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# WILDLIFE BIOLOGY

## Review

### Hunting and fishing harvest data collection: a horizon scanning exercise from the French context

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Legal and societal moves increasingly lead leisure hunting and fishing practitioners to record their harvest. The total number of individuals harvested per population per year is the minimum required information to feed into demographic models and allow science-based management. Some few schemes record more detailed data, hence allowing better-informed decisions to be made. France has an extended list of legally

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harvested species and a wide variety of exploitation modes, which leads to a large number of harvest data collection schemes. This country is therefore taken as a case study to review the variety of situations and the pros and cons of each protocol. This review outlines a set of best practices that can guide future harvest data collection schemes both nationally and internationally, distinguishing basic information that is needed for minimum management from additional data that allow for more detailed knowledge. It highlights the trade-off between using simple tools and clear protocols to encourage user participation, and the need for more detailed data to support advanced modeling techniques used for modern population and harvest management.

Keywords: fishing, France, harvest statistics, hunting, protocols

## Introduction

Harvest statistics based on relevant and reliable data are essential for sustainable and ethical management of exploited wildlife and fish populations (Williams et al. 2002, Belhabib et al. 2014, Rudd and Branch 2017, Van Beveren et al. 2017, Breisjøberget et al. 2018, Johnson et al. 2018, Hilborn et al. 2020, Moreno-Zarate et al. 2023). For a long time and in most countries, exploitation was accepted as long as it was not demonstrated to threaten animal populations. It is currently considered as one threat to biodiversity on a global scale (Maxwell et al. 2016, Costa et al. 2021), and a major paradigm shift is occurring: occidental societies nowadays increasingly question the very principle of wildlife exploitation, for both terrestrial animals and fish, especially when this is practised as a leisure activity (Heberlein and Willebrand 1998, Arlinghaus et al. 2007, 2012, Byrd et al. 2017, Gamborg and Jensen 2017, Raftogianni et al. 2022). Generally speaking, such exploitation of natural resources is better accepted within clear regulatory conditions aiming at maintaining the conservation status of harvested species (e.g. AEWA sustainable harvest guidelines in Madsen et al. 2015; management of harvested mammals in Apollonio et al. 2010 or Ripple et al. 2016; management of harvested fish in FAO 2015, Hilborn et al. 2015, Charles 2023). Policy-makers and managers therefore now require, prior to exploitation, that those willing to harvest first demonstrate the innocuity of their offtake, especially for species with a poor conservation status, prior to exploitation (Pope and Powell 2021, Samarelli and Van der Steegen 2024). In line with such changes in regulation, a number of schemes collect such bag size information in a variety of countries (e.g. through Article 12 of the European Birds Directive or 1224/2009 EU regulation for the common fisheries policy in Europe, see also PACEC 2014, Aubry et al. 2016, Aebischer 2019, Hirschfeld et al. 2019, Raftovitch et al. 2022), sometimes over the very long term (e.g. a 120-years' time series in Reimoser et al. 2014; 50 years for ungulates in France as described by Réseau Ongulés Sauvages 2024). However, such information is actually not systematically collected and, when it is, coordination of protocols among countries is often lacking, making international data compilation complicated or even impossible (Aubry et al. 2020a). Such challenges can, for example, prevent the effective implementation of international adaptive management approaches for Western Palearctic migratory bird flyways. This is a critical issue as most harvest collection protocols have their own strengths and pitfalls, so that they do not provide the same information depending

on exactly what, when and who is surveyed. National values cannot therefore simply be pooled with each other in order to obtain an overall European or worldwide total (Pauly and Zeller 2016, Aubry et al. 2020a). Furthermore, harvest data collection schemes may even differ among species or taxonomic groups within a given country, creating further confusion. For hunters and fishers, the multiplicity of procedures and reporting tools, sometimes without a clear link with the objective of the survey, likely contributes to build defiance against what may look as an excessive surveillance, doubts about what the data will be used for or ignorance about who will analyse the data and how this will be done, all leading to high non-response rates (Stern and Coleman 2015, Pauly and Zeller 2016, Aubry and Guillemain 2019) with negative consequences for management itself.

The present work aims at drawing a sketch for leisure hunting and fishing data collection in France. It reviews the variety of long-lasting existing systems along with the strengths and weaknesses of their protocols, with the goal of potentially informing international initiatives. France is taken as an example given its wide variety of exploitation schemes and administrative structures at national scale, and a significant exploitation of natural resources in many cases (Aubry et al. 2016). Wildlife and fish harvest have a large historical, cultural and political importance in the country (Herfaut et al. 2013, Stepanoff 2021). France is also consistently among the nations with the longest list of harvested species (mammals and birds; Supporting information) and the largest hunting bags for some species (e.g. two million ducks harvested annually in the country while the second largest national bag is one million in the UK; Guillemain et al. 2016).

