# ICES SIMWG REPORT 2008

ICES Living Resources Committee

ICES CM 2008/LRC:15

# Report of the Stock Identification Methods Working Group (SIMWG)

## By Correspondence

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Recommended format for purposes of citation:

ICES. 2008. Report of the Stock Identification Methods Working Group (SIMWG). By Correspondence. ICES CM 2008/LRC:15. 21 pp. https://doi.org/10.17895/ices.pub.9833

## Contents

## Executive summary

The Stock Identification Methods Working Group met by correspondence in 2007-2008.

The agenda comprised four Terms of Reference:

a ) liaise with ICES working groups and study groups dealing with stock identification issues; provide technical reviews to expert groups and LRC; specifically provide advice on methods analyses and procedures for wide ranging shark species and demersal skates in the North Sea, Celtic Seas and Bay of Biscay/Iberian ecoregions 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.

Despite the excellent efforts over the last decade, we highlight the still considerable lack of knowledge on stock identity, especially for new MoU species. The need for a formal reappraisal and update of all stock identification methods that are proving successful since the publication of the Cadrin *et al.* (2005) book, as well as the intention to develop formal protocols for stock ID and the integration of different disciplines, will require the Working Group members to meet in person during 2009, for a period of 3–5 days.

# 1 ToR a) - Stock identification issues

## 1.1 Wide ranging shark species and demersal skates

The Working Group on Elasmobranch Fishes (WGEF) has shown that in the vast majority of cases stock structure in wide ranging sharks and rays is uncertain. In uncertain situations, there is a tendency to provide advice at the local level, with the intent to avoid local depletion of what may be a self-sustaining resource. Although this tendency seems reasonable, it may confound perceptions of stock status. For example, a recent review of demersal elasmobranchs in the Northwest Atlantic (Frisk *et al.*, 2008) concluded that an increase in skate and dogfish biomass on Georges Bank resulted from a shift in distribution from the Scotian Shelf rather than increased production on Georges Bank. In this case a broader, transboundary stock definition would have promoted more accurate interpretation of fishery and survey data. Some of the resource trends in demersal elasmobranchs in the Northeast Atlantic (WGEF) also appear to transcend traditional fishing areas (e.g. depletion of spurdog in IIIa, VI, VIIa, VIId, VIIe-k). This may result from similar fishery development (i.e. overfishing separate resources), but the possibility of wide-ranging stocks should be considered in the provision of advice for smaller management units.

A number of research groups in the North Atlantic are now focusing on the study of deep-sea wide ranging sharks, many of which are of some commercial value (*Centrophorus squamosus, Centroscymnus coelolepis, Deania calcea, Centroselachus crepidater*, etc.). Many of these studies are funded under National and transnational initiatives (MARECO, NERC, Portuguese Science Foundation, etc.) and include work-packages relevant to stock identification. It is important to assess the outcome of these studies as they become available. Contact persons for these investigations – some of which are actively involved with ICES – are N.C. Stenseth, University of Oslo; Gui Menezes, DOP, Azores; Ivone Figuereido, IPIMAR; Chip Cotton at the Virginia Institute of Marine Science, and Rus Hoelzel, University of Durham. SIMWG will ensure that evidence arising from these projects will be tracked and implemented in the expert group advice.

Another investigation that may provide useful feedback to SIMWG is a project on the life history and genetics of the coastal smooth-hound sharks (*Mustelus spp.*) in the Northeast Atlantic (http://www.ucd.ie/zoology/marbee/edward_farrell.html), being conducted at University College Dublin. This is likely to complement nicely the work being carried out on wide ranging oceanic and deep-sea species, and will add to previous studies on continental shelf skates (*Amblyraja radiata* and *Raja clavata*), which already showed how species with presumably similar life-histories and ability to move, can be structured in space and time in very different ways (Chevolot *et al.*, 2006 and 2007).

Given the growing interest in elasmobranch fisheries, and the natural higher vulnerability to harvesting of this taxon, it is advisable that SIMWG monitor more closely the developments on elasmobranch stock structure, and that the scientific community pushes for more research efforts on these fish. A renewed attention will also be paid to studies reporting on the status of small cetacean stocks, especially in ICES areas (www.ascobans.org).

## 1.2 MoU species

Working Group on Assessment of New MoU Species (WGNEW) – WGNEW covers a number of new species for ICES advice (sea bass, striped red mullet, red gurnard, tub gurnard, grey gurnard, brill, turbot, lemon sole, dab, flounder, witch flounder and possibly John dory). Stock identification is considered a primary objective of WGNEW, as management strategies are still to be planned for most of these species.

