index. The analyses of old and recent age distributions show that strong year classes spread into other areas where they spawn as adults (a phenomenon known as ''twinning''). The larval index in the North Sea was found to be negatively correlated with the larval index in the Celtic Sea (Figure 3). They interpreted these results to indicate that these two spawning components are connected by straying; however, this could also be indicative of alternative responses of spawning components to environmental conditions. Overall, Jansen and Gislason (2013) concluded that the mackerel population in the NEA is best described as a dynamic cline, rather than three spawning components.

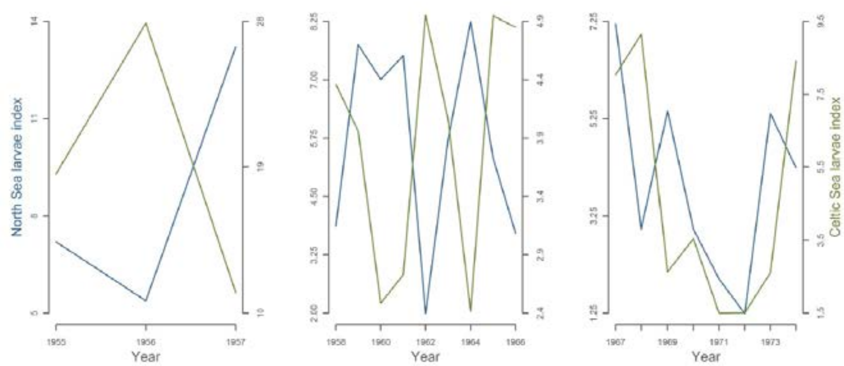

Figure 3. Mackerel larval indices in the North and Celtic Seas broken into three periods (from Jansen and Gilason 2013).

7.2 Conclusions and Recommendations

SIMWG reviewed existing stock identity information on NEA mackerel, with a focus on the North Sea component. SIMWG concludes that the evidence of population structure within the NEA mackerel stock unit is equivocal. The long-held view of the resource was that it is composed of three spawning components (North Sea, Western, and Southern). However, new studies suggest an alternative view of NEA mackerel as a population that exhibits a cline of different genetic and behavioural adaptations generated through spatial segregation of spawning migrations and straying.

Existing genetic information indicates genetic differentiation of the Western spawning component from the North Sea and Adriatic Sea components. This suggests that the Western spawning component may be reproductively isolated; however, there is not strong evidence to suggest that North Sea and Southern component are genetically distinct. Overall, there is lack of consistent phenotypic and/or genotypic differentiation across the three spawning components (North Sea, Western, and Southern) and no tool that would enable discrimination of the stock of origin of fish. The distribution of early life stages, tagging data, parasites, and otolith growth supports connectivity between components. There is extensive interaction between the North Sea component of mackerel and the Western and Southern components through a northward migration after spawning. Furthermore, there is evidence of the Southern and Western components moving into the North Sea when they migrate towards the Norwegian Sea. SIMWG recommends further work to resolve the genetic structure within the Northeast Atlantic and the particular question of the degree of isolation of the North Sea spawning component, using state-of-the-art genetic techniques.

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8 ToR d) Review and report on advances in mixed stock analysis, and assess their potential role in improving precision of stock assessment

In recent years, there have been advancements in the field of mixed stock analysis (MSA) and new applications of the approach, which are relevant to ICES science and advice. However, despite an increasing number of applications of mixed stock analysis, there are few examples where this approach has been integrated into the assessment and management of stocks.

Kerr *et al.* (*In Press*) describes a range of approaches to improve assessment and management in situations where complex spatial structure has led to an observed mismatch between the scale of biological populations and spatially-defined stock units. They profile the use of mixed stock analysis to parse data to the appropriate stock of origin before being input to stock assessment and/or used in management. Two case studies from the ICES region are highlighted: 1) Eastern and Western Baltic Atlantic cod, and 2) Western Baltic spring spawning herring and North Sea autumn spawning herring.

Baltic cod stocks exhibit stock mixing and asymmetry in biomass with the eastern stock exceeding the western stock in its magnitude (ICES, 2015a). Mixed stock analysis of Baltic cod stocks has allowed for parsing of survey and catch data back to the stock of origin. This parsing of data enables an assessment that is representative of the populations and able to more closely track the magnitude and trends in population dynamics (Hüssy *et al.*, 2016).

Stock identification methods (otolith shape analysis, vertebral counts and otolith microstructure; Clausen *et al.*, 2007; ICES, 2015b) have enabled assignment of North Sea and Western Baltic herring individuals to their respective stock of origin and this information that has been utilized to improve assessment of stock status. This information is used to adjust the time-series of survey and landings data, and the mean value of recent mixing (previous two years) is used in projections to give short term catch advice (total allowable catch) for each herring stock.

