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Report of the

EXPERT WORKSHOP ON INCORPORATING GENETIC DIVERSITY AND INDICATORS INTO STATISTICS AND MONITORING OF FARMED AQUATIC SPECIES AND THEIR WILD RELATIVES

Rome, 4–6 April 2016

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ABSTRACT

At its 15th Regular Session held in Rome in 2015, the Commission on Genetic Resources for Food and Agriculture requested FAO to develop and finalize a thematic study on "Incorporating genetic diversity and indicators into statistics and monitoring of farmed aquatic species and their wild relatives." The following report includes the discussions and outputs of an expert group that addressed the topic, Incorporating genetic diversity and indicators into regular statistics and monitoring of farmed aquatic species and their wild relatives.

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BACKGROUND

The important role of aquatic genetic resources (AqGR) in contributing to global food security and nutrition as well as sustainable livelihoods is well known and documented, but information on AqGR at species level and below tends to be scattered and extremely incomplete. Though the aquaculture statistics production statistics collected globally by FAO provide useful benchmark information about the utilization of AqGR in aquaculture, there are major gaps in the information available to FAO in terms of the detailed description of the large variety of aquatic organisms employed in aquaculture production across the world. For this reason, the FAO Commission on Genetic Resources for Food and Agriculture (the Commission) called upon FAO Members to report on the state of aquatic genetic resources for food and agriculture in their countries. On the basis of Country Reports received, thematic background studies and other information, FAO will prepare The State of the World's Aquatic Genetic Resources for Food and Agriculture (*SoWAqGR*). The *SoWAqGR* will be the first global assessment based on national reports on aquatic genetic resources for food and agriculture (AqGR). The scope of the global report will be farmed aquatic species and their wild relatives within national jurisdictions.

At its 15th Regular Session held in Rome in 2015, the Commission requested FAO to develop and finalize a thematic study on "Incorporating genetic diversity and indicators into statistics and monitoring of farmed aquatic species and their wild relatives." The following report includes the discussions and outputs of an expert group that addressed the topic, Incorporating genetic diversity and indicators into regular statistics and monitoring of farmed aquatic species and their wild relatives.

Rationale for the thematic background study

Reporting the production and value statistics for farmed aquatic species and their wild relatives is often at the species or higher taxonomic levels. Management of fish stocks, traceability of fish and fish products, and management and development of responsible aquaculture require identification, management and monitoring of genetic diversity. Increasingly, resource managers and the development communities are asked to identify indicators of the status of AqGR. Once better data are available at the species level and below the species level, indicators can be developed for monitoring and assessment of AqGR, which will then inform better management practices. Production volume and value statistics for farmed aquatic species and their wild relatives are highly aggregated to species or higher levels, with many reports not even identifying the species used. Management of fish stocks, traceability of fish and fish products, and oversight and development of responsible aquaculture require management of genetic diversity, linked to production. Increasingly, resource managers and the development communities are asked to identify indicators of the status of AqGR. Once better production data are available, indicators can be developed for monitoring and assessment.

FAO capture fishery and aquaculture production statistics

FAO is the repository for global information on fisheries and aquaculture. National level statistics are submitted by member countries and harvested by FAO on an annual basis. FAO summarizes and performs some analyses of this information on a biennial basis in its flagship publication, the State of World Fisheries and Aquaculture (SOFIA). Apart from information on fisheries and aquaculture FAO is currently hosting other information systems providing statistical data on genetic resources for food and agriculture, e.g. the "Domestic Animal Diversity Information System" (DAD-IS)[1]. DAD-IS is a communication and information tool for implementing strategies for the management of animal genetic resources. It provides the user with searchable databases of breed-related information and images, management tools, and a library of references, links and contacts of Regional and National Coordinators for the Management of Animal Genetic Resources. This system also provides countries with a secure means to control the entry, updating and accessing of their official National data. The objectives of DAD-IS are to (1) involve, coordinate and assist governments, international agencies,

[1] link: http://dad.fao.org/

NGOs, training and research groups throughout the world; and (2) help to achieve better management of all Animal genetic resources used for the production of food and agriculture in all countries.

OBJECTIVES OF THE MEETING

The overall objective of the meeting was to provide advice to FAO on the incorporation of information on aquatic genetic diversity and indicators into statistics and monitoring of farmed aquatic species and their wild relatives into FAO and National statistics. The expert workshop provided guidance towards the preparation of the thematic background paper, "Incorporating genetic diversity and indicators into statistics and monitoring of farmed aquatic species and their wild relatives".

DELIBERATIONS OF THE EXPERTS

The agenda (Annex I) was adopted by the experts (Annex II). The experts in consultation with FAO staff reviewed the current systems for collection, monitoring and reporting of information on fisheries and aquaculture at the global level.

Review of current information on AqGR
As the global repository for national statistics on fisheries and aquaculture production, FAO updates and publishes annually the global production statistics database/dataset with access (see Zhou Annex III). The FAO Fisheries and Aquaculture Statistics and Information Branch (FIAS) collates world capture and aquaculture production statistics at either the species, genus, family or higher taxonomic levels in 2 189 statistical categories (as of 2013) referred to as "species items". The capture and aquaculture productions volume (for aquaculture farm gate value, too) registered in FAO database are categorized into species items with standard names according to the Aquatic Sciences and Fisheries Information System (ASFIS) list and the classification system of the International Standard Statistical Classification of Aquatic Animals and Plants (ISCAAP). The 2015 edition of ASFIS list of species includes 12 600 species items selected according to their interest or relation to fisheries and aquaculture (see Garibaldi Annex III).

For monitoring and reporting fishery and aquaculture information at the species level and at the infraspecific level, standard and consistent nomenclature is essential. Therefore, the ASFIS list adopts only standard and accepted nomenclature. As in other fora on genetic diversity[2], the experts recognized that nomenclature describing aquatic genetic resources is not standardized and often leads to confusion and misunderstanding. In order to clarify use of terms, FAO has established glossaries[3] on fisheries and aquaculture and a set of terms relevant to aquatic genetic resources is available to assist with the compilation of country reports. Members of the COFI Advisory Working Group on Aquatic Genetic Resources and Technologies are currently reviewing these definitions.[4]

The group of experts adopted the ASFIS list of species as the appropriate format for incorporating AqGR into any additional monitoring system as this list is the basis for the global information maintained by FAO and widely cited in government, scientific and popular media. For farmed aquatic genetic resources a general term 'farm type' was adopted that would include, species, hybrids, triploids, mono-sex groups, other genetically altered forms, varieties and strains. Wild relatives of farmed types were defined to be conspecific organisms found in the wild, i.e. not in aquaculture facilities. For infraspecific nomenclature, i.e. below the species level, the experts followed practices from the terrestrial sector and adopted the use of 'strain' to indicate a farmed type that has distinguishing characteristics and can maintain these characteristics through repeated propagation (Table 1).

[2] FAO/NACA Aquaculture in the Third Millennia. FAO/NACA, Rome.
[3] http://www.fao.org/fishery/glossary/en
[4] http://www.fao.org/3/a-i5553e.pdf

The term ‘stock’ has been commonly used in fisheries management to mean whatever a manager wanted to designate as the management unit. For example the stock of Pacific salmon would involve five species of *Oncorhynchus*; the stock of Chinook salmon in the Pacific would signify one of those five species *O. tshawytscha*; the stock of Sacramento River Chinook salmon would include a specific river system, and the stock of winter run Chinook salmon in the Sacramento River would indicate a specific spawning migration of the species. Thus, for wild relatives the experts adopted the term ‘stock’ and the user of the term is tasked with defining the scope of coverage. For infraspecific use, ‘strain’ refers to farmed types, and ‘stock’ would refer to wild relatives.

