Contribution to the:

European Commission Consultation on the Common Fisheries Policy Control System Reform

The Potential and Applicability of Modern Technologies based on Biotechnology, Genetics, Chemistry and Forensics for Fisheries Control.

The FishPopTrace Consortium

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FishPopTrace

European Commission Consultation on the Common Fisheries Policy Control System Reform

The Potential and Applicability of Modern Technologies based on Biotechnology, Genetics, Chemistry and Forensics for Fisheries Control

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Summary

Monitoring, Control and Surveillance (MCS) form an integral part of sustainable fisheries management and are an intrinsic component of the Common Fisheries Policy (CFP). Efficient means to guarantee enforcement in the case of non-compliance are crucial to a successful implementation of existing rules, since they promote fairness, sustainable fisheries and support socio-economic stability as well as conservation measures.

In this respect monitoring and control of fishing activities by remote sensing technologies is well established and anchored in EU legislation[1]. However a corresponding EU-wide infrastructure based on modern technologies, derived from the fields of **biotechnology**, **genetics, chemistry and forensics**, to ensure compliance among all operators with existing rules, and referred to in the EU legislation is not yet available.

In this document we summarize the potential and value of such technologies for MCS, by addressing some of the issues and pitfalls raised in the consultation paper on the CFP control system reform published by the European Commission. We discuss under which circumstances these technologies are applicable and propose a future venue to ensure the integration of such technologies into a MCS and enforcement framework under the CFP remit. We argue that due to the rapid ongoing progress in the development of modern technologies there is a major opportunity to transfer the results of these developments to fisheries control applications. We believe furthermore that an interdisciplinary dialogue should be established immediately not to miss this opportunity. While we mainly refer to objective No.7 ("Use of modern technologies"), we would like to point out that the use of technologies as described by us do also have a considerable impact on objectives No.1 ("Develop a new approach as regards inspection and control") and No.8 ("Increase cost effectiveness").

We specifically conclude that:

1. There is an urgent need for the CFP control system to establish further control and enforcement measures, which are independent of primary information provided by the parties to be controlled (such as catch data by fishermen or labelling by suppliers), certifiable across the EU, and lead rapidly to results, while being cost effective;
2. Analytical methods based on modern technologies do fulfil the above mentioned criteria and can sustain traceability of fish and fish products;
3. Such technologies are in principle available, but a coherent and consistent approach for their transfer into applications for fisheries control is currently lacking;
4. Numerous results of value for MCS have already emerged from research in the EU and elsewhere, but due to dispersion and heterogeneity, their transfer into MCS applications is greatly impeded;
5. A major EU wide effort should therefore be made to generate continuity, homogeneity and coherence in the area of research and technology development related to MCS;
6. Tools for MCS should be developed by scientists in close cooperation with the end-users (such as inspectors and enforcement bodies) of such applications;
7. To be applicable in a forensic and legal framework these methods should be certified and validated and come under scrutiny according to highest international standards;
8. The realisation of a truly Pan-European MCS framework, based on modern technologies, will depend on intense cooperation between all stakeholders, including scientific institutions, control authorities, economists and policy makers;
9. This multidisciplinary cooperation would ideally be initialized and supported by a summit, with the aim to identify and develop implementation strategies, and reporting to the European Commission.

[1] COUNCIL REGULATION (EC) No 1966/2006 on electronic recording and reporting of fishing activities and on means of remote sensing; Official Journal of the European Union L409 (30.12.2006), pp.1.

Definition of modern technologies for fisheries control

For the purpose of this document, for reasons of simplicity and to facilitate comprehension, by using the term "modern technologies" we refer to methods and technologies emanating from molecular biology, biotechnology, genetics, genomics, proteomics, biochemistry, microchemistry and forensics.