In addition to this review of applied mixed stock analysis there have been new applications of mixed stock analysis to ICES species of interest in the past year, including:

- Bekkevold *et al.* (2015) synthesized data from 156 single-nucleotide polymorphisms applied to 1039 herring, *Clupea harengus* L., spanning the Northeast Atlantic to develop the ability to assign individual herring to their origin. They analyzed the mixed stock composition from two areas (Skagerrak and western Baltic) and documented herring from the Baltic Sea contributed to catches in the North Sea, and found western Baltic feeding aggregations mainly constitute herring from the western Baltic with contributions from the Eastern Baltic.
- Yu *et al.* (2016) evaluated the combined impact of genetic markers with an adaptive meristic trait (gill raker count) on performance of mixed-stock analysis of Baltic whitefish. They analysed 586 individuals from 13 spawning locations and a simulated mixtures analysis showed that the combination of gill raker count and nine microsatellites improved the accuracy and precision of mixed stock aanlysis for distinguishing two sympatric ecotypes.

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10 Cooperation

Over the past three years, SIMWG was asked to provide expert feedback on the status of stock structure of several species (Table 1, Annex 4). These requests came from a range of ICES working groups including WGWIDE, WGBIE, WGHANSA, and NWWG; benchmark workshops including WKPLE and WKHAD, and advice drafting groups such as ADGDEEP, and in previous years we have connected with many more ICES groups to fulfil requests. SIMWG's advice has been well received by the groups of interest and there are a growing number of requests from different groups which speaks to the service that SIMWG provides to the ICES community. We believe that more Working Groups may be interested in receiving feedback from SIMWG, and that improved communication in the future can considerably facilitate exchange of ideas within the ICES community.

11 Summary of Working Group self-evaluation and conclusions

The Stock Identification Methods Working Group (SIMWG) has successfully addressed its terms of reference over the past three year term (chaired by Lisa Kerr, USA) and has contributed to ICES Science Plan priorities in several ways. SIMWG contributes to the general understanding of the biological features of the north Atlantic ecosystem through its work to describe fish population structure. Additionally, SIMWG's annual reviews on advances in stock identification methods keeps ICES members abreast of best practices in this field of study. SIMWG expert reviews on questions of stock structure for particular ICES species are directly relevant to the appropriate definition of stock and contribute to the accuracy of stock assessment and effectiveness of management actions.

Some of the highlights of SIMWG work over the past three years includes the following:

- SIMWG organized and held a physical meeting in Portland, Maine June 10-12 2015. SIMWG worked by correspondence in 2014 and 2016.
- SIMWG developed a glossary of terms for consistent usage of terminology relevant to stock identification.
- SIMWG provided annual updates on recent applications of stock identification methods to ICES species and on recent advances in stock identification methods.
- A 2nd edition of the book **Stock Identification Methods: Applications in Fishery Science** was published in 2014. SIMWG members S. Cadrin, L. Kerr and S. Mariani edited the edition and several SIMWG members contributed chapters to this book.
- SIMWG provided expert advice on the following species over the past three years:
    1) Blue whiting (*Micromesistius poutassou*) in Subareas 1–9, 12, and 14 as requested by WGWIDE;
    2) Atlantic cod (*Gadus morhua*) in: 1) inshore waters of NAFO Subarea 1, and 2) offshore waters of ICES Subarea 14 and NAFO Subarea 1 as requested by NGWG;
    3) Haddock (*Melanogrammus aeglefinus*) in ICES Subareas 4 and 6a (North Sea and West of Scotland) as requested by WKHAD;
    4) Megrim (*Lepidorhombus whiffiagonis*) in ICES Subareas 8c and 9a as requested by WGBIE;
    5) Anchovy (*Engraulis encrasicolus*) in ICES Division 9a as requested by WGHANSA;
    6) Greater silver smelt (*Argentina silus*) in ICES Subareas 1, 2, 4, 6, 7, 8, 9, 10, 12 and 14 and Divisions 3a and 5b as requested by ADGDEEP;
    7) Plaice (*Pleuronectes platessa*) in ICES sub-area 3a and Adjacent Areas as requested by WKPLE;
    8) Mackerel (*Scomber scombrus*) in ICES Subareas 1-7 and 14 and Divisions 8a-e and 9a as requested by WGWIDE;

- SIMWG developed a summary table of past SIMWG reviews on issues of stock identity for ICES species (1998–2016). This table and past reports are now linked through the SIMWG website so that they are more easily accessed by other ICES groups.
- SIMWG developed a table summarizing the history and progress of SIMWG dating back to 1998.
- SIMWG provided an annual review of advances in mixed stock analysis.

We see an important role for SIMWG in the future as ICES copes with the shifting distributions of fishery resources and questions regarding the appropriate definition of fish stocks. Understanding stock structure is a fundamental requirement before any assessment or modelling on a stock can be contemplated and SIMWG will continue to work with ICES expert groups to address pressing stock identification issues.