Table 1. Nomenclature suggested by the meeting to designate genetic diversity

Breed	A specific group of domestic animals having homogeneous appearance (phenotype), homogeneous behavior, and/or other characteristics that distinguish it from other organisms of the same species and that were arrived at through selective breeding. Despite the centrality of the idea of "breeds" to animal husbandry and agriculture, no single, scientifically accepted definition of the term exists[5].
Cultivar or variety	A plant or grouping of plants selected for desirable characteristics that can be maintained by propagation. The International Union for the Protection of New Varieties of Plants requires that a cultivar be distinct, uniform and stable. To be distinct, it must have characteristics that easily distinguish it from any other known cultivar. To be uniform and stable, the cultivar must retain these characteristics under repeated propagation.
Strain	A farmed type of aquatic species having homogeneous appearance (phenotype), homogeneous behavior, and/or other characteristics that distinguish it from other organisms of the same species and that can be maintained by propagation. As with breeds and cultivars a strain must be distinct, uniform and stable.
Stock	A group of similar organisms in the wild that share a common characteristic that distinguishes them from other organisms at a given scale of resolution. For infraspecific use a stock would signify a segment of a species that can be distinguished from other segments of that species.
Farmed type	A farmed organisms that could be a species, hybrid, triploid, mono-sex group, other genetically altered form, variety or strain. Wild relatives of farmed types were defined to be
Wild relative	An organism of the same species as a farmed organism (conspecific) found established in the wild, i.e. not in aquaculture facilities.

Currently the ASFIS list contains no strains or stocks, but does contain 12 hybrid taxa (Table 2). The list does not include any subspecies, stocks, strains or varieties of farmed species or their wild relatives.

[5] FAO 2007a. The First Report on the State of the World’s Animal Genetic Resources for Food and Agriculture. FAO, Rome.

Table 2. Hybrids in the ASFIS list and indication of whether data are reported to FAO

Scientific name	Family	Production data registered in FAO database	English name (FAO)	Names in other languages used by FAO
P. mesopotamicus x C. macropomum	Characidae	Yes	Tambacu, hybrid	Spanish: Pacotana, híbrido
C. macropomum x P. brachypomus	Characidae	Yes	Tambatinga, hybrid	
Clarias gariepinus x C. macrocephalus	Clariidae	Yes	Africa-bighead catfish, hybrid	French: Poisson-chat, hybride Spanish: Pez-gato, híbrido Chinese: 尖齿胡鲇与大头胡鲇杂交种
Morone chrysops x M. saxatilis	Moronidae	Yes	Striped bass, hybrid	French: Bar d'Amérique, hybride Spanish: Lubina estriada, híbrida Arabic: قاروس أمريكيّ هجين Chinese: (current name is wrong and needs to be corrected)
Oreochromis aureus x O. niloticus	Cichlidae	Yes	Blue-Nile tilapia, hybrid	Spanich: Tilapia azul-del Nilo, híbrido
P. mesopotamicus x P. brachypomus	Characidae	No	Patinga, hybrid	Spanish: Patinga, hibrido
Ictalurus punctatus x I. furcatus	Ictaluridae	No	Channel-blue catfish, hybrid	Chinese: 斑点-长鳍叉尾鮰杂交种
Pseudopl. corruscans x P. reticulatum	Pimelodidae	No		
Oreochromis andersonii x O. niloticus	Cichlidae	No		Chinese: 奥尼罗非鱼杂交种
Channa maculata x C. argus	Channidae	No		Chinese: 斑鳢-乌鳢杂交种
Leiarius marmoratus x P. reticulatum	Pimelodidae	No		

A preliminary review of some of the country reports submitted to FAO in preparation for the first SoWAqGR indicated several more species and species units are being farmed than are currently listed in ASFIS (Table 3), and identified additional hybrids including.

Table 3. Indicative list of additional species reported in country reports

Country	Total number of species reported	Number included in ASFIS	Additions to ASFIS
Philippines	56	46	10
Venezuela	8	8	0
Vietnam	69	47	22
Tanzania	7	7	0
Malaysia	52	46	6
Japan	24	14	10
Paraguay	12	12	0
Iran	19	17	2
Colombia	24	0	11
Kenya	36	13	23
Lao	7	5	2
Tonga	12	8	4
Malawi	5	4	1

Oreochromis mossambicus x O. niloticus from the Philippines;
Epinephelus lanceolatus x E. coides, E. coides x E. fuscoguttatus, E. lanceolatus x E. fuscoguttatus from Viet Nam and Malaysia;
Onchorryncus mykiss x O. masou from Japan;

Barboniomus gonionotus x B. schwanefeldi, *Clarias batrachus x C. microcephalusfrom,* and *Channa micropeltes x C. striata* from Lao PDR.
Patinopecten caurinus x P. yessoensis from Canada.

FAO as developer and curator of the ASFIS nomenclature is reluctant to add additional items to the list unless it can be shown that the new taxon, i.e. new hybrid or species, would be reported in a reliable and consistent manner by members of FAO. There is no mechanism within the structure of the ASFIS list to include strains, stocks or subspecies. The new hybrids and species reported by countries in their national reports will be reviewed and compiled by FAO for potential inclusion in the ASFIS list.

Uses of information on AqGR
Information on aquatic genetic resources has a variety of uses for resource managers, private industry and consumers (Table 4). However, this information is only available at the infraspecies level for a few important species in specific locations, e.g. Pacific salmon, Atlantic salmon, brown trout and Atlantic cod. For farmed aquatic species there are breeding centers and databases that have genetic information for a few important species.

Table 4. Possible uses of information on AqGR[6]

Aquaculture	
	Identify organisms for selective breeding programmes
	Monitor inbreeding and genetic diversity in farmed groups
	Broodstock management (in general as well, not only for cultured based fisheries) for culture based fisheries
	Conservation hatcheries
	Strain registry
	Specific pathogen resistance
	Specific tolerance to certain environmental conditions (e.g. salinity, oxygen levels and temperature)
	Useful genes or markers for breeding programmes
	Traceability of farmed species and products
Fisheries	
	Stock identification
	Cryptic species identification
	Fishery management GSI
	Assess introgression with farmed or introduced species
	Traceability of fish and products
	Conservation
	Genetic viability
	Alien species identification
	Effective population size
	Inbreeding
	Compatible species or stocks for population recovery programmes
Conservation	
	Genetic viability
	Alien species identification
	Effective population size
	Inbreeding
	Compatible species or stocks for population recovery programmes.
	Cryptic species identification

The experts acknowledged that in order to address the request of the Commission, information below the species level, i.e. infraspecific information, is needed and therefore a system in addition to the current system that uses the ASFIS list would be required. The experts therefore recommended a

[6] This list is not exhaustive and other uses may be possible.

structure for this new information system and further acknowledged that genetic information could improve the reporting at the species level.

Aquatic genetic resources information (AQUAGRIS)
The experts designed the structure of a potential information system for recording and monitoring aquatic genetic resources (Table 5) and tentatively called the information system Aquatic Genetic Resources Information (AQUAGRIS). Information needs on farmed types and wild relatives are slightly different and therefore treated separately in the information system. Key information for any information system include, accepted name; location; distinguishing character and who collected or supplied the information.