*Sea bass* – This is probably the most high profile of these "new" species, as its market value and its societal importance are very high. Traditional stock boundaries followed previous work by SGBASS (no longer active); these identified six areas for the purpose of management: 1) North Sea, 2) Eastern Channel, 3) Western Channel, 4) North Brittany and the Channel Islands, 5) Irish waters, 6) Bay of Biscay. Recent studies, also employing genetic methods, have shown a general lack of geographical differentiation, possibly suggesting the existence of one single demographic unit (Fritsch *et al.*, 2007). Yet tagging has shown some degree of natal homing with fish in the Bay of Biscay migrating differently from fish in the English Channel. Furthermore, the situation around Ireland is poorly understood, as the ban on commercial fishing hinders data collection, despite the anecdotal evidence of discrete spawning aggregations in the Celtic Sea. Some policy-makers believe that commercial activities could be resumed, in the face of a current lack of understanding of stock boundaries, which is of course a reason for concern. An ongoing project at University College Dublin (http://www.ucd.ie/zoology/marbee/ilaria_coscia.html) is producing evidence of the existence of more than one stock in the NE Atlantic, but with a very complex spatial and temporal pattern that certainly requires more investigation. SIMWG questions the decision to manage sea bass as the six traditional stocks, but also opposes the assumption of one single panmictic unit. For sea bass, a robust, integrated, Europe-wide research project is strongly advised. The huge amount of knowledge on the physiology of the species, and the new genetic resources available (Chistiakov *et al.*, 2005), would certainly allow for a very powerful and fruitful investigation. SIMWG will look into the possibility of facilitating the development of a collaborative project proposal by sea bass scientists across Europe, perhaps for submission to the EU or the ERC. A good starting point would be to organize a theme session on sea bass population biology (broad sense) at the ICES 2009 ASC.

*Red mullet* – Seasonal patterns in catch suggest there are separate stocks in the English Channel and in the North Sea. Morphologic differences exist between red mullet in the eastern English Channel and those in the Bay of Biscay. The Working Group concluded that these preliminary results should be supplemented with genetic information to identify stocks.

*Gurnards* – The only information on red, tub and grey gurnards relies on distribution and abundance from survey data. Although these data have been interpreted as possibly reflecting the existence of three sub-populations in the North Sea and Skagerrak/Kattegat (one to northwest of the Dogger Bank, one around Shetland and one in the Skagerrak/Kattegat), SIMWG believes that without a targeted study on stock structure, there is no evidence to support any stock structure pattern.

*Flounder* – recent studies using molecular markers proved successful at identifying separate flounder populations. Based on the studies by Florin & Hoeglund (2008) and Hemmer-Hansen *et al.* (2007), the view of SIMWG is that the following areas should be considered for management: 1) Faroe Islands waters, 2) Barents Sea, 3) North Sea with Skagerrak/Kattegat and Irish Sea, 4) Southern Baltic with Oresund straits, 5) Northern Baltic (unique demersal spawning population). This provides a new, clearer

picture for this species, for which in the past up to 15 management units in the Baltic alone had been proposed.

*Brill* – An EU funded study on 'Stock discrimination in relation to the assessment of the brill fishery' (Project No 96/001, unpublished report), including information on distribution, genetics, biological parameters, and catch compositions concluded that northeastern Atlantic brill can be separated into two groups: 1) those occupying the Bay of Biscay, the English Channel, the Celtic Sea and the Irish Sea, and 2) those in the North Sea and Skagerrak & Kattegat. The first group can further be split up into two subgroups: English Channel-Celtic Sea and Irish Sea-Bay of Biscay. However, further research on spawning areas and migration through respectively egg surveys and tagging experiments are needed throughout its entire range.

*Turbot* – Based on the conclusions of the 2005 Working Group on Environmental Interactions of Mariculture (http://www.ices.dk/iceswork/wgdetail.asp?wg=WGEIM), there are distinct turbot populations in the Baltic Sea and in the Irish Sea. There are also indications that turbot from the North Sea, the southern coast of Iceland, the western coast of Scotland and Ireland, and the Celtic Sea forms another stock, the northern Atlantic stock, which is different from the stock originating from the Bay of Biscay and the Atlantic side of southern Europe, the southern stock. Transition zones between the northern stock and the southern stock are found in the English Channel and between the northern stock and the Baltic Sea in Kattegat and the Belt Sea. The situation of turbot stocks in the Mediterranean is still unclear, although there are indications that samples from the Aegean Sea are genetically different from those originating from other areas.

*Lemon sole* – Tagging information suggests that seasonal movements in the Western Channel were restricted and that lemon sole in this area could be considered as a separate stock, but further work on lemon sole stock identity is required.

*Dab* – The existence of several spawning grounds and the wide distribution of dab may indicate the presence of more than one stock. Meristic data are significantly different between populations from western British waters and the North Sea and the Baltic. Further, tagging experiments and significant meristic differences within Baltic populations indicate an individual stock around Bornholm, separated from IIIc22. However, SIMWG by no means assumes the existence of these three stocks, as more targeted studies should be undertaken to unveil this species' spatial population structure.

## 1.3 Herring west of the British Isles

*Herring Stock Structure West of the British Isles (EU project WESTHER)* - A working document on the implications of the WESTHER project's results to the assessment and management of herring stocks to the west of the British Isles was presented to the Herring Assessment Working Group (HAWG) in March 2007. An updated version of this document was presented at the ICES ASC in September 2007 and published as an ICES CM document (Hatfield *et al.*, 2007). The WESTHER project proposed, tested and reported on one null hypothesis, and three alternative hypotheses, on the structure of herring populations to the west of the British Isles and suggested alternative assessment units based on the results. Hatfield *et al.* (2007) presented detailed reasoning and conclusions for each hypothesis and a summary is given below.