Annex 1: List of participants

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Annex 2: Recommendations

Recommendation	Adressed to
1. SIMWG concludes that the evidence for three spawning populations (Southern, Western, North Sea) within the NEA mackerel stock unit is equivocal. SIMWG recommends further work to resolve the genetic structure within the Northeast Atlantic using state-of-the art genetic techniques.	WGWIDE, SCICOM, ACOM

Annex 3: SIMWG draft terms of reference 2017–2019

Working group meeting draft resolution for multi-annual ToRs (Category 2)

The **Stock Identification Methods Working Group** (SIMWG), chaired by Lisa Kerr will work on ToRs and generate deliverables as listed in the Table below.

	MEETING DATES	VENUE	REPORTING DETAILS	COMMENTS (CHANGE IN CHAIR, ETC.)
Year 2017	By correspondence	By correspondence	Interim report by 1 August to SSGEPI	
Year 2018	June	TBD	Interim report by 1 August to SSGEPI	
Year 2019	By correspondence	By correspondence	Interim report by 1 August to SCICOM	

ToR descriptors

ToR	Description	Background	Science Plan topics addressed	Duration	Expected Deliverables
a	Review recent advances in stock identification methods	a) Tracks best practices in stock ID b) Promotes new technologies c) Relevant to all ICES species	28, 31	3 years (and continued)	EG report
b	Provide technical reviews and expert opinions on matters of stock identification, as requested by specific Working Groups and SCICOM	a) Contributes to understanding of structure and connectivity of fish populations/stocks b) Highly relevant to assessment and management	1, 2, 3, 10, 25, 27	3 years (and continued)	EG report and updated table of species reviews
c	Review and report on advances in mixed stock analysis, and assess their potential role in improving precision of stock assessment	a) Relevant to resolving mixed stock composition issues in assessment and management	15	3 years	EG report and contribution to ICES ASC; methodological paper in international journal

Summary of the Work Plan

Year 1	Address terms of reference through work by correspondence in 2017
Year 2	Organise a physical meeting for SIMWG for summer 2018.
Year 3	Address terms of reference through work by correspondence in 2019

Supporting information

Priority	Understanding stock structure is a fundamental requirement before any assessment or modelling on a stock level can be contemplated. SIMWG liaises with ICES expert groups and working groups on stock identification issues and continues to review new methods as they develop
Resource requirements	SharePoint website and clear feedback from expert groups, SCICOM and SSGEPI is pivotal for the efficacy of SIMWG.
Participants	The Group is normally attended by some 10–15 members and guests.
Secretariat facilities	Access to SharePoint to all members and Chair-nominated guests.
Financial	None
Linkages to ACOM and groups under ACOM	ACOM
Linkages to other committees or groups	SIMWG has recently worked closely with a range of ICES working groups including WGWIDE, WGBIE, WGHANSA, and NWWG; benchmark workshops including WKPLE and WKHAD, and advice drafting groups such as ADGDEEP, and in previous years SIWMG connected with many more ICES groups to fulfill requests.
Linkages to other organizations	There are no obvious direct linkages, beyond the SIMWG members' affiliation and commitment to their own employers.

Annex 4: Copy of Working Group self-evaluation

1) **Working Group name:** Stock Identification Methods Working Group (SIMWG)
2) **Year of appointment:** 2014
3) **Current Chairs:** Lisa Kerr (USA)
4) **Venues, dates and number of participants per meeting:** SIMWG met by correspondence in 2014 and 2016 and met in-person in 2015 in Portland, ME. Annual participation range from 11-15 people.
5) **If applicable, please indicate the research priorities (and sub priorities) of the Science Plan to which the WG make a significant contribution.**

ICES science plan priorities and how SIWMG's work is relevant to these priorities is listed below:

1. Assess the physical, chemical and biological state of regional seas and investigate the predominant climatic, hydrological and biological features and processes that characterise regional ecosystems

How SIMWG Addresses Priority: SIMWG contributes to understanding of the biological features of the ecosystem through its work to describe fish stocks

1. Quantify the nature and degree of connectivity and separation between regional ecosystems:

How SIMWG Addresses Priority: SIMWG contributes to understanding of connectivity between fish stocks

5. Quantify the role of structural and functional diversity in marine ecosystems in providing stability and resilience

How SIMWG Addresses Priority: Through stock ID and stock structure analysis SIMWG contributes to understanding of population diversity for ICES species of interest.

8. Define and quantify north Atlantic Ecosystem Goods and Services, model their dependence on ecosystem processes and habitat condition and their social, economic and cultural value.

How SIMWG Addresses Priority: Through synthesis of stock ID and stock composition analysis SIMWG contributes the definition of fish stocks in the north Atlantic Ecosystem.

