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Review and guidance for decision-makers

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Edited by

Johanne Fischer
Senior Fishery Resources Officer
Marine and Inland Fishery Resources Branch
FAO Fisheries and Aquaculture Department
Rome, Italy

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Preparation of this document

This document is a result of the contributions and deliberations of the workshop "Fish Identification Tools for Biodiversity and Fisheries Assessments" (Vigo, Spain, 11–13 October 2011) convened by the University of Vigo and the FAO FishFinder Programme. Although not a "Proceedings" as such, it does reflect the presentations and discussions of participants regarding user perspectives and user requirements, definition of criteria for the characterization of identification tools, description of identification tools and scenarios as well as recommendations for research and development. However, it also contains observations and summaries added after the workshop with the intent to make this document more accessible to the reader. A draft version of this document was circulated to workshop participants, and this finalized version incorporates substantive comments and corrections received from them.

The workshop participants consisted of 15 invited experts from 10 countries, two FAO officers and one FAO consultant. The first part of the workshop was dedicated to 14 plenary presentations on fish identification methods and tools. The workshop then proceeded to provide definitions for the criteria used to characterize each identification tool addressed by the workshop. Each expert reviewed the summary description and visual characterization of the ID tools prepared by FAO and the workshop then evaluated the results in a non-comparative manner. It was agreed that the visual characterization would serve as an approximate qualitative indication of the strengths and weaknesses of each method. After the workshop, a comparative review was undertaken by the editor and some adjustments were made to the figures.

The subsequent development and description of relevant scenarios took place in three subgroups: one focusing on research and development, the second on conservation, responsible use and trade, and the third on education, awareness building, consumer considerations and non-consumptive uses. The scenarios were intended to illustrate a variety of user requirements for species identification and recommending appropriate identification tools for each of these scenarios. The workshop concluded with a statement containing a number of recommendations by workshop participants.

The papers contained in Annex 3 to this work have been reproduced as submitted by the participants, without editorial intervention by FAO.

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Abstract

This review provides an appraisal of existing, state-of-the-art fish identification (ID) tools (including some in the initial stages of their development) and shows their potential for providing the right solution in different real-life situations. The ID tools reviewed are: Use of scientific experts (taxonomists) and folk local experts, taxonomic reference collections, image recognition systems, field guides based on dichotomous keys; interactive electronic keys (e.g. IPOFIS), morphometrics (e.g. IPez), scale and otolith morphology, genetic methods (Single nucleotide polymorphisms [SNPs] and Barcode [BOL]) and Hydroacoustics.

The review is based on the results and recommendations of the workshop "Fish Identification Tools for Fishery Biodiversity and Fisheries Assessments", convened by FAO FishFinder and the University of Vigo and held in Vigo, Spain, from 11 to 13 October 2011. It is expected that it will help fisheries managers, environmental administrators and other end users to select the best available species identification tools for their purposes.

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Monica Barone (FAO consultant) and Kathrin Hett (Associated Professional Officer at FAO) are thanked for their significant input and assistance in the planning phase of the workshop and development of the agenda. Monica also helped running the workshop, ensured that all records and outputs were saved and accessible and prepared a first outline of this document.

Elisa Pérez Costa (Junior Research Assistant, University of Vigo) and Luigia Sforza (FAO Office Clerk) assisted in the meeting preparations and provided logistical support to the workshop which was much appreciated by all. Last but not least, Julian Plummer and Marianne Guyonnet are thanked for their meticulous proofing of the document.