The null hypothesis is that there is only one herring population to the west of the British Isles, with no detectable differences between any of the geographically and

temporally separated spawning components. Examination of the null hypothesis involved the consideration of three alternative hypotheses relating to the spawning components, juveniles and feeding aggregations and lead to the following conclusions:

Alternative hypothesis 1: The different spawning aggregations sampled are discrete at spawning time and are, therefore, separate components. WESTHER found that classification success of spawners was generally high suggesting that there is strong evidence to reject the null hypothesis and accept alternative hypothesis 1 because the different spawning aggregations sampled are discrete at spawning time.

Alternative hypothesis 2: There is clear distinction of juveniles sampled on different nursery grounds. WESTHER found that parasites and otolith microchemistry act as tags for the juvenile stages of herring. There was a clear distinction between many of the different juvenile samples. There was also strong evidence that juveniles from separate spawning areas mix in some of the nursery areas sampled. WESTHER could distinguish the origin of juveniles even in mixtures, and thus accepted the alternative hypothesis 2.

Alternative hypothesis 3: Fish from each spawning aggregation remain discrete on their feeding grounds. WESTHER rejected alternative hypothesis 3 because there was evidence of mixing of adults from separate spawning components, especially in VIa North. The evidence also suggested that the Celtic Sea and VIIj adults do not mix as much as the more northerly herring. The science, therefore, suggests links between the areas, with fish spawning in different areas mixing, to varying extents, on feeding grounds. However, it was difficult to assess the level of mixing of non-spawning adults.

WESTHER recommended assessing herring west of the British Isles as two stocks units: 1) Malin Shelf (a combination of the current ICES stocks VIa North, VIaS and VIIb-c, Clyde and Irish Sea (VIIaN)) and 2) Celtic Sea (current Celtic Sea and VIIj stock). HAWG recommended the formation of a study group to review the WESTHER implications and its recommendations. This study group, called SGHERWAY, will meet twice, first in Aberdeen from 8–12 December 2008, and will report its findings to ICES for the 2010 HAWG.

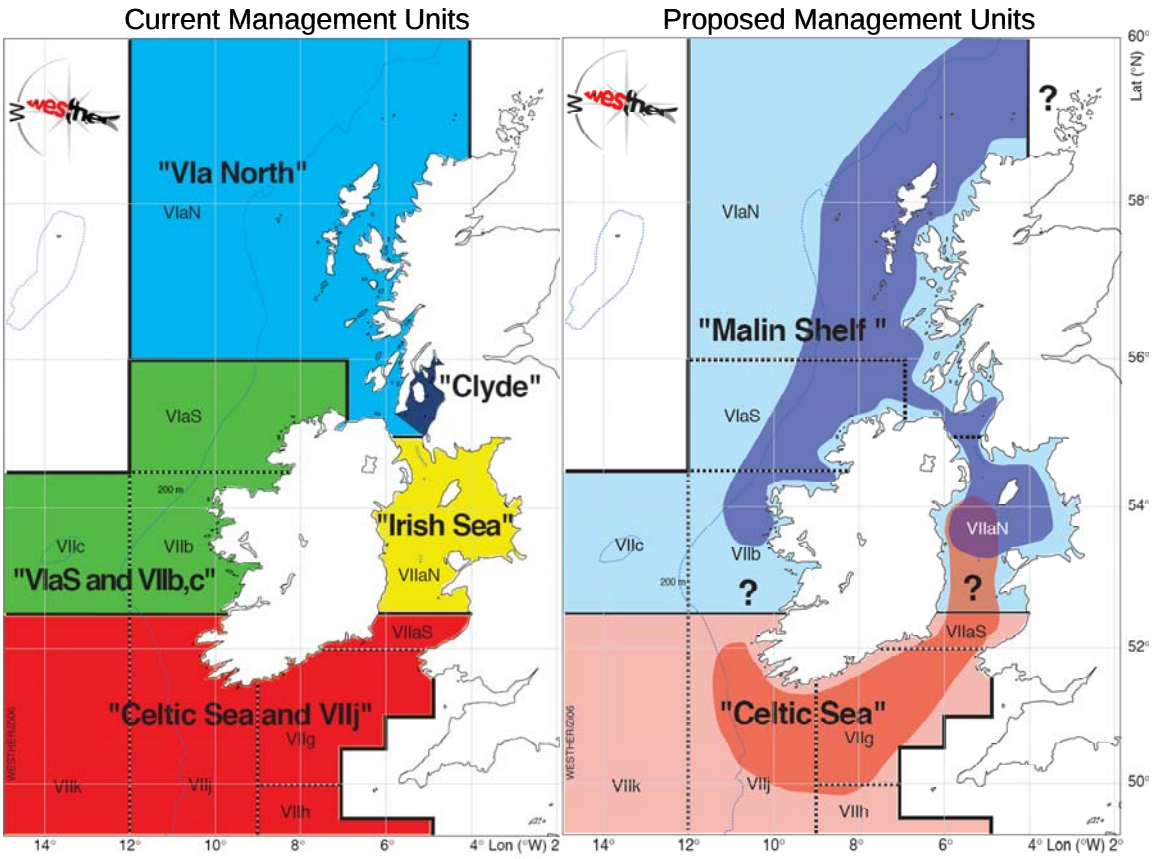


**Figure 3.1. Current and proposed management units for herring west of the British Isles, including resource distributions and areas of uncertain stock boundaries (modified, from Hatfield *et al.*, 2007).**