Table 5. Data structure for aquatic genetic resources of farm types and there wild relatives

Information for farmed types	Information for wild relatives
Respondent – name of person providing information	Respondent – name of person providing information
Taxonomic status, genus and species	Taxonomic status, genus and species
Genetic characteristics of the farmed type	Genetic status and characteristic of the wild relative
Source of farmed type, from wild or aquaculture	Source of wild relative, native or introduced
Breeding history	Migratory pattern
Distinguishing characteristics and common name	Designation of stock name and distinguishing characters
Where farmed	Records of occurrence
Farming system(s)	Habitat(s), distribution, range
Time series of production	Exploitation or use
Status	Status, presence and abundance
Source of further information	Source of further information

Monitoring
The monitoring of aquatic genetic resources is necessary to track changes in the status and trends in use and conservation of aquatic genetic resources. This is routinely being done at the species level in fisheries and aquaculture (see for example FAO SOFIA publications) and in other sectors at the breed or variety level.[7]

The country reports are being incorporated into a database that would allow some monitoring on the status and trends of aquatic genetic resources through the process of producing the report on the State of the World's Aquatic Genetic Resources for Food and Agriculture; the reporting is currently scheduled for once every 10 years. However there is a need for monitoring at shorter intervals to provide more current information on change, opportunities and threats. Another aspect that indicates monitoring is needed more frequently is the speed at which the field of genetics and genetic technologies is progressing, e.g. the rapid development of genomics and new technologies such as CRISPER[8].

The experts considered that the monitoring and assessment of the state of aquatic genetic resources reporting intervals should be ideally 2–3 years to capture the trends, threats and opportunities. This schedule of reporting would further promote capacity building and continuity, i.e. a body of experts, resource managers, industry representatives and other interested stakeholders that would provide, analyse and use the information.

The experts discussed in general terms the modality for collection and input of data, and institutional aspects of a new information system such as AQUAGRIS. However, very few specifics were discussed at this stage. The DADIS is open to continuous input for example and the AQUAGRIS system could also accept data in this manner.

[7] FAO 2007. State of the World's Animal Genetic Resources for Food and Agriculture. (eds. B. Rischkowsky and D. Pilling). FAO, Rome.
[8] Jao, Li-En, Susan R. Wente, and Wenbiao Chen. 2013. Efficient multiplex biallelic zebrafish genome editing using a CRISPR nuclease system. Proceedings of the National Academy of Sciences 110: 13904-13909.

The above data structure would allow for the monitoring of the status and trends in use and conservation of aquatic genetic resources. However, certain fields in the data structure, e.g. genus and species, name and distinguishing characters would provide an inventory of farmed strains and their wild relatives. This inventory of aquatic genetic resources would be useful to fishery managers, private industry, regulators and consumers. Thus, an information system that contained an inventory and description of aquatic genetic resources for food and agriculture could be created in advance of a system that required regular reporting to monitor status and trends. This inventory would serve as an indicator of the vast genetic resources being used in fisheries and aquaculture; it would also serve as a source of aquatic genetic resources to be accessed as appropriate by stakeholders.

Indicators

Once data have been entered into the information system and a monitoring plan has been established, indicators of the status of aquatic genetic resources will be necessary for resource managers and other stakeholders. Potential indicators should address use and conservation status of the farmed type and wild relatives (Table 6).

Table 6. Indicators for assessing the status of genetic diversity of farmed types and wild relatives

Indicators for farmed type	Indicators for wild relatives
Country level/regional level trends	Extent of distribution
Diversity of production systems	Level of abundance Change in level of abundance Change in trends and level of effective population size (Ne)
Numbers of species, farmed types, population data	Extent of exploitation
Extent of use and conservation of each farmed type • Distribution of production • Total number of farms/farmers using farmed type • Number and size of hatcheries producing the AqGR species, strain etc. • Assess the threats to Farmed AqGR • Genetic diversity (e.g. measures of heterozygosity, number of alleles, gene diversity, polymorphisms and level of inbreeding) • Effective population size – change in trends and level of Ne	Conservation status or risk of loss • Estimate of the risk of introgression/hybridization between farmed types and wild relatives (e.g. escapees, stocking of farmed stock into open waters; translocations) • Level of gene flow between wild relative and farm type • Altered phenotypic traits (e.g. body shape, environmental tolerance) • Altered life history traits (e.g. early maturation, migration pattern) • Loss or change of habitat
In situ and ex situ conservation facilities	Accessions found gene banks (cryobanks or living gene banks) Ex situ collections kept for breeding purposes Numbers of dedicated reserves or protected areas for maintaining wild relative, farm type, stock or strain

The extent to which these indicators will be meaningful relies heavily on how complete the country level information is and how regularly it is provided, i.e. how actively the information system is maintained. Thus, incentives were identified to encourage stakeholders to participate in the information system (see below).

Reference points for management

Once a monitoring system is in place, reference points are needed to indicate when a certain management action is required. The value of the database is that it provides the basis for the development of effective monitoring tools and reference points for countries and stakeholders. For example it would enable a country or sector to determine:

- when the level of inbreeding for a farmed type has reach unacceptable level;

- the risk of losing a strain or wild relative;
- the extent of monopolization/diversification of supply of a species; and
- the risk of introgression of farmed type with wild relatives.

FAO has commonly used target and limit reference points in relation to the precautionary approach to fisheries management and species introduction[9]. Target reference points indicate a desirable situation, whereas limit reference points indicate a situation to be avoided. Some reference points were identified in relation to farmed aquatic species (Table 7).

Table 7. Some reference points regarding AqGR (T= Target and L= Limit reference points)

Number of brood stock for long term maintenance of genetic diversity	Ne = 500 (T)
Number of brood stock for short term maintenance of genetic diversity	Ne = 50 (T)
Levels of inbreeding in the short term	F < .18 (L)
Levels of inbreeding in the long term	F < .05 (L)
Percent sterile fish in production system	100% (T)
Level of gene flow between farmed type and wild relative	Less than 1 migrant/generation (L)
Fishing mortality	Fishing mortality less than 20% of unfished biomass (L); MSY (T)
Risk of extinction	Ne<50 in the wild; order of magnitude decrease in population size

Reference points are related to actions that are developed to manage aquatic genetic resources. For example if the level of inbreeding reached the limit reference point, new genes would be introduced through new broodstock; if fishing mortality was consistently lower than the limit reference point additional harvest could be allowed. These actions would be taken at national or sub-national level in response to the evidence which emerges from the monitoring process. The IUCN Red List and the appendices of the CITES employ a variety of criteria and reference points that indicate when a species should be listed. For CITES it is not management actions that are undertaken in response, but rather actions related to international trade.

Incentives to incorporate information on aquatic genetic resources

The data requirements, and technical and human resource requirements for such an information system are significant. FAO and partners have unsuccessfully tried to establish an information system on aquatic genetic resources. Reasons for the lack past failures centred on lack of dedicated resources and a funding mechanism for such a large undertaking. In order for an information system such as AQUAGRIS to function properly, there must be incentives for countries, resource managers and the private industry to adopt the system and participate in data submission.

Significant constraints to the establishment an AQUAGRIS in addition to financial and technical limitations, include the fact that private industry is often reluctant to disclose proprietary information on their farmed types. Farmers are often reluctant to report species illegally imported, species not permitted for culture or possession (e.g. piranha, CITES or IUCN protected species and invasive species) and new, better-performing strains that are under development for which the farm wishes to keep information confidential.

None the less, there are real and significant benefits to be gained by contributing to an information system on aquatic genetic resources (Table 8). At the national level, contribution to the information system would be seen as part of the sustainable management and advancement of the aquaculture sector. National governments who are signatories to the Convention on Biological Diversity (CBD) and are members of FAO have committed themselves to implement the articles of the CBD, to

[9] FAO 1996. The precautionary approach to fisheries management and species introduction. FAO Fisheries Technical Paper xxx, FAO, Rome.

developing and implanting National Biodiversity Strategic Action Plans under the CBD, and to implementing the articles of the FAO Code of Conduct for Responsible Fisheries. Contributing to AQUAGRIS would be a significant step in meeting those commitments and would open the door for international assistance to facilitate meeting the commitments. National governments would use the information system to coordinate regional actions to enable producers to sustain their access to specific genetic resources.