The research question addressed here is that of the efficiency of the various possible harvest data protocols, trying to assess whether each of these actually reaches its goal of efficient data collection. To our knowledge, such a horizon scanning exercise built on a wide variety of schemes has never been carried out. The paper therefore provides a prospective analysis relying on a typology of existing situations of bird, mammal and fish exploitation in France. The ultimate goal is to suggest a canvas: standardized and perennial rules that can be followed here and translated to other countries, to provide reliable and comparable information, representative of actual offtake and allowing comparison over time. This is absolutely crucial to a robust evaluation of wildlife and fish harvest, hence to fulfill the obligations of international agreements and meet the increasing public demand for a transparent and sustainable exploitation of wildlife and fish populations.

## Material and methods

The analytic frame is restricted to hunting and fishing statistics collection schemes currently implemented in France for some time. To enforce such regulations, a wide range of harvest data collection schemes have been put in place over the years (e.g. linked with the law on freshwater fishing in 1984 [www.legifrance.gouv.fr/jorf/id/JORFTEXT000000692732](http://www.legifrance.gouv.fr/jorf/id/JORFTEXT000000692732), on hunting in 2000 [www.legifrance.gouv.fr/jorf/id/JORFTEXT000000584127](http://www.legifrance.gouv.fr/jorf/id/JORFTEXT000000584127) or in the frame of the introduction of adaptive management in 2019 [www.legifrance.gouv.fr/jorf/id/JORFTEXT000038821234](http://www.legifrance.gouv.fr/jorf/id/JORFTEXT000038821234)). However, there has been no coordination or proper global strategy among such schemes. These are therefore very likely to differ in terms of enforcement (mandatory versus voluntary), type of data collected, governance (role of authorities, academics, hunter/fisher organizations) or collection frequency.

We here provide a typology of such existing schemes, i.e. a description of current practices. We listed all common hunting and fishing statistics collection schemes we were aware of, some of which the authors themselves are directly involved in. We focused on common and national-scale schemes, as well as some regional ones when they shed light on particular data, regulations or information collection practices. We distinguished each fishing/hunting practice associated to a given harvest statistics survey and recorded the taxa concerned (species or group of species); the detailed exploitation mode; who the practitioners are; the precise data being collected, with a special focus on the units being used (e.g. whether it is expressed per day or per season, whether totals are broken down into age and sex categories); the data transmission modes; the geographic coverage of the survey; whether it allows computing exploitation pressure (e.g. if auxiliary data on the number of days afield are also recorded); whether reporting is mandatory and the penalty for not reporting; and the legal framework into which the survey is implemented. Professional fishing in salt and freshwater in France is associated with specific regulations not covered here. Only in a few cases where a given exploitation mode is practised by both hobbyists and professionals is this mode considered in the review (e.g. net and trap fishing). At the time of writing this article, France has just introduced new reporting schemes for some species (e.g. to monitor compliance with new waterfowl bag limits), but it is too early to evaluate their efficiency, strengths and weaknesses, so these are not considered here.

## Results

### A variety of fishing and hunting data collection protocols

Table 1 provides a simplified typology of fishing and hunting data collection schemes in France, showing whether they mostly provide the basic data required (one evaluation of national uptake in terms of total number of animals per season) or additional information such as the legal framework (mandatory or voluntary), composition of the harvest in terms of age and sex classes, details at daily or monthly

time intervals, or estimation of harvest pressure. Detailed information for each data collection scheme is provided in the Supporting information. Despite not being comprehensive, this overview already shows a wide variety of fishing and hunting statistics collection schemes, which generally differ by the harvest methods and often the species concerned. The major strengths and weaknesses of each scheme are shown in Table 2.

### Species and exploitation modes

Apart from the national hunting bag survey, which covers all hunted species but is only conducted very episodically, there is generally one single survey for a given exploitation mode and a given species (or group of species, e.g. ungulates, or area covered, e.g. rivers in public domain; Table 1). A bagged individual hence usually only has to be reported once, following a given survey method for that species or that harvest method (e.g. thrushes *Turdus* sp. and blackbird *Turdus merula* depending on trapping/shooting methods), which is a strength. There are, however, exceptions such as in waders (Charadrii), where a hunter may be submitted to one survey if hunting on the public seashore, plus a second one if this is done during the night from a hut. This is a major weakness, as practitioners may easily get lost in a jungle of procedures.