## 1.4 Additional comments on Redfish (*Sebastes mentella*)

The SGRS (Study Group on Redfish Stocks) and other Working Groups have requested the opinion of members of SIMWG on the long-standing issue of redfish stock boundaries. Based on the study that Stefansson *et al.* presented to the SIMWG last year, it is unambiguous that there are at least three different stocks of *Sebastes mentella*, as inferred by powerful techniques, and confirmed by temporal analyses. However, it is the opinion of SIMWG that the existence of further subdivisions cannot be discounted. The identified stocks are: 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"). It is important to stress that the apparent lack of differentiation within the vast "shallow stock" simply shows an inability to "reject a null hypothesis of no substructure within this group", but it by no means demonstrates that such a null hypothesis is necessarily true. Further analyses could be conducted on the same dataset, which could reveal subtle patterns. Then, even if the complete lack of spatial genetic heterogeneity was confirmed, this might still be coherent with large demographic independence or, possibly, complex patterns of migration/life history, as well as local genetic adaptation. SIMWG believes that, given the huge area across which the "shallow stock" is distributed, and the high international conflicts of resource use, a targeted meeting should be held, involving all redfish experts and a couple of stock I.D. experts, in order to evaluate whether additional, complementary evidence exists to treat certain areas covered by the "shallow stock" separately.

# 2 ToR b) – Advances in stock identification methods

Apart from increased power and sophistication of equipment (IT, image analysis, etc.), no significant advances are being recorded in the field of biometry, morphometrics or meristics. Life-history traits and other biological data are increasingly being collected, and they provide a good basis for generating hypotheses on stock structure as well as for integrating with genetic data.

Considerable methodological advances are instead being observed in the fields of Tagging and Molecular Genetics.

## 2.1 Tagging

*Advances in Electronic Tagging* – A recent publication (Sheridan *et al.* 2007, available online: http://www.sefsc.noaa.gov/PDFdocs/TM_NMFS_FSPO_82_Sheridan_etal.pdf) describes a workshop on advances in electronic tagging. On 23–25 August 2005, the National Marine Fisheries Service (NMFS or NOAA Fisheries Service) Advanced Sampling Technology Working Group (ASTWG) sponsored a workshop at the Northwest Fisheries Science Center (NWFSC) in Seattle. The specific goals were to: 1) identify present and future research needed to improve electronic tagging technologies, 2) discuss specific data management requirements for each technology, and 3) develop ways to improve how tagging and environmental data are incorporated into stock assessments.

Approximately 80 scientists from the NOAA Fisheries Service attended the workshop. Vendors were specifically excluded from the workshop so that scientists could openly share their experiences using the various technologies. The workshop was organized into two days of researchers giving presentations of their experiences applying the various technologies. The presentations were grouped into the following sessions: acoustic tags, pop-up tags (including pop-up satellite tags), radio tags, archival tags, linkages between tagging and environmental data, and stock assessment and ecosystem applications. A third day was devoted to smaller breakout sessions that were organized by type of tagging technology (acoustic, pop-up, radio, and archival) and animals (pinnipeds, cetaceans, turtles, pelagic fish, bottom fish, and invertebrates).

Electronic tagging is a key methodology that NOAA Fisheries Service scientists use to gather information on stock productivity and recruitment, fish behaviour and feeding ecology, habitat selection, and individual and population-level responses to environmental and climate variability. This information is needed for accurate and responsible fisheries management. The workshop highlighted the cutting-edge nature of these technologies. In many cases, scientists are just at the initial stages of developing electronic tagging techniques to sample animals in their habitats in real time; to address specific questions about patterns of vertical, diel, and feeding movements; and to identify intra- and interspecific behavioural differences. Obtaining more detailed information on habitat selection at smaller time-scales and linking this information to concurrently measured environmental parameters will greatly enhance knowledge of what species require to maintain their viability and productivity through time and in varying environmental conditions.

The workshop produced the following recommendations for the ASTWG to consider: improve tag power management, decrease tag size, increase the use of sensors on tags, improve the accuracy of geolocation data, enhance data transmission capabilities between tags and receivers, reduce biofouling on tags, establish database

sharing mechanisms and protocols, increase tag and software reliability, reduce tag costs through bulk purchases, co-sponsor an international tagging symposium with invited vendors, improve collaboration and communication, and develop a budget initiative within the agency to address the workshop recommendations. Workshop participants expressed an overwhelming appreciation for the information and lessons learned, and supported conducting similar workshops in the future.

