CONVENTION ON INTERNATIONAL TRADE IN ENDANGERED SPECIES
OF WILD FAUNA AND FLORA

Seventy-eighth meeting of the Standing Committee
Geneva (Switzerland), 3-8 February 2025

Regulation of trade

LABELLING SYSTEM FOR TRADE IN CAVIAR

1. This document has been submitted by Georgia as a Chair of the Standing Committee working group on labelling system for trade in caviar.*

Background:

2. At its 19th meeting (CoP19; Panama City, 2022), the Conference of the Parties adopted Decisions 19.175 and 19.176 on the Labelling system for trade in caviar as follows:

Directed to the Secretariat

19.175 *Subject to external funding, the Secretariat shall prepare, in consultation with relevant information technology, industry and other experts, an analysis of the benefits and drawbacks of incorporating QR codes into the application of the CITES guidelines for a universal labelling system for the trade in and identification of caviar contained in Annex 1 of Resolution Conf. 12.7 (Rev. CoP17) on* Conservation of and trade in sturgeons and paddlefish*, and present its analysis and recommendations to the Standing Committee.*

Directed to the Standing Committee

19.176 *The Standing Committee shall:*

a) establish an intersessional working group that will examine the analyses and recommendations of the Secretariat once they are available and report to the Standing Committee;

b) consider the report on the use of QR codes in the application of the CITES guidelines for a universal labelling system for the trade in and identification of caviar prepared by the Secretariat;

c) taking into account the study on Identification of species, subspecies, source and origin of sturgeons and paddlefish species and specimens (Acipensiformes spp.) in trade in the Annex to document SC74 Doc. 47, review the caviar labelling system set out in CITES guidelines for a universal labelling system for the trade in and identification of caviar, considering practical challenges in its implementation and opportunities to improve its functioning; and

* *The geographical designations employed in this document do not imply the expression of any opinion whatsoever on the part of the CITES Secretariat (or the United Nations Environment Programme) concerning the legal status of any country, territory, or area, or concerning the delimitation of its frontiers or boundaries. The responsibility for the contents of the document rests exclusively with its author.*

   d) *make recommendations to improve the functioning of the caviar labelling system to the 20th meeting of the Conference of the Parties, as appropriate.*

3. The Standing Committee established a working group with the following mandate:

   a) examine the analyses and recommendations of the Secretariat once they are available and report to the Standing Committee;

   b) consider the report on the use of QR codes in the application of the CITES guidelines for a universal labelling system for the trade in and identification of caviar prepared by the Secretariat;

   c) taking into account the study on Identification of species, subspecies, source and origin of sturgeons and paddlefish species and specimens (Acipensiformes spp.) in trade in the Annex to document SC74 Doc. 47, review the caviar labelling system set out in CITES guidelines for a universal labelling system for the trade in and identification of caviar, considering practical challenges in its implementation and opportunities to improve its functioning; and

   d) make recommendations to improve the functioning of the caviar labelling system to the Standing Committee, as appropriate for its consideration.

4. The composition of the working group, comprising Parties and Non-Party observers, is as follows:

   Parties: Belgium, Canada, China, Czech Republic, France, Georgia (Chair), Germany, Italy, Japan, Malaysia, United States of America.

   Observers: International Union for Conservation of Nature (IUCN); Association of Midwest Fish and Wildlife Agencies, Associazione Piscicoltori Italiani, International Caviar Importer Association, IWMC-World Conservation Trust, TRAFFIC; Word Wide Fund for Nature (WWF).

Working group discussion:

5. Discussion mostly took place through e-mail exchanges and one online meeting.

6. Members of the working group identified shortcomings of the existing caviar labelling system which could potentially be improved by the Parties, among others, these included poor quality of labels (e.g. not resistant to water or abrasion, simple paper), print quality and positioning of code (e.g. size of code, small font size, hard to find among other writing), production of labels by caviar processing and repackaging companies, vulnerability to counterfeiting, difficulties in verifying label authenticity, limitations of information provided by the code, especially in case of multiple repackaging, lack of traceability. It was also mentioned that sometimes labelling requirements are not sufficiently implemented (e.g. labels not sealing the containers, reusable labels, use of incomplete codes).

7. As in the previous intersessional periods, some members of the working group suggested to use “country of processing or repackaging” instead of “country of origin”. However, the same concerns were also expressed as in the previous intersessional period that such change could result in reduced traceability and enforcement. Some members of the group considered using “country of processing or repackaging” not acceptable for these reasons and did not support reopening the discussion. However, a number of members highlighted importance of such discussion in the future.

8. Some members of the group expressed their concerns over switching from the use of existing labelling system to QR codes from the beginning of the discussions. Once the study on the QR codes became available (see Annex), the members had opportunity to review it. Many members found information presented in the report useful, particularly on size and readability of QR codes even in case of degradation of labels and some members believe that the use of QR codes could address certain shortcomings of the existing caviar labelling system. However, members of the working group share the view that switching to any new system should be beneficial for implementation while not reducing enforceability. Members of the group expressed the views that the report did not provide enough information for the working group to adequately evaluate QR codes as a potential solution to the current systems shortcomings and insufficient justification that the use of QR codes would be beneficial. Some members noted that implementation of the QR codes would only be useful if combined with an associated information system as also outlined in the report. Serious concerns were raised on capabilities of all Parties to be able to implement this technology at points of inspection as in many cases they do not have access to smartphones or internet. It is also not

clear that the caviar industry at all levels of the process is ready to implement the QR code system. Additionally, the cost of implementing an information system remains unknown. It was also noted that optional use of QR codes in addition to the existing labelling system could be useful to provide any additional information.

9. Overall, given the results of the report and additional unanswered logistic questions, there was no overwhelming support to replace the current labelling system in favour of QR codes. However, some members thought that piloting the QR codes could be a reasonable next step and useful for further discussion, in particular as a form of supplemental information in addition to the current labelling system. Some members expressed the biggest challenge to achieving better traceability in the international trade of caviar is not the labelling system but the insufficient accountability in some aquaculture practices, which is outside the scope of the working group to address.

Recommendations

10. The Standing Committee is invited to:

    a) note this report;

    b) encourage Parties interested to use the QR codes to carry out a pilot to test the use of QR codes for caviar labelling and present the information on the results to the Standing Committee at its 81st meeting to facilitate further discussions; and

    c) agree that Decisions 19.175 and 19.176 have been implemented and can be proposed for deletion.

Benefits and drawbacks of QR codes as part of the universal labelling system for trade in and identification of caviar under CITES

Dr Heiner Lehr, Consultant

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List of abbreviations

C

COO ..... *Country of origin*

D

dpi ..... *dots per inch*

E

EPC ..... *Electronic product code*

G

GTIN ..... *Global Trade Identification number*

I

ISO ..... *International Standards Organisation*

L

LAN ..... *Local Area Network*

P

phishing ..... *A form of social engineering where relevant information is extracted by assuming a false identity*

R

rMQR ..... *Rectangular micro QR code*

S

symbol ..... *Technical term for "barcode" (i.e. the graphical representation of a text)*

U

URL... *Uniform resource locator, typically called a "link". Clear text address of an internet resource*

1 Summary of main findings

At the 74th meeting of the Standing Committee (SC74; Lyon, 2022), the use of QR codes as a technology to potentially consider improving traceability along the production, processing and trade chain for caviar was discussed (see SC74 Doc.47, p.21). At its 19th meeting (CoP19; Panama City, 2022), the Conference of the Parties adopted Decisions 19.175 on Labelling system for trade in caviar which called for a consultation of relevant experts under the overall supervision of the Legal Unit of the CITES Secretariat.

This report is the result of said consultation. It investigates the use of the QR code technology in the context of labelling for CITES, in particular for but not necessarily limited to caviar. The report does not attempt to review the underlying rules for CITES codes[1]; instead, it looks at QR codes as a means to flexibly encode any kind of identifier in a compact and control-friendly fashion.

QR codes are often used in the context of an information system, by encoding for example a uniform resource locator (URL), often called a "link". The existence of such system was not assumed a given for this report and therefore the main body of the report is concerned purely with the codification of CITES codes in form of a QR code.

The main findings can be summarised as follows:

- QR codes are a versatile technology to encode information elements, such as the relatively long CITES codes for caviar (approximately 23-50 characters). QR codes are used in many industries for a large variety of purposes from marketing to authentication.
- QR codes save significant amounts of space in comparison to clear text (32-65%). With the new rMQR code which is rectangular instead of square there are also shapes available that seem well suited for product labels.
- Independently of the debate around the country of origin[2], QR codes can handle CITES codes easily. As such, it is a technology that can encode in a space-efficient manner a significant amount of information.
- An experiment undertaken specifically for this report revealed that a symbol[3] of about $1cm^2$ surface area can be read easily with a mobile phone even in cases of significant degradation. If 1 cm^2 is a concern within the context of small caviar tins, DataMatrix codes would represent a feasible, yet not so user-friendly alternative.
- QR codes are very recognisable – facilitating the work of border officials – and quite user-friendly. Mobile phones support them natively but there are also several free apps that can be downloaded for that purpose.
- Printing QR codes either directly on the primary packaging or on a label is not costly. Most label printers already support QR codes natively; if investment is necessary, simple label printers with support for QR codes can be bought for about 200 USD. For integration into the packaging line, a cost of approximately 2,000-3,000 USD is to be considered.
- QR codes, if they simply encode a clear text, are just as safe or unsafe as the clear text itself. They can be copied just as easily and have no additional security features. Given

[1] "Code" is here synonymous with the technical term "identifier". In this report and following normal use, "code" as e.g. in "QR code" can also be synonymous with the technical term "symbol", i.e. the graphical codification of an identifier, e.g. as a barcode.

[2] Where some propose the country of origin to be interpreted as the country of processing or repacking, while others interpret it as the origin of the fish producing the roe.

[3] Colloquially often referred to simple as the "barcode".

that QR codes have to be scanned in order to be deciphered, an argument could be made that enforcement officials under time pressure may find the extra step cumbersome (if there is no added value)

- One of the great strengths of QR codes is their ability to allow users to access information on the internet in a user-friendly way. Even a very simple information system would probably assist those involved in CITES controls. Potential security risks and general availability of a network connection have to be considered, though.
- In the absence of an information system, the main benefit of QR codes relies in their efficient use of space and their recognisability. It is not immediately obvious in this case that the costs associated with changing the status quo are outweighed by the benefits of using QR codes
- In order to better weigh the pros and cons in case there was sufficient interest in applying QR code technology, a pilot study is recommended

In summary, QR codes are apt for encoding in a space-efficient and recognizable manner CITES codes, such as the ones that have to be put on every primary container of caviar. If they are used stand-alone, they do not provide more information or more security than a clear text code. In the context of an information system – even a very simplistic one – QR codes could provide additional value to those involved in ensuring legality of trade. In the absence of such a system, the added value is not immediately apparent, especially when compared to the cost and difficulty of introducing new coding technology on a global scale.

1.1 Acknowledgements

This report was made possible by the CITES Secretariat under contract 2500363417. Guidance by Thomas Deleuil, Legal Officer, was much appreciated, as was the assistance of the IT team at the Secretariat. Contributions by the chair of the working group, Ms Teona Karchava, Head of the Protected Areas Policy Division, Ministry of Environmental Protection and Agriculture of Georgia and its individual members are kindly acknowledged.

2 Aim and scope

At the 74th meeting of the Standing Committee (SC74; Lyon, 2022), the use of QR codes as a technology to potentially consider improving traceability along the production, processing and trade chain for caviar was discussed (see SC74 Doc.47, p.21). The working group on the labelling system for trade in caviar reported to the Standing Committee on their discussion on the benefits and drawbacks of using QR codes for labelling, as suggested in the informal background document prepared by the Secretariat.

The working group indicated that there were mixed views, with some members of the working group supporting the inclusion of QR codes as a way to provide fulsome tracking information, including production and packaging dates; while various challenges were also identified in terms of technological capabilities and size of the code needed. The working group however agreed that the use of QR codes would merit further exploration (see SC74 Doc. 48, p. 3). These conclusions were further reported to the 19th meeting of the Conference of the Parties (CoP19; Panama City, 2022) (see CoP19 Doc.45, p. 2).

At its 19th meeting (CoP19; Panama City, 2022), the Conference of the Parties adopted Decisions 19.175 on Labelling system for trade in caviar which called for a consultation of relevant experts under the overall supervision of the Legal Unit of the CITES Secretariat with the following tasks:

- Review and analyse CITES decisions and resolutions, Standing Committee documents and reports, and all relevant documentation on labelling system for trade in caviar, as well as opinions expressed by Parties to the Convention and members of the intersessional working group on this topic;
- Review and analyse existing data on trade in caviar issued from aquaculture and corresponding labelling requirements;
- Review and analyse the existing literature and data on the use of QR codes for labelling trade products;
- Consider and assess the benefits and drawbacks of incorporating QR codes into the application of the CITES guidelines for a universal labelling system for the trade in and identification of caviar, including vis-à-vis technical capabilities. Assess if Management Authorities, law enforcement, caviar producers, and re-packagers have the technical capabilities necessary to implement QR codes as a universal labelling system for the trade in and identification of caviar;
- Develop the requirements for an efficient use of QR codes into the application of the CITES guidelines for a universal labelling system for the trade in and identification of caviar;
- Support the CITES Secretariat in preparing the presentation of this analysis and proposed recommendations to the Standing Committee.