### Collected harvest data

The basic data being collected are always the number of individuals or total weight taken per species over a time period (Table 1). For hunting, such time period is the season, which often covers the end of a calendar year and the beginning of the next one, i.e. autumn to the end of winter. Data can be collected daily (e.g. Atlantic salmon *Salmo salar* fishing), monthly (e.g. net and trap fishing) or annually (e.g. ungulate hunting). Some schemes ask for the number of active days, even for days with no bag, which can later be used to evaluate harvest success and pressure (e.g. traditional hunting of blackbird, thrushes and pigeons). In the case of woodcock *Scolopax rusticola*, hunters can also voluntarily report the number of birds seen (in addition to the number shot). Apart from mountain Galliformes and often ungulates, sex and/or age information are not mandatory in the other surveys. Similarly, few schemes routinely require collection of body measurement data such as mass or size/length: this is only asked for migratory salmonids and mountain Galliformes, and done on a voluntary basis by many ungulate hunters to evaluate population health status. Even fewer schemes collect biological samples for later scientific analyses: fish scales for life history of migratory salmonids, wing and/or digestive tracts for sexing and assessing diet of waterbirds or mountain Galliformes in some départements (French administrative units of ca 6000 km<sup>2</sup> on average). In some départements such collection of body parts (or pictures) is used to show compliance with pre-determined hunting quotas, not for research. Biological sample collection is instead often conducted as separate survey schemes, such as done by the Association Nationale des Chasseurs de Gibier d'eau (National Wildfowling Association), which collects over 10 000 duck wings annually ([www.ancge.fr/actions/recolte-ailes](http://www.ancge.fr/actions/recolte-ailes)).

Table 1. Simplified typology of hunting and fishing bag survey schemes in France. Grey columns indicate the basic requirements (an annual estimation of total number of individuals harvested). Columns to the right indicate if a given scheme records additional information. A tick in the box indicates the given scheme (line) collects data for the given topic (column). See the Supporting information for details. <sup>1</sup>a given scheme aims to provide a total estimation of harvest at the national scale (number or volume of individuals taken). <sup>2</sup>a given scheme covers the entire European France territory (i.e. continental France and Corsica) where this precise harvest is legally practised (some harvest modes are only legal in a part of the national territory). <sup>3</sup>reporting is mandatory for a given scheme. <sup>4</sup>a given scheme, in addition to recording the total number/volume of animals taken, also collects data on the age or sex of the individuals. <sup>5</sup>a given scheme, in addition to recording harvest size, collects some biological samples on the harvested individuals. <sup>6</sup>a given scheme records information at a finer scale than the annual total. <sup>7</sup>a given scheme records auxiliary information allowing harvest pressure (e.g. harvest per day or per participant) to be computed. <sup>8</sup>Survey so far carried out ca every ten years.

Activity	Basic requirements		Additional information				
	Total number of individuals harvested <sup>1</sup>	National scale <sup>2</sup>	Mandatory report <sup>3</sup>	Age/sex structure <sup>4</sup>	Biometrics/biological samples <sup>5</sup>	Daily/monthly data <sup>6</sup>	Some evaluation of exploitation pressure <sup>7</sup>
Migratory salmonid fishing	✓	✓	✓		✓		✓
Net and trap fishing	✓	✓	✓			✓	
General hunting <sup>8</sup>	✓	✓					
Nocturnal waterbird hunting	✓	✓	✓			✓	✓
Wader hunting on public seashore	✓	✓	✓				
Woodcock hunting	✓	✓	✓	✓	✓	✓	✓
Mountain Galliformes hunting	✓	✓	✓	✓	✓		
Waterbird hunting (Camargue)	✓	✓	✓		✓	✓	✓
Wild ungulates hunting	✓	✓	✓	✓	✓	✓	✓
Adaptive management of turtle dove	✓	✓	✓				✓
Traditional pigeon and dove hunting (hunting huts)	✓	✓				✓	✓
Traditional skylark hunting (falling traps)	✓	✓	✓			✓	✓
Traditional skylark hunting (live netting)	✓	✓	✓			✓	✓
Traditional thrushes and blackbird hunting (falling stones)	✓	✓	✓				✓
Traditional thrushes and blackbird hunting (snares)	✓	✓	✓				✓

Table 2. Strengths and weaknesses of hunting and fishing bag survey schemes in France. See the Supporting information for details.