The value of modern technologies for fisheries control

Catch reporting and recording has been identified as one of the weakest points in the current CFP control scheme for fisheries by the European Court of Auditors[2] and the European Commission. Modern technologies can supply data independent of primary information provided by the parties to be controlled (such as catch data by fishermen). They are therefore ideally suited to sustain control schemes. The same is true in the context of establishing a control regime in support of traceability. Currently the measures to reduce opportunities for infringements after the landing or during the import of fish into the EU rely essentially on documentation at every stage during the processing and marketing chain which has to be transmitted to the relevant authorities. Monitoring is further supported by provisions in the reformed Common Organisation of the Markets, where rules have been introduced for labelling of live, fresh and chilled fishery products. The name of the species, the method of production (inland, sea fishing or aquaculture) and the area where the fish was caught or reared has to be provided[3].

These measures certainly raise the hurdle for breaching regulations, and support consumer protection, information and confidence building. However, mislabelling is worldwide an imminent problem and has severe consequences, such as resource losses, consumer misconceptions, economic losses and it leads to a feeling of insecurity on the consumer side[4]. It would therefore be indeed a major improvement if labelling rules, basically a "faith-based" system since it primarily relies on the information provided by the supplier, could be monitored by independent control methods. This is especially true in the context of an ever increasing complexity of the fish marketing pattern and the great dependence of the EU on fish imports[5].

From an analytical point of view, control in the fisheries sector can relate to either the species used for a product or the determination of the geographic origin of where the fish was caught. Both aspects will be delineated in the following.

Species identification

Seafood substitution, *i.e.* fraud in the sale of seafood by substituting species of lower value for a more valuable species has a high incentive and occurs frequently[6].

Fish species can be identified by visual inspection of the external features provided the fish is intact. In this case a basic education in fish species determination will be sufficient, and only if there is a high degree of resemblance between species will expert taxonomic knowledge be necessary. Other methods based on visual inspection like species identification by otoliths (fish ear-bones) exist, but they require specialized knowledge and the availability of the feature to be examined.

For traceability, fish species identification should ideally be possible on processed fish (fillets, canned and cured fish etc.) and not depend on a highly specialized educational background. In this

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[2] European Court of Auditors (2007) *Special Report No 7/2007 (pursuant to Article 248(4) second paragraph, EC) on the control, inspection and sanction systems relating to the rules on conservation of Community fisheries resources together with the Commission's replies*.

[3] European Commission (2002) "The common organisation of the markets in fishery and aquaculture products" ISBN 92-894-2125-8

[4] Jennifer L. Jacquet and Daniel Pauly (2008) *Trade secrets: Renaming and mislabelling of seafood*, Marine Policy; In Press.

[5] European Commission (2007) *Trade in agricultural goods and fishery products*. (http://ec.europa.eu/trade/issues/sectoral/agri_fish/fish/index_en.htm; updated March 2007)

[6] Source: European Commission DG Fish D – personal communication, and US Food & Drug administration (http://www.cfsan.fda.gov/~frf/econ.html)

respect identification based on DNA sequence analysis is very well suited. Immense progress has been made in the area of species identification based on molecular biology methods. This is emphasized by the Fish Barcode[7] of Life initiative (FISH-BOL - http://www.fishbol.org/). FISH-BOL is a global endeavour aiming at the assembly of a standardised reference DNA sequence library for all fish species. The identifying DNA sequence is derived from voucher specimens, which are in parallel identified by taxonomists. Currently more than 4000 fish species are barcoded (April 2008). In the USA, groups within the National Atmospheric and Oceanic Administration (NOAA) already integrate the FISH-BOL database for species identification purposes into their support for fisheries inspection and control paralleled by attempts to develop a vouchered NOAA DNA sequence database[8]. Interestingly in Europe such a vouchered database already exists (FishTrace – www.fishtrace.org) and it is planned to use specimen of FishTrace also for FISH-BOL. Additionally there is a European working group actively supporting the extension and maintenance of FISH-BOL[9]. However, regrettably, a link between these projects and control/enforcement bodies or policy makers does not yet exist.

The species identifying DNA sequences are publicly accessible and therefore available for control authorities. For control purposes a possible scenario would therefore be that inspectors take samples of fish or fish products, and send those to certified analytical laboratories. The laboratories would determine the DNA sequence and send the result back to the control authorities in charge. In this scenario the expert knowledge needed (DNA sequencing and analysis) is available through officially recognised laboratories that adopt appropriate forensic standards. In favour of such an approach, DNA sequencing results can be obtained rapidly, and at low cost, even when starting from tissue samples[10].