These tasks were identified in collaboration with the intersessional working group on caviar labelling that was established by the Standing Committee at its 72nd meeting in Geneva in 2020.

The discussion in the working group on the labelling system for trade in caviar originated around a proposal to employ as country of origin (COO) the country where roe is extracted from the fish instead of the country or countries where the fish originated. The resolution of this question has an impact on the space requirements for the CITES code on the primary container. One of the possible solutions to an added space requirement could be the use of space-efficient technologies, such as two-dimensional bar codes.

The question whether it is preferrable to use the country of origin of the fish or the country of origin of the roe is not part of this study. This study looks at the feasibility of using QR codes in caviar labelling, independent of the underlying code (or, more general, information).

Equally, there were some discussions in the working group and some contribution asking for improvements of the labelling system by guaranteeing authenticity of labels e.g. via an information system. As the study will elaborate, QR codes by themselves are neither less nor more protected against falsification than clear text. The use of an information system together with the code can increase that protection – even with a very simplistic information systems like the one outlined in Annex II. However, although measures to strengthen the authenticity of CITES codes are an important consideration, this topic also falls outside the scope of this report.

This is a technical report focusing on the benefits and disadvantages of using QR codes in the CITES context and specifically in caviar labelling, independent of coding systems and additional resources, such as information systems.

3 Methodology

In order to draft this report, the consultant used the following resources:

- Relevant CITES documents
- Literature study
- An experimental study undertaken specifically for this report on the readability of QR codes which informs the discussion on required technical means in the use of QR codes
- Consultation with the members of the working group on the labelling system for trade in caviar. For this purpose, an open invitation was sent to all members of the working group.

4 Current CITES caviar labelling requirements

KEY TAKEAWAYS

- All primary containers containing caviar must be labelled with a lot-based identifier
- The code contains the country of origin; there is an on-going debate whether country of origin should refer to the country where the roe originated or where the fish producing the roe originated
- CITES Conf. Resolution 12.7 provides no limitations of the length of the code; its length is approximately between 23 and 50 characters for one country of origin.
- Adding another country as country of origin requires a least two more characters. For up to 10 additional countries, this means a 36-78% longer code, resulting in a substantially bigger space requirement
- Space on labels is usually very limited, in particular for small primary containers regularly used in caviar
- Several routes are possible to reduce the impact of adding more countries of origin. Two of these routes are outside the scope of this report:
  - The use of codes that are not human interpretable and require an information system to be understood
  - Changing the CITES coding system to use the country of extraction of caviar instead of the country of origin of the fish

At CoP17 in 2016, Conference Resolution 12.7 on the Conservation of and trade in sturgeons and paddlefish was revised. In Annex 1 of said Resolution, the following universal labelling system was outlined:[4]

In the country of origin, a non-reusable label must be affixed to any primary container with at least the following information:

- *Standard species code (listed in Annex 2 of the same Resolution) [3-7 characters]*
- *Source code of the caviar (as by CITES Resolutions, e.g. "W", "C" or "F") [1 character]*
- *2-letter ISO code for the country of origin [2 characters]*
- *Year of harvest [4 characters]*
- *Official registration code of the processing plant [variable length, not limited]*
- *Lot identification number for the caviar [variable length, not limited]*

Example:

HUS/W/RU/2000/xxxx/yyyy

In case the caviar is repackaged in a country different from the country of origin, a non-reusable label has to be affixed to every primary container with at least the following information:

- *Standard species code (listed in Annex 2 of the same Resolution) [3-7 characters]*
- *Source code of the caviar (as by CITES Resolutions, e.g. "W", "C" or "F") [1 character]*

[4] https://cites.org/sites/default/files/vc-files/files/universal_labelling_requirements_caviar.pdf

- *2-letter ISO code for the country of origin [2 characters]*
- *Year of repackaging [4 characters]*
- *Official registration code of the repackaging plant which incorporates the 2-letter ISO country code of the country of repackaging if different from the country of origin [variable length, not limited]*
- *Lot identification number for the caviar or CITES export permit or re-export certificate number [variable length, not limited]*

Example:

PER/W/IR/2001/IT-wwww/zzzz

Conference Resolution 12.7 (Rev CoP17) does not provide any limitations on the length of the variable parts of the code, i.e. the official registration code of the processing or repackaging plant and the lot code. The latter is company dependent and should provide a link into the traceability information held by the processor or repacker.

Registration codes range from 3-26 characters. Figure 1 shows the length of the registration code of all 485 registered exporters as available on the CITES website July 1st, 2024.[5] The most frequent code length is 4 characters, the median[6] is 5 and the mean is 7 characters.

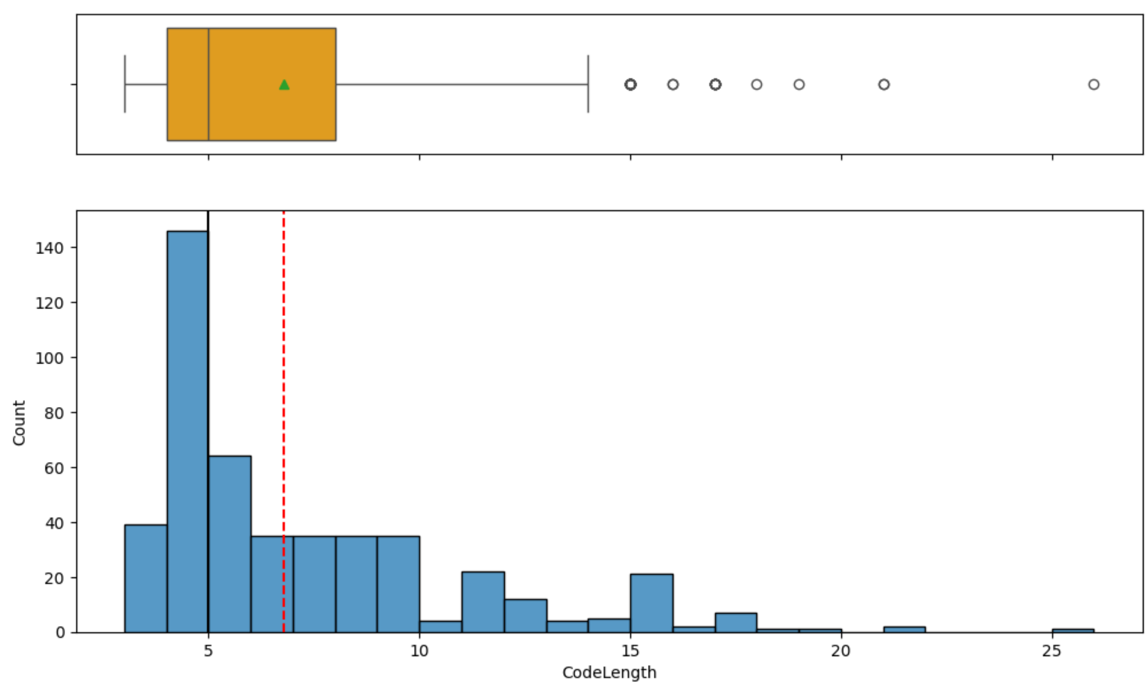

Figure 1 Length of the CITES registration codes for all 485 registered exporters. The most common length is 4 characters; the black vertical line represents the median (5 characters), the dashed red line the mean (about 7 characters). Code lengths over 14 characters are considered outliers.

[5] https://cites.org/eng/common/reg/ce/AR

[6] The character length for which half of the registration codes are shorter or equal and half are longer

Assuming a lot code to be at least 5 characters, this yields a minimum code length of 18 characters + 5 separators[7] = 23 characters for processors and repackaging plants (in the same country). However, a code could have a length of 50 characters or even more for one country of origin.

For each additional country of origin, at least 2 more letters need to be added. Table 1 shows the increase of the code length for up to 10 countries of origin.

Table 1 Effect of adding multiple countries of origin (COO) on the minimum, average and maximum code length assuming the lot code is 5 characters long. Average here is the point between median and mean (6 characters).

No of COO	Min	%	Avg	%	Max	%
1	23	0%	26	0%	50	0%
2	25	9%	28	8%	52	4%
3	27	17%	30	15%	54	8%
4	29	26%	32	23%	56	12%
5	31	35%	34	31%	58	16%
6	33	43%	36	38%	60	20%
7	35	52%	38	46%	62	24%
8	37	61%	40	54%	64	28%
9	39	70%	42	62%	66	32%
10	41	78%	44	69%	68	36%

If codes are printed in clear, human-readable text, an increase in code length is roughly equivalent to the increase in space needed for the code (or rather in length, as typically the codes are printed in a single line, although the Resolution does not impose any rule on the presentation of the code).

Figure 2 shows an example of a CITES-compliant code on a primary caviar container. This particular code is printed by a matrix printer integrated into the production line. Judging from the picture,

Figure 2 Example of a CITES code on a primary caviar container. Photo taken from the brochure “Caviar Labelling” made available by the project “Life for Danube Sturgeons”; accessible at https://danube-sturgeons.org/wp-content/uploads/2018/11/Brochure-Caviar-Labelling.pdf.

[7] The “/” character

either the primary container was rotated while printing or the printer head was moving in an arc around the lid. In this particular case, it might be possible to make the code longer (by adding additional countries of origin) and retain code readability.

In a more general case, however, space for coding purposes is very limited, so any way to reduce that space requirement is welcome.

Several paths seem available to reduce the impact of a longer code. The first one is the one discussed in this document, i.e. reducing the space required to print a code on a primary container by means of a graphical codification, for example a one- or two-dimensional barcode.

A totally different route – which will however not be discussed here – is the use of non-significant codes, i.e. codes that humans can only interpret via lookup in an information source[8]. Removing the requirement that a human without an information source can interpret the code, allows for a very significant reduction in code length; see the box on the right for an example on the size reduction potential.

However, using non-significant codes requires an always and everywhere available information source which for all practical purposes would have to be an information system.

The study of additional information systems under CITES is not part of this consultancy.

The third path is the one proposed by some members of the working group: to replace the country of origin of the fish with the country of origin of the roe, i.e. the processing plant. This would mean that the information where the fish originates is not part of the code but would have to be investigated using the lot code (on premise of the processor or repacker, probably).

This means that the country of origin would always be 2 characters long and the code would remain intact in length independently of how many countries the contributing fish came from.

Discussing the CITES labelling system is not part of this consultancy; this path – equal to the use of non-significant codes – will therefore not be discussed any further.

Example: size reduction

If we were to identify every possible *combination* of countries of origin from any of the 45 exporting countries listed on the CITES website with a single code made up from letters and numbers, we would need a code with a length as listed in Table 2 – which is significantly shorter than concatenating ISO country codes.

If we were to adopt this system, however, the country part of the CITES code would then be e.g. “12AAF5A” instead of “FRITARGE” (or any other encoding of 4 countries of origin). Officers at the border would be none the wiser unless they had an information source to look up the code.

Similar reductions could be made with the whole code, of course. If CITES were to base its coding system on product identity and movements (similar to the cattle passport that is in use in the European Union and other countries), it is fairly clear that 7 digits would suffice. Taking the lot as the product identity, a 7-digit code consisting of letters and numbers can encode 80 billion lots without repetition. If we assume that each day of the year, each of 1000 processors creates a new lot, this would amount to 215,000 years of production.

[8] *Information source* is any source of information, including also e.g. printed lists. An *information system* is an electronic lookup system – which today is understood to be available online.

Table 2 Possible combinations of countries of origin (COO) and number of characters of alphanumeric type required to encode them.

No of COO	No of exporting countries (as listed on CITES web)	Combinations	Base	Characters required
1	45	4.50E+01	36	2
2	45	9.90E+02	36	2
3	45	1.42E+04	36	3
4	45	1.49E+05	36	4
5	45	1.22E+06	36	4
6	45	8.15E+06	36	5
7	45	4.54E+07	36	5
8	45	2.16E+08	36	6
9	45	8.86E+08	36	6
10	45	3.19E+09	36	7

5 QR codes in labelling trade products

KEY TAKEAWAYS

- QR codes are a type of two-dimensional barcodes, mainly designed for speed of reading. Smartphones support reading QR codes natively.
- There are several types of QR codes. Relevant for caviar labelling are the "normal" square QR code and a fairly new rectangular QR code, the so-called rMQR code
- QR and rMQR codes are standardised under ISO with references ISO/IEC 18004:2015 and ISO/IEC 23941:2022, respectively
- QR codes are being used in many sectors including marketing, manufacturing, logistics and banking. QR codes are also being used for authentication and food traceability
- The use of QR codes is clearly rising and especially strong in East, South and South-East Asia. Their use is also rising in other parts of the world. In the United States of America, an estimated 100 million citizens will use a QR code in 2025
- The readability of a QR code depends on print quality, camera quality, size and deterioration of the code
- An experiment showed that both normal and rMQR codes require about $1cm^2$ in order to be readable at medium to high degradation. This shows that relatively small symbols are perfectly readable with a smartphone in spite of some level of deterioration
- The use of QR codes requires a printer; most label printers in the market today are capable of printing QR codes. However, those processors or repackers with old printing technology are most likely to be the smaller and therefore more vulnerable entities
- If a printer must be bought, many options are available ranging from low volume solutions for under 200 USD to industrial solutions for around 2,000-3,000 USD.
- QR codes as used here have the same security level as clear text. There are ways to secure QR codes, but they are impractical. Probably the only real way to secure the correctness of the information is by use of an additional information system
- There are alternatives to QR codes, most notably DataMatrix codes which use less space but are also less user-friendly. If space $<1cm^2$ is crucial, DataMatrix codes should be considered

5.1 Definition

Barcodes are an essential component in automated identification and data capture. They allow machines to read text with great precision, i.e. without resorting to image or optical character recognition. Barcodes became popular in the 1960s as part of a semi-automated checkout process in retail. However, the use of barcodes expanded to manufacturing, trade, marketing and other areas.