Abbreviations and acronyms

AIS	aquatic invasive species
BMU	Beach Management Unit (Kenya)
CBD	Convention on Biological Diversity
CBD-GTI	CBD-Global Taxonomy Initiative
CITES	Convention on International Trade in Endangered Species of Wild Fauna and Flora
CoF	Catalog of Fishes
CoL	Catalogue of Life
FCO	fisheries control officer
GM	genetically modified
ID	identification (tool)
IEK	interactive electronic key
IPOFIS	integrated photo-based online fish-identification system
IRS	image recognition system
IUU	illegal, unregulated and unreported (fishing)
NGO	non-governmental organization
RFMO	regional fisheries management organization
SNP	single nucleotide polymorphism
UNEP-WCMC	United Nations Environment Programme – World Conservation Monitoring Centre
WoRMS	World Register of Marine Species

Contents

Preparation of this document iii
Abstract iv
Acknowledgements vii
Abbreviations and acronyms viii

Recommendations 1

1. Introduction 3

2. User perspectives 7
2.1 Fish taxonomy in biodiversity and fishery assessment and management 7
2.2 A fishery inspector's view of fish identification 8
2.3 Identification and commercial names of fishery products: a view from the industry 9

3. Species identification tools 11
3.1 Species ID tools included in this review 11
3.2 Criteria for the evaluation of species identification tools 12
3.3 Evaluation of species identification tools 13
3.3.1 On-site taxonomist 13
3.3.2 Local (folk) expert 13
3.3.3 Local reference collection 14
3.3.4 Image recognition system 15
3.3.5 Field guides based on dichotomous keys 16
3.3.6 Integrated Photo-based Online Fish-Identification System (IPOFIS) exemplifying Interactive Electronic Keys (IEKs) 17
3.3.7 IPez (morphometric software) 17
3.3.8 Scales 18
3.3.9 Otoliths 19
3.3.10 Genetic identification through single nucleotide polymorphisms (SNPs) 19
3.3.11 Genetic identification using barcoding 20
3.3.12 Acoustic fish identification 21
3.4 Web-based fish identification and information resources 22

4. Selecting an identification tool 25
4.1 Users 25
4.2 Selection criteria 25
4.2.1 Response time 28
4.2.2 Accuracy 28
4.2.3 Resolution 28
4.2.4 Type 29
4.2.5 Resources 29

5. Description of scenarios 31

5.1 Catch reporting by fishers (logbooks) 32
5.2 Assessment of introduced fish species in a lake 32
5.3 Monitoring catch during exploratory fishery 33
5.4 Reporting catches of lake fisheries (exotic species) 33
5.5 Reporting catches of marine artisanal fisheries 34
5.6 Fingerlings of aquaculture species are correctly identified by suppliers 34
5.7 Reduction of bycatch through pre-harvest survey 35
5.8 Port inspections of fishery catches 35
5.9 Vessel inspection on the high seas 36
5.10 Live fish inspection by customs (CITES) 36
5.11 Verification of origin of catches 37
5.12 Fish product inspection by customs (CITES) 37
5.13 Distribution and characteristics of populations 38
5.14 Provision of data for the ecosystem modelling of living marine components 38
5.15 Development of application to distinguish living objects from submarines 39
5.16 Fish inventory for gear development to minimize bycatch 39
5.17 Changes in species diversity due to climate change 39
5.18 Taxonomic training of students 40
5.19 Anglers track the spread of aquatic invasive species (AIS) 40
5.20 Assessment of genetically modified fish in waters and markets 41
5.21 Corroboration of the geographic origin of fishes as documented in catch certificate 41
5.22 Traded fish is labelled correctly 42
5.23 Investigating the alleged presence of exotic and GM species 42
5.24 Divers identify marine organisms 43

6. Conclusions 45

Annex 1 - List of participants 47

Annex 2 - Workshop agenda 49

Annex 3 - Participants' contributions 51

Recommendations

At the conclusion of the workshop "Fish Identification Tools for Biodiversity and Fisheries Assessment", held in Vigo, Spain, from 11 to 13 October 2011, the participants prepared the following statement and recommendations.