A further development in this setting would be DNA-microarrays (also called DNA-chips)[11]. It is possible to monitor thousands of different (*i.e.* species identifying) DNA sequences simultaneously with one such chip (size about 1x1cm). While the development of DNA-microarrays is still considerably laborious, the running costs using this chip are moderate. Theoretically using just one chip it would be possible to screen for all major economic fish species simultaneously. This could be a valuable asset when examining blocks of frozen imported fish of which the species composition is dubious[12]. Microchip technology would allow rapid identification of the species contained in such fish admixtures and to validate the content and labelling specifications.

Origin assignment

Determining where a fish has been caught would greatly help to confirm breaches of fisheries regulations. For instance identifying a fish as having been caught from a closed area would clearly help monitoring and control.

Generally misrepresenting where a fish has been caught constitutes a huge challenge to control authorities. In the context of the CFP this aspect is of very high importance, since the allocation of total allowable catches (TACs) is a cornerstone in the management of Community fisheries resources. Each Member State is allocated a quota of the TAC of a species for which they bear managing and monitoring responsibility. They must take the necessary steps to avoid quota overruns, if necessary by closing the fisheries concerned. The Commission verifies that the Member States fulfil their obligations and has the possibility of stopping the exploitation of a particular stock on its own initiative. The incentive of breaching such measures is potentially high since presenting a fish taken in

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[7] "Barcoding" refers here to the use of a short DNA sequence, from a specific locality on the genome, used for identifying species (see also http://www.dnabarcodes.org/)

[8] Personal Communication with Dr. Linda Park; Program Manager of the Genetics and Evolution Program; NOAA; USA.

[9] Chaired by Prof. R. Carvalho; University of Bangor; Wales; UK.

[10] For barcoding of fish a 655 base pair long region of the mitochondrial cytochrome c oxidase subunit I gene (COI) is used. Currently DNA sequencing enterprises firms can deliver results within 24hrs and costs would be roughly between 10 and 30 Euros per sequenced fish sample. Prices for sequencing have a clear and steep downward tendency.

[11] M. Kochzius *et al.* (2008) "*DNA Microarrays for Identifying Fishes*"; Marine Biotechnology 10 pp.207.

[12] Occurrence reported by the European Commission DG Fish.D.

an area where the quota was used up as having been caught in an area with a less restrictive quota could bring substantial financial gain.

However, determining where a fish has been caught is only feasible if:

1. A population of a given fish species (the stock[13]) can be found exclusively within certain geographical limits;
2. Analytical methods allow clear separation of different stocks of the same species.

Origin assignment methods rely primarily on stock identification using identical methods that are also employed for traceability purposes. This allows traceability in the sense of a “fish to fork” approach to be put into practice.

For a long time it was commonly assumed that the apparent lack of geographical barriers in the marine environment have resulted in a low level of stratification in marine fish populations. This of course would greatly hamper attempts to identify the origin of individuals/populations. However this picture has dramatically changed by now. Scientific data, produced by the use of modern technologies, clearly show that for many exploited fish species, population structuring is evident even at small geographic scales[14]. This provides a great opportunity to take fish population biology out of a purely academic realm and to develop applications for control measures.

Fish stock identification has an extensive history in fishery science and numerous methods have been developed and used. Lately chemical analysis and the use of isotopic and elemental markers have gained importance in solving questions related to the geographic origin of fish. Because trace elements are taken up by fishes from the surrounding waters, the chemical composite of hard tissues such as otoliths, scales and spines reflects the physical and chemical properties of the environment to which the fish have been exposed. Modern, extremely sensitive and powerful technologies, allow the production of “elemental fingerprints” which in turn reveals the origin of fish.

Genetics have been applied to fisheries management from the late 1950s[15]. However until recently it was not straightforward to use methods based on molecular genetics for control and enforcement purposes mainly due to difficulties concerning the transferability of developed analytical protocols from one laboratory to another. This in turn made it difficult to validate and certify methods, an absolute prerequisite for their use for forensics in a legal context.