The most well-known barcode is the so-called EPC (electronic product code) or GTIN-13 (Global Trade Identification number). This is the barcode that is found on practically every retail product in the world. The underlying codes are managed by an organisation called GS1.

When designing the underlying identifier which will be graphically coded into a symbol, one can select one of the following strategies:

- Linking a code to an information system, so that a lookup in that system is necessary to know what the code refers to

- Creating a humanly readable code with several “parts” that allow a knowledgeable human to decipher the code without needing to look it up in an information system

While the first solution has endless flexibility and is very efficient in terms of code size[9], it requires a (fast access) information system with near 100% uptime.

Most identifiers therefore choose the second solution. As an example, the first digits of the aforementioned GTIN-13 refer to the country where the company is registered with the issuing agency GS1.

Global Trade Item Number (GTIN-13 Structure)												
GS1 Company Prefix							Item Reference					Check Digit
N_1	N_2	N_3	N_4	N_5	N_6	N_7	N_8	N_9	N_{10}	N_{11}	N_{12}	N_{13}

Figure 3 A GTIN-13 code (also known as EPC-13) which is widely used in retail. The code consists of a company identifier (which contains the country of registration) also called “company prefix” and a non-structured item identifier (“item reference”). A check-digit ensures that the code is well-formed.

In the beginning, barcodes were “one-dimensional” and came in the shape of stripes where stripe distance and thickness encoded the contents. Once the great potential of barcodes was realised, the desire arose to code more information.

In order to encode more information, several solutions were found:

- Stacked barcodes where the code itself contained special symbols (called Application Identifiers) that separate the parts of the code
- Two-dimensional barcodes that with better camera systems allowed to make use of the second dimension of the barcode (instead of repeating the same information in the second dimension).

QR codes or “quick response” codes are a family of two-dimensional barcodes. They were designed by Masahiro Hara of DENSO WAVE INCORPORATED (then a division of DENSO CORPORATION).[10] The first QR code was made public in 1994. The design goal was primarily the speed of optical recognition which is why the original QR code has the very recognisable upper left, lower left and upper right corners. These “orientation patterns” allow for a quick reading of the code even if the camera is not well aligned with the code.

While DENSO WAVE INCORPORATED hold a patent on QR codes, they are now an international standard under ISO with number ISO/IEC 18004:2015 (for normal and micro QR codes) and ISO/IEC 23941:2022 for rectangular micro QR codes (rMQR codes).

[9] With a 33-digit code consisting of uppercase letters and numbers each individual atom on earth could have a unique identifier; see discussion in section 4

[10] https://www.qrcode.com/en/history/

5.2 Types and uses of QR codes

Relevant for the discussion in this document are the following QR codes:

Table 3 Types of QR codes

Type	Description	Capacity	Use
Normal	Standard QR code, now available as Model 2 with better recognisability	Maximum of 4,296 characters (model 2)	Inventory Marketing Automotive Banking Transportation Authentication Counterfeit detection Traceability
Micro	Smaller version QR code with limited capacity. Only has one position detection pattern.	In dependence of symbol version and error correction level up to 35 characters	Production and inventory of small-sized items Marketing
Rectangular micro (rMQR)	Matrix-type, two-dimensional code that is easy to read and can store large amounts of information, while being a rectangular shape that makes it easy to print in narrow spaces.	Depending on the symbol version up to 219 characters	Very new code family, not in widespread use yet; some use in medical and pharmaceutical industry
SQRC©	QR code with public and private information. Private information can only be read by a compatible scanner with a cryptographic key (“certificate”)	Not known	Not known

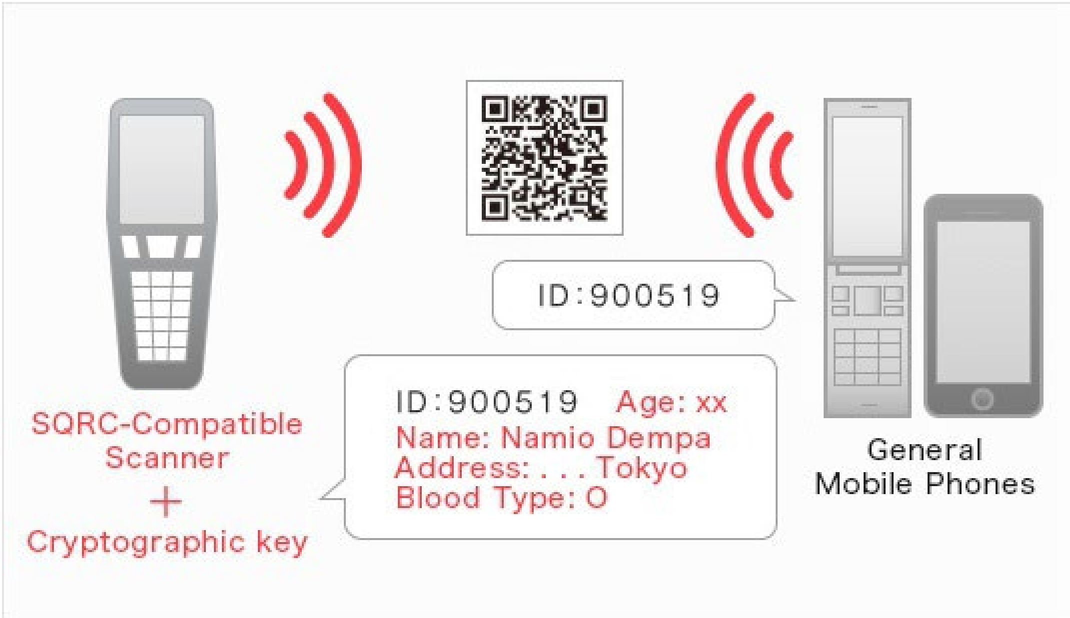

Figure 4 Operation of the SQRC© code; taken from https://www.denso-wave.com/en/system/qr/product/sqrc.html

The relatively new and quite special SQRC codes are further explained in Figure 4. They require specialised hardware and contain both a public part, very similar to other QR codes, as well as a private part that needs to be decrypted with specialised hardware and a cryptographic key.

Some examples of QR codes in use in logistics/traceability and mobile banking are shown in Figure 5. Figure 6 shows an example of a traceability system that uses QR codes to access traceability information in a user-friendly way.

A special feature of QR codes is that they have the application-specific ability to store:

- Text and numbers
- Phone number, email address or SMS
- Business card (vcard)
- URLs
- Wireless LAN connection details

QR codes became popular in marketing because they facilitated access to online content (web pages, videos etc) in combination with mobile phones without the hassle of typing in complex

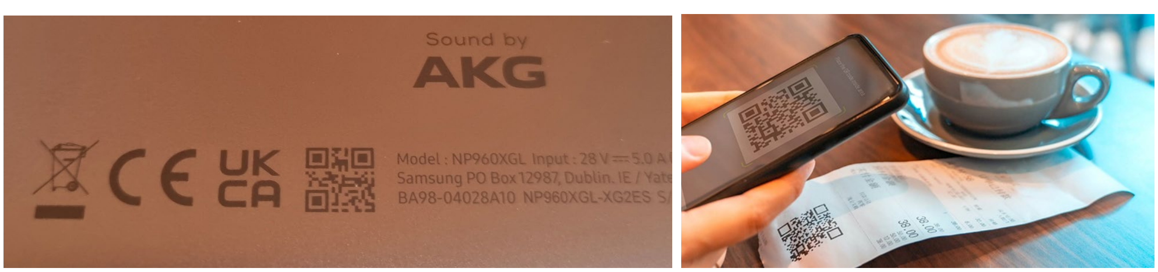

Figure 5 Example of a QR code in identification of electronic equipment and for mobile payments.

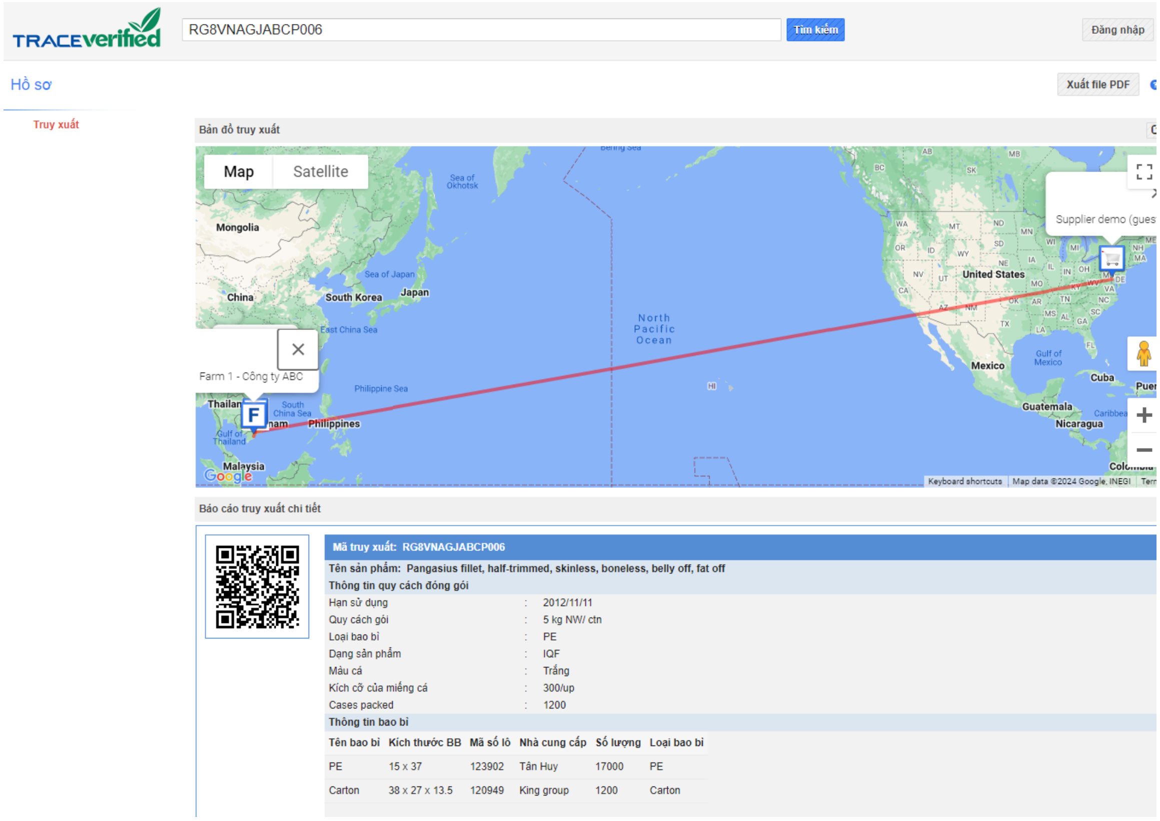

Figure 6 Example of the use of QR codes in food product traceability, here by the Vietnamese company TraceVerified. Accessible at: https://portal.traceverified.com/Report.aspx?doc=RG8VNAGJABCP006

URLs. However, QR codes are used in many circumstances now, also for product traceability, mobile payments and even authentication. WhatsApp and Netflix use QR codes for authenticating users, as do other companies.

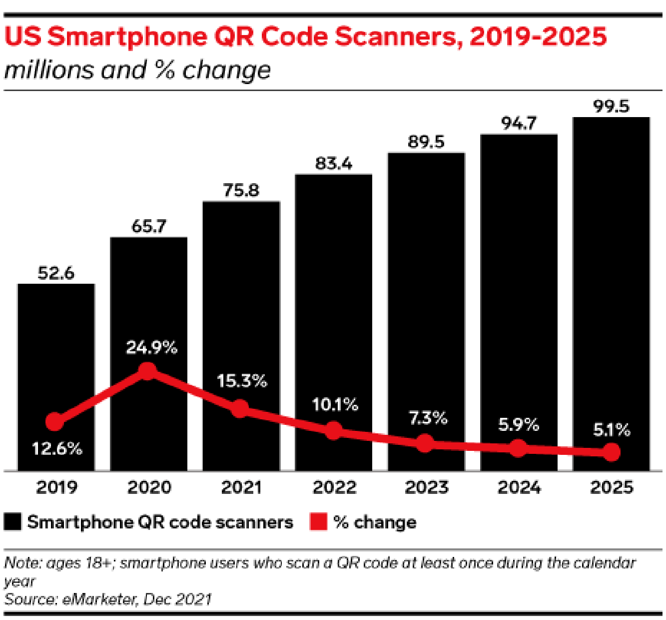

Figure 7 US smartphone users scanning a QR code;
Source: https://www.emarketer.com/content/qr-codes-forecast-trends-2022

QR codes are also used in some countries to facilitate administrative procedures. The Spanish tax authority is implementing a requirement to include a QR code on all invoices by July 2025. The aim is to reduce tax fraud.