10. Develop historic baseline of population and community structure and production to be used as a basis for population and system level reference points.

How SIMWG Addresses Priority: SIMWG contributes to increased understanding of population structure for ICES species of interest.

15. Develop tactical and strategic models to support short and long term fisheries management and governance advice and increasingly incorporate spatial components in such models to allow for finer scale management of marine habitats and populations

How SIMWG Addresses Priority: SIMWG contributes to this process through review and assessment of available information on stock structure in advance of benchmark stock assessments

16. Quantify and map biological, ecological and environmental values with an aim to optimize ecosystem use and minimize environmental impacts in relation to ecosystem carrying capacity

How SIMWG Addresses Priority: Through synthesis of stock ID and stock composition analysis SIMWG contributes the definition of fish stocks. Stock ID is a critical step in optimal utilization of fish stocks.

25. Identify monitoring requirements for science and advisory needs in collaboration with data product users, including a description of variable and data products, spatial and temporal resolution needs, and the desired quality of data and estimates

How SIMWG Addresses Priority: Upon review of a questions of stock ID for a particular species SIMWG does make suggestions regarding data collection or monitoring that should take place in order to resolve the stock identity of fish (e.g. stock composition analysis).

27. Identify knowledge and methodological monitoring gaps and develop strategies to fill these gaps

How SIMWG Addresses Priority: Upon review of a questions of stock ID for a particular species SIMWG does make suggestions regarding data collection or monitoring that should take place in order to resolve the stock identity of fish (e.g. stock composition analysis).

28. Promote new technologies and opportunities for observation and monitoring and assess their capabilities in the ICES context

How SIMWG Addresses Priority: SIMWG reviews advances in stock id methods annually and evaluates their utility.

31. Ensure the development of best practice through establishment of guidelines and quality standards for (a) surveys and other sampling and data collection systems; (b) external peer reviews of data collection programmes and training and capacity building opportunities for monitoring activities

How SIMWG Addresses Priority: SIMWG does report on best practices in stock id methods

6) In bullet form, list the main outcomes and achievements of the WG since their last evaluation. Outcomes including publications, advisory products, modelling outputs, methodological developments, etc. *

- SIMWG organized and held a physical meeting in Portland, Maine June 10-12 2015. SIMWG worked by correspondence in 2014 and 2016.
- SIMWG developed a glossary of terms for consistent usage of terminology relevant to stock identification.
- SIMWG provided annual updates on recent applications of stock identification methods to ICES species and on recent advances in stock identification methods.
- A 2nd edition of the book Stock Identification Methods: Applications in Fishery Science was published in 2014. SIMWG members S. Cadrin, L. Kerr and S.

Mariani edited the edition and several SIMWG members contributed chapters to this book.

- SIMWG provided expert advice on the following species over the past three years:
    1) Blue whiting (*Micromesistius poutassou*) in Subareas 1–9, 12, and 14 as requested by WGWIDE;
    2) Atlantic cod (*Gadus morhua*) in: 1) inshore waters of NAFO Subarea 1, and 2) offshore waters of ICES Subarea 14 and NAFO Subarea 1 as requested by NGWG;
    3) Haddock (*Melanogrammus aeglefinus*) in ICES Subareas 4 and 6a (North Sea and West of Scotland) as requested by WKHAD;
    4) Megrim (*Lepidorhombus whiffiagonis*) in ICES Subareas 8c and 9a as requested by WGBIE;
    5) Anchovy (*Engraulis encrasicolus*) in ICES Division 9a as requested by WGHANSA;
    6) Greater silver smelt *(Argentina silus*) in ICES Subareas 1, 2, 4, 6, 7, 8, 9, 10, 12 and 14 and Divisions 3a and 5b as requested by ADGDEEP;
    7) Plaice (*Pleuronectes platessa*) in ICES sub-area 3a and Adjacent Areas as requested by WKPLE;
    8) Mackerel (*Scomber scombrus*) in ICES Subareas 1–7 and 14 and Divisions 8a-e and 9a as requested by WGWIDE;
- SIMWG developed a summary table of past SIMWG reviews on issues of stock identity for ICES species (1998–2016). This table and past reports are now linked through the SIMWG website so that they are more easily accessed by other ICES groups.
- SIMWG developed a table summarizing the history and progress of SIMWG dating back to 1998.
- SIMWG provided an annual review of advances in mixed stock analysis.

7) **Has the WG contributed to Advisory needs? If so, please list when, to whom, and what was the essence of the advice.**

Over the past three years, SIMWG has contributed to ICES advisory needs by providing expert feedback on the status of stock structure of several species. These requests came from a range of ICES working groups including WGWIDE, WGBIE, WGHANSA, and NWWG; benchmark workshops including WKPLE and WKHAD, and advice drafting groups such as ADGDEEP, and in previous years we have connected with many more ICES groups to fulfill such requests.