Activity	Major strengths	Major weaknesses
Migratory salmonid fishing	<ul style="list-style-type: none"> <li>– Data collected, analysed and processed since 1987</li> <li>– Frequent collection of biological samples and morphological data</li> <li>– For salmon, responds to a legal requirement</li> </ul>	<ul style="list-style-type: none"> <li>– Reporting rate far too low for sea trout (voluntary survey)</li> <li>– Unknown reporting rate</li> </ul>
Net and trap fishing	<ul style="list-style-type: none"> <li>– Responds to a legal requirement</li> </ul>	<ul style="list-style-type: none"> <li>– Lack of means to motivate amateur fishers</li> <li>– Unknown data quality</li> <li>– Reporting rate far too low for amateur fishers</li> </ul>
General hunting	<ul style="list-style-type: none"> <li>– Clear and statistically robust survey design</li> <li>– National estimate with confidence interval at national scale</li> <li>– Single method for all species</li> </ul>	<ul style="list-style-type: none"> <li>– Time- and budget-consuming (several survey rounds including direct telephone interviews)</li> <li>– Conducted very infrequently (ca every 10 years)</li> </ul>
Nocturnal waterbird hunting	<ul style="list-style-type: none"> <li>– Targeted at a particular hunting mode</li> <li>– Responds to a legal requirement</li> </ul>	<ul style="list-style-type: none"> <li>– No distinction between inactive and non-responding participants</li> <li>– Requires double reporting for waders on public seashore</li> </ul>
Wader hunting on public seashore	<ul style="list-style-type: none"> <li>– Provides an evaluation for a specific area (seashore)</li> <li>– Responds to a legal requirement</li> </ul>	<ul style="list-style-type: none"> <li>– Reporting rate far too low</li> <li>– Requires double reporting for nocturnal hunting</li> <li>– Data not readily accessible</li> </ul>
Woodcock hunting	<ul style="list-style-type: none"> <li>– Has introduced systematic bag reporting for a migratory game bird (mind-changer)</li> <li>– Has initiated transition from paper to app reporting</li> <li>– Responds to a legal requirement</li> </ul>	<ul style="list-style-type: none"> <li>– Reporting rate highly heterogeneous in space and far too low at national scale</li> </ul>
Mountain Galliformes hunting	<ul style="list-style-type: none"> <li>– Helps managing restricted harvest on some fragile populations</li> <li>– Strong compliance by practitioners</li> <li>– Provides a good estimate of the harvest</li> </ul>	<ul style="list-style-type: none"> <li>– Scale of management unit sometimes inadequate</li> <li>– Multiple stakeholders</li> </ul>
Waterbird hunting (Camargue)	<ul style="list-style-type: none"> <li>– Has helped building collaboration locally</li> <li>– Collection of biological samples (direct link with hunters in the field)</li> <li>– Records hunting effort (number of hunters site<sup>-1</sup> day<sup>-1</sup>)</li> </ul>	<ul style="list-style-type: none"> <li>– Limited geographic scale</li> <li>– Based on volunteers only</li> <li>– Sampling mostly at property scale (not individual hunters)</li> </ul>
Wild ungulates hunting	<ul style="list-style-type: none"> <li>– Generally records age and sex of bagged individuals (sometimes morphometric data)</li> <li>– Collection of biological samples</li> </ul>	<ul style="list-style-type: none"> <li>– Often reported for a party (driven hunt), not a single hunter</li> </ul>
Adaptive management of turtle dove	<ul style="list-style-type: none"> <li>– Has largely relied on smartphone app</li> <li>– Together with warden app, allows monitoring of quota realization</li> </ul>	<ul style="list-style-type: none"> <li>– Requires massive police checks to properly evaluate compliance</li> </ul>
Traditional pigeon and dove hunting (hunting huts)	<ul style="list-style-type: none"> <li>– Very high reporting rate</li> <li>– Records bag and harvest pressure</li> <li>– Often also records the number and size of pigeon flights</li> </ul>	<ul style="list-style-type: none"> <li>– Lacks centralization of data at regional/national scale</li> <li>– Protocol implemented in its full extent in only one département</li> <li>– No information on age ratio of killed birds</li> </ul>
Traditional skylark hunting (falling traps)	<ul style="list-style-type: none"> <li>– Responds to a legal requirement</li> <li>– Number of capture settings known</li> </ul>	<ul style="list-style-type: none"> <li>– Administratively cumbersome: various data transmission means</li> </ul>
Traditional skylark hunting (live netting)	<ul style="list-style-type: none"> <li>– Responds to a legal requirement</li> <li>– Number of capture settings known</li> <li>– Very high reporting rate</li> </ul>	<ul style="list-style-type: none"> <li>– Administratively cumbersome: various data transmission means</li> </ul>
Traditional thrushes and blackbird hunting (falling stones)	<ul style="list-style-type: none"> <li>– Responds to a legal requirement</li> <li>– Number of capture settings known</li> </ul>	<ul style="list-style-type: none"> <li>– Administratively cumbersome: various data transmission means</li> </ul>
Traditional thrushes and blackbird hunting (snares)	<ul style="list-style-type: none"> <li>– Responds to a legal requirement</li> <li>– Number of capture settings known</li> <li>– Harvest pressure known from declaration of days without bagged birds</li> </ul>	<ul style="list-style-type: none"> <li>– Administratively cumbersome: various data transmission means</li> </ul>

### Geographic area

The area covered by each survey depends a lot on administrative limits and on the spatial distribution of both the species and the harvest modes (Table 1). For example, widely scattered birds harvested by gun shooting are usually surveyed at the entire national scale, while mountain game, traditional hunting methods or migratory fish are obviously only surveyed locally. In the case of mountain Galliformes

or traditional pigeon and dove hunting methods, however, the protocols and rules differ among départements. Generally speaking, the geographic scale of surveys is often adapted to what people consider to be the appropriate management unit for the species or practice, and the data obtained eventually provide a national picture (sometimes of a regionally restricted activity), except when different protocols prevent such national-scale compilation.