*The Second International Symposium on Tagging and Tracking Marine Fish with Electronic Devices (from http://unh.edu/taggingsymposium)* – The symposium was held 8–11 October 2007 at the Palacio de Miramar, in Donostia-San Sebastian, Spain. It provided an opportunity for scientists working in the marine environment to review the state-of-the-art of electronic tagging and tracking, to examine the type and quality of information currently obtained and to identify future research challenges and tag developments. The Proceedings for the Second International Symposium on Tagging and Tracking Marine Fish with Electronic Devices will be published in collaboration with Reviews in Fish Biology and Fisheries (Springer). The proceedings will be published as a stand alone book (allowing for a larger number of manuscripts and earlier release than a special journal issue). All the manuscripts are currently undergoing a rigorous peer-review process.

## 2.2 Genetics

*Mitochondrial DNA* – Recent studies are increasingly showing that the dual application of nuclear and mtDNA is more likely to reveal inconsistencies than congruent patterns (Gonzalez & Zardoya, 2007), especially in areas, such as most of the North Atlantic, that have been re-colonized by marine species relatively recently after the retreat of glacial ice. SIMWG advice is that – despite the fact that mitochondrial DNA is still a very useful marker to investigate past events in the evolutionary history of a taxon – it should not be employed as a primary tool for the purpose of stock identification, as it is unlikely to reflect recent or contemporary demographic processes. Microsatellites and SNPs (see below) should be the preferred tools for studying stock structure to inform management.

*SNPs* – One of the more recent additions to the "molecular toolbox" is single nucleotide polymorphisms (SNPs), which comprise a usual alternative of only two possible nucleotides at a given position. Even though their development and application is still at an early stage, they seem to represent a potentially very powerful technology for stock identification. The Working Group for the Application of Genetics in Fisheries and Mariculture (WGAGFM) 2008 report (http://www.ices.dk/iceswork/wgdetail.asp?wg=WGAGFM) contains a thorough review of SNPs in fisheries science, which explains clearly the state-of-the-art in the field. A good example of SNPs effectiveness is provided by a recent study on Pacific salmon (Narum *et al*., 2008) whereby SNP polymorphisms were employed alongside microsatellite markers. Both marker types were very effective in differentiating populations and assigning individuals, but accuracy was the highest when marker types were used in combination. SIMWG will monitor the future application and effectiveness of SNP approaches in stock identification.

*Adaptive markers* – A new class of molecular markers, the Expressed sequence tags (ESTs) can provide the means to study adaptive genetic variation in many fish and, with the help of available genome databases and linkage maps for many fish species, can help identifying candidate genes underlying adaptation. Given the tremendous recent advances in inexpensive sequencing technologies, it is likely that fisheries science will increasingly using ESTs in the years to come, in order to uncover

processes of adaptation in local stocks. On the one hand, this can be seen as a shift from the "neutral" view of population structure, where markers are used to identify barriers to gene flow and estimates of genetic drift; on the other hand, the implementation of methods to study natural selection in the wild may complement the neutral approaches, and help providing a fuller picture of stock structure. In some cases, even in the absence of specific adaptive genetic markers, the application of common-garden experiments has proven effective in identifying genetic differences among putative stocks, whereby neutral molecular markers failed to detect differentiation (e.g. Atlantic cod; Hutchings *et al.*, 2007). SIMWG will assess to what extent these approaches can contribute to the stock identification process.

*Mixture analysis* – Estimating specific stock contributions to mixed fisheries is now becoming a widespread and useful practice in genetic stock identification (GSI), especially through the use of powerful Bayesian computational approaches. Simulations are widely used for evaluating the effectiveness of a genetic baseline in estimating the composition of mixed fisheries. Conventional methods can sometimes overestimate the predicted accuracy in mixed-stock analysis, but a new study by Anderson *et al.* (2008) proposes an improved method for performing simulations, based on cross validation, that provides nearly unbiased estimates of GSI accuracy.

*Landscape genetics* – A new analytical approach that seems to be very promising for stock identification applications is that termed "Landscape genetics" (Fontaine *et al.*, 2007). This method consists in combining information on geographical landscape features with analysis of molecular markers in order to understand how environmental factors affect the dispersal of individuals and the size and density of populations. The use of GIS and the development of new software for the implementation of genetic data in spatially explicit models will facilitate the visualization and interpretation of spatial and temporal patterns of stock structure.

## 2.3 Theory and Application

*ICES ASC Theme Session* – A theme session was proposed for ICES ASC for 2008 or 2009 emanating from WKTEST, titled, "Life cycle diversity, population structuring mechanisms and consequences," Co-chairs: Dave Secor (USA), Pierre Petitgas (France), Ian McQuinn (Canada), Steve Cadrin (USA).