There is very little doubt that QR code adoption is on the rise. Recent statistics are not available, but the market information consultancy eMarketer projected in 2021 that by 2025, about 100 million US citizens will scan a QR code; see Figure 7.

QR codes are even more popular in South-East and East Asia, mainly related to health requirements and mobile banking. Go Click China estimated[11] in 2021 that citizens of the People's Republic of China interact 10-15 time per day with QR codes.

5.3 Information density, error correction, print quality and size

The readability of a QR code depends on many factors:

- Amount of information contained
- Error resilience
- Physical size in combination with print quality
- Camera quality

QR codes have a built-in error correction to deal with broken or deteriorated labels. The higher the error correction mode, the lower the amount of information that can be encoded in a QR code with the same "modules". Modules can be thought of as a cell in a matrix, in their totality "constructing the QR code. The number of modules determines the so-called *version* of the QR code.

NOTE: *The number of modules and the physical size of the code are not directly related. Each module can have any size in the real world, limited only by the resolution of the printer and the material on which it is printed.*

Table 4 shows the minimum version and module sizes for different code lengths taken from Table 1. The higher the desired error resilience, the lower the information density of the code and the higher the requirements on physical size, print quality and quality of the cameras trying to read the code.

Note that a lack of resolution of the printer can be remedied by increasing the physical size of the code. In our case, however, physical space requirements are a concern.

Table 4 Minimum version and module numbers required for different relevant code lengths

Code length	Low error correction		High error correction	
	Version	**Modules**	**Version**	**Module**
23	1	21x21	3	29x29
26	2	25x25	3	29x29
41	2	25x25	4	33x33
44	2	25x25	4	33x33
50	3	29x29	4	33x33
68	3	29x29	6	41x41

[11] https://www.goclickchina.com/blog/rising-popularity-of-qr-code-in-china-and-how-to-use-qr-code-for-business/

In order to better understand the requirements in the physical world, an experiment was conducted. Details can be found in Annex I. The experiment consisted of printing QR codes of CITES codes with two different lengths (39 characters and 47 characters) in different physical sizes. QR codes were degraded in five different levels to simulate typical printing problems (stripes, blurring, dust, low printer resolution etc). Codes were printed on a home inkjet printer with 300 dpi.

Then a smartphone was used to read the codes with three different apps, all of which were free of charge. There was no consistent difference between apps, apart from the fact that currently only the free-of-charge QRQR app of Denso Wave is able to read rMQR codes.

Figure 8 Minimum size normal QR code with 5 countries in three different deterioration levels (no deterioration, medium, and strong deterioration). For more examples, see Annex I.

The most important result was that increasing the code length from 39 (one country of origin) to 47 characters (five countries of origin) did not result in any change in the code readability. This means that, effectively, QR codes are a good way to store additional information.

The second most important result was that QR codes represent a space saving of 30-60% when compared to a clear text code. This means that producers – relatively independently of whether the sturgeons or paddlefish producing the caviar lot come from one or from five countries of origin – can save valuable label space by using QR codes.

The third important result was that for low to strong deterioration levels the area of the code had to be larger than 0.56-1.00 cm^2. For reference, a 5cm diameter round container for caviar has a top surface area of about 20 cm^2, so that the code represents 3-5% of the top surface area. If printed on a strip of at least 0.35cm width, the code would occupy 2.0-2.7cm, i.e. around 50% of a 5cm strip.

For very badly deteriorated codes, a larger area is needed. In that case, the minimum area was 3.3cm^2 in the experiment.

5.4 Required technical capabilities for issuance and reading of QR codes

ISSUING

- No particular technical capabilities are necessary for code issuance.

PRINTING

- In order to create a QR code, software is necessary. There are free generators online and free software packages in different programming languages (Python, C, C#, Java and surely many more). There is even the possibility to generate QR code images from Excel.[12] There are also free mobile phone apps like QRQR from Denso Wave.
- A printer is necessary. Two types of printing procedures are used: in-line high-speed printing directly on the primary packaging material or printing of labels which are then applied either manually or automatically to the primary packaging. For low volumes, a standard

[12] https://www.howtoexcel.org/generate-qr-codes/

laser printer might be suitable. Given that the position of the code is not prescribed by CITES, a square code can be printed anywhere on the label. Alternatively, an rMQR code can be printed on narrower parts of the label.
- QR codes can also be applied to primary containers via laser marking. Laser markers are quite expensive; on the other hand, there is next to no consumable cost and the laser marking might be attractive from a marketing viewpoint.

READING

- QR codes can be read by most scanners
- QR codes can also be read by smartphones. Decoding a QR code is not a computationally complex task, so even low-spec smartphones can decode QR codes well. It does require a functioning camera. For older phones which do not natively decode QR codes, free of charge apps can be downloaded from the internet.

5.5 Label printers

Table 5 collects a few label printing technologies with some information regarding costs. There are generally two very different classes of printers:

1) Industrial in-line printers that mark products on the production line
2) Industrial or non-industrial label printers that print on adhesive labels, later to be applied manually or automatically to the primary packaging

For small-scale production, companies will probably buy a ready-made label from an external supplier and then print the code on the label. For this, a desktop label printer that is compatible with the label used is sufficient.

For larger scale and fully automated production, the two classes have differences in their application. The first class can be used to print directly onto the primary packaging material (as seen in Figure 2), i.e. the application of the commercial label can be separated from the printing of variable information (such as lot number, expiry date and CITES code).

For the second class, both steps can be merged. Labels can be pre-printed or not and variable information is printed on the label before it is applied.

Laser engraving is different technology; typically, this would print only very essential information directly onto the packaging material.

Most label printers today are capable of printing QR codes. Very few will be able to print natively rMQR codes; however, many can print graphics and therefore also rMQR codes.

It is not clear, therefore, that an adoption of QR codes by CITES would necessarily result in investment cost. On the other hand, it stands to reason to assume that smaller processors are more likely to have to invest than more modern, larger processors.

Table 5 Different printing technologies and associated costs and product examples. Product examples were taken from an internet search. Not for all products prices were readily available. In any case prices are indicative.

Technology	Description	Cost factors		Substrate	Example
		Printer	Con-suma-bles		
Inkjet	Propels ink droplets on substrate	++	+	Cardboard, pa-per, wood, metal, plastic, and others	High-end: INKJET Dura-Code, RN Mark RNJet 100+
Thermal	Uses heat and a spe-cific paper to print	+	+	Cardboard, pa-per, synthetics, textile	Low-end: Zebra ZD220 (ca 250USD), Brother VC-500W (color) (ca 220 USD)
Thermal trans-fer	Melts material from a ribbon, so that it becomes "glued" to the substrate	+	++	Cardboard, pa-per, synthetics, textile	Low-end: TSC TE 200 (ca 400 USD)
Thermal inkjet	Uses heat to pressur-ize and eject drop-lets	+++	++	Metal, wood, plastic, textile, cardboard, pa-per	High-end: INKJET Answer U2, RN Mark RNJet H1+ (ca 1,700-2,200 USD)
Case Coder (mainly for secondary packaging)	Propels oil-based ink droplets for more contrast codes	+++	++	Cardboard, pa-per, wood, and other porous materials	High-end: INKJET Preci-sion 18mm, RN Mark RNJet H1+ (ca 1,700-2,200 USD)
Laser marking	Engraves the sub-strate with laser	++++	+	Varies, but in-cludes glass and metal	High-end: INKJET F8100U

5.6 How to secure a QR code

It is very important to note that from a security perspective QR codes are the logical equivalent of the clear text CITES code itself: there is absolutely no guarantee that the code was legally issued, and that the information encoded is true.

NOTE: *QR codes encoding URLs have been flagged as a security risk, because they can be used in phishing attacks; see the box on the right.*

Border officials would have exactly the same information as with the clear text CITES code and would still have to use the same methodology to ascertain the legality of the export process. Given that the export control authority has to do an extra step (scanning the code), one might even argue that this will lead to fewer rather than more checks.

As in general food traceability, there are two main concerns regarding the CITES code when trying to establish legality of trade for a specific sample:

1) That the code was falsified by assuming a false identity
2) That the information encoded is incorrect

The first concern involves a third party copying or otherwise falsifying a code, whereas the second involves the processor and potentially business partners of that processor.

FALSE CODES
QR codes can be copied easily, just as the clear text version of a CITES code can be copied easily.

The structure of the code is public information, so it is very easy to generate a synthetic code even without having access to an example from a particular processor (which in itself is easy to find, given that the code has to be on primary packaging, so it can be copied in any retail store).

Denso Wave has created the so-called SQRC code which theoretically addresses that issue. The code has a public and a private part. In order to decode the private part a particular reading device is necessary, as well as a secret key.

In order to use this solution, every legal caviar processing and repackaging company would have to have such a secret key. Management Authorities (and anyone else whose task it is to ensure the legality of export) would have to have access to the secret key (or if public/private keys are used to the public key).

Needless to say, if anyone who has access to a secret key shares it, codes can be falsified.

QR codes and phishing

Malicious organisations which try to exploit QR codes would typically create a web page that is nearly identical to the one the user is really trying to access. Under the disguise, the false web then tries to extract confidential information from users, e.g. credentials.

Alternatively, malicious organisations can produce a site that looks identical to the real web page and disseminate incorrect information.

A remedy against phishing is the so-called two-factor authentication where users have to answer a challenge on more than one “factor”, e.g. log into the website with username and password and a code sent to their mobile phone.

In general, users should always check the URL when scanning a QR code.

Holograms have been used in order to guarantee label safety. While simple holograms are copiable, holograms can also contain secret features that make them very hard if not impossible to copy. However, apart from being costly, this requires that enforcement employees know the secret features (and don't divulge them).

FALSE INFORMATION

This is a much harder challenge to address and, in reality, there is no foolproof solution available.

The "false information" concern should be divided into several subclasses:

i) Entry of false information at any stage of the supply chain without the knowledge of the supply chain partners
ii) Wrongful modification of information in the supply chain without the knowledge of the supply chain partners
iii) Collusion with supply chain partners and/or individuals in charge of checking the information

An example for challenge (i) would be the sales of a sturgeon from the wild to a processor in the same country making the latter believe it came from an aquaculture operation.[13]

An example for challenge (ii) would be the processor having purchased a wild sturgeon but then declaring that the caviar is from a farmed sturgeon.

An example for challenge (iii) would be a processor declaring that caviar comes from a farmed sturgeon when in the declared country of origin there are no aquaculture operations and colluding with supply chain partners and/or individuals in charge of controlling the legality of the trade process to ignore that fact.

Challenge (i) can only be solved with an inspection of the traceability records (as access to the sturgeon might be lost) in combination with an inspection of the premises of the supply chain partner. It might be possible to identify fraudulent behaviour from the records alone (by using a mass balance approach, for example), but this would likely require access to all business records (and therefore most likely a site visit).

Challenge (ii) can be solved by using a secure transport mechanism of the electronic data, such as a blockchain. Blockchain is a technology that uses a "distributed ledger", of which every supply member has a copy and in which all changes are recorded. Any alteration of the ledger can be identified with relative ease. Blockchains require an information system to generate, hold and add to the ledger. Such information system can be centralized (e.g. operated by some authority in the country) or distributed (where e.g. every supply chain partner has their own information system).

NOTE: *Contrary to common belief, blockchain systems only protect against wrongful alteration of information, not against wrong information entered into them. In the example for challenge (i), the blockchain would happily transport the incorrect information that the sturgeon is from an aquaculture operation. It is true, however, that the party providing the wrong information can be easily singled out and therefore becomes more vulnerable.*

[13] Seemingly more frequent is the opposite case where caviar of farmed origin is sold as wild, according to A. Petrossian in a conversation on July 9th, 2024

Challenge (iii) is part of the general challenge of corruption. It goes far beyond the scope of this report to consider corruption.

In general, however, the more information is available, the easier it is to check and to identify parties that participate in illegal activities. More available data also allows those involved in ensuring the legality of trade to formulate more precise questions which may lead to the identification of fraudulent activity. In the end of the day, this is the raison d'être of the CITES trade database.

In this sense, the implementation of a global registration system/traceability system for sturgeon and paddlefish and their products would sure help in guaranteeing the authenticity of CITES codes and the legality of trade.

5.7 Advantages/disadvantages of QR codes when compared to alternatives

YYYxXXX/I/GBRYEEAECL/1000/E573020250506/L948390

Figure 9 For comparison, a GS1-128 barcode encoding a CITES code with 47 characters. Note that normal mobile phones do not support reading this code.