### Data transmission means

Paper notebooks are still a very common recording tool, although websites and smartphone applications are increasingly being used (Supporting information). In all cases the official application for mandatory hunting data is *Chassadapt*, developed by the National Federation of Hunters. Other applications may be used for some hunting modes on a voluntary basis, such as *Géochasse* where ungulate hunters can record both the number of killed animals and hunting effort (e.g. area of driven hunts, number of hunters, number of dogs). There is also one official website to declare Atlantic salmon and sea trout *Salmo trutta* catches in rivers: DeclarationPeche.fr, provided by the National Fishing Federation (<https://declarationpeche.fr>), and another for all catches using traps and nets in the waters of the public river domain: cesmia.ofb.fr, provided by the French Biodiversity Agency (OFB; <https://cesmia.ofb.fr/connexion>). For coastal leisure fishing, other initiatives are just starting as EU regulation 2023/2842 entered into force on 9 January 2024, and this introduces a mandatory registration and catch declaration for certain species, through a certified application, by 2026. As a consequence, experimental mandatory catch declarations have already been implemented as early as 2024, in two Marine Natural Parks (Calanques and Golfe du Lion MNPs). The Supporting information illustrates the variety of lines of command involved in the different schemes (see the various institutions and acronyms), which may quickly become confusing for practitioners.

### Evaluation of exploitation pressure

There is great heterogeneity in the way harvest pressure is measured in the different surveys. Some surveys mandatorily record the number of participants plus the time spent harvesting or the total number of outings (e.g. nocturnal waterbird hunting), while others only record the number of participants asking for a quota or a dedicated permit (e.g. woodcock hunting). When general activity is monitored instead of individual pressure, it is the number of exploitation outfits that is recorded (e.g. traditional trapping of birds). In the general situation, however, actual data to estimate exploitation pressure are often lacking, or only provided on a voluntary basis (e.g. number of fishing hours for migratory salmonid fishing) (Table 1).

### A variety of legal frameworks

The Supporting information provides a typology of fishing and hunting data collection schemes regarding their legal frameworks, and URLs of the actual legal texts.

Thirteen of the 15 bag collection schemes reviewed here are mandatory, and highly specific to one or a small number of species. Conversely, some few schemes are based on volunteer data reporting, and are mostly required for scientific purposes rather than legal obligation.

One striking result of this survey is the large number of different legal texts (notably laws followed by application decrees) applied to hunting and fishing bag collection schemes within this single country, basically different from

one species to another, sometimes from a harvest method to another for the same species (e.g. Eurasian skylark *Alauda arvensis*), and sometimes with different rules in different areas (see also the Supporting information). In line with this, the Supporting information also illustrates the extent to which data transmission processes differ, as the exploiter sometimes directly reports to the national authorities, sometimes via a suite of different organizations. Beside handing a notebook or declaring on a website or application, enforcement is also performed by checks of bagged animals by environmental police officers such as national environment inspectors, or wardens from the local hunting/fishing society. For Atlantic salmon, woodcock, mountain Galliformes and most ungulate species, fishers and hunters have to mark the taken animals and they can have a limited number of such marks available. For mountain Galliformes, there are even two types of marks: a pre-label put on-site by the hunter, and then a definitive label put on by the local owner of the hunting rights once the bag is reported.

The official penalty for non-reporting in a mandatory bag survey is generally the loss of the licence for a duration of one or more years. In ungulates and mountain Galliformes, non-reporting hunters may have to pay a fee to be allowed to continue hunting the next season (EUR20 in the Hautes-Alpes département). Theoretically, hunters may also lose the lease of their hunting grounds if not reporting, e.g. for ungulates or for wader hunting on the public seashore (which is rented to the state).

### Strengths and weaknesses of the existing protocols

As shown in Table 2, there is no universally 'good' protocol fitting all situations, and all currently existing schemes have their own strengths and weaknesses. These have generally been introduced in response to a legal requirement, which they at least partly satisfy. Beyond the legal issue, it should be noted on scientific and technical grounds that a major strength of having such a wide variety of schemes is that this has promoted the development and implementation of many new tools, some of which are efficient and easy to use (e.g. app reporting). The large number of schemes also leads to massive amounts of data and information (e.g. biological samples) being collected, although sometimes in a disorganized and imperfect way.