As fish stocks are getting depleted and experience is gained on the mechanisms of stock recovery, the diversity of contingents and life cycles within populations as well as knowledge transfer between generations are increasingly recognized to play an important role in population resilience. Concepts explaining life cycle diversity within populations and its persistence include spatial heterogeneity, genetic polymorphism, density-dependent habitat selection, natal homing, partial migration, and social transmission of learned migration behaviour. Infra-population structure and diversity have population-level consequences that will affect stock resilience and its habitats. Therefore infra-population structure and diversity have implications on spatial management strategies and recovery plans, for which conservation of the diversity within populations is an objective to ensure population viability. Papers would be welcome on the following topics: life cycle diversity and persistence within populations, social transfer of migration patterns, population genetic structure and polymorphism, population-level effects of infra-population diversity, recovery plans accounting for spatial effects, spatial management strategies and essential habitats.

*Workshop on U.S. Management units* - A report was recently issued on a US workshop held to reconcile some difference in the way population structure of fish, mammals

and endangered species is considered for different conservation purposes (Eagle *et al*. 2008; http://www.sefsc.noaa.gov/PDFdocs/TM_NMFS_OPR_37_Eagle_etal.pdf).

The National Marine Fisheries Service (NMFS) is responsible for the conservation of living marine resources and their habitats with primary authority from three Federal statutes: the Magnuson-Stevens Fishery Conservation and Management Act (MSA) governs the exploitation of fish stocks for the maximum net benefit of the Nation, while preventing overfishing and rebuilding overfished fish stocks to biomass levels capable of producing Maximum Sustainable Yield (MSY). The Endangered Species Act (ESA) governs the taking of species that have an elevated risk of extinction to ensure that effects of human activity are restricted to levels that would allow recovery of the species to the point it is no longer threatened or endangered. The Marine Mammal Protection Act (MMPA) governs the taking of marine mammals so that the total of such taking is sustainable, that is, it would allow populations of marine mammals to recover to or to be maintained within their Optimum Sustainable Populations (OSP).

Meeting the different objectives mandated by each law requires potentially different definition of biological stocks and management units. NMFS convened a workshop of scientists, managers, and policy advisors to discuss issues related to conservation units, exchange information about the biological basis for stock structure, learn about case studies in which particular aspects of population structure are important, discuss strengths and weaknesses of NMFS' identification of conservation units under the three statutes, and to recommend alternative approaches or revisions for identifying conservation units under the three statutes. Presentations and discussions at the workshop provided a basis to address two pressing questions for the agency: 1) Why are our conservation units different under MSA, ESA, and MMPA? 2) Is there a biological paradigm that may be used to explain differences noted in conservation units?

Much, but not all, of the answer to the first question can be found in the objectives of these laws. A major motivating factor for the ESA was a desire to preserve genetic variability, between and within species. Accordingly, conservation units under the ESA should be substantially reproductively isolated from one another to be listed under this act. On the other hand, objectives of the MMPA include keeping populations or stocks of animals above their Optimum Sustainable Populations (OSP) levels. The MSA allows for management units that may contain multiple species as members of a complex, but the concept of demographically independent stocks within a species is commonly used to determine the status of fishery resources. Thus, demographic independence is an appropriate basis for identifying conservation units (distinguishing among populations or stocks) for the MSA and MMPA.

A low amount of exchange among groups for breeding may be sufficient to prevent development of important genetic differences; however, these groups may remain demographically independent from one another. Therefore, it is generally expected that conservation units identified on the basis of reproductive isolation would be larger than those identified on the basis of demographic independence. Thus, discrete groups under the ESA policy would often be larger than discrete groups identified for management under the MSA or MMPA. Furthermore, marine mammal biology includes internal fertilization, live birth, parental care, and maintenance of family groups; these features act as barriers to mixing among groups and help produce fine-scale population structure.

Demographic Independent Populations (DIP) represent a paradigm that may be used to explain differences in conservation units identified under the ESA vs. the MSA or MMPA. A single DIP would be an appropriate conservation unit of managed fish or marine mammals due to the demographic nature of the objectives of the MSA and MMPA. However, although DIPs are discrete from one another demographically, they may be genetically similar. Therefore, a discrete group under the DPS policy formulated for implementation of the ESA may contain individuals from two or more DIPs.

Participants at the workshop agreed that guidance used to identify conservation units under the three statutes is generally acceptable and has worked well for a number of years. Despite this general acceptance, discussions at the workshop revealed a number of places where each set of guidance could be improved and noted two specific challenges for identifying conservation units common under all three statutes: 1) seasonal mixing of individuals from various stocks and 2) clines or continuously distributed species. The steering committee recommends that NMFS, along with appropriate partner agencies or organizations, revise the statute-specific guidance to incorporate necessary improvements.

# 3 ToR c) – Future meetings and new Terms of Reference

SIMWG has met by correspondence for the last three years. Several ICES Working Groups have increasingly expressed the need to receive feedback and advice on Stock Identification issues. The methods and approaches available seem to evolve and refine at a very high pace, and more integrative studies are beginning to be completed. Thus, it became apparent that SIMWG should reconvene for a physical meeting in the spring of 2009.

The proposed date for the 2009 meeting is in June. Candidate venues are Aberdeen (FRS Marine Lab) and Öregrund (Institute of Coastal Research, Swedish Fisheries Board).