In recent decades, biodiversity research has been prioritized and new fish identification techniques have been developed. However, the actual transfer and application of fish identification technologies in projects and management schemes has lagged. It is an important objective of the present document to encourage and promote the informed use of appropriate identification techniques in all areas, specifically:

- Take initiatives to strengthen the links and enhance communication between scientists, stakeholders and end users.
- Strengthen the taxonomic community through additional training opportunities, the creation of jobs for taxonomists, research funding and infrastructure to ensure the stability of nomenclature and development of reliable diagnostic data sets.
- Strengthen the fish identification expertise of officers and others who need to identify fish in the execution of their jobs in order to ensure that the identification is authoritative and current.
- Develop more local, scientifically reviewed and curated reference collections of fish specimens (in fishery agencies, institutes) and encourage their use.
- Develop more local, scientifically reviewed and curated fish photographic reference collections (in fishery agencies, institutes) and encourage their use.
- Encourage users to assist in the population of reference databases.
- Promote the appropriate use of fish identification techniques by publicizing the range of techniques available to address diverse fishery and biodiversity questions (promote the right tool for the job).
- Encourage collaboration and increased integration of methodological approaches used by taxonomists and other scientists to increase accuracy, repeatability and the creation of enhanced tools.
- Improve access to fish identification tools.
- Make available more open-access fish identification tools or tools in the public domain.
- Create central repositories of metadata (e.g. web-links, experts) and/or clearing houses.
- Develop and improve identification tools for early life history stages of aquatic organisms.
- Strengthen the development of new and user-friendly fish identification tools through improved investment.
- Develop legally binding standards and guidelines for fish identification for fishery compliance purposes.
- Make available primary data (such a barcodes and images) that support development and maintenance of automatic and semi-automatic identification tools for improved cost-effectiveness.

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- Ensure that scientific documents report on the species identification methods the authors have used.
- Increase awareness among the public and policy-makers of the importance of accurate fish identification through the use of user-friendly media and advocacy.
- Identify and address gaps in information for the identification of aquatic species.

1. Introduction

The current review intends to provide an overview of existing, state-of-the-art fish identification (ID) tools (including those in the initial stages of their development) and to show their potential for providing the right solution in different real-life situations. The content of this review is based on the results and recommendations of the workshop "Fish Identification Tools for Fishery Biodiversity and Fisheries Assessments", convened by FAO and the University of Vigo and held in Vigo, Spain, from 11 to 13 October 2011. It is expected that the review will help fisheries managers, environmental administrators and other end users to select the best available species identification tools for their purposes. The experts involved in this review also hope that it will help renew public interest in taxonomy and promote the need for taxonomic research including user-friendly species ID tools.

Although the need for taxonomic expertise has never been as pronounced as it is today, this has not translated into training more taxonomists and providing more funding for necessary developments in taxonomy. Instead, more and more individuals without a taxonomic background, such as fishery inspectors and observers, customs officers, data collectors, traders and others, have been tasked with the complex and often difficult assignment of identifying aquatic species. These less-experienced users are often faced with confusing and inadequate information on the species they encounter and how to identify them reliably. Products such as the species catalogues and field guides produced by the FAO FishFinder Programme can help in countries and regions for which they exist, and web resources, such as FishBase[1] and the Catalog of Fishes[2] offer guidance to resolve issues regarding the correct scientific name for a species. Nonetheless, greater efforts are needed to ensure a correct identification of aquatic resources under management and conservation regimes.

In recent decades, many new and promising techniques for the identification of fishes have emerged, in particular based on genetics, interactive computer software, image recognition, hydroacoustics and morphometrics. However, with few exceptions, such advances in academic research have not yet been translated into user-friendly applications for non-specialists and still require further investments to mature into globally applicable tools.

Public consciousness about the need to conserve biodiversity has recently been growing. In all parts of the world, policy-makers, funding agencies and scientists have made it a priority to advance policies and knowledge for this purpose. This interest was prompted by the realization that taxonomic resources around the world are declining at a rapid pace and that this is having a negative impact on human well-being and survival.