Indeed, the clear shared weakness of most schemes is the low response rate, hence showing only partial compliance. Harvest data reporting rate by leisure hunters and fishers is often totally unknown (Table 2). When it is evaluated, the rate is often far from 100%, being less than one out of three hunters for wader shooting on the public maritime domain (seashore; FNC 2020). A notable exception is traditional pigeon and dove live netting and gun shooting from huts, where it approached 90% during the last published survey, despite being non-mandatory (Fédération des Chasseurs de la Gironde 2021). In ungulates, too, reporting rate is considered to be very high by the network of observers. Lastly, the data are doubtful in some cases, especially for nocturnal waterfowl hunting from huts, where bag reporting rate was

reported as 99.7%, but 37.8% of huts were declared as non-hunted (Urbaniak et al. 2022).

## Discussion

### Only basic data are generally recorded

Modern management of exploited wildlife populations requires that harvest (bag size) is evaluated at regular intervals (Johnson et al. 2018, Aebischer 2019, Lindström and Bergqvist 2020, Lormée et al. 2020, Eraud et al. 2021, Johnson and Koffijberg 2021, ICES 2024). The review conducted here first shows that, in many cases, only the total number of individuals taken per species over a time period (often season) is recorded. However, structured population dynamic models are increasingly used for management, where individuals of different age and/or sex classes are distinguished (Cooch et al. 2014, Gamelon et al. 2021, Lebot et al. 2022). Sustainability of harvest may largely depend on the composition of the bag in terms of sex or age classes (Tahvonen 2008, Weinbaum et al. 2013, Lebot et al. 2022). It is therefore unfortunate that such information is seldom collected, especially since harvest bag structure may differ and cannot be inferred from the population structure due to potentially selective harvest (Bunnefeld et al. 2009). Similarly, there is a growing interest for inter-individual heterogeneity within populations, which can buffer the demographic impact of harvest (Kuparinen and Merilä 2007, Heino et al. 2015, Grzegorzczak et al. 2024). Recording some basic individual characters upon declaration may be a first step towards understanding the possible existence of selective harvest and hence compensatory harvest mortality, yet this is rarely done, including in France. When individuals cannot be directly sexed or aged upon harvest, the collection of biological samples such as feathers, scales or flesh may allow determination to be performed later on, can provide additional information based on isotope or genetic signatures, and should hence be promoted (Mooij 2005, Hobson et al. 2009, Guillemain et al. 2010, 2019, Perrier et al. 2011, Pöysä and Väänänen 2018, Baglinière et al. 2020, Beacham et al. 2020). This obviously complicates bag collection schemes compared to the current situation, and requires appropriate management and long-term storage systems (Marchand et al. 2018). Nevertheless, it is unfortunate that most data collection schemes currently do not collect information beyond the mere number of individuals, although there is also a trade-off between the complexity of data required from end users and response rate to such surveys (Aebischer 2019), so a balance needs to be found. In this context, it is remarkable that some countries such as Denmark obtain a response rate > 90% for waterfowl hunting despite a very comprehensive set of information collected (Aubry et al. 2020a).

### A labyrinth of procedures

Another striking feature highlighted by this review is the number of very different systems, information collected and data circulation processes (lines of command, see the

number of institutions and acronyms in the Supporting information). Basically, each hunting/fishing mode for each (group of) species has its own protocol, which may also differ according to geographic areas. This is particularly striking for traditional hunting modes, where basically each species and technique has its own bag data survey scheme. This is likely to be considered as too complicated by fishers and hunters, potentially leading to non-compliance (FAO 1999, Rodhouse et al. 2022, Gruntorad et al. 2024), as exemplified by the low response rate to most current French schemes. A single bag collection scheme may not be possible owing to the specific objectives and hence specific data requirements of each species and harvest method, yet there is ample room for improvement and homogenization. Generally speaking, promoters of bag survey schemes should try to ease the life of users in the field, and make potential differences among schemes as transparent as possible, avoiding multiple reports at different levels of territorial organization that likely cause participant fatigue (Parrott et al. 2003). To date, a French waterfowler practising at night from a hut on the public seashore should theoretically report to two different schemes via different processes.