Although the use of QR codes is widespread, there are other ways to encode a CITES code. One-dimensional codes are not advisable, as they would require a significant amount of space, very likely larger than the clear text. By means of an example, Figure 9 shows a GS1-128 encoding of a 47 character (imaginary) CITES code.

Another example is shown in Figure 10. MicroPDF417 codes have good capacity but are quite vulnerable to deterioration.

Figure 10 MicroPDF417 code encoding YYYxXXX/I/GBRYEEAECL/1000/E573020250506/L948390

Figure 11 shows the most interesting alternative to the QR code, the so-called DataMatrix code. DataMatrix codes are used widely in the pharmaceutical industry and in manufacturing because of their very limited space requirements. DataMatrix codes can encode fifty characters of data in a symbol of 2 or 3mm^2 and the code can be read with only a 20 percent contrast ratio[14] and with up to 30% damage[15]. DataMatrix codes used to require specialised scanners, but (modern) smartphones will read them perfectly well. The main advantage of the DataMatrix code is its smaller size. The main advantage of a QR code is that they are better known outside of the pharmaceutical and the manufacturing industry and that therefore it will be more likely that a person knows how to deal with a QR code.

Figure 11 GS1 DataMatrix code encoding YYYxXXX/I/GBRYEEAECL/1000/E573020250506/L948390

If code sizes of about a 1 cm^2 are too large, using a DataMatrix code would be preferable.

[14] https://web.archive.org/web/20170914052646/http://www.jollytech.com/technologies/barcode-symbologies/data-matrix-barcode.php

[15] https://www.cognex.com/resources/symbologies/2-d-matrix-codes/data-matrix-codes

6 Shortcomings of CITES labelling requirements

KEY TAKEAWAYS

- QR codes were proposed as a measure to efficiently deal with very long CITES codes
- Interviews were held with a number of members of the intersessional working group on caviar labelling
- The interviewees welcomed the study to inform the discussion of the working group
- Interviewees referred to the need to balance the effort necessary to change a well-working system with the added value of the implementation of QR codes in CITES
- QR codes as simple replacements of the clear text CITES code are not likely to provide sufficient added value, given that in practice only 2-3 countries of origin are mixed
- QR codes in combination with an information system are much more promising; internet connection issues and security concerns have to be addressed

6.1 Background

At its 72nd meeting in Geneva in 2020, the Standing Committee established an intersessional working group on caviar labelling.[16] This working group has the following mandate:

a) *consider the practical challenges in the implementation of the provisions of the Convention with regard to the application of the "CITES guidelines for a universal labelling system for the trade in and identification of caviar" contained in Annex 1 of Resolution Conf. 12.7 (Rev. CoP17) on Conservation of and trade in sturgeons and paddlefish in light of the recognized shift in many instances from trade in wild-caught specimens to non-wild specimens produced in aquaculture facilities;*
b) *as needed, prepare draft recommendations for CoP19 to address the identified challenges with the aim of arriving at a practical approach for trade in caviar from aquaculture production, including as necessary amendments to Resolution Conf. 12.7 (Rev. CoP17); and*
c) *report on the above to the Standing Committee.*

The working group consists of 11 Parties (Belgium, Canada, China, Czech Republic, France, Georgia (Chair), Germany, Italy, Japan, Malaysia, United States of America) and 7 observers, (International Union for Conservation of Nature, Association of Midwest Fish and Wildlife Agencies, Associazione Piscicoltori Italiani, International Caviar Importer Association, IWMC-World Conservation Trust, TRAFFIC, Word Wide Fund for Nature).

One of the proposals that were brought forward in the working group, was to interpret the country of origin as the processing or repacking country instead of the country of origin of the fish. The main reason for this proposal was to avoid having to including several country-of-origin codes in the CITES code for caviar, citing space requirements and complexity as main arguments.

In aquaculture facilities, fish can be placed and grown out from a series of countries. When roe is processed, it is usually first placed in a holding container for a period of time; in this holding container (or at any other time further down in the process), roe from different fish is mixed. For this reason, different lots of caviar originate from multiple and varying fish and therefore countries of origins of the same.

[16] https://cites.org/sites/default/files/notifications/E-Notif-2020-081.pdf

A similar argument can be made at repacking, where potentially different lots (and ergo origins of the fish) can be mixed for greater product quality, operational efficiency and avoidance of losses.

If country of origin is interpreted as country of the fish, a sound traceability system is required which may generate potentially very long lists of countries of origin.[17]

Such traceability requirements would go beyond the European Union's General Food Law[18] with its "one step up, one step down" approach, but at the same time would be equivalent to the European Union's regulations for import of fish and fish products[19], created to combat illegal, un-reported and unregulated fishing.

In this sense, the requirement to identify the origins of all fishes contributing to a lot of caviar is not extraordinary, but more stringent than that of other food items.

In the context of the discussions, QR codes were highlighted as having the potential to provide a significant amount of information in a relatively small space. QR codes are also often used as a user-friendly way to access an information resource on the internet.

The proposed interpretations of the labelling requirements were discussed in the working group without conclusion; the group felt technical guidance was a required next step before the discus-sion could continue.

6.2 Interviews with representatives of the Caviar Labelling Working group

The list of interviewed parties and observers can be found in Annex III. Rather than report on the individual contributions, Table 6 summarises the main discussion topics categorised by Party, Ob-servers (NGO) and Observers (private sector). Observers have been differentiated in this way, as they are likely to represent different views.

Although the consultant informed each interviewee that this study was concerned only with the use of QR codes in replacement or in addition to a clear text CITES code, most of the discussions referred back to the use of QR codes in the context of an additional information resource.

It is likely a fair summary of the views that a QR code as a simple replacement of a CITES clear-text code did not create a lot of interest. The argument that codes might become too long (and there-fore font size used on the label too small) was accepted, but those that prefer to keep the country of origin of the fish were not overly concerned given that in practice the number of country codes required is not that large.

If QR codes were to simply replace clear text CITES codes, the added value of its introduction was questioned; a general feeling was that given the effort and costs required to change the system globally, there is probably not enough added value.

Most of the interviewees agreed that some information system linked to a QR code would change the discussion significantly. The purpose of such information system varied from a simple "decoder system" of the CITES code (similar to the system detailed in Annex II) to a full-blown traceability system. Private operators were also interested in adding marketing information.

All interviewees welcomed the study as contribution to the discussion around the reform of the caviar labelling system.

[17] It is difficult to say how many countries of origin really contribute to commercial products. Mr Bardong from the German CITES Management Authority reported that at most two or three countries of origin had been observed under their supervision.

[18] Regulation (EC) No 178/2002, https://eur-lex.europa.eu/legal-content/EN/ALL/?uri=CELEX:32002R0178

[19] Regulation (EU) 2023/2842, https://eur-lex.europa.eu/legal-content/EN/TXT/PDF/?uri=OJ:L_202302842

Table 6 Topics and concerns raised in interviews with Parties and Observers. Observers have been split into Observers (NGO) and Observers (private sector) to separate different viewpoints.

Topic	Description	Party	Observer (NGO)	Observer (private sector)
Value of changing the status quo	Given that the current labelling system has had satisfactory results, is there a clear added value in changing the system? The vast majority of caviar comes from aquaculture production and therefore does not impact wild stocks. (That some smugglers declare caviar coming from aquaculture as being “wild” is deplorable, but has no impact on the conservation of sturgeons and paddlefish)	X		X
QR codes are not used anywhere else in CITES	No other CITES labelling system currently uses QR codes	X		
Technical requirements	QR codes require cameras and software to be read. In some countries, border officials are not issued smartphones, and at the same time are not allowed to use private phones	X		
Traceability required for effective protection of sturgeons and paddlefish	While progress has been made and most caviar now comes from aquaculture, wild populations of sturgeon and paddlefish are still under pressure from (illegal) trade. A traceability system would be a great tool; QR codes would allow for easy access to traceability information.		X	
Trade in live sturgeons and paddlefish is complex	Live fish trade for use in aquaculture is complex and often not transparent. Losing traceability information (e.g., by replacing the country of origin of the fish by the country of processing) would result in even less control. On the other hand, traceability at farm level and because of all the fish movements can become cumbersome and potentially result in an undue burden	X	X	X
Country of origin of the fish is a distinctive mark	Some countries trade with live fish from their hatcheries. Replacing the country of origin of the fish with the country of processing in the CITES code would remove the link to the original country and with it the associated marketing opportunities. On the other hand, repackers might not want to disclose so publicly the origin of their product for marketing reasons			X
QR codes are too commercial	QR codes found on commercial products usually are linked to marketing materials; the use of such a system seems inappropriate for the purpose of ensuring legal trade		X	
Internet connection not available everywhere	If the QR codes were to be linked to an information system, scanning would require an internet connection. In places where goods are controlled (warehouses etc.), this might not be feasible	X		

Cost of implementation	Concerns regarding the impact of costs related to QR codes, especially for small producers and repackers	X	X	
Current CITES code unintelligible	The current CITES code is not understandable for consumers and other non-experts. A QR code linked to an information system could help understand it and provide better information	X	X	X
QR codes and security	QR codes do not provide any additional security. They can be copied and falsified as easily as clear text codes. If linked to an information system (i.e., encoding a URL), QR codes can be used for phishing or for provision of wrongful information	X	X	X
Illegal trade and wrong declarations	Currently, the main problems are illegal trade and incorrect declarations. In neither case a labelling system, whether or not based on QR codes, is a solution.	X		
QR codes more complex to create	QR codes require a certain level of expertise to create	X		
QR codes versatility	In many countries, in addition to the CITES code, other information elements are required, such as veterinary registration or similar. If the QR code could encode all the required information, that would surely save a significant amount of space on the label	X	X	

7 Benefits and drawbacks of QR codes as part of the CITES labelling system

KEY TAKEAWAYS

- QR codes are designed to contain a significant amount of information in a small physical space. They save 32-65% of space when compared to clear text (and DataMatrix codes save even more)
- QR codes can contain very different codes in the same physical space, so different CITES coding schemata can have the same physical appearance
- QR codes are user-friendly; in combination with an information system (even a simplistic one), they can help in border control – but then require an internet connection and increase the risk of online threats
- Without an information system, there is no real improvement over the status quo from an enforcement point of view. The need to scan might reduce the amount of checks

This section attempts to summarise the benefits and drawbacks of using QR codes as part of the CITES labelling system not only for caviar, but also for other products.

As has been established during this report, a stand-alone QR code without an information system behind it, is logically equivalent to a clear text code.

In Annex II a very simplistic information system is outlined that could be implemented and maintained at a very low cost. Even such a simple system would provide a significant amount of extra benefit to using QR codes instead of clear text codes.

The main advantages of using QR codes (or equivalent two-dimensional barcodes like DataMatrix codes) can be summarised as follows:

- For a code of any reasonable length, QR code represents significant space savings when compared to clear text codes. For most CITES purposes, 1 cm^2 symbol should be sufficiently resilient to deterioration to be used for CITES labelling purposes
- QR codes are flexible by nature, i.e. if the coding system changes, within certain limits the size of QR codes will not have to be altered; this makes them "future-proof" for business operators, as these only have to design labels once and can rely on the size of the symbols not changing in the future
- In the same line, QR codes would allow for practically any number of countries of origin without running into space problems.
- If at some stage of the supply chain for whatever purpose there is a desire to store CITES codes in a database or similar, having codes in a machine-readable format greatly assists in automated data capture. If a CITES Party, for example, would decide to record codes in a database for which an export license is required, QR or DataMatrix codes would be very helpful
- In combination with an information system (even a simplistic like the one described in Annex II), QR codes could offer human-understandable information to enforcement agencies or others involved in the export process. It could also allow consumers to access more information that is relevant for the legality of the product they are buying (and perhaps some traceability or commercial information).

- QR codes are more user-friendly and well-known than DataMatrix codes. QR codes are easily recognisable and therefore facilitate finding CITES codes on the container (which currently is not always trivial).

On the other hand, the main drawbacks can be summarised as such:

- In the absence of an information system that delivers enriched or easier to digest information, there is no advantage to enforcement agencies when using QR codes. On the contrary, officers in this case will have to have access to a smartphone. The need to scan a code might reduce the checks of border officials under time pressure.
- If an information system is used and for better usability a URL is encoded in the QR code, there is need for an internet connection and there is additional risk for phishing. Users would have to be alerted to always check the URL before opening the web page. A typical remedy is not to codify the URL and print it as clear text on the packaging material, but this greatly reduces the user-friendliness of the scanning process. A mobile app could resolve this issue
- If a QR code were to be required by CITES, in a few cases this will require investment for commercial operators. Most label printers can print QR codes, but some older models or some industrial marking machines might not be able to.
- Normal QR codes require a square space which might not be easily available on the label; rMQR codes are surely a remedy, but given that they are very new, label printers will not be able to print them natively.
- Except in unlucky circumstances, humans are better in reading badly printed text than cameras are in decoding badly printed symbols.
- QR codes require more physical space than DataMatrix codes.

The arguments can be found in a more summarised form in Table 7.