The Census of Marine Life[3] has just finished an ambitious and large-scale ten-year project that includes an inventory of aquatic species. A number of large national and international funding organizations (Convention on Biological Diversity [CBD],[4] DIVERSITAS[5], European Environment Agency,[6] European Commission,[7] Global Biodiversity Information Facility,[8] Global Ocean Observing

[1] www.fishbase.org/search.php
[2] http://researcharchive.calacademy.org/research/ichthyology/catalog/collections.asp
[3] www.coml.org/
[4] www.cbd.int/
[5] www.diversitas-international.org/
[6] www.eea.europa.eu/
[7] http://ec.europa.eu/index_en.htm
[8] www.gbif.org

System,[9] Intergovernmental Platform on Biodiversity and Ecosystem Services,[10] International Union for Conservation of Nature,[11] United Nations Environment Programme – World Conservation Monitoring Centre [UNEP-WCMC][12] and many others) are currently supporting broad worldwide attempts to summarize all knowledge on aquatic organisms and provide global species inventories (All Catfish Species Inventory,[13] Continuous Planktonic Recorder project,[14] UNEP-WCMC Species Database,[15] Fish Barcode of Life Initiative[16] and Marine Biodiversity and Ecosystem Functioning EU Network of Excellence[17] among many others). The FAO Commission on Genetic Resources for Food and Agriculture[18] has been mandated to cover all components of genetic resources relevant to food and agriculture, and it is now preparing a global review of aquatic resources.

The CBD uses the following definition: "'Biological diversity' means the variability among living organisms from all sources including, inter alia, terrestrial, marine and other aquatic ecosystems and the ecological complexes of which they are part; this includes diversity within species, between species and of ecosystems".[19] This definition clarifies that biological diversity does not only apply to the number of species in an ecosystem but also considers the difference between subspecies, populations and other meaningful units below the species level.

The CBD-Global Taxonomy Initiative (CBD-GTI)[20] recognizes a "taxonomic impediment" to the sound management of biodiversity consisting in "the knowledge gaps in our taxonomic system (including those associated with genetic systems), the shortage of trained taxonomists and curators, and the impact these deficiencies have on our ability to conserve, use and share the benefits of our biological diversity". The CBD-GTI also states that "simple-to-use identification guides for the non-taxonomist are rare and available for relatively few taxonomic groups and geographic areas. Taxonomic information is often in formats and languages that are not suitable or accessible in countries of origin, as specimens from developing countries are often studied in industrialized nations. There are millions of species still undescribed and there are far too few taxonomists to do the job, especially in biodiversity-rich but economically poorer countries. Most taxonomists work in industrialized countries, which typically have less diverse biota than in more tropical developing countries. Collection institutions in industrialized countries also hold most specimens from these developing countries, as well as associated taxonomic information."[21]

It has become clear that taxonomic information is not a luxury – it is a real need in a world with a still-growing human population generating enormous pressure on natural resources. More and more organisms are shipped around the world and marketed continents away from their origins, thus generating an increased need for global fish identification tools to provide reliable information to consumers, customs officers and fishery inspectors. However, worldwide, there exist more

[9] www.ioc-goos.org/
[10] www.ipbes.net/
[11] www.iucn.org/
[12] www.unep-wcmc.org/
[13] http://silurus.ansp.org/
[14] www.sahfos.ac.uk/
[15] www.unep-wcmc-apps.org/isdb/Taxonomy/
[16] www.fishbol.org/index.php
[17] www.marbef.org/
[18] www.fao.org/nr/cgrfa/en/
[19] CBD, Article 2. Use of Terms.
[20] www.cbd.int/gti/
[21] www.cbd.int/gti/problem.shtml

than 32 500 species of finfishes[22] and the amount of information required to separate them all is extremely difficult to process; therefore, fish identification is usually conducted at local or regional scales. The increasing globalization of fishery products thus introduces new challenges to the identification of aquatic organisms. In addition, new emerging applications require accurate species identification (e.g. marine hydrokinetic energy and ocean observatories).