Private industry would participate in order to reinforce the image of aquaculture as a sustainable and responsible food production sector and make the sector more attractive to improved investment flows. At the farm level improved reporting could qualify farms for subsidies in the case of loss of production or some other forms of financial support. For example in the United States of America, farmers were compensated for increased feed costs if they could demonstrate accurate levels of production that involved the use of fish feed. Communities have been compensated for loss of marine biodiversity following oil spills when accurate fish harvests from the affected area could document the loss.

With the increasing use of markets to promote conservation and sustainability the information system would help meet traceability and labelling requirements as there is usually a requirement for producers to clearly identify the stock being produced and its origin.[10] This has proved successful in pond to fork traceability systems e.g. in shrimp, tilapia and channel catfish, and in efforts to distinguish between farmed and wild species e.g. sea bass in Europe.[11]

Table 8. Incentives for contributing to an information system on genetic diversity

National governments	**Incentives**
	Improved sustainable management and advancement of the aquaculture and fisheries sector
	Meeting commitments to international instruments such as the CBD and the FAO Code of Conduct for Responsible Fisheries
	Access to multi-lateral or bilateral funding sources to help meet commitments to international instruments
	Improved coordination of the aquaculture and fisheries sector to ensure access to and conservation of aquatic genetic resources
Private sector	Strengthened image of the aquaculture sector as sustainable and responsible
	Improved market access through better traceability aquatic organisms and their products
	Improve compliance with national, regional and international certification standards (ecolabelling and other certification schemes) – standard setting bodies
	At farm level to better document production to qualify for subsidies or other financial assistance in the event of lost production
	Improved dissemination and awareness of productive or otherwise important strains or stocks
	Improve compliance with biosecurity standards e.g. OIE and WTO in the case of SPF and SPR strains of shrimp
International	Global record on the status and use of aquatic genetic resources for food and agriculture to complement other global databases e.g. DADIS[12] and IUCN Red List

Institutionalization and implementation issues

Although still at the conceptual stage, there are institutional aspects that will be important to consider early on and will eventually help define an indicative budget for the development of the information system. As stated earlier, information gained through the country reports on new aquatic species farmed and fished, and on new hybrids will be provided to FAO for incorporation into the ASFIS list as appropriate. At the infraspecies level the names and description of new strains or stocks could be

[10] See FAO Technical Guidelines on Aquaculture Certification www.fao.org/docrep/015/i2296t/i2296t00.htm and FishPop Trace https://fishpoptrace.jrc.ec.europa.eu/

[11] Aquatrace https://aquatrace.eu/

added to the Fisheries and Aquaculture Species Fact Sheet.[14] An inventory of new species, farmed types and stocks could be established without the need for monitoring and assessment, and would serve as a global registry on the diversity of aquatic genetic diversity for food and agriculture.

Currently there is no global information system on aquatic genetic diversity that would allow monitoring and assessment and this system would need to be created. Databases do exist that contain genetic information and could serve as sources of information and as models for any new database (Table 9).

Table 9. Examples of databases containing information on aquatic genetic diversity

Database	Description
Genetic	
FishTrace	Species identification using genetic markers (https://fishtrace.jrc.ec.europa.eu/)
FishBol	Species identification using genetic markers (www.fishbol.org/)
FishPopTrace	Origin Assignment, genetic information accessible but genetic data not yet available (https://fishpoptrace.jrc.ec.europa.eu/)
AquaTrace	Origin Assignment; data not yet publicly accessible – work in progress (https://aquatrace.eu/)
SalSea	Potentially a very valuable and comprehensive database on Atlantic salmon genetics but not publically available (www.nasco.int/sas/salsea.htm)
Non-genetic	
DCF	data available through data dissemination too (https://datacollection.jrc.ec.europa.eu
FishFrame	(www.ices.dk/marine-data/data-portals/Pages/RDB-FishFrame.aspx
EMODNET	Overarching databases and information portals (www.emodnet.eu)
BlueBridge	(www.bluebridge-vres.eu)

The information system would need a central hub or home to control and ensure quality of the submission. The mechanisms used by FAO through DADIS could serve as a model. FAO would be a logical center for the system, however as with other information systems, e.g. FishBase, the development of partners or a consortium would be important to move the process forward. Several entities exist (Table 10) that would serve both as information sources and potential partners in a consortium.

Members of the consortium could further help leverage funding as in the Genetic Gain Platform model[15] used by the annual reporting mechanism of the CGIAR breeding programmes (e.g. current state of genetic improvement in the CGIAR) to report to multiple-donors.

Table 10. Potential partners in a consortium to host and manage AQUAGRIS

Entity	Website
FishBase/SeaLife Base	www.fishbase.org; www.sealifebase.org
Barcode of Life	www.fishbol.org
WorldFish Center	www.worldfish.org
Bioversity International	www.bioversityinternational.org

At the country level the responsibility for the maintenance of the database could be lodged with the National Focal Point for AqGR. Formal establishment of this function with an accompanying committee or group of experts will facilitate initial institutionalization of the development of a regular monitoring and reporting system. Questionnaires similar to the one developed for the country reports (i.e. dynamic pdf)[16] would further facilitate data entry and reporting.

[14] www.fao.org/fishery/factsheets/en
[15] http://repository.cimmyt.org/xmlui/bitstream/handle/10883/4818/57801.pdf?sequence=1
[16] www.fao.org/nr/cgrfa/cthemes/aqua/en/

Thus, in addition to the updated ASFIS list, there would be two related information systems: 1) a global inventory of aquatic genetic resources that can be queried; and 2) a monitoring system that can generate trends, indicate status and suggest management responses.

An important consideration is who has authority on data submission and quality control on the data. The information from country reports is official information endorsed by national governments. The information in AQUAGRIS could have the same status, or it could include unofficial information for example from research groups, e.g. universities and government facilities, user groups, e.g. aquaculture associations and private industry, and inter and non-governmental organizations, e.g. regional fishery bodies, CG centers and IUCN. The experts stated that this latter non-official information would be a valuable component of AQUAGRIS and recommended its inclusion. The experts further recommended that information submitted to the system would become public domain, i.e. an open source of information especially if the establishment of the information system were paid for by public funds.

Selected species for proof of concept

The experts recognized the challenges involved in improving existing information systems such as ASFIS and in creating a new system such as AQUAGRIS and recommended initially focussing on a few key species to demonstrate the utility and challenges of the endeavor. The experts identified 13 aquatic groups that represent the breadth of aquatic genetic diversity (Table 11) to serve case studies to demonstrate the proof of concept for the information systemThe 13 groups represent a range of taxa and aquatic habitat, they are all both farmed and fished, and they have significant infraspecific variability. Other potential species considered by the experts were the gastropods *Anadara* spp. and Abalone (*Haliotis* spp); the crustacean Artemia (as a feed species); the ornamental species of giant clam (*Hippopus hippopus*); and the additional finfish turbot, red drum, barramundi and gilthead seabream.