This situation has changed with the advent of genomic approaches, most notably Single Nucleotide Polymorphisms (SNPs), single nucleotide alterations in the genome sequence. As compared to other polymorphic genetic markers SNPs have numerous advantages, above all their suitability for automated, high-throughput genotyping, and the facilitated transferability of SNP based analytical protocols from one laboratory to another (*i.e.* standardization and certification). These properties render SNPs tremendously attractive for MCS purposes.

It must be stressed again though that any of the mentioned approaches rely entirely on the existence of baselines, that is, a comprehensive analysis of fish populations in order to reveal and document their differences!

Establishing such a baseline demands a considerable research effort. Determining whether an individual fish has been caught in area A or area B (or from stock A or B), requires the previous analysis of samples from both areas (both stocks). There exist examples of successful applications of such an approach for marine fish. For instance, Nielsen *et al.* successfully assigned individual cod

[13] For the purpose of this document the terms “stock” and “population” are used interchangeably, even though strictly speaking, while both cases the belonging of individuals to a distinct group is measured by a census, “stock” is a technical term, basically describing a group of individuals that is under consideration for exploitation and management purposes, while “population” takes biological parameters into account.

[14] E.g. Nielsen,E. E. (2003) “*Evidence of a hybrid-zone in Atlantic cod (Gadus morhua) in the Baltic and the Danish Belt Sea revealed by individual admixture analysis”* Molecular Ecology 12 (6) 1497-1508 and Pampoulie,C. et al. (2006) “*The genetic structure of Atlantic cod (Gadus morhua) around Iceland: Insight from microsatellites, the Pan I locus, and tagging experiments”* Can. J. Fish. Aquatic Sci. 63 (12) 2660-2674.

[15] F. M. Utter (1991) “*Biochemical genetics and fishery management: an historical perspective*” J. Fish Biology 39 (sa)

unambiguously to three populations - North Sea, Baltic Sea, and northeast Arctic Ocean – using genetic methods combined with appropriate statistical analysis[16]. Recent genetic work, even on highly migratory marine fish such as herring, have demonstrated the feasibility of using stock baseline information to subsequently assess the composition and source of individuals taken from mixed stock feeding grounds[17].

To maximise the efficiency of origin assignment for fishery control purposes, a holistic approach should be followed which does not solely rely on genetic methods but rather integrates other methods, such as stable isotope analysis, microchemistry and fatty acid analysis, as complementing analytical technologies. Moreover, such multiple data sets allow inference on the origins and distribution of different life history stages- information that can underpin our ability to predict response to harvesting and environmental change, therefore being useful for fisheries management and conservation (see below).

Added value of modern technologies for the fisheries sector

A coherent and efficiently operating framework for MCS, based on modern technologies, can be of considerable value for a variety of important issues inherent to the CFP. Three of the most imminent are shortly outlined.

Illegal Unregulated & Unreported (IUU) fishing: The Commission's recent Communication on IUU fishing proposes "*Introduction of a new regime governing the access to the Community territory of third country fishing vessels and imported fisheries products. This regime should be based on the principle that only those fisheries products certified as legal by the flag state concerned are entitled to enter into the Community.*"[18]. Evidently validated species identification techniques and techniques for tracing the geographic origin of traded fish can provide invaluable support to inspection and for enforcing legislation in the fight against IUU fishing.

Conservation & management: Conservation and sustainable exploitation of living aquatic resources are key features inherent to the CFP which are aimed at by applying the precautionary approach.Additionally to the TAC based annual management scheme, two types of multi-annual plans exist: recovery plans, to help rebuild stocks that are in danger of collapse; and management plans for stocks at safe biological levels, ensuring a *status quo*. For these management approaches as well as Ecosystem Based Fisheries Management, genetic data on fish populations can be used to analyse the condition of fish populations and to monitor population structure changes, which is known to impact stock recovery and resilience. This can be envisioned as accompanying measures to long term approaches in European fisheries management. In this context it is of interest to note that genetic diversity is one of the three forms of biodiversity recognized by the World Conservation Union (IUCN-International Union for the Conservation of Nature and Nature Resources), as deserving conservation, along with species and ecosystem diversity[19].