In this respect, we believe that the Terms of Reference for 2009 should be revised and proposed as follows:

ToR a): liaise with ICES working groups and study groups dealing with stock identification issues; provide technical reviews to expert groups and LRC;

ToR b): review and report on new advances in stock identification methods as they develop, and new results that are relevant to ICES work;

ToR c): provide an updated review on all available information on stock structure in elasmobranchs;

ToR d): review and report on all available multidisciplinary attempts for Stock Identification, and produce a first draft protocol for the integration of results from multiple disciplines;

ToR e): produce a first draft practical protocol (suitable to constant updating) for Stock Identification;

ToR f): review and report on the "Linking Herring" symposium 2008 (University of Galway), the ICES 2008 ASC theme session on "Life cycle diversity, population structuring mechanisms and consequences", and the Northeast Regional Tagging symposium at the University of New Hampshire.

# 4 ToR d) – Theme session L – ICES 2007 ASC - Stock identification: applications for aquaculture and fisheries management

Conveners: Terje Svåsand (Norway) and Steve Cadrin (USA)

**Introduction**

Advances in methods for identifying specific stocks have been significant in recent years and provide better possibilities for stock-specific catch advice (at international, regional, river, and tributary level). Furthermore, new genetic markers for aquaculture species are being developed, which may identify escapes to a specific fish farm and determine if or how escapees are incorporated into wild stocks. The same methodological advances that are being developed for aquaculture objectives can also be used to study stock structure of capture fishery resources. The theme session allowed the potential for these applications to be reported and the implications for fisheries management to be discussed with the scientific community, stakeholders, and resource managers.

**Overview**

The session consisted of 15 oral papers and 9 posters, most of them addressing applications for fisheries management. A wide diversity of topics was presented, addressing several topics on *methods and applications of stock identification in aquaculture and fisheries management:*

i ) Genetic interactions between aquaculture and wild populations

During the past 10 years, worldwide production of farmed fish has more than doubled, with farming activities now producing half of the fish directly consumed by humans. The potential genetic effects of aquaculture on natural fish populations have aroused a great deal of concern among scientists as well as the general public. The perceived risks are often associated with the possible interactions between cultured and native fish with harmful consequences on ecosystem dynamics. Paper L:06 reviewed the status of genetic impact of aquaculture activities on native populations, with a focus on genetic tools for stock identifications (for further information see: www.genimpact.imr.no). Another paper (L:08) reported loss of genetic variability in juvenile hatchery reared Atlantic salmon released in three Spanish rivers to support the natural populations.

ii ) Stock identification in fisheries management

Several case studies were presented that had implications for managing fisheries. Presentations were grouped taxonomically, but many advances can be applied across a wide range of fishery management issues. For example, genetic techniques and statistical mixing models developed to identify aquacultural broodstocks can be applied to stock composition of mixed-stock fisheries, particularly those with rare components. As a side note in this discussion was the critical need to determine $F_{ST}$, as an indicator of whether there is enough genetic difference among groups to support stock composition analysis. Despite the excitement about genetic developments, several presentations illustrated how a range of stock identification techniques should be applied to fishery management issues. For example, parasites were useful for determining stock identity of horse mackerel, morphological variation was valuable for cod, herring and whelk, and

tagging is important for reconciling large-scale coherence of cod stocks and fine-scale genetic structure.

One practical issue that emerged from several presentations and discussions is the need to sample and archive tissues for genetic analysis. Incorporating tissue samples into routine survey and fishery sampling will provide valuable exploratory samples for examining genetic diversity and stock structure as well as the potential for baseline data for stock composition analysis of mixed-stock fisheries.

**Conclusions**

The presentations and posters addressed the objective of the theme session and continued to show that stock identification is an important issue in fishery science and management. The session continued a successful series of theme sessions at ICES Annual Science Conferences that have served as a way for scientists from diverse disciplines to interact and learn of advances in related fields. The conveners hope that the proposed theme session on life cycle diversity for the 2008 ASC will help to extend this successful series of sessions.

## 5 References

Anderson EC, Waples RS, Kalinowski ST, 2008. An improved method for predicting the accuracy of genetic stock identification. Canadian Journal of Fisheries and Aquatic Sciences, 65: 1475–1486.

Chevolot M, Hoarau G, Rijnsdorp AD, et al., 2006. Phylogeography and population structure of thornback rays (Raja clavata L., Rajidae). Molecular Ecology, 15: 3693-3705.

Chevolot M, Wolfs PHJ, Palsson J, et al., 2007. Population structure and historical demography of the thorny skate (Amblyraja radiata, Rajidae) in the North Atlantic. Marine Biology, 151: 1275-1286.

Chistiakov DA, Hellemans B, Haley CS, et al., 2005. A Microsatellite Linkage Map of the European Sea Bass Dicentrarchus labrax L. Genetics, 170: 1821–1826.

Eagle TC, Cadrin SX, Caldwell ME, et al., 2008. Conservation units of managed fish, threatened or endangered species, and marine mammals. NOAA Technical Memorandum NMFS-OPR-37.