Table 11. Thirteen species as potential case studies for inclusion in AQUAGRIS. All taxa are both farmed and fished and represent a global coverage of AqGR

Taxon	Species	Continent/multi-country	Marine (M) or Inland (I)
Plant (alga and vascular)	Elkhorn sea moss (*Kappaphycus alvarezii/cottonii*)	Asia, Africa	M
	Lotus (*Nelumbo nucifera*)	Asia	I
Micro-organism	Spirulina (*Spirulina species* & varieties)	Worldwide	I
Mollusc	Pacific oyster (*C. gigas*)	Americas/Asia	M
	Manilla clam (*Ruditapes philippinarum*)		M
Crustacea	Whiteleg shrimp (*Lito)penaeus vannamei*	North and South America/Asia	M
	Giant FW prawn *(M. rosenbergii*)	SE Asia, S Asia, Guyana	I
Fish	Atlantic salmon (*S. salar*)	Europe, Chile, Australia, NZ	I/M
	Common carp (*C. carpio*)	Global – temperate to tropical	I
	Nile tilapia (*O. niloticus*)	Global tropical	I
	Pacu (*Piaractus brachypomus /Colossoma macropomum*)	Latin America, Asia	I
	European sea bass (*Dicentrarchus labrax*)	Europe	M
	Catfish (*Clarias/Pangassius/Ictalurus*)	Africa, Europe and Asia	I

CONCLUSION

The experts noted the substantial benefits to be derived from incorporating information on genetic diversity into national reporting and monitoring systems, but further recognized the significant challenges associated with developing an information system that would compile and analyse this information. The experts derived the following general conclusions:

- Genetic information can help improve the reporting at species level in national and global databases;
- Nomenclature is non-standard and inconsistent and therefore needs to be standardized and this standard widely promoted;
- Monitoring genetic diversity would provide a variety of benefits to resource managers, private industry and consumers;
- An information system that would contain an inventory of genetic diversity, i.e. farmed types and wild relatives, would be useful, even without the capacity to monitor changes in genetic diversity;
- Financial resources and capacity building will be required to establish and maintain an information system that would allow monitoring and status and trend analyses;
- Incentives need to be promoted more widely as to why governments and private industry should establish and contribute to existing information systems, e.g. FishStat of FAO at the species level, and any new information system at the genetic level;
- Structures already exist that could accommodate descriptions of genetic diversity as part of an inventory of genetic diversity of farmed types and wild relatives;
- Examples exist of more extensive information systems that allow monitoring of genetic diversity;
- In-depth analysis of the genetic diversity of 13 important species would serve as a useful proof of concept for the development of a new information system;
- Institutional arrangements and a home for the information system need to be defined.

The workshop further recommended key actions to help with the monitoring of and reporting on AqGR (Table 12).

Table 12. A summary of key recommendations to improve monitoring and reporting on AqGR (see Halwart Annex III)

	Recommendations for improving national reporting on AqGR of farmed aquatic species and their wild relatives	Recommendations for improving FAO statistics on AqGRof farmed aquatic species and their wild relatives
Recommendations for improved reporting at the species level	- Capacity building and institutional strengthening on aquaculture data collection, compilation, analysis and reporting. - Improvement of taxonomic classification of farmed aquatic genetic resources and their wild relatives.	- Inclusion of new species items in the ASFIS list. - Capacity building of FAO members on aquaculture data collection, including at the infra-specific level. - Development of guidelines on aquaculture data collection, compilation, analysis and reporting at the infra-specific level.
Recommendations for improved reporting at the infra-specific levels	- Improve characterisation of farmed-types, e.g. hybrids, polyploids, strains, stocks and varieties	- Establishment of a database with capacity to record relevant information and data on aquatic genetic resources below the species level; and at least establish a registry of farmed-types, e.g. hybrids, polyploids, strains, stocks and varieties.

FAO thanked the experts for their contributions and closed the meeting.

ANNEX I

Agenda

Day 1	**Monday, 04 April 2016**	
Time	Topic	Presenter
09.00h – 10.00h	Registration/coffee	
10.00h – 10.15h	Opening speech and welcoming of participants	FAO (Malcolm Beveridge)
10.15h – 10.30h	Participants' introduction	All participants
10.30h – 10.45h	Housekeeping remarks	FAO (Ruth Garcia)
10.45h – 11.00h	Workshop content, process, technical justification and main objective	FAO (Devin Bartley)
11.00h – 11.15h	Introduction to the CGRFA	Secretariat of the CGRFA
11.15h – 11.30h	Introduction to the Aquatic Genetic Resources Component and the steps towards the State of the World's Aquatic Genetic Resources (*SoW AqGR*)	FAO (Matthias Halwart)
11.30h – 12.00h	General discussion	All participants
12.00h – 14.00h	Lunch break	
14.00h – 14.30h	FAO statistics on aquaculture production – current status, major limitations and constraints and future perspectives	FAO (Xiaowei Zhou)
14.30h – 15.15h	ASFIS List of Species for Fishery Statistics Purposes – current status, main limitations and future trends	FAO (Luca Garibaldi)
15.15h – 15.45h	Discussion – all participants	
15.45h – 16.15h	Coffee break	
16.15h – 16.45h	1. – Introduction to the thematic background studies for the *SoW AqGR*. 2. – Thematic background study on statistics.	FAO and World Fisheries Trust (WFT) (Devin Bartley)
16.45h – 17.15h	Review of FAO statistical data and data from country reports (under the *SoW AqGR*): number of farmed genetic types (species and below the level of species) reported by countries in both systems.	FAO (Ruth Garcia)
17.15h – 17.45h	Case studies on aquaculture data inconsistency (e.g. for specific species and/or specific countries and regions)	FAO (Xiaowei Zhou)
17.45h – 18.15h	Special Concerns for AqGR data reporting (e.g., governance and policies, national capacities, confidentiality, etc.)	FAO (Ruth Garcia)

Day 2	**Tuesday, 05 April 2016**	
Time	Topic	Presenter
09.00h – 10.30h	Discussion on the selection of top-5/top-10 aquatic species for long-term genetic data assessment: - Establishment of selection criteria for inclusion (e.g., contribution to national, regional, global food security, etc.). - List of potential key species	All participants FAO/WFT officers as moderators
10.30h – 11.00h	Coffee break	
11.00h – 12.00h	Discussion on the type of data and information to be collected, compiled and analysed for selected top-5/top-10 species.	All participants FAO/WFT officers as moderators
12.00h – 13.30h	Lunch break	
13.30h – 15.30h	Discussion on possible information sources for selected top-5/top-10 species	All participants FAO/WFT officers as moderators
15.30h – 16.00h	Coffee break	
16.00h – 16.30h	Wrap up	All participants

Day 3	**Wednesday, 6 April 2016**	
Time	Topic	Presenter
09.00h – 10.00h	Review of previous discussion items (e.g., ASFIS list, top-5/top-10 species, issues for data collection, etc.)	All participants FAO/WFT officers as moderators
10.00h – 10.30h	Coffee break	
10.30h – 12.00h	General discussion on strategies to incorporate genetic data into FAO and National statistics	All participants FAO/WFT officers as moderators
12.00h – 13.30h	Lunch break	
13.30h – 15.00h	Conclusion on strategies to incorporate genetic indicators into FAO and National statistics	All participants FAO/WFT officers as moderators
15.00h – 15.30h	Coffee break	
15.30h – 17.00h	Final discussion and recommendations	All participants

ANNEX II

LIST OF PARTICIPANTS

Name	Organization	E-mail
Invited Experts		
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ANNEX III

ABSTRACTS OF PRESENTATIONS

Review of FAO statistical data and data from the State of the World's Aquatic Genetic Resources for Food and Agriculture country reports

Ruth Garcia Gomez

The FAO's Fisheries and Aquaculture Department is leading the preparation of the First State of the World's Aquatic Genetic Resources for Food and Agriculture (SoW AqGR), under the umbrella of the Commission on Genetic Resources for Food and Agriculture (CGRFA). The SoW report is being developed following a country-driven approach, based on information and data provided by FAO members through their National Focal Points on Aquatic Genetic Resources, which is being complemented by specific thematic background studies and information and data from relevant international organizations.

The reporting process implemented by FAO members through their country reports has given an excellent opportunity to the FAO's Fisheries and Aquaculture Department to review and assess data reported by countries through the official FAO fisheries and aquaculture statistics. This presentation is focused on the comparison of data obtained through the SoW process and data from FAO official statistics, in order to identify main gaps, inconsistencies and limitations of both reporting process, with a clear objective on the streamlined and improvement of both processes.