### The recurrent problem of non-respondents

Reporting rate is a crucial parameter to evaluate, since it is likely to profoundly affect the reliability of total bag size estimate (Aebischer and Harradine 2007, Aubry and Guillemain 2019, Aubry et al. 2020b, Moreno-Zarate et al. 2021). Unfortunately, reporting rate is entirely unknown in most schemes reviewed here, sometimes probably poorly evaluated and often too low for the declaration data to be properly analyzed. The few values available here suggest only a ca 50% reporting rate for woodcock (Le Rest 2021), and less than 30% for waterbird hunting on the public seashore (Fédération Nationale des Chasseurs 2020). For nocturnal waterbird hunting from huts, close to 40.0% of the sites are considered as either nonrespondents or inactive, but the 99.7% response rate of the other huts (Urbaniak et al. 2022) seems very unlikely, so that non-response and inactivity are probably pooled in unknown proportions. Outside France, reporting rate to waterfowl harvest surveys is also known to differ markedly among European countries (Aubry et al. 2020b). Despite most data collection schemes reviewed here being mandatory, they often have low reporting rates, which suggests that penalties for non-responding are not dissuasive enough: either they are not enforced, or their consequences are too weak for non-respondents. Conversely, it is notable that reporting rate was very high (over 85%) for traditional pigeon hunting and trapping, likely because holding and handing in a diary is a culturally rooted practice for those hunters. Similarly, managers of the Réseau Ongulés Sauvages consider that reporting rate for ungulate hunting is very high (albeit non-evaluated), which is probably linked to the social pressure associated with the commonly collective nature of such a practice, often with driven hunts by groups of hunters. It is thus possible to obtain high reporting rates when data collection schemes are promoted by the instances of harvest

themselves (see also Parrott et al. 2003 for the Danish survey), which are likely more trusted by respondents, or when users see a clear benefit in contributing (Stern and Coleman 2015). For example, the North American online waterfowl hunting declaration tool provides fancy dataviz features, making it attractive to respondents ([www.fws.gov/harvestsurvey](http://www.fws.gov/harvestsurvey)). In some countries, the search for a high reporting rate is pursued by a significant penalty or withholding of the entire hunting licence for non-respondents (Parrott et al. 2003; see also Denmark in Aubry et al. 2020a), but then the quality of the data themselves may sometimes be questionable, if practitioners simply declare anything to show compliance.

### Recording data beyond known offtake

Beyond actual bag size, regulation of the practice when there are no legal quotas often has to consider harvest pressure: instead of the sole total number of animals taken, survey schemes need to evaluate catch per unit effort (Grauer et al. 2015). To do so, it is crucial to record not only the successful outings, but also those with no take, such as done for waterbird hunting in Camargue or hunting of blackbird and thrushes with snares (see also the USFWS Harvest Information Program in Haugen et al. 2015). Even more precisely, digital tools may automatically record outing start and end times, thus providing direct measures of hunting effort. Beyond the recovered offtake, future data collection schemes may also consider collecting information about hit animals not found at the end of the hunt in order to evaluate crippling losses, which can represent a substantial addition to the total known bag (i.e. 20.0% in waterfowl in Anderson and Burnham 1976; 9.6% in turtle dove *Streptopelia turtur* after hunter declarations in Moreno-Zarate et al. 2023). Similarly, the number of fishes caught and released should be recorded, as it provides useful information to evaluate the potential indirect delayed lethal effects of fishing onto populations (Ferber et al. 2013). To date, such indirect lethal consequences of harvest are entirely overlooked in the French data recording schemes.

### Dematerialized tools as the way forward

Reliance on a single electronic data collection portal (Chassadap application for hunting data collection schemes, and [Declarationpeche.fr](http://Declarationpeche.fr) for fishing) is increasingly used in France, and is a way to overcome many of the above issues. Such unique tools may then gradually guide users and collect different information depending on situations, and potentially store the appropriate data to several survey databanks automatically. When smartphone applications are used, quasi-immediate data transmission and access to scientists is also a strong asset (Venturelli et al. 2017), and can turn hunters and fishers into citizen scientists (Cretois et al. 2020). Sustainable harvest and adaptive harvest management are now being promoted by most recording schemes, often with annual decision loops (see Nichols et al. 2007), and such tools are quicker, more practical and more reliable in collecting data than traditional mailed paper questionnaires. Quick declaration after harvest also reduces non-reporting as well as memory or rounding errors, which are

common when bags are reported only at the end of the season (Aebischer and Harradine 2007, Aubry and Guillemain 2019, Skov et al. 2021) and most usually lead to over-declaration (Landry 1983; see, however, Brown et al. 2021). This was one of the reasons for switching to an online declaration system for North American waterfowl hunting ([www.fws.gov/harvestsurvey](http://www.fws.gov/harvestsurvey), see Raftovitch et al. 2023). App declaration (and control) is also an efficient means of ensuring in real time that potential quota limits are not exceeded. Lastly, there is a greater adhesion to such declaration applications when they are seen as more than just a mandatory tool and provide valuable feedback to the user (Venturelli et al. 2017 for angler applications). In France, Chassadap has evolved in this direction recently, with the application producing an individual hunting diary at the end of the season ([www.chasseurdefrance.com/chassadap](http://www.chasseurdefrance.com/chassadap)). However, one drawback of dematerialized tools is related to hunting or fishing practices that require the user to send back biological samples (i.e. scales for salmonids or wings for waterbirds) to authorities. Once digital reporting is implemented, the transmission of such samples may be overlooked (as has been the case in salmonids). It is also a fact that the 'digital divide' may be an issue with such gear, or that electronic tools may be associated with privacy or security issues. These may also be seen as a major constraint by hunters 'wanting to be out in the countryside and free of intrusive regulation' (Cromie et al. 2015). However, such hurdles to the use of electronic reporting tend to disappear (Compaine 2001).