The collection of species- and population-specific information for the purpose of sustainable fishery management has a long tradition. For many decades, FAO has been collecting global statistical catch data and analysing the results in two of its flagship publications: (i) *The State of World Fisheries and Aquaculture* and the *Review of the state of world marine fishery resources*. While progress has been made in the reporting of fishery data, much improvement is still needed for a more reliable and comprehensive assessment of the stock status of many commercially exploited aquatic species. Not only the taxonomic resolution of catch data could be better for many areas and species, but there is a real concern about the proportion of possible misidentifications in the catch statistics received by FAO, with severe implications for the ability to manage aquatic organisms sustainably. With its FishFinder Programme,[23] FAO has contributed to improving fish identification everywhere and produced more than 200 species identification guides including taxonomic descriptions for more than 8 000 species and an archive of more than 40 000 scientific illustrations. Although the programme struggles owing to funding constraints and competing priorities at FAO, it continues generating products to assist with fish identification in many parts of the world, including the guidance provided in this publication.

[22] The cumulative species description curve for fishes is not yet close to its asymptote and, hence, the number of species will continue to increase.

[23] www.fao.org/fishery/fishfinder/en

2. User perspectives

User considerations provide the background and scope against which the different species ID tools are evaluated. The following summaries describe the user requirements from three different perspectives.[24] The first introduces the views of a taxonomist and ichthyologist, the second illustrates the difficulties and urgent needs for correct species identification experienced by a fisheries control officer on the high seas, and the third explains requirements of the fishing industry and consumers for non-ambiguous species identification and labelling. Notwithstanding the pronounced differences of these three perspectives, they are unified in their conviction that improving the identification of aquatic species will have considerable positive impacts for biodiversity research, fisheries management and law enforcement as well as trade and consumer safety.

2.1 FISH TAXONOMY IN BIODIVERSITY AND FISHERY ASSESSMENT AND MANAGEMENT

A stable naming and indexing system is essential to global communication about organisms, and such a system is maintained by the International Code of Zoological Nomenclature. The science of taxonomy, among other things, provides the methods and the manuals for the identification of organisms. Although largely based on observations of characters that local fishers may also use, taxonomic research offers the tools for a regionally and globally valid identification. Some examples of fundamental taxonomic tools for the use in fisheries include FishBase[25], the book *Fishes of the North-eastern Atlantic and the Mediterranean*[26]and a series of catalogues and regional checklists provided by FAO.[27] Although surveying, mapping, taxonomic characterization, and naming of the global marine and freshwater fish fauna are fundamental to a healthy fishery, the importance of taxonomic work is not fully recognized in the fisheries sector, particularly not in the boreal regions where "everything is known". However, a lack of pertinent taxonomic information or lack of user experience can actually or potentially lead to undesired consequences for fishery management, and fish taxonomists are urgently needed to provide reliable name standards and identification tools for fishery purposes.

In many regions of the world, fish stocks are being exploited without much taxonomic assistance. However, it is impossible to develop conservation plans and long-term management without knowing what species are involved, and preferably also whether subpopulations exist, and how to identify them. Important faunal guides have been published by South Africa, Japan and Australia, but in these regions new species continue to be discovered, both from fresh material and from old museum specimens.

Taxonomic resources may also play a role in prospecting for new resources as is done particularly in aquaculture. Involving taxonomists in aquaculture is always recommended in order to prevent expensive errors based on the erroneous identification of species, e.g. to avoid a "new" species being imported to locations where it (or a very similar form) already exists but is known under an incorrect name.

[24] See Annex 3 for full papers submitted by workshop participants.

[25] Froese, R. & Pauly, D., eds. 2013. *FishBase* [online]. [Cited 19 June 2013]. www.fishbase.org

[26] Whitehead, P.J.P., Bauchot, M.-L., Hureau, J.-C., Nielsen, J. & Tortonese, E., eds. 1984–86. *Fishes of the North-eastern Atlantic and the Mediterranean*. Paris, UNESCO.

[27] See www.fao.org/fishery/fishfinder/publications/en

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