The current status regarding country reports on the status of aquatic genetic resources for the first SoW is presented below:

- There are 72 officially nominated National Focal Points on Aquatic Genetic Resources.
- A total of 57 officially submitted country reports on the status of aquatic genetic resources for food and agriculture.
- 57 countries account for 42 percent of the total number of countries reporting aquaculture data to FAO in regular bases (135 countries in 2014).
- 57 countries account 92 percent of the global aquaculture production in volume (China case).
- The FAO's Fisheries and Aquaculture Department is expecting to have around 70–80 country reports at the end of 2016.
- 11 of the top-15 producers in the world have submitted their reports.
- Specific strategies to obtain the remaining 4 reports and to increase the number of officially submitted questionnaires:
  - Regional workshop in Asia.
  - Regional workshop in Central-Asia and Eastern Europe.
  - Regional workshop in Africa.
  - Exchange with FAO Representatives and Fisheries/aquaculture colleagues.

A basic comparison of data from the country reports on aquatic genetic resources prepared for the SoW and the FAO official fisheries and aquaculture statistics, both at species and sub-species (hybrids) levels gives us a clear picture of some of the major inconsistencies found: (1) differences regarding the total number of farmed species in a given country; (2) species that are no longer being farmed in a country but are still being reported to statistics; (3) species being currently farmed by a country but not reported because of various reasons; (4) species not reported because they are not included in the ASFIS list; and (5) new hybrids that are not reported because they are not included in the ASFIS list.

A brief summary is provided below:

- Differences regarding the number of farmed species, main reasons:
  - Additional species that haven't been reported to FAO official statistics.
  - Species that are no longer being farmed.
  - Aquatic microorganisms used as live feed and other applications.

- o Additional hybrids.
- o Information at sub-species level (just a few countries).

The country reports for the SoW report they also provide additional useful information:

- Qualitative future trends in production by species.
- List of potential species/species of interest for aquaculture diversification.

Table 1. Example of differences between the number of farmed species reported by countries through the SoW process and to the FAO Fisheries and Aquaculture Department's official statistics (Fishstat):

Country	Species in Sow			Species in FishStat
	Total	**In ASFIS**	**No ASFIS**	
Philippines	56	46	10	28
Venezuela	8	8	0	16
Vietnam	69	47	22	25
Tanzania	7	7	0	7
Malaysia	52	46	6	42
Japan	24	14	10	44
Paraguay	12	12	0	11
Iran	19	17	2	10
Colombia	24	0	11	24
Kenya	36	13	23	6
Lao	7	5	2	14
Tonga	12	8	4	8
Malawi	5	4	1	9

To conclude, a basic list of major limitations regarding reporting at sub-species levels included:

- Limited phenotypic and/or genotypic characterization.
- Limited standardization.
- Big differences between regions, sub-regions, countries and at national level.
- Hybrids: different approach.
- Good example – China: establishment of accredited national stock aquatic farms (PEDIGREE Centres).

The Aquatic Genetic Resources component under the FAO Commission on Genetic Resources for Food and Agriculture

Matthias Halwart

Fisheries and aquaculture are crucial for food security, poverty alleviation and general well-being especially for many poor people around the world. Capture fisheries for food, industrial (fishmeal and fish oil), ornamental, sport and baitfish species target about 5 000 species. Aquaculture involves the farming of over 500 species of finfish, molluscs, crustaceans and other invertebrates, about 20 species of seaweeds, over 30 species of freshwater macrophytes, a few species of amphibians and aquatic reptiles as well as about 50 species of microalgae and invertebrates as fish food organisms in hatcheries. Capitalizing on the enormous potential of aquatic genetic resources requires overcoming specific constraints:

- Lack of information regarding the genetic characteristics, performance, location and accessibility of fish genetic resources and regarding threats to their survival.
- Inadequate national programmes and information systems for aquatic genetic resources.
- Lack of a global policy and management approach to aquatic genetic resources.

The FAO's Fisheries and Aquaculture Department is leading the preparation of the First State of the World's Aquatic Genetic Resources for Food and Agriculture (SoW AqGR), under the umbrella of the Commission on Genetic Resources for Food and Agriculture (the Commission, CGRFA). Main outputs and milestones on AqGR under the Commission's programme of work are:

- Presentation of The State of the World's Aquatic Genetic Resources (2017) as a country driven process.
- Development of elements related to the Code of Conduct for Responsible Fisheries aimed to maintain a broad genetic basis to ensure sustainable use and conservation of AqGR (2018–2019).

Recognizing the urgency of the situation, and as a first step toward compiling the first report on The State of the World's Aquatic Genetic Resources for Food and Agriculture for completion in 2017, the Commission launched a review of existing information systems, and will work to develop a more informative reporting system for national and international organizations. With the number of farmed aquatic species, strains, hybrids and other genetic resources increasing, information systems are needed in order to identify and determine their relative contributions to farmed fish production. Similarly, better information on the genetics of wild fish populations should contribute to better understanding of how they can be conserved and used sustainably.

At its 13th and 14th Regular Sessions, the Commission considered the Scope of The State of the World's Aquatic Genetic Resources: ***Farmed aquatic animals and their wild relatives within national jurisdiction.*** At its 14th Regular Session, the Commission agreed on the structure and contents of the SoW AqGR, approving the "Guidelines for the Preparation of Country Reports for the State of the World's Aquatic Genetic Resources for Food and Agriculture". The Commission called on countries to participate in the process by preparing national reports on aquatic genetic resources and to strengthen related information systems.

Therefore, the steps towards the finalization of the first SoW AqGR are:

- Nomination of National focal points
- Guidelines for preparation of country reports
- Country reports elaboration and submission
- Thematic background studies
- Reports from International Organizations
- Data and information collection by FAO
- Review by the Intergovernmental Working Group on AqGR
- Submission of a First draft of the Report to the Commission
- Development of elements related to the Code of Conduct of Responsible Fisheries

The FAO's Fisheries and Aquaculture Department is leading the coverage of AqGR, under the monitoring of the CGRFA, in collaboration with:

- The FAO Committee on Fisheries (COFI).
- The FAO Sub-committee on aquaculture (COFI/AQ).
- Regional organizations and networks involved in aquaculture.
- FAO Regional, sub-regional and country offices.
- National focal points on aquatic genetic resources.

Since the Commission's last session, the FAO's Fisheries and Aquaculture Department has undertaken the following initiatives towards the preparation of the SoW AqGR:

- Revision and translation into all UN languages of the Guidelines and Questionnaire for the Preparation of Country Reports for the State of the World's Aquatic Genetic Resources for Food and Agriculture in accordance with the Commission's decision on the scope of the SoW AqGR.
- Prioritization of thematic background studies to be prepared for the SoW AqGR in accordance with the Commission's request.
- Organization of three capacity building Regional Workshops: Africa, LAC and Asia-Pacific.
- 72 National Focal Points on Aquatic Genetic Resources have been officially nominated, and 47 National Reports have been submitted, and are currently being analysed.

Main recommendation from this expert workshop should be focused on 4 main areas of action:

Key actions	Recommendations for improving national reporting on AqGR (farmed species and their wild relatives)	Recommendations for improving FAO statistics on AqGR (farmed species and their wild relatives)
Recommendations for improving reporting at aquatic species level		
Recommendations for improving reporting below the species level (infra-specific levels)		

The ASFIS List of species for fishery statistics purposes

Luca Garibaldi

Capture fisheries and aquaculture production is made up of a huge number of species in comparison to other food-producing sectors (e.g. livestock and agriculture). Recent updates with 2014 data of FAO's global capture and aquaculture production databases included statistics for 2 033 and 580 species items respectively.

The "ASFIS list of species for fishery statistics purposes" was established in 2000 to make available to national correspondents submitting statistics to FAO and fishery agencies a codification e-system covering most of the species related to fishery activities.

Each record in ASFIS contains three codes**,** taxonomic information, FAO names in six languages, and yes/no info if that record has fishery production statistics in the FAO databases.