### Conclusion: recommendations for future improvement

The current review highlights a wide variety of protocols, data types and aims of hunting and fishing data collection schemes within a single country, France. Its roots may lie in a heterogeneous legal framework, where distinct laws and decrees have been passed to manage or solve new situations without much aim for consistency. This is likely to be a general issue beyond the sole French context. It seems unrealistic to recommend a single legal framework and data collection system in the short term (Aubry et al. 2020a, Ruiz-Rodríguez et al. 2023). One could also wonder whether modern analytical techniques may simply allow the computing of improved bag estimates from relatively inconsistent data in the near future (Lindström and Bergqvist 2020). However, the Convention on the Conservation of Migratory Species of Wild Animals (CMS), recognizing the important role of (over)exploitation on the conservation status of such species, still calls users to 'Improve and encourage the use of tools for monitoring and collecting standardized data on legal take at the national level' (UNEP-WCMC 2024). The multiplication of electronic devices and applications also needs the development of guidelines and standards if one wants to be able to use such data from a scientific perspective (Venturelli et al. 2017). The current analysis therefore recommends use of the following rules, distinguishing those absolutely required in the short

term from those that would be useful to follow in the longer term.

### Need to have (in the short term)

- Promotion of declaration immediately upon offtake, or quickly thereafter (the same day), to minimize reporting errors, memory bias or exceeded quotas.
- Establishment of surveys at relevant geographic scale given the ecology of the target species, i.e. management units (from a patch of habitat to a continental flyway).
- Promotion of digital tools such as websites and smartphone applications instead of paper notebooks, to reduce reporting errors and obtain data quickly; digital tools also allow setting of likely ranges and sending of warning messages to users in case of declaration outside such ranges (e.g. unlikely number of animals day<sup>-1</sup> or unusual body measurements).
- Maintenance of the number of portals at a minimum and promotion of homogeneous schemes at the various geographic scales (ideally one tool for fishing and/or hunting, wherever possible harmonized among countries), to enhance adhesion and use of reporting tools (whether digital or not). When these ask for different data under different situations, stick to one single layout and logic, and avoid gradually asking for an increasing number of new data to be reported over time: keep digital tools as basic, intuitive and user-friendly as possible.
- Homogenization of the legal rules, at least for a given (group of) species in a given country, to promote compliance.

### Nice to have (in the medium term)

- Collaboration with inside champions during the data collection process, e.g. hunting/fishing federations, which users may trust better than governmental organizations, to boost reporting rate.
- Training of users on animal sex and age determination, and recording of such data whenever possible, instead of only the total number of individuals. Whenever possible also set up simple and clear protocols to record relevant morphometric measurements (e.g. size, body mass) and organize biological sample collection and storage.
- Promotion of voluntary rather than mandatory data collection by users by strengthening their understanding and awareness of the obvious benefits provided by harvest monitoring to the sustainability of their own activity. This could be taught during the training to obtain the hunting licence, or as extra information when getting the fishing licence. When mandatory, apply stringent penalties to non-respondent. Where relevant, also enforce police control of offtake and declaration.
- Aim for catch per unit effort estimate, in addition to total bag size. For this purpose, also record appropriate harvest pressure/effort in the most relevant way for the given species and harvest mode, e.g. the systematic record of outings (including those with no bag), or distance travelled using a GPS logger.

- Evaluation of both known harvest and the total (including indirect) consequences of harvest, also recording of presumed crippled animals and released fish or trapped birds/mammals.

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This piece of work is issued from a collaborative workshop. **Matthieu Guillemain**: Conceptualization (co-lead); Writing – original draft (co-lead); Writing – review and editing (equal). **Laurent Beaulaton**: Conceptualization (co-lead); Writing – original draft (co-lead); Writing – review and editing (equal). **All other co-authors**: Conceptualization (equal); Writing – original draft (equal); Writing – review and editing (equal).

### Data availability statement

Data sharing is not applicable to this article as no new data were created or analyzed in this study.

### Supporting information

The Supporting information associated with this article is available with the online version.

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