Aquaculture & Marine Stock Enhancement: In the light of increasing aquaculture activity in European waters, molecular genetics can be applied for monitoring and surveillance to avoid negative environmental impacts resulting from fish farming (*e.g.* "genetic pollution" caused by farm escapees)[20]. As mentioned above, in this case a holistic approach, integrating other biomarkers such as transcriptome and lipid profiles can be highly valuable. In some countries such a strategy is already actively pursued[21]. In the long term, if appropriately carried out, research into such a direction can be

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[16] Nielsen, E.E., et al. (2001) "*Population of origin of atlantic cod"* Nature, 413 (6853), p. 272.

[17] Ruzzante et al. (2006) "*Biocomplexity in a highly migratory pelagic marine fish, Atlantic herring"* Proc.Biol.Sci. 273 (1593) 1459-1464.

[18] "*On a new strategy for the Community to prevent, deter and eliminate Illegal,Unreported and Unregulated fishing*." Brussels, 17.10.2007 COM(2007) 601 final

[19] McNeely, *et al.* (1990) "*Conserving the world's biological diversity*." IUCN, World Resources Institute, Conservation International, WWF-US, and the World Bank, Washington, DC.

[20] Roberge, C. et al. (2008) "*Genetic consequences of interbreeding between farmed and wild Atlantic salmon: insights from the transcriptome*" Mol. Ecol. 17 (1) 314-324; and GENIMPACT (http://genimpact.imr.no/).

[21] Personal communication: Dr. Rune Andreassen. Norwegian School of Veterinary Science. Norway.

used to control regulations and laws related to aquaculture activities. Similar issues and potential uses of genetic markers also apply to marine stock enhancement, which involves intentional release of cultured individuals.

Transferring modern technologies into a framework for control under the CFP remit

The transfer of methodologies emerging from research into applications for control measures in the fisheries sector is an extremely critical point, and depends on a common effort of all involved stakeholders. Indeed up to now, modern technologies were almost exclusively used in the context of fundamental fisheries research (even though scientists have repeatedly pointed out in publications that their research could be taken into account for policy issues), which might explain a certain general reluctance to commit to this endeavour.

Interestingly, in contrast to this lack of initiative, published statements, documents and websites prove that there is a general awareness amongst scientists, the fishing industry, control authorities and policy makers about the value of modern technologies for MCS. However despite the existence of this notion, up to now practically no technology transfer has been taken place in this area. Remarkable exceptions to this are sporadic cases of suspected fraud in EU member states, where individual assignment of fish to populations based on genetic methods was admitted as evidence in court[22].

In other countries such as the USA and Canada a similar awareness of the potential of modern technologies in the area of traceability, inspection and enforcement is prevalent, but as in the EU a coordinated programme in this area does not yet exist. As in Europe there are several genetic fish databases, and authorities such as the NOAA Office for Law Enforcement (OLE) have sporadically made use of genetic analysis for criminal and civil cases, but methods for use in routine inspections are not available[23]. This is not due to a lack of resources: At least for salmon, forensic identification methods based on SNP assays are available[24]. Also recently, utilizing DNA analysis conducted by various forensic labs, OLE has helped to reveal major counterfeit conspiracies during which large quantities of falsely labelled low prized fish species (catfish) were imported into the US and sold as precious fish species such as "wild caught grouper" or "sole"[25]. Presumably the country, where at present one of the most comprehensive and coherent efforts is made towards a transfer of modern technologies into applications for MCS, is Canada. In a statement by the Ministry of Fisheries and Oceans addressed to the European Commission Joint Research Centre it is pointed out that "*Fisheries and Oceans Canada (DFO) currently uses molecular (genetic) techniques to detect, identify and track fish populations, and also as a powerful tool for enforcement officers to identify illegal catches and to prosecute offending fish harvesters*". Indeed the DFO dedicates a great part of its resources to aquatic biotechnology and a genetic research and development program[26]. Also forensic genetic applications for the analysis of Pacific salmonid samples emanated from research for species and stock identification[27].