Codes

- ISSCAAP code: according to the FAO "International Standard Statistical Classification for Aquatic Animals and Plants" (ISSCAAP), which divides commercial species into 50 groups on the basis of their taxonomic, ecological and economic characteristics
- Taxonomic code: used by FAO for a more detailed classification of the species items and for sorting them out within each ISSCAAP group
- 3-alpha code: an unique code made of three letters that is widely used for the exchange of data with national correspondents and among fishery agencies

Taxonomic information

- Scientific name by "species item": this is the term used for the statistical taxonomic unit, which can correspond to species, genus, family or to higher taxonomic levels (no subspecies)
- Author name(s): only for "species items" at the species level
- Family
- Higher taxonomic level: order or class, etc.

FAO names in six languages

- English (75 percent of the records)
- French (40 percent)
- Spanish (36 percent)
- Arabic (17 percent)
- Chinese (20 percent)
- Russian (5 percent)

FAO names are not intended to replace local species names, but they are considered necessary to overcome the considerable confusion caused in some cases by the use of a single name for many different species, or several names for one species. As FAO deals with aquatic species at a global level, selected names should be recognizable as much as possible at both local and international levels.

The first version of the ASFIS List released in 2000 included 10 275 records. Only FAO-FIAS, being the manager of the list, can create or modify records. An update with new and modified records is prepared every year after the closure of the FAO production databases and it is released at about April. The 2016 annual update included 12 700 records.

The ASFIS list has no authority on taxonomic matters and to resolve uncertain cases specialized sources are consulted. Given its fishery statistics purposes, updating of the ASFIS list follows a pragmatic and conservative approach. Changes of scientific names and creation of new species proposed by taxonomists in the literature are included in the ASFIS list only when such changes have been recognized by the majority of taxonomists and are well consolidated among people dealing with fishery matters and, in particular, fishery statistics. For the most controversial cases, the ASFA database has been consulted to verify if a newly proposed scientific name has become of current use.

Currently, the ASFIS List includes 11 records for hybrids (see Table A). Only 5 out of 11 records for hybrids have aquaculture production statistics associated with them. Hybrids do not fit into the standard ten-digit classification of the taxonomic code. For hybrids and other special cases (e.g. scientific names used for more than one species item, etc.) three additional digits are added resulting in a 13-digit code. Items with 13-digits are created only when strictly necessary as they disrupt the consistency of the list and create problems in the management of the database (e.g. the three additional digits are not shown in the FAO Yearbooks).

However, the Workshop could identify some (around 5–10) additional hybrids for which is supposed that aquaculture production statistics will be submitted in the future and request their inclusion in the ASFIS List. It is important to clarify that submission of statistics for a species item not included in ASFIS does not prevent the input of the data into the FAO production databases because a new record is added to ASFIS when statistics are reported and the item is not yet listed in ASFIS.

To download the ASFIS List: www.fao.org/fishery/collection/asfis/en
Contact: Luca.Garibaldi@fao.org

Reference

Hard copy version of the ASFIS List:
Garibaldi, L. and S. Busilacchi (comps.), 2002. ASFIS list of species for fishery statistics purposes. *Aquatic Sciences and Fisheries Information System Reference Series,* No. 15. Roma, FAO. 258 pp.

Table A. Records for hybrids in the 2016 releases of the ASFIS List

ISSCAAP	TAXOCODE	3A_CODE	Scientific_name	English_name	French_name	Spanish_name	Arabic_name	Chinese_name	Author	Family	Order	Stats_data
12	[illegible]	OXW	Oreochromis aureus x O. niloticus	Blue-Nile tilapia, hybrid		Tilapia azul del Nilo, híbrido		[illegible]		Cichlidae	PERCOIDEI	Yes
13	[illegible]	TAZ	C. macropomum x P. brachypomus	Tambatinga, hybrid						Characidae	CHARACIFORMES	Yes
13	[illegible]	TAY	P. mesopotamicus x C. macropomum	Tambacu, hybrid		Paratama, híbrido				Characidae	CHARACIFORMES	Yes
13	[illegible]	CGM	Clarias gariepinus x C. macrocephalus	Africa-bighead catfish, hybrid	Poisson-chat, hybride	Pez gato, híbrido	[illegible]	[illegible]		Clariidae	SILURIFORMES	Yes
13	[illegible]	SBH	Morone chrysops x M. saxatilis	Striped bass, hybrid	Bar d'Amérique, hybride	Lubina estriada, híbrida	[illegible]	[illegible]		Moronidae	PERCOIDEI	Yes
12	[illegible]	AXV	Oreochromis andersonii x O. niloticus							Cichlidae	PERCOIDEI	No
13	[illegible]	[illegible]	Channa maculata x C. argus					[illegible]		Channidae	OTHER PERCIFORMES	No
13	[illegible]	TGS	P. mesopotamicus x P. brachypomus	Patinga, hybrid		Patinga, híbrido				Characidae	CHARACIFORMES	No
13	[illegible]	IIP	Ictalurus punctatus x I. furcatus	Channel-blue catfish, hybrid				[illegible]		Ictaluridae	SILURIFORMES	No
13	[illegible]	PIQ	Leiarius marmoratus x P. reticulatum							Pimelodidae	SILURIFORMES	No
13	[illegible]	PXW	Pseudopl. corruscans x P. reticulatum							Pimelodidae	SILURIFORMES	No

Incorporating genetic diversity and indicators into statistics and monitoring of farmed aquatic species and their wild relatives

Devin M. Bartley and Xiaowei Zhou

The FAO Commission on Genetic Resources for Food and Agriculture, realizing that substantial production from aquaculture and capture fisheries is based on groups below the level of the species and that genetic information has a variety of uses in fishery management, requested FAO to undertake a thematic study to explore incorporating genetic diversity and indicators into statistics and monitoring of farmed aquatic species and their wild relatives.

FAO serves as the global repository for national statistics on fisheries and aquaculture production. The international standard for reporting this production is the Aquatic Sciences and Fisheries Information System (ASFIS) list and the classification system of the International Standard Statistical Classification of Aquatic Animals and Plants (ISCAAP). To date the ASFIS list nomenclature includes only twelve taxa below the species level, i.e. interspecies hybrids (Table B). The nomenclature does not include any subspecies, stocks, strains or varieties of farmed species or their wild relatives. FAO as developer and curator of the ASFIS nomenclature is reluctant to add additional items to the list unless it can be shown that the new taxon, i.e. subspecies, new hybrid or stock/strain/variety, would be reported in a reliable and consistent manner by members of FAO.

Information about aquatic genetic resources can be extremely useful to resource managers, policy makers, private industry and the general public. Not only is genetic diversity the basic building block for selective breeding programmes in aquaculture and for natural populations to adapt to changing environments and evolve, information on genetic diversity can be used *inter alia* to help meet production and consumer demands, to prevent and diagnose disease, to trace fish and fish products in the production chain, to monitor impacts of alien species on native species, to differentiate cryptic species, to manage broodstock, and to design more effective conservation and species recovery programmes. However, the majority of resources managers and those government officials submitting information to FAO, do not use or have sufficient access to information of aquatic genetic diversity of farmed species and their wild relatives.

An examination of the literature, discussions with aquaculturists and some of the country reports submitted for the production of the first State of the World's Aquatic Genetic Resources for Food and Agriculture, revealed several more hybrids and numerous stocks and strains of farmed species and their wild relatives that are contributing to global fishery production. These species for which substantial genetic diversity exist include *inter alia* tilapia, snakehead, groupers, barbs, sturgeon, common carp and catfishes. For some natural populations, genetic differentiation has been acknowledge by declaring them subspecies, e.g. cutthroat trout in North America, common carp in Asia and Eastern Europe and Nile tilapia in Africa.