Given that the topic is complex and a solution not necessarily obvious, a recommendation tree was created; see Figure 12. This tree can be employed to reach a conclusion based on a few simple considerations.

Table 7 Summary of benefits and drawbacks of using QR codes as part of the CITES labelling system

BENEFITS	
Space saving	QR codes save between 32-65% of label space when compared to clear text codes
Flexibility	The dimension of the code will not change even if there is a change in the underlying code
Long codes possible	There is no restriction e.g., on the number of countries of origin in a code (within reason)
Automation	If CITES codes must be registered in the supply chain or in the export process, machine-readability is a great advantage
More information	In combination with an information system, more information can be provided to improve legality checks and to provide consumers with information
User-friendly	QR codes are well-known by users, employed in a large variety of circumstances and easily recognizable, making it easier to find a CITES code on a primary container
DRAWBACKS	
No improvement	The *status quo* is not really improved, as the same code is simply written in another form on the container. The need for a smartphone and scan time might reduce code checks
Investment	In some cases, investment in printing (or reading) technology might be necessary. It is not expected for that to happen frequently
Label space	Normal QR codes require a square space; rMQR codes are rectangular but not generally natively supported by label printers and phones. (Free software is available for printing and reading)
Resilience	The human brain is in most cases better at error correction than cameras (and software)
Online	If linked to an information system requires internet connection and increases online threats
More space	QR codes need more space than DataMatrix codes

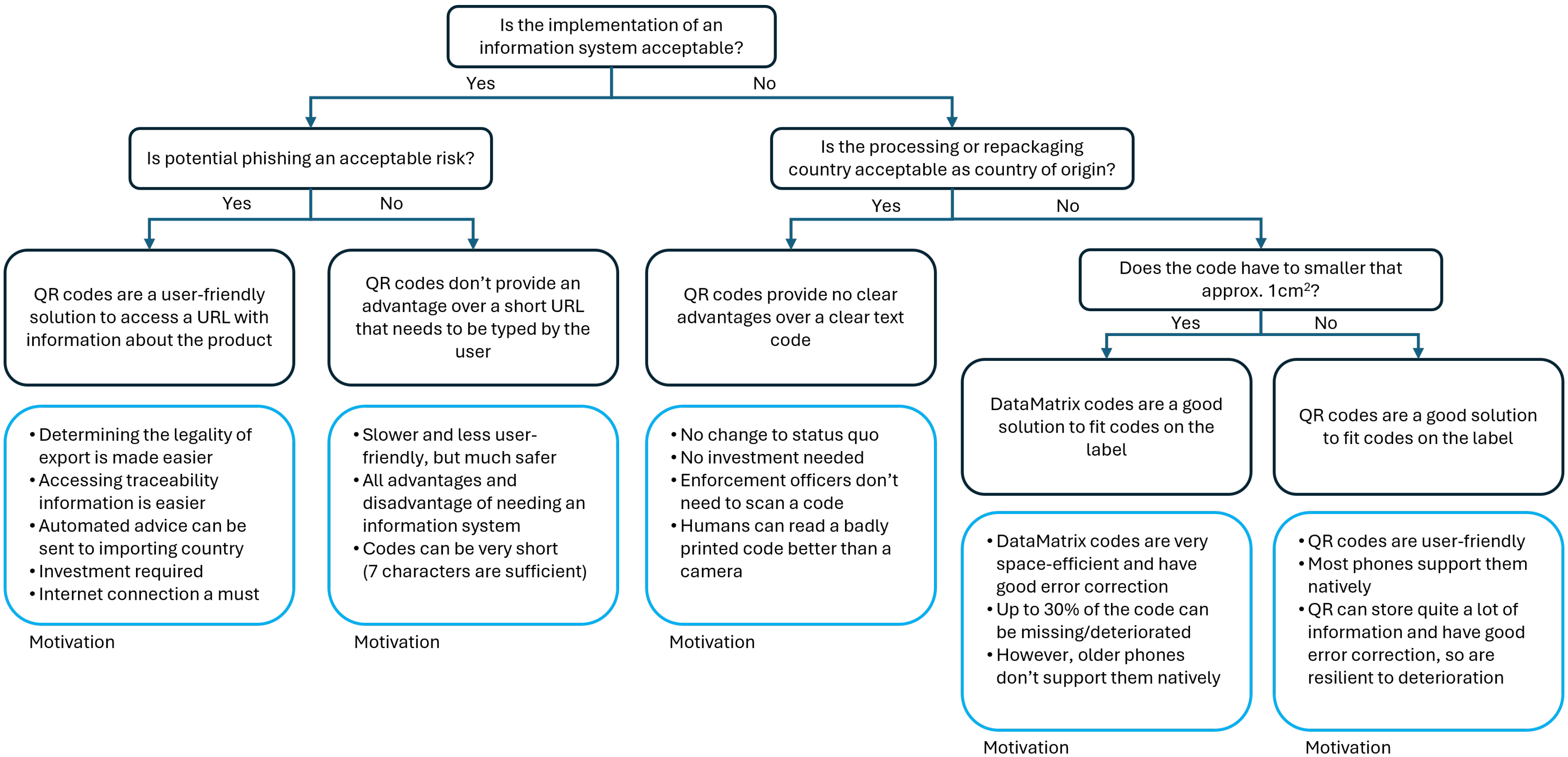

Figure 12 Recommendation tree diagram

8 Requirements for efficient use of QR codes in CITES

KEY TAKEAWAYS

- QR codes are very efficient in themselves; their application to CITES only comes with two requirements:
  1) That a reference to readability of the symbol needs to be included in the CITES guidelines and
  2) That if an information system was to be used together with the QR code, then reasonable measures must be taken to avoid the risk of phishing

In the case that CITES were to adopt QR codes into the application of the CITES guidelines for a universal labelling system for the trade in and identification of caviar, here are some requirements and suggestions for an efficient use of them.

REQUIREMENTS

1) CITES guidelines should include a reference to the readability of the code.
2) If an information system were to be used in combination with QR codes, reasonable measures need to be taken to reduce the risk of phishing

SUGGESTIONS FOR CONSIDERATION

1) The readability of QR codes depends on their size amongst other things, especially when codes are degraded in their transition through the supply chain. It would help if the guidelines contained a minimum size of the code (in surface area).
2) If a minimum size is established, a maximum code length should be established; the precise length requires some consideration, but a first approximation might be 50 characters.
3) It would be suggested to make the readability of the code a requirement for export, i.e. containers with codes that cannot be successfully scanned, should be rejected for export.
4) If the QR code does not encode a URL, a mechanism could be considered to include additional, non-CITES information in the same QR code. This could be accomplished e.g. by pre-facing the code with "C/" and leaving a space after the CITES code and before any other information.
5) It would be advisable to implement a practical pilot study in a caviar supply chain to gather further experience

9 Recommendations for consideration of the working group

The following recommendations seem particularly relevant in the context of this report:

1. The members of the working group are recommended to consider the implementation of an information system, even if very basic like in Annex II, to hold simple information elements as contained in the CITES code. Having such a resource available will allow for very simple checks (correctly formed code, existence of the registration etc) and would provide both officials and consumers the means to easier consider the information provided on the CITES code.

2. The members of the working group, having developed a view on the above question, are recommended to consider the recommendation tree shown in Figure 12 in order to determine whether the introduction of QR codes is beneficial to the legality of trade in caviar.

3. If there is sufficient interest in using QR codes for the purpose of labelling caviar, a pilot implementation in a particular caviar supply chain is recommended to gain practical insights into the adaptation of controls to the new technology.

4. It is suggested to consider adding requirements to the caviar labelling guidelines regarding a maximum length of the CITES code and the readability of it. In case of the adoption of QR codes, that readability requirement should include directions on the minimum size of the code.

5. In case of the adoption of QR codes, it is also suggested for the working group to consider making the readability of the code a responsibility for its issuer and to disallow export in case the code is not readable.

10 Annex I: Readability experiment of QR codes

10.1 Objective of the experiment

In order to better understand the readability of QR codes by mobile phones, an experiment was conducted that attempted to understand how readability is affected by

- Code size
- Printer and phone camera resolution
- Code type
- Degradation of the code
- QR code app on the phone

Degradation of the code was simulated by including random stripes, applying Gaussian blurring, introducing noise, simulating dust particles and different print qualities by varying the compression level of the image. The source code is available upon request.

10.2 Experimental setup and materials

Materials:

- Samsung phone S21+
- Three applications were used to scan QR codes (Samsung Camera V14.1.01.7, QR Scanner - Barcode Scanner by Apps Wing, QRQR by Denso Wave)
- Ink-based home printer (HP Smart Tank 650)
- 80g white paper

Experimental setup:

- Two fictitious codes were generated from random data
  - The first was generated with a single country origin and has a length of 39 digits: **YYYxXXX/F/IR/1000/E635046283726/L711524**.
  - The second was generated with five countries of origin, concatenated without separator, resulting in 47 digits: **YYYxXXX/I/GBRYEEAECL/1000/E573020250506/L948390**
- Each code was printed at 300 dpi for
  - Two types of codes (normal and rMQR)
  - Five respective six sizes
  - Five levels of degradation (with the "amount" of stripes being the leading factor)
- The code parts not belonging to the countries of origin were chosen to be relatively long; there is no rule in CITES how long a code can be, so the maximum length was estimated from examples
- The codes were then scanned with the mobile phone without keeping the distance constant but rather simulating how a person would scan a code
- In a few cases, the app took longer to read the code; this was not separately noted
- The differences between the three apps for reading normal QR codes was negligible. The rMQR code could only be read by the QRQR app.

10.3 Codes

Depicted in Figure 13 and Figure 14 are the QR codes that were used for the experiment.

NOTE: *the depicted codes are not at scale (due to page margins).*

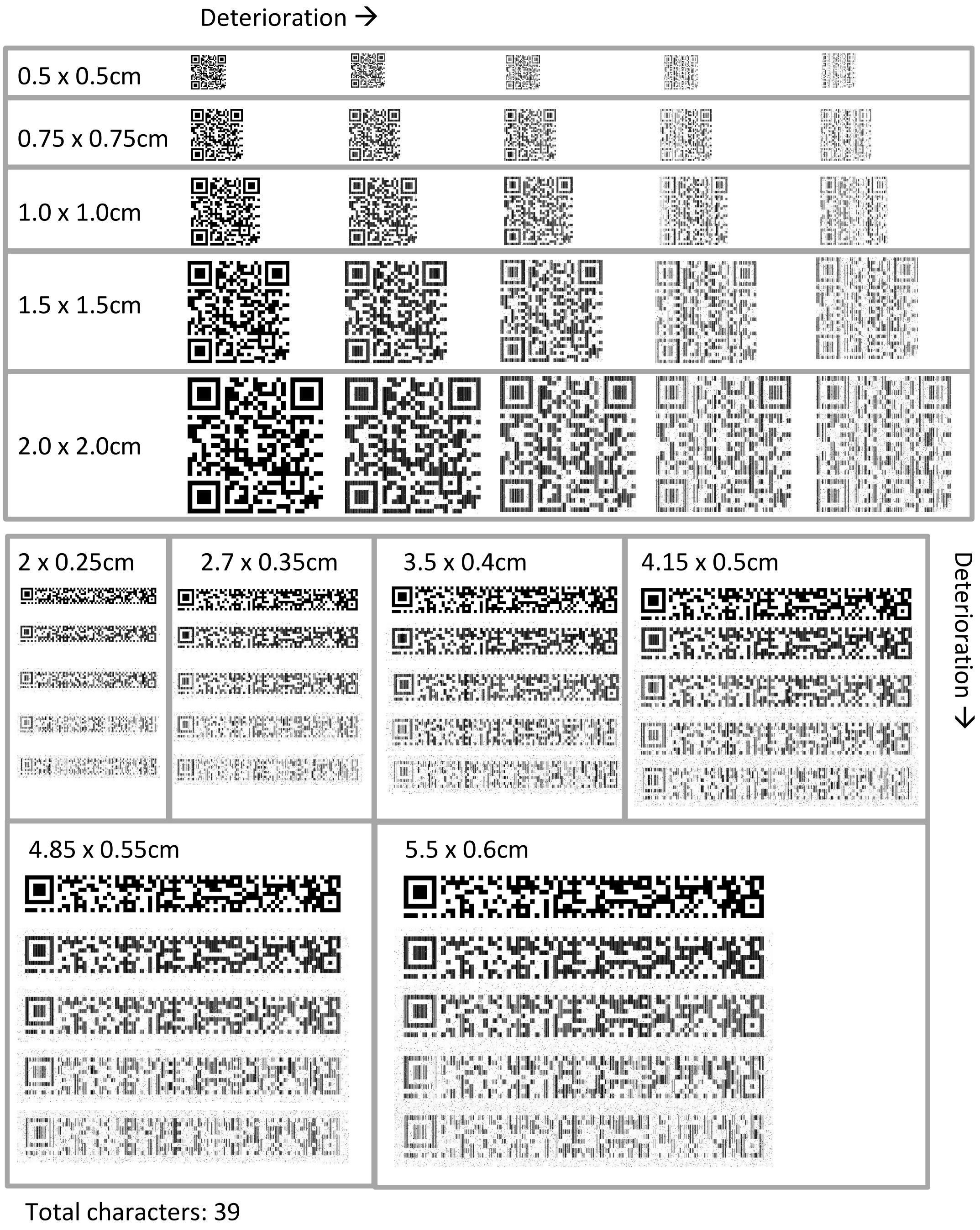

Figure 13 Normal and rectangular micro QR codes for 39 characters and different sizes and deterioration level. Symbol sizes refer to their reproduction at scale, not size in this figure.