Florin AB, Hoglund J, 2008. Population structure of flounder (Platichthys flesus) in the Baltic Sea: differences among demersal and pelagic spawners. Heredity, 101: 27-38.

Fontaine MC, Baird SJE, Piry S, et al., 2007. Rise of oceanographic barriers in continuous populations of a cetacean: the genetic structure of harbour porpoises in Old World waters. BMC Biology, 5: 30.

Frisk MG, Miller TJ, Martell SJD, et al., 2008. New hypothesis helps explain elasmobranch "OutBurst" on Georges bank in the 1980s. Ecological Applications, 18: 234–245

Gonzalez EG & Zardoya R., 2007. Relative role of life-history traits and historical factors in shaping genetic population structure of sardines (Sardina pilchardus). BMC Evolutionary Biology, 7: 197.

Hatfield EMC, Nash RDM, Zimmermann C, et al., 2007. The scientific implications of the EU Project WESTHER (Q5RS - 2002 – 01056) to the assessment and management of the herring stocks to the west of the British Isles. ICES CM 2007/L:11. 23 pp.

Hemmer-Hansen J, Nielsen EE, Grønkjær P, et al., 2007. Evolutionary mechanisms shaping the genetic population structure of marine fishes; lessons from the European flounder (Platichthys flesus L.). Molecular Ecology; 16: 3104–3118.

Hutchings JA, Swain DP, Rowe S, et al., 2007. Genetic variation in life-history reaction norms in a marine fish. Proceedings of the Royal Society of London B, 274: 1693-1699.

ICES, 2008. Report of the Working Group on the Application of Genetics in Fisheries and Mariculture (WGAGFM), 1-4 April 2008, Pitlochry, Scotland, UK. ICES CM 2008/MCC:04. 76 pp.

Narum SR, Banks M, Beacham TD, et al., 2008. Differentiating salmon populations at broad and fine geographical scales with microsatellites and single nucleotide polymorphisms. Molecular Ecology, 17: 3464–3477.

Sheridan P, Ferguson JW, Downing SL (editors), 2007. Report of the National Marine Fisheries Service Workshop on Advancing Electronic Tag Technology and Their Use in Stock Assessments. U.S. Dept. Commerce, NOAA Tech. Memo. NMFSF/ SPO-82.

## Annex 1: List of participants

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## Annex 2: SIMWG terms of reference for the next meeting

The **Stock Identification Methods Working Group** [SIMWG] (Chair: S. Mariani, Ireland) will meet at Aberdeen, UK or Öregrund, Sweden (venue to be confirmed) in June 2009 to:

a ) liaise with ICES working groups and study groups dealing with stock identification issues; providing technical reviews to expert groups and LRC;

b ) review and report on new advances in stock identification methods as they develop, and new results that are relevant to ICES work;

c ) provide an updated review on all 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;

SIMWG will report by 1 August 2009 for the attention of the Living Resources Committee.

### Supporting Information

| | |
|---|---|
| Priority: | Essential. Stock structure is a fundamental requirement before any assessment or modelling on a stock level can be contemplated. SIMWG liaises with ICES study groups and working groups on stock identification issues and continues to review new methods as they develop. |
| Scientific Justification and relation to Action Plan: | Action Plan No 1 – Action 1.2.1: Understand and quantify stock structure of commercially and ecologically important species. [LRC]<br>Stock structure and stock identification have been identified as part of the work programme of the Living Resources Committee and SIMWG continues to make progress on the development of its Stock Identification Methodology. After the publication of a book on Stock Identification Methods (2005), SIMWG will now develop practical standardized protocols for the stock identification process, and for the integration of results from multiple disciplines |
| Resource Requirements: | Some ICES financial and logistic support is required to assist the 2009 meeting. |
| Participants: | 15-20 |
| Secretariat Facilities: | None |
| Financial: | possibly some contribution towards the 2009 meeting |
| Linkages to Advisory Committees: | ACFM |
| Linkages to other Committees or Groups: | AGFM – Chairs of these two Working Groups are corresponding to ensure that there is no unnecessary overlap in their work.<br>WGNEW, WGDEEP, NWWG, WGEF, WGAGFM. |
| Linkages to other Organizations | There are no direct linkages to other organizations. |

## Annex 3: Recommendations

| Recommendations |
|---|
| 1. SIMWG will meet in person in June 2009. Candidate venues are Aberdeen and Öregrund. |
| 2. SIMWG proposes to extend the membership to the following three scientists:<br>- Mikaela Bergenius, Swedish Fisheries Board, Öregrund<br>- Christophe Pampoulie, Marine Research Institute, Reykjavík<br>- Robin Waples, NOAA Fisheries Service, Seattle. |
| 3. It should be a priority for ICES to promote more integrated work on sea bass. SIMWG will commit to propose a theme session on sea bass population biology for the 2009 ASC. |
| 4. An updated protocol for stock identification procedures will be drafted. |
| 5. More work is necessary to develop methods for the integration of results from multiple disciplines. |
| 6. ICES should support the participation of external experts at WGNEW, WGEF, SGRS, WGDEEP. |