Examples of incorporating genetic diversity into national and global reporting and monitoring do exist, but primarily in the terrestrial agriculture sector where nomenclature for breeds and varieties has been standardized and used for centuries. In the aquaculture sector, the establishment of breeds of most species is a much more recent practice and thus the nomenclature and characterization of breeds is not standardized. In capture fisheries genetic diversity is sometimes used in fishery management of high value species, but this is dependent on the establishment of baseline data, the availability of which is limited for many species. The high financial and technical requirements for using genetic diversity for fishery management render this option beyond the capacity of many areas. Stock identification in capture fisheries has traditionally been based on geographic location; production has been reported and monitored accordingly. Some countries maintain registries of nationally important aquatic species, but production information is not routinely included unless the stock or species is considered threatened or endangered.

The lack of standardized description of a 'strain' or 'stock' constrains the use of information below the species level in national and global reporting. Further constraining the use of genetic diversity is the lack of complete baseline data that genetically characterize a strain or stock, and the fact that the private aquaculture industry often views genetic information on their product as proprietary.

Options do exist for incorporating genetic diversity into statistics and monitoring programmes and include:

- Regular reporting by national resource managers using ASFIS after standard and consistent nomenclature has been established and agreed;
- Semi-regular reporting e.g. every four years, by national resource managers or groups of experts (with or without modifying the ASFIS list);
- Reporting on a limited number of commercially important species as case studies in order to establish nomenclature and reporting standards;
- Ten year reporting through the State of the World's Aquatic Genetic Resources for Food and Agriculture process and coordinated by national focal points;
- Ad hoc listing of strains and/or stocks of important species.

These options all entail increased resources and capacity, as well as the participation and cooperation of private industry. As a result some options may not be practical or cost effective in many areas. A plausible first step could be the establishment of a standard nomenclature for strains or stocks of key aquatic species.

Once clear designations of what level of genetic diversity will be monitored and reported, appropriate indicators can be developed and agreed. At present, the main indicator of the state of genetic diversity of a breed or stock is the number of individuals. In general, genetic diversity is directly related to population size. Other indicators at the genetic level include level of heterozygosity, allelic diversity, rate of gene-flow, inbreeding coefficient and effective population size. These indicators have been used in specific cases involving important, high value or endangered species.

In light of the need to efficiently feed a growing human population, national resource managers and the public will be well served by incorporating genetic diversity information into national management, reporting and monitoring programmes and then reporting this information to the global community. This will involve increased resources and capacity building in many areas of the world.

Table B. Hybrids listed in the ASFIS list and indication of whether data are reported

Scientific name	English name	Family	Order	Data
P. mesopotamicus x C. macropomum	Tambacu, hybrid	Characidae	CHARACIFORMES	yes
C. macropomum x P. brachypomus	Tambatinga, hybrid	Characidae	CHARACIFORMES	yes
Clarias gariepinus x C. macrocephalus	Africa-bighead catfish, hybrid	Clariidae	SILURIFORMES	yes
Morone chrysops x M. saxatilis	Striped bass, hybrid	Moronidae	PERCOIDEI	yes
Oreochromis aureus x O. niloticus	Blue-Nile tilapia, hybrid	Cichlidae	PERCOIDEI	yes
Oreochromis andersonii x O. niloticus		Cichlidae	PERCOIDEI	no
P. mesopotamicus x P. brachypomus	Patinga, hybrid	Characidae	CHARACIFORMES	no
Ictalurus punctatus x I. furcatus	Channel-blue catfish, hybrid	Ictaluridae	SILURIFORMES	no
Channa maculata x C. argus		Channidae	OTHER PERCIFORMES	no
Leiarius marmoratus x P. reticulatum		Pimelodidae	SILURIFORMES	no
Pseudopl. corruscans x P. reticulatum		Pimelodidae	SILURIFORMES	no

Usefulness and limitation of FAO global Aquaculture Statistics in monitoring the utilization of aquatic genetic resources

Xiaowei Zhou

Collection of national aquaculture production statistics worldwide and dissemination are integral part of the regular FAO fisheries and aquaculture statistics related programme activities. Compared with capture fisheries statistics, FAO's aquaculture statistics collection system is relatively new and was developed in the 1980s by borrowing experiences and structure of capture fisheries statistics. The prevailing FAO aquaculture statistics collect, stores and disseminate national aquaculture production quantity data and value data by species, by production areas, by type of water used and by the farming method used. Additional data on aquaculture hatchery/nursey production and the use of land/water areas and specific production facilities are also collected from the national authorities.

National aquaculture production quantity and farm gate value registered in FAO database include (a) data reported by national governments, (b) data harvested by FAO from alternative sources, and (c) data estimated by FAO for non-reporting countries and missing data, based on evidence and information available to FAO. Aquaculture production quantity and value data registered in FAO database are categorized into the basis statistical units called "species items", referring to species, genus, family or higher taxonomic levels. The species items are the standard names in certain structured manner set by the list of Aquatic Sciences and Fisheries Information System (ASFIS). The production of species items can be grouped at different aggregate levels according to the classification system of the International Standard Statistical Classification of Aquatic Animals and Plants (ISCAAP). The ASFIS list and ISCAAP classification are used for both capture and aquaculture production statistics.

For the purpose of monitoring the status and trend in the utilization aquatic genetic resources in aquaculture at national, regional and global levels, the current existing FAO aquaculture statistics are useful information baseline at species level and above species levels. While much of the aquaculture productions worldwide are reported and registered at species level, there are also large volume of aquaculture production identifiable only at higher taxonomic levels due to various reasons such as the difficulty in species identification, use of a mixture of species in aquaculture and confidentiality of data according to national laws that govern the release of statistical information.

According to the Global Aquaculture Production Quantity and Value Statistics 1950–2014 published in March 2016, a total of 580 species items, including those once farmed in the past, have been registered with production data by FAO. These species items include 362 finfishes (including hybrids), 104 molluscs, 62 crustaceans, 6 amphibians and reptiles, 9 aquatic invertebrates, and 37 aquatic plants.

Limited by the nature of ASFIS list, existing FAO aquaculture statistics system cannot accommodate or reflect additional genetic characteristics the farmed aquatic organisms such sub-species, strains and varieties, etc. However, several artificial interspecific hybrids with desirable traits for farming have been registered by FAO with production data. Inclusion of more artificial hybrids in the ASFIS list is possible if the producing countries their productions to FAO.

Among the 580 species items, 440 (76 percent) of them are single species and the rest are aggregates at genus or higher levels. In 2014, aquaculture production registered at single species level collectively accounted for 66 percent of the total world production of 101 million tonnes aquatic animals (73.8 million tonnes), aquatic plants (algae, 27.3 million tonnes) and non-food products (48 thousand tonnes). The production registered at genus level was 25.8 million tonnes, or 26 percent of the total aquaculture production.

Number and type of species items with production data registered by FAO	
Number of species items at species level (including hybrids)	440
Number of species items at genus level	86
Number of species items at family or higher level	54
TOTAL	**580**

Not all the species items appear as single species are real single species and may actually include more than one species. For example, the production of all farmed channel catfish (*Ictalurus punctatus*) in the United Stated of America registered in the statistics actually include channel catfish, blue catfish (*Ictalurus furcatus*) and their hybrid. The production from China registered as Amur catfish (*Silurus asotus*) in fact include several other catfish species in the genera *Silurus* and *Clarias* and interspecific hybrids of these species. Before reliable information becomes available, FAO is prevented from disaggregating those untrue single species production into more than one species.

At its 15th Regular Session held in Rome in 2015, the Commission on Genetic Resources for Food and Agriculture requested FAO to develop and finalize a thematic study on "Incorporating genetic diversity and indicators into statistics and monitoring of farmed aquatic species and their wild relatives." The following report includes the discussions and outputs of an expert group that addressed the topic, Incorporating genetic diversity and indicators into regular statistics and monitoring of farmed aquatic species and their wild relatives

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