8) **Please list any specific outreach activities of the WG outside the ICES network (unless listed in question 6). For example, EC projects directly emanating from the WG discussions, representation of the WG in meetings of outside organizations, contributions to other agencies' activities.**

There were no specific outreach activities outside the ICES network, beyond the SIMWG members' affiliation and commitment to their own employers.

9) Please indicate what difficulties, if any, have been encountered in achieving the workplan.

None

Future plans

10) Does the group think that a continuation of the WG beyond its current term is required? (If yes, please list the reasons):

Yes, SIMWG provides a service to ICES through is reviews on questions of stock structure.

11) If you are not requesting an extension, does the group consider that a new WG is required to further develop the science previously addressed by the existing WG.

(*If you answered YES to question 10 or 11, it is expected that a new Category 2 draft resolution will be submitted through the relevant SSG Chair or Secretariat*.)

12) What additional expertise would improve the ability of the new (or in case of renewal, existing) WG to fulfil its ToR?

The continued participation of stock identification experts across disciplines (genetics, otoliths, parasites, etc.) is needed. We currently have this expertise within our groups composition, but as specific expertise leaves the group we will need to replace it.

13) Which conclusions/or knowledge acquired of the WG do you think should be used in the Advisory process, if not already used? (please be specific)

SIMWG's advice has been well received by the groups of interest and there are a growing number of requests from different groups which speaks to the service that SIMWG provides to the ICES community. Our expert opinion on specific questions of stock structure should be considered in the advisory process in the context of whether the stock units are appropriate for accurate assessment and sustainable management of ICES fishery resources.

Annex 5: ToR b) Tables

Table 1 Summary table of existing species-specific reviews conducted by SIMWG on the ICES stocks (1998–2016).