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[22] Personal communication: Dr. Einar E. Nielsen, Danish Institute for Fisheries Research. Denmark and C.R. Primmer *et al.* (2000) "*The one that did not get away: Individual assignment using microsatellite data detects a case of fishing competition fraud*." Proceedings of the Royal Society - Biological Sciences (Series B) 267: 1699-1704.

[23] Personal communication: Mr. Paul Ortiz - Attorney Advisor /Senior Enforcement Attorney. Office of General Counsel. National Oceanic and Atmospheric Association (NOAA). USA.

[24] P.L. Schwenke *et al.* (2006) *Conservation Genetics* 7: 983-989.

[25] Personal communication Mr. Paul Raymond, Assistant Special Agent-in-Charge (supervisor); NOAA Office for Law Enforcement (OLE), USA; and Mr. Gregory R. Miller; US Attorney – Northern District of Florida, US Department of Justice, Press release August, 11, 2006; and http://www.seafood.com (2006) "*Major indictment of Panhandle Trading for importing 1 million pounds of catfish labeled grouper*."

[26] http://www.dfo-mpo.gc.ca/biotech/sci/rd_research_themes_e.htm

[27] Withler, R.E., *et al.* (2004). "*Forensic DNA analysis of Pacific salmonid samples for species and stock identification*." Environmental Biology of Fishes, 69 (1-4), pp. 275-285.

To assure integration into a control scheme the respective methods must have the following characteristics:

- Robust, Reliable and Reproducible;
- Transferable;
- Fast;
- Cost effective.

Collectively, these drivers coincide with an already established forensic framework, though this is typically applied to human applications. However wildlife forensics is an established and rapidly growing field[28].

Robustness (no need for repetition for any given sample), reliability (accurate and correct results), reproducibility (identical results during repetitions from sample to sample) and transferability (the protocols underlying the methods must be certifiable and transferable between analytical laboratories) are indispensible especially in a legal context. An example would be analytical results which are admitted as proof for prosecution or defence in court trials. Speed is an important asset, as the findings resulting from an inspection must be available with the shortest delay possible to allow for immediate response in the case of a suspected infringement. Ideally inspectors would have devices leading to results on-the-spot and generally whatever method employed, it should not demand too specialized technical knowledge from the inspector's side. Obviously illegal actions in the fisheries sector can have a considerable socio-economic impact. Nevertheless the costs of any proposed method to be employed in the frame of MCS have to remain within reasonable limits.

An estimate of the inherent costs of both chemical and genetic analysis technologies as brought forward here is difficult, since to begin with the Research & Technological Development (RTD) component establishing the baselines has to be financed. However the running costs once the baseline is established are expected to be relatively low (especially when compared to losses and damages due to illegal activities), but this also depends on various factors, such as the available infrastructure, the number of fish species examined, the geographical area covered *etc.*. We believe that a Cost-Benefit Analysis (CBA) should be carried out by experts taking into account all relevant aspects. The baseline for such a CBA could be "*Costs and Benefits at the current Status Quo i.e. inherent Risks and Consequences of No Action taken.*"[29].

Conclusions and outlook

With current scientific knowledge it is in principle possible to develop a framework incorporating strict forensic validation ("fisheries forensics") which is based on molecular biology and complementing modern methods, in support of MCS in the fisheries sector.

From a purely technical point the applications necessary are available. However the prevailing lack of coherence within the scientific world as well as of cooperation between scientific institutions, control authorities and policy makers impedes the realisation of a truly Pan-European framework for MCS in the fisheries sector, based on modern technologies, and referred to in the EU legislation.

With respect to the implementation of modern methods for MCS, the identification of an unknown species of fish from a sample of tissue, or fish products, is highly advanced. The global Fish Barcode of Life Initiative (FISH-BOL) project could provide an underlying baseline by supplying verified reference DNA sequences for identification purposes[30]. What is lacking, however, is a link between

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[28] Dr. Rob Ogden; Manager of Wildlife DNA Services (www.tepnel.com/wildlife) and member of the FishPopTrace consortium and see e.g. "*Forensic and Management Applications of Genetic Identification*" in Allendorf & Luikart "Conservation and the Genetics of Populations" Wiley-Blackwell; 1 ed., 2006.