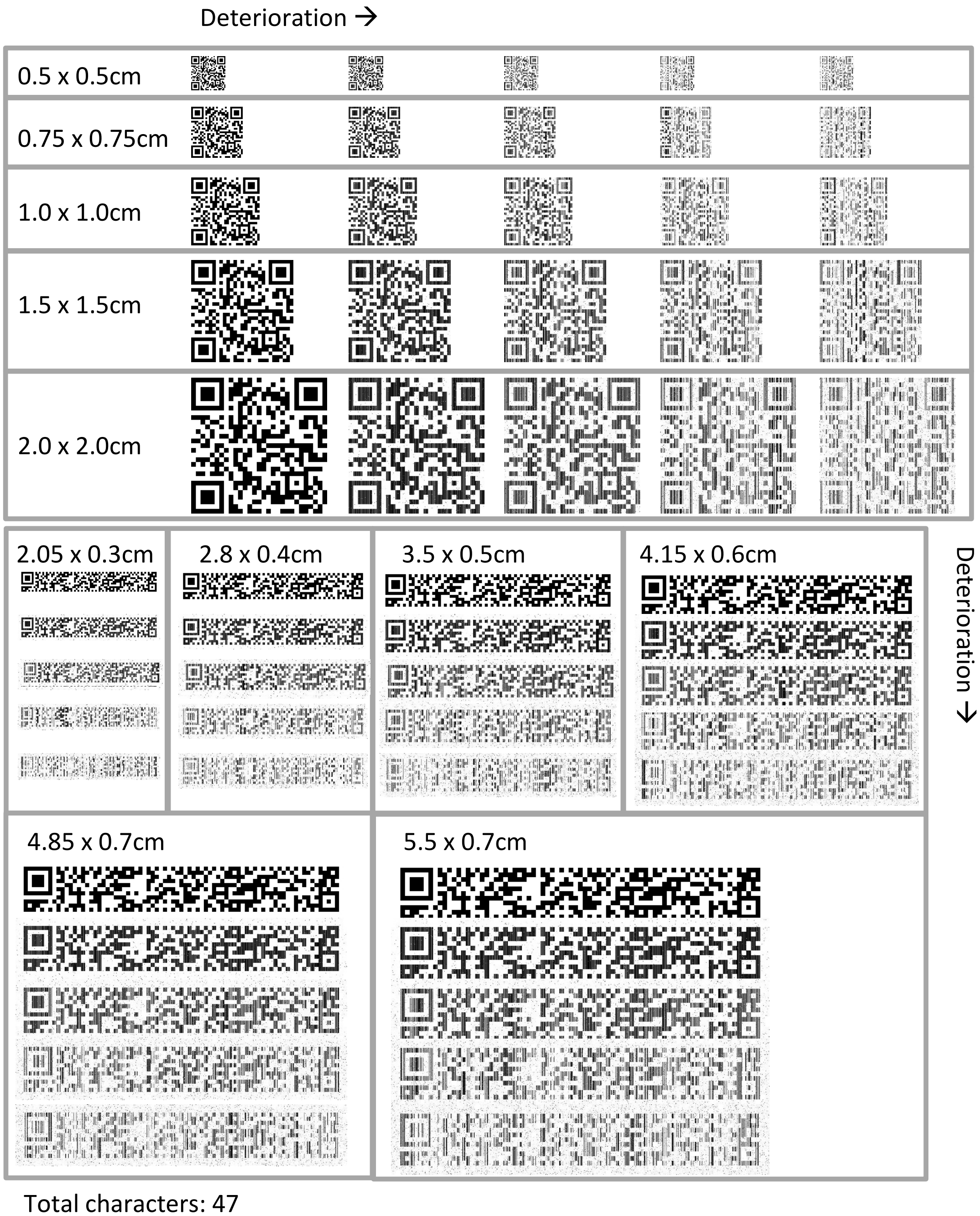

Figure 14 Normal and rectangular micro QR codes for 47 characters and different sizes and deterioration level. Symbol sizes refer to their reproduction at scale, not size in this figure.

10.4 Results and discussion

Table 8 Results of the experiment scanning different types of QR codes with different sizes and levels of deterioration. All images were generated at 300 dpi. For deterioration, random stripes were introduced, Gaussian blurring applied, noise introduced, dust particles and different print qualities simulated by varying the compression level of the image. Images were scanned on a Samsung S21+ phone under ambient light conditions. Distance to the image was not held constant. In some cases, the application took a longer time to recognise the code; this was still counted as "success". In the table, "X" refers to a successful reading of the code and an empty cell refers to an unsuccessful attempt to read the code. The names of the countries were concatenated without delimiter, so caviar from Georgia and Armenia would have "GEAM" as countries of origin. It was attempted to choose long values for the length of the remainder of the fields. The rules on caviar identifiers do not include any maximum length of the individual code parts.

Type	Width (cm)	Height (cm)	Area (cm²)	Nº of countries	Nº of characters	Deterioration level				
						0	1	2	3	4
Normal	0.50	0.50	0.25	1	39					
Normal	0.75	0.75	0.56	1	39	X	X			
Normal	1.00	1.00	1.00	1	39	X	X	X		
Normal	1.50	1.50	2.25	1	39	X	X	X	X	
Normal	2.00	2.00	4.00	1	39	X	X	X	X	X
rMQR	2.00	0.25	0.50	1	39	X	X			
rMQR	2.70	0.35	0.95	1	39	X	X	X		
rMQR	3.50	0.40	1.40	1	39	X	X	X	X	
rMQR	4.15	0.50	2.08	1	39	X	X	X	X	
rMQR	4.55	0.55	2.50	1	39	X	X	X	X	
rMQR	5.50	0.60	3.30	1	39	X	X	X	X	X
Normal	0.50	0.50	0.25	5	47					
Normal	0.75	0.75	0.56	5	47	X	X	X		
Normal	1.00	1.00	1.00	5	47	X	X	X		
Normal	1.50	1.50	2.25	5	47	X	X	X	X	
Normal	2.00	2.00	4.00	5	47	X	X	X	X	
rMQR	2.05	0.30	0.62	5	47	X	X			
rMQR	2.80	0.40	1.12	5	47	X	X	X		
rMQR	3.50	0.50	1.75	5	47	X	X	X	X	
rMQR	4.15	0.60	2.49	5	47	X	X	X	X	
rMQR	4.85	0.70	3.40	5	47	X	X	X	X	
rMQR	5.50	0.70	3.85	5	47	X	X	X	X	X

Observations

1. QR and rMQR yield similar results when considering the surface area required
2. Augmenting the length of the code from 39 to 47 character (20% increase) did not significantly change the ability to read the code; larger increases would be expected to have an impact on readability
3. Deterioration has a major impact on readability; there is a need for a certain print quality and therefore a certain level of technological capabilities. However, the minimum print quality did not depend on the code length in this experiment
4. For low to strong deterioration levels the area of the symbol had to be larger than 0.56-1.00 cm^2.[20] In comparison, a 5cm diameter round container has a top surface area of about 20 cm^2, so that the code represents 3-5% of the top surface area. If printed on a

strip of at least 0.35cm width, the code would occupy 2.0-2.7cm, i.e. around 50% of a 5cm strip

5. For very strong deterioration levels, codes had to have an area of at least 3.3 cm^2.[20]

Regarding the space savings by using a QR code, the code was printed in 8-point Courier New and its space requirements compared to a normal and rMQR code that is readable even for significant levels of deterioration, i.e. which has at least about 1cm^2 of area. This is shown in Figure 15.

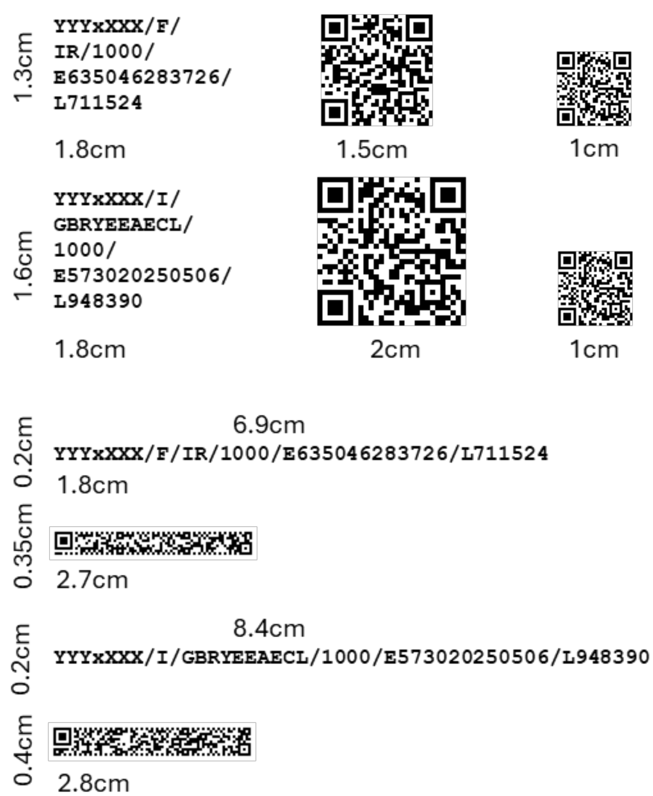

Figure 15 Space requirements by clear text codes when compared to QR codes. Clear text was printed in 8-point Courier New.

Table 9 summarises the space savings when using QR codes as opposed to clear text codes. The space savings of the different QR code types were measured in reference to an 8-point Courier New human-readable code. Given that in multiline codes space is required between lines, the space savings are higher when comparing a multi-line code to a QR code. However, if the basis is a single line code, space savings are consistently around 30-40%.

[20] The precise value will depend on the materials printed on, printer and the scanning phone.

Table 9 Calculation of space savings by using QR codes when compared to clear text in 8-point Courier New.

Type	Width (cm)	Height (cm)	Area (cm^2)	Nº of countries	Nº of characters	Reduction in area [%]
Clear text	1.80	1.30	2.34	1	39	57%
Normal	1.00	1.00	1.00	1	39	
Clear text	1.80	1.60	2.88	5	47	65%
Normal	1.00	1.00	1.00	5	47	
Clear text	6.90	0.20	1.38	1	39	32%
rMQR	2.70	0.35	0.95	1	39	
Clear text	8.40	0.20	1.68	5	47	33%
rMQR	2.80	0.40	1.12	5	47	

11 Annex II: Information systems to enhance CITES codes

11.1 Outline of a barebone information system

While the use of an information system in addition to the code is out of scope for this report, it might make sense to consider a very simple solution in further discussions of the working group.

Producers, but also enforcement officers have an interest in obtaining as effortlessly as possible relevant information about a product. The CITES code already provides a lot of that information, but in a way that is efficient in space, but not easy for humans to understand.

Given that the CITES code already contains a lot of information, the CITES Secretariat or in lieu any organization that the Parties deem appropriate, could operate a very simplistic dynamic web page.