Year	Species	ICES Stock (s)	Ecoregion	Requested by
2016	Atlantic mackerel (*Scomber scombrus*)	Northeast Mackerel Stock Identity in ICES Subareas I-VII and XIV and Divisions VIIIa-e and IXa	Widely distributed and migratory stocks	WGWIDE
2015	Haddock (Melanogrammus aeglefinus)	Haddock in ICES Subareas IV and VIa (North Sea and West of Scotland)	North Sea and West of Scotland	WHHAD
	Megrim (Lepidorhombus whiffiagonis)	megrim in ICES Subareas VIIIc and IXa	Bay of Biscay and Iberic waters	WGBIE
	Anchovy (Engraulis encrasicolus)	European anchovy in ICES Division IXa	Bay of Biscay and Iberic waters	WGHANSA
	Plaice (Pleuronectes platessa)	Plaice in ICES sub-area IIIa and Adjacent Areas	North Sea and Baltic Sea	WKPLE
	Greater silver smelt (Argentina silus)	Greater silver smelt in ICES Subareas I, II, IV, VI, VII, VIII, IX, X, XII and XIV and Divisions IIIa and Vb	Greenland and Iceland Seas, Barents Sea, Faroes, Norwegian Sea, Celtic Sea North Sea, South European Atlantic Shelf, Baltic Sea, and Oceanic northeast Atlantic	ADGDEEP
2014	Blue whiting (Micromesistius poutassou)	Blue whiting in Subareas I–IX, XII, and XIV	Widely distributed and migratory stocks	WGWIDE
	Atlantic cod (Gadus morhua)	1) Cod in inshore waters of NAFO Subarea 1 (Greenland cod), 2) Cod in offshore waters of ICES Subarea XIV and NAFO Subarea 1 (Greenland cod)	Iceland and East Greenland	NWWG
2013	Turbot (Scophthalmus maximus)	ICES Subarea IIId	Baltic Sea	WKFLABA
	Dab (Limanda limanda)	ICES Subarea IIId	Baltic Sea	WKFLABA
	Brill (Scophthalmus rhombus)	ICES Subarea IIId	Baltic Sea	WKFLABA
	Anglerfish (Lophius budegassa) and the white anglerfish (Lophius piscatorius)	1) The northern shelf stock consisting of Anglerfish in Division IIa (Norwegian Sea), Division IIIa (Kattegat and Skagerrak), Subarea IV (North Sea), and Subarea VI (West of Scotland and Rockall) 2) The northern southern shelf stock consisting of Anglerfish in Divisions VIIb–k and VIIIa,b,d 3) The southern southern shelf stock consisting of Anglerfish in Divisions VIIIc and IXa	northeast Atlantic	WKFLAT
2012	Atlantic cod (Gadus morhua)	ICES Subarea XIV and NAFO Subarea 1 (Greenlandic cod)	East and West Greenland	NWWG
	Plaice	ICES Subarea IIIa	North Sea	WKPESTO
	Baltic flounder	ICES Subarea IIId	Baltic Sea	WKFLABA
	Deepwater stocks: Roundnose grenadier (Coryphaenoides rupestris) Black scabbardfish (Aphanopus carbo) Blue Ling (Molva dypterygia) Ling (Molva molva) Tusk (Brosme brosme) Greater Forkbeard (Phycis blennoides) Alfonsinos (Beryx splendens and Beryx decadactylus) Great silver smelt (Argentina silus) Black-spot red sea bream (Pagellus bogaraveo) Redfish (Sebastes mentella)		Widely distributed and migratory stocks	WGDEEP
2011	Redfish (Sebastes mentella)	1) a 'Deep Pelagic' stock (ICES Vb, XII, XIV >500m), 2) a 'Shallow Pelagic' stock (ICES Vb, XII, XIV <500m), and 3) an 'Icelandic Slope' stock (ICES Va, XIV).	Iceland and Greenland Seas, Faroes	NEAFC and ACOM
	Sprat (Sprattus sprattus)	ICES sub-areas VI and VII	Celtic Sea	HAWG
	Haddock (Melanogrammus aeglefinus) in the North Sea and the West of Scotland	ICES area VI (west of Scotland) and IV (North Sea)	North Sea and west of Scotland	WKBENCH
2010	Redfish (Sebastes mentella)	1) a 'Deep Pelagic' stock (ICES Vb, XII, XIV >500m), 2) a 'Shallow Pelagic' stock (ICES Vb, XII, XIV <500m), and 3) an 'Icelandic Slope' stock (ICES Va, XIV).	Iceland and Greenland Seas, Faroes	NEAFC
2009	Redfish (Sebastes mentella)	1) a 'Deep Pelagic' stock (ICES Vb, XII, XIV >500m), 2) a 'Shallow Pelagic' stock (ICES Vb, XII, XIV <500m), and 3) an 'Icelandic Slope' stock (ICES Va, XIV).	Iceland and Greenland Seas, Faroes	WKREDS
	Blue whiting (Micromesistius poutassou)	ICES Subareas I–IX, XII, and XIV	Widely distributed and migratory stc	ACOM
	Deep sea fish	General comments across ICES areas.	Across ICES ecoregions	WGDEEP
2008	Redfish (Sebastes mentella)	1) Western Icelandic shelf, 2) Deep Irminger Sea and Western Faroe, 3) all other localities comprised between the shallow Irminger Sea off Newfoundland all the way to the Barents Sea and the offshore Northern Norwegian waters ("shallow stock").	Iceland and Greenland Seas, Faroes, Norwegian and Barrents Seas	SGRS
	Herring west of the British Isles	ICES Area VIaN, VIaS, VIIc, VIIb, VIIk, VIIj, VIIg, VIIh, VIIaS	Celtic Seas	HAWG
	New MoU species (sea bass, striped red mullet , red, tun and gray gurnards, flounder, witch flounder, brill, turbot, lemon sole, dab)	General comments across ICES areas.	Across ICES ecoregions	WGNEW
	Wide ranging shark species and demersal skates	General comments across ICES areas.	Across ICES ecoregions	WGEF
2007	Deepwater stocks:		Widely distributed and migratory stocks	WGDEEP
	Tusk (Brosme brosme)	ICES Area I,II, Va, Vb, IV, VIa, VIb		
	Blue ling (Molva dypterygia)	ICES Area Va, Vb, VIa		
	Ling (Molva molva)	ICES Area II, Va, Vb, IV, VI		
	greater argentine (Argentina silus)	ICES Area IIIa, Va,Vb,VII		
	roundnose grenadier (Coryphaenoides rupestris)	MAR, ICES Area VIb2, XIIb		
	blackscabbardfish (Aphanopus carbo)	ICES Area VIa, IX		
	red seabream (Pagellus bogaraveo)	ICES Area IX, X		
	Redfish (Sebastes mentella)	ICES Areas Va, Vb, and XIV, V, VI, XII, and XIV,	Iceland and East Greenland	AFWG and NWWG
2006	No species reviewed	NA	NA	NA
2005	Whiting (Merlangius merlangus)	ICES Subarea IV and Division VIId	North Sea	SGSIMUW
2004 2003 2002 2001 2000 1999 1998 1997	No species reviewed	NA	NA	NA

Table 2 History of SIMWG activity, including previous chairs, meeting locations, terms of reference, and species for which issues of stock identity were reviewed.