[29] Based on a suggestion brought forward by Prof. Giancarlo Moschini (Department of Economics; Pioneer Chair in Science and Technology Policy; Iowa State University; USA) during the "*Workshop on Risk and cost benefit analysis of traceability in the agri-food chain*"; 13-14 December 2007; EC DG Joint Research Centre, Italy)

[30] FISH-BOL - http://www.fishbol.org/; At the moment of the writing of this document 4559 fish species are barcoded and 24132 barcodes available through FISH-BOL.

FISH-BOL and EU inspection and control authorities and a functional infrastructure, allowing fisheries control bodies to send tissue or product samples to acknowledged sequencing laboratories.

Identifying where a sample has been caught, *i.e.* origin assignment, is a more challenging endeavour. Scientific work has shown that origin assignment is feasible in certain cases but there is no reliable single source of information available yet, providing a complete picture as to what has been done and as to how research results could be implemented for MCS.

The probably farthest reaching project in this respect is currently FishPopTrace, a joint venture of 13 European, one Norwegian, one Russian research groups and an external advisor from the USA. This project, starting from April 2008, is financed under FP7 and is designed to promote technology transfer in order to provide a framework for traceability and forensics in the fisheries sector. Moreover FishPopTrace is strongly supported by the International Council for the Exploration of the Sea (ICES). A number of the FishPopTrace consortium members are also affiliates of the ICES Working Group on the Application of Genetics in Fisheries and Mariculture (WGAGFM) which is directly reporting to ICES and which recently included "genetic applications for traceability" into its agenda.

However due to budgetary constraints FishPopTrace is momentarily focussing on only four major European fish species. Also, it is not clear whether and how this approach could be sustained and enlarged beyond the limits set under the FP7 conditions.

As mentioned above, to identify and characterise the fish populations in European and also Extra-European waters is an absolute pre-condition for any attempt to transfer modern technologies to applications supporting MCS within a legal context. A concerted interdisciplinary effort is therefore needed to identify the fish whose origins might be disguised for commercial gain, to characterise them, to identify whether the stocks are sufficiently unique and to determine the most appropriate analytical methods. The data generated during such an approach should be compiled in a professionally curated and publicly accessible European Fish Stock & Population Databank. The European Bioinformatics Institute (EBI) genetic databank in Hinxton (UK) could serve as an example with respect to management.

Tools for inspection and traceability purposes should be developed by scientists but in close cooperation with the end-users of such tools. Possibly the newly inaugurated Community Fisheries Control Agency and the European Commission (*e.g.* the DG Joint Research Centre) could play a mediating role here. It can be envisioned to design a forensic framework for traceability of fish and fish products within the context of MCS, legal enforcement and also conservation policies. To be effective it is mandatory that such tools are validated according to international forensic standards. In this respect the enormous progress in the field of human forensics, especially with view to modern molecular technologies and validation strategies, should be taken into account. Analysis of samples provided by control authorities could be performed according to these standards by a network of accredited and certified EU fishery research institutes. This would constitute a major step towards an efficient and appropriate persecution of infringements thereby supporting the fight against fraud in the fisheries sector as recently stipulated by the European Court of Auditors and the European Commission[31].

In summary in the face of the precarious state of fisheries the European Union should be aiming at continuity, coherence and homogeneity when developing a framework based on modern technologies to support MCS on a legal basis. Such a framework cannot emerge exclusively from research, neither alone from control authorities or policy makers. Much closer cooperation and reciprocal dialogue must underlie such an endeavour. In our opinion the first step in this direction should be a meeting of relevant stakeholders such as scientists, control authority members and policy makers in order to identify priorities and to set up a coordinated work scheme and organisational framework.

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[31] European Court of Auditors (2007) *Special Report No 7/2007 (pursuant to Article 248(4) second paragraph, EC) on the control, inspection and sanction systems relating to the rules on conservation of Community fisheries resources together with the Commission's replies*.

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