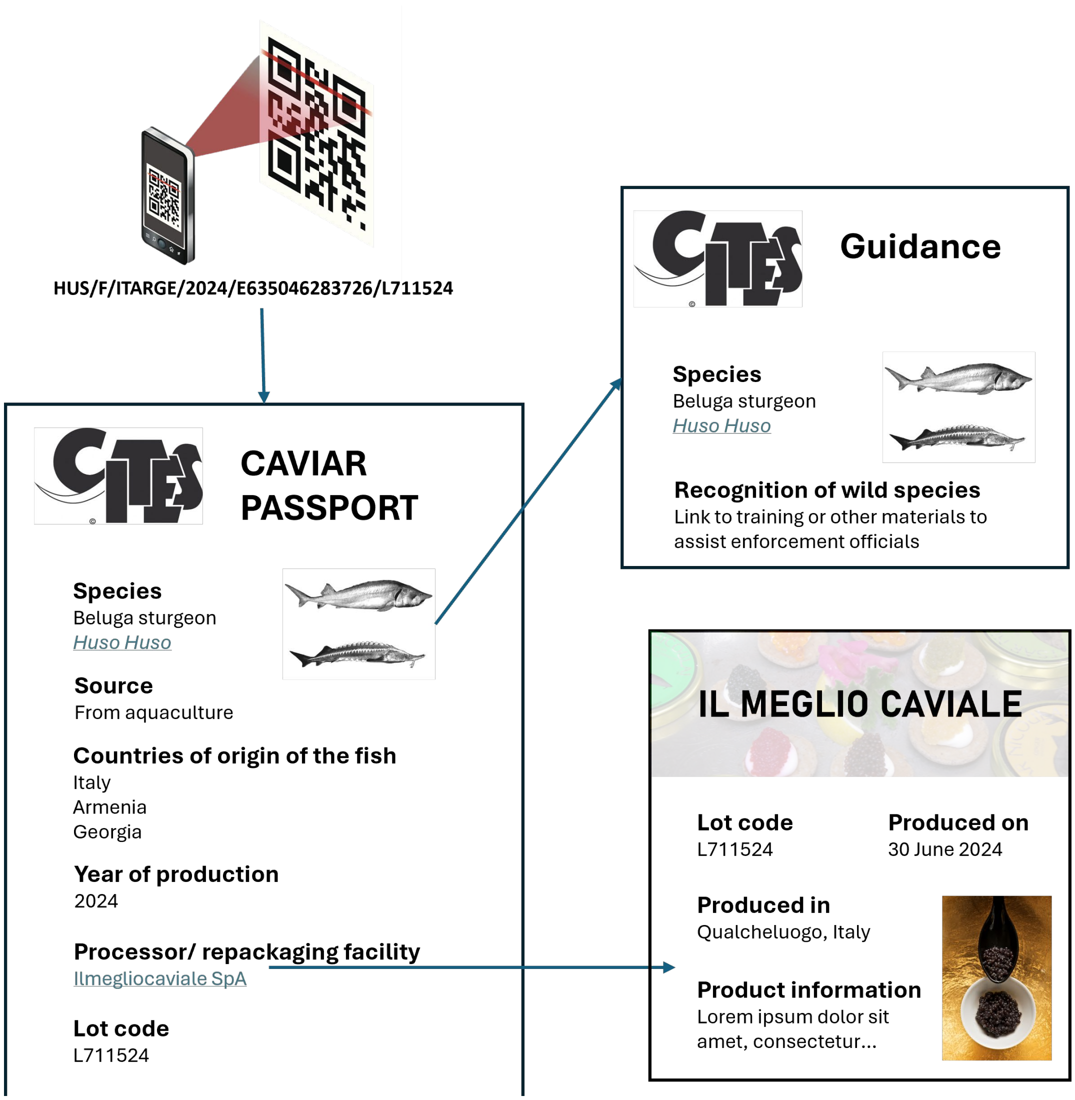

Figure 16 Conceptual representation of simplistic information system that could be operated by a CITES appointed organisation, such as the Secretariat. Caviar picture taken from THOR. Species picture taken from T Chu

As shown in Figure 16, the URL for this web page could be either encoded in the QR code or if security concerns prevail could be printed on the packaging material.

Once accessed, the enforcement officer, a consumer or anyone else could visualise a "product passport" which shows:

- Name of the species (and a picture of it)
- Clear text source code (e.g. "Wild")
- Countries of origin (as a list of clear names, i.e. "United States of America" instead of "US")
- Year of production
- Clear name of the processor/repacker
- Lot number

If guidance material is or becomes available (relevant resolutions, guidance how to recognise specimens from the wild or similar resources), these could be linked, so that enforcement officers in the CITES Parties have access to such information.

In addition, processors and repackers might have an interest to provide consumers with additional information, e.g. traceability information. They could provide a URL to CITES which would be added to the processor name, making it clickable. Upon clicking that URL, the user would be taken to a web site of the processor who can then make additional information available.

On the CITES side, this would require only a very simple dynamic webpage (in the official languages of CITES) which in turn has access to the existing caviar exporters list in order to find the name of the processor/repacker from the registration code present in the CITES code for the caviar.

A mobile application could also be considered. A mobile app would not require an internet connection for decoding the CITES identifier in border control processes. Any updates to the exporter list could be handled through updates from the corresponding app store.

Such simplistic system could later be extended to carry some information on CITES permits or certificates or any other documents if there is an interest in doing so.

This system would allow for basic error checking, such as

- The CITES code is well-formed
- The processor/repacker is part of the CITES caviar exporter list maintained by the Secretariat (if not, an enforcement officer might want to check the country's own list of processors and repackers)
- The time between the scan and the year of production is reasonable

Although such a simplistic approach is not safe against fraudulent activity, it could be a simple and easy to implement tool for simple checks. The system could also record scans that were unsuccessful and report them to the appropriate organisation. In the same manner, the lot codes could be saved in a simple database with the view of potential detection of re-used lot codes.

11.2 Other information systems

As discussed in detail in Section 5.6, there are a number of challenges in guaranteeing that a CITES code is correct. Information systems – such as the simplistic described above – can be used to strengthen the validity of a CITES code.

While the implementation of information systems requires a much more in-depth analysis, a few types of systems can be imagined in addition to the above-described simplistic system.

Of course, each system has its own complexities and costs for implementation and operation. The exact cost cannot be determined without a thorough analysis and a detailed description of the system. For this reason, information on this aspect is provided on a scale of 1-5 where 1 is the least complex and therefore least costly and 5 the most complex, hence most expensive to implement.

Simplistic system

Already described in section 11.1

Signed QR code

There are a number of ways to digitally sign an information element. The CITES-internal document "Guideline on the Use of 2D barcodes on CITES Permits/Certificates"[21] describes different ways to secure a CITES permit or certificate which apply identically to a CITES code.

The CITES code (or a suitable hash) is encrypted using the private key of the signing party and this information is incorporated into the QR code. Different ways to sign exist, as for example the SQRC code (see Figure 4) or the open standard of the World Wide Web Consortium called "Verifiable Credentials"[22]. There are also proprietary solutions.

Most logically, the processor or repacker would have to have the necessary software to generate a secure QR code. Verifiers, such as border officials, would have to have an information system to validate (or decrypt) the code with the public key of the exporter. This means at the least that there is a need for an online resource to store and distribute public keys to verifiers (and probably private keys to exporters).

This system can be distributed, i.e. each CITES management authority could manage its own key infrastructure. However, in this case validation would have to be resolved, so that a code scanned e.g. in Germany can confirm its validity on a system provided by the Georgian authority. If the appropriate URL is incorporated into the QR code, this should not be difficult.

Such a system guarantees that the QR code is authentic, but it does not guarantee that:

1) The scanned code is the "original"; QR codes remain imminently copiable
2) The information contained in the QR code is correct

A verification tool could be delivered as a smartphone app; however, when processors or repackers change, the app would need to be updated. The biggest advantage of an app would be that it can work without an internet connection.

Code register

An alternative path to authentication of codes is to create a registry of legally generated codes. For this, processors and repackers upload the QR codes they have generated for each lot in a timely fashion.

[21] Made available by the Secretariat.
[22] https://en.wikipedia.org/wiki/Verifiable_credentials

The verifier then uses an information system to make sure that the code scanned was previously registered.

Management authorities could ask for some details when the code is registered.

This system can be distributed, i.e. each CITES management authority could manage its own register. However, in this case validation would have to be resolved, so that a code scanned e.g. in Germany can confirm its validity on a system provided by the Georgian authority. If the appropriate URL is incorporated into the QR code, this should not be difficult.

Such a system guarantees that the QR code is authentic, but it does not guarantee that:

1) The scanned code is the “original”; QR codes remain imminently copiable
2) The information contained in the QR code is correct

A verification tool could be delivered as a smartphone app; The app would have to update valid CITES codes on a regular basis (at least daily, similar to an antivirus software updating virus definitions). Once it has a valid list, it can work without an internet connection.

Alternatively, analysis of possible breaches of the CITES rules can be done *post-hoc*. Given that the exporter’s details are known, they can be handed over to the local authority.

Mass-balance traceability

Mass balance is the simplest and coarsest traceability mechanism[23]. It relies on the comparison of incoming quantities with outgoing quantities through a conversion factor.

Applied to the caviar trade, a mass-balance system could record fishes against relevant CITES categories (wild vs farmed and by country of origin). In a timeframe to be specified, the production of caviar in one of the categories should not exceed what can reasonably assumed to be produced (via an average caviar yield).

For repackers, this procedure would record incoming quantities of caviar by category, as well as outgoing quantities by category. Assuming a yield of the repacking process, the outgoing quantities per category should never exceed the incoming quantities.

Mass-balance systems are a kind of Pareto rule system which try to achieve 80% of impact with 20% of effort. They cannot detect small quantities of counterfeit material. On the other hand, they require much less effort on behalf of the caviar processor or repacker than alternative traceability systems.

Mass-balance traceability systems can be distributed, and they can be managed in a blockchain. Verifiers, however, have to a way to access the system to verify the information contained. Very likely this requires access right management with a simple summary of the data provided to the general public and more comprehensive access for border official.

Alternatively, data could be analysed by local or global authorities *post-hoc*, so that the verification process is not linked to a particular CITES code but rather to a processor or repacker.

[23] A good review for typical traceability systems can be found here: https://www.redcert.org/images/SP_EU_Massbalance_Vers07.pdf

Lot-based traceability system

Lot-based traceability is the gold standard in food traceability. It requires identification of all ingredient lots for each product lot, as well as recording key data elements (KDEs) at each critical tracking event (CTE).

Applied to the caviar trade, it would consist in recording reception of each fish (and recording when such fish is sold or removed from stock for any other reason). A lot of caviar would then have to be linked to each contributing fish (though not necessarily the quantity it contributed). Records connecting the lot code to a buyer would document where the lot went to.

For repackers, incoming caviar lot codes would be recorded. For the product lot, all contributing ingredient lots would have to be recorded. Records connecting the lot code to a buyer would document where the lot went to, unless it is retailed.

If there is a single fish per lot, this is special case of lot-based traceability usually referred to as "identity preserved".

Such systems have the most requirements on private operators. If the information is kept centrally, it also raises privacy concerns, as much of competitive information is contained in the traceability system.

Mixed models exist where only partial information is made available to the authority but said authority has the right to inspect the full dataset in a case of reasonable doubt.

Lot-based traceability systems can be distributed, and they are often managed in blockchains. Verifiers, however, have to have a way to access the system to verify the information contained. Very likely, this requires access right management with a simple summary of the data provided to the general public and more comprehensive access for border official etc.

NOTE: *Table 10 provides an overview over the different options in table format.*

11.3 Comparison

Table 10 Comparison between different information system types with the purpose of strengthening CITES codes as a control tool for legality of trade.

#	Name	Description	Involves	Advantages/disadvantages	Cost[24]
1	Simplistic system	Simple "decoder" of information contained in CITES code, plus static information. Possibility to deliver as mobile app.	Secretariat or designated entity; timely communication of exporters by Parties	Makes information more accessible; can perform very basic checks	1
2	Signed QR code	A digital signature is added to the QR code whose authenticity can be verified (phishing is still a risk). Can be based on the Verifiable Credentials standard, but proprietary solutions also exist.	Requires public key infrastructure; agents of management authorities need to download and install public keys. Tool is required to validate signature. Code issuers have to have access to a private key.	Guarantees to some extent the authenticity of codes – might generate illusion that the information contained is correct also. Codes can still be copied (but not made up).	2
3	Code register	System where processors and producers register each CITES code they generate. A code in the supply chain can then be checked for authenticity.	Requires a secure online registry for CITES codes (can be distributed). Lookup can be manual but would ideally be incorporated into an online system. Requires internet connection for checking – which can, however, be done *post-hoc*.	Guarantees that the code was issued. Does not guarantee that information contained in code is correct. Codes can still be copied (but not made up).	3
4	Mass-balance traceability	Mass-balance based traceability system limited to acquisition of fish and sales of caviar. Does not provide details on the composition of each lot but allows statistics-based verification of outputs. Small quantities of counterfeit material will not be detected.	Processors and repackers file basic information every time unit (e.g. monthly) on an information system (can be decentralised). If basic information is made available, requires secure online system with user management.	Simplest possible verification that information underlying the CITES code is correct; has loopholes especially for small quantities of illegal material but is used by several sustainability standards (e.g. RSPO, EU-RED). Can be combined with options 2 and 3.	4

[24] Cost of implementation and operation on a scale of 1-5 with 1 being the lowest and 5 the highest

			Verification is done *post-hoc* (similar to CITES trade database). Consumer validation requires a verification system with different access rights.		
5	Lot-based traceability system	Traceability system (typically based on blockchain) that holds specific information for each lot of caviar produced. Records precise origins for each lot. (If single fish is enforced, called "identity preserved" system.) Hiding small quantities of counterfeit material increasingly cumbersome.	Processors and repackers file information for every lot generated on an information system (can be decentralised). Requires secure online system with user management for validation. Consumer validation requires a verification system with different access rights.	Best known method to validate information contained in a supply chain. Probably requires legislation to enforce its use as companies are often hesitant to provide detail. Blockchain should be secured e.g. by encryption to avoid data breaches.	5

12 Annex III: persons and organisations contacted

The following persons and organisations have provided input into this report.

Organization	Type	Person
Germany	Party	Jacqueline Günter Andreas Bardong
United States of America	Party	Amanda Lamberson Somma Angela Naimah Aziz Russel Husen Daniel A Sahakian Michelle Turton Laura Cimo Shireen Yousef
Canada	Pary	Lise Jubinville
IWMC World Conservation Trust	Observer	Jacques Berney
Associazione Piscicoltori Italiani	Observer	Andrea Fabris
WWF	Observer	Jutta Jahrl
ICIA (International Caviar Importers Association)	Observer	Armen Petrossian