Year	Species Reviews	Meeting	Chairs	Terms of Reference
1997	No species reviewed	By correspondence	K. Friedland (Chair) USA	a) continue development of the Stock Identification Methodology; b) advise on future meetings of the Working Group.
1998	No species reviewed	By correspondence	K. Friedland (Chair) USA	a) continue development of the Stock Identification Methodology; b) advise on future meetings of the Working Group.
1999	No species reviewed	By correspondence	K. Friedland (USA) and J. Waldman (USA)	a) continue development of the Stock Identification Methodology; b) advise on the need for future meetings of the Working Group, and prepare appropriate terms of reference if required; c) obtain peer-review of the Working Group report from a member of the Living Resources Committee prior to the 1999 Annual Science Conference; d) comment on the draft objectives and activities in the Living Resources Committee component of the ICES Five-Year Strategic Plan, and specify how the purpose of the Working Group contributes to it.
2000	No species reviewed	By correspondence	K. Friedland (USA) and J. Waldman (USA)	a) continue development of the Stock Identification Methodology; b) advise on the need for future meetings of the SIMWG, and prepare appropriate Terms of Reference if required
2001	No species reviewed	By correspondence	S. Cadrin (Co-Chair) USA, K. Friedland (Co-Chair) USA, J. Waldman (Co-Chair) USA	a) continue development of the Stock Identification Methodology; b) advise on the need for future meetings of the SIMWG, and prepare appropriate Terms of Reference if required.
2002	No species reviewed	By correspondence	S. Cadrin (Co-Chair) USA, K. Friedland (Co-Chair) USA, J. Waldman (Co-Chair) USA	a) prepare a complete draft of the Stock Identification Methodology publication; b) advise on the need for future meetings of the SIMWG, and prepare appropriate Terms of Reference if required.
2003	No species reviewed	By correspondence	S. Cadrin (Co-Chair) USA, K. Friedland (Co-Chair) USA, J. Waldman (Co-Chair) USA	a) prepare a complete draft of the Stock Identification Methodology publication; b) advise on the need for future meetings of the SIMWG, and prepare appropriate Terms of Reference if required.
2004	No species reviewed	By correspondence	S. Cadrin (Co-Chair) USA, K. Friedland (Co-Chair) USA, J. Waldman (Co-Chair) USA	a) work with the publisher in producing “Stock Identification Methodology”; b) advise on the need for future meetings of the SIMWG, and prepare appropriate Terms of Reference if required.
2005	whiting (Merlangius merlangus)	By correspondence	S. Cadrin (Co-Chair) USA, J. Waldman (Co-Chair) USA	a) advise on the need for future meetings of the SIMWG, and prepare appropriate Terms of Reference if required; b) liaise with SGSIMUW on developments in stock identity studies in North Sea whiting.

2007	Deepwater stocks and redfish (Sebastes mentella)	By correspondence	S. Mariani (Ireland)	a) liaise with ICES working groups and study groups dealing with stock identification issues; providing technical reviews to expert groups and LRC; Specifically provide advice methods, analyses and procedures, on wide ranging shark species to WGEF, new MoU species to WGNEW, and herring west of the British Isles to HAWG; b) review and report on new advances in stock identification methods as they develop and new results that are relevant to ICES work; c) advise on the need for future meetings of the SIMWG, and prepare appropriate Terms of Reference if required; d) review the papers presented at Theme Session L at the 2007 ASC and make recommendations for future work.
2008	Wide ranging shark species and demersal skates, MoU species, Herring west of the British Isles , Redfish (Sebastes mentella)	By correspondence	S. Mariani (Ireland)	a) liaise with ICES working groups and study groups dealing with stock identification issues; providing technical reviews to expert groups and LRC; Specifically provide advice methods, analyses and procedures, on wide ranging shark species to WGEF, new MoU species to WGNEW, and herring west of the British Isles to HAWG; b) review and report on new advances in stock identification methods as they develop and new results that are relevant to ICES work; c) advise on the need for future meetings of the SIMWG, and prepare appropriate Terms of Reference if required; d) review the papers presented at Theme Session L at the 2007 ASC and make recommendations for future work.
2009	Deep sea fish, blue whiting (Micromesistius poutassou), redfish (Sebastes mentella)	By correspondence	S. Mariani (Ireland)	a) liaise with ICES working groups and study groups dealing with stock identification issues; provide technical reviews to expert groups and LRC; b) review and report on new advances in stock identification methods as they develop, and also new results that are relevant to ICES work; c) provide an updated review of available information on stock structure in elasmobranchs; d) review and report on all available multidisciplinary studies in Stock Identification, and produce a first-draft protocol for the integration of results from multiple disciplines; e) produce a first-draft, practical protocol (suitable to constant updating) for Stock Identification.
2010	Redfish (Sebastes mentella)	In person meeting held in Oregrund, Sweden	S. Mariani (Ireland)	a) Liaise with ICES working groups and study groups dealing with stock identification issues and provide technical reviews to these groups and SCICOM; b) Review and report on new advances in stock identification methods as they develop, and new results that are relevant to ICES work; c) Consider the available multidisciplinary studies in Stock Identification, and produce a first draft “SIP” (Stock Identification Protocol) for the integration of results from multiple disciplines; d) Review the scientific resources and tools available to ICES for investigating stock structure and determining appropriate management units, including technologies, sampling programmes, laboratories; e) Identify limitations and gaps in the scientific capacity of ICES for investigating stock structure and determining appropriate management units, including technologies, sampling programmes, laboratories; f) Consider stock identification methods used for non-fish biology (e.g. marine mammals) and whether any lessons may be learned for fish stock assessment; g) Develop terms of references based on a work plan for the next two years, which complement the objectives of the ICES science plan; h) Express expert advice on the NEAFC request to ICES regarding additional review of the stock structure of Sebastes mentella in the Irminger Sea and adjacent areas, with specific consideration of NEAFC documents AM 2009/23 and AM 2009/29-rev1.
2011	Redfish (Sebastes mentella), sprat (Sprattus sprattus) , haddock (Melanogrammus aeglefinus)	By correspondence	S. Mariani (Ireland)	a) Review and report on new advances in stock identification methods as they develop, as well as new results that are relevant to ICES work; b) Provide technical reviews and expert opinions on matters of Stock Identifications, as requested by specific Working Groups and SCICOM; c) Present and illustrate a “Stock Identification Procedure for the Integration of Multiple Methods”. d) Review the scientific resources and tools available to ICES for investigating stock structure and determining appropriate management units, as well as the relevant limitations and gaps in the scientific capacity of ICES for carrying out such activities; e) Evaluate any new information relevant to the stock identity of deep-water stocks and to make recommendations to WGDEEP on the geographical composition of stock units where new information is available.

2012	Deepwater stocks, Atlantic cod (Gadus morhua), plaice (Pleuronectes platessa), and flounder (Platichthys flesus)	In person meeting held in Manchester, UK	S. Mariani (United Kingdom)	a) Review and report on new advances in stock identification methods as they develop, as well as new results that are relevant to ICES work; b) Provide technical reviews and expert opinions on matters of Stock Identifications, as requested by specific Working Groups and SCICOM; c) Evaluate any new information relevant to the stock identity of deep-water stocks and to make recommendations to WGDEEP on the geographical composition of stock units; d) Consider the results of WGAGFM in terms of using parasites as stock discrimination tools and comment on whether these methods can be brought to bear on contemporary stock identification issues addressed by SIMWG.
2013	Turbot (Scophthalmus maximus), dab (Limanda limanda), brill (Scophthalmus rhombus), the black anglerfish (Lophius budegassa) and the white anglerfish (Lophius piscatorius)	In person meeting held in Hamburg, Germany	S. Mariani (United Kingdom)	a) Recent advances in stock identification methods, with a particular emphasis on technological and conceptual progress in tagging approaches; b) Reviews and advice on matters of Stock Identification, which specifically focused on the three tasks below: i) Advice on stock structure of turbot, dab and brill in the Baltic Sea ii) Evaluation of stock identity of anglerfish in ICES and adjacent areas and proposed new methodologies for future studies iii) Considerations on the role of genetic markers under directional selection in stock identification analysis; c) A systematic appraisal of the terminology used in the field of stock identification.
2014	Blue whiting (Micromesistius poutassou), Atlantic cod (Gadus morhua)	By correspondence	L. Kerr (USA)	a) Review recent advances in stock identification methods; b) Build a reference database with updated information on known biological stocks for species of ICES interest; c) Technical reviews and expert opinions on matters of stock identification, as requested by specific Working Groups and SCICOM; c) Develop a universal framework for consistent usage of terminology relevant to stock identification; d) Review and report on advances in mixed stock analysis, and assess their potential role in improving precision of stock assessment.
2015	Haddock (Melanogrammus aeglefinus) , anchovy (Engraulis encrasicolus), megrim (Lepidorhombus whiffiagonis), plaice Pleuronectes platessa , greater silver smelt (Argentina silus)	In person meeting held in Portland, Maine (USA)	L. Kerr (USA)	a) Review recent advances in stock identification methods ;b) Build a reference database with updated information on known biological stocks for species of ICES interest; (B1) Technical reviews and expert opinions on matters of stock identification, as requested by specific Working Groups and SCICOM; c) Review and report on advances in mixed stock analysis, and assess their potential role in improving precision of stock assessment.
2015	Atlantic mackerel (Scomber scombrus)	By correspondence	L. Kerr (USA)	a) Review recent advances in stock identification methods; b)Build a reference database with updated information on known biological stocks for species of ICES interest; c) Provide technical reviews and expert opinions on matters of stock identification, as requested by specific Working Groups and SCICOM; d) Review and report on advances in mixed stock analysis, and assess their potential role in improving precision of stock assessment.