EFCA
European Fisheries Control Agency

ANALYSIS FOR THE WEIGHING PROCESS OF FISHERY PRODUCTS IN THE MEMBER STATES AND STRATEGY

Funded by the European Union

FINAL REPORT

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Subject: Analysis for the weighing process of fishery products in the Member States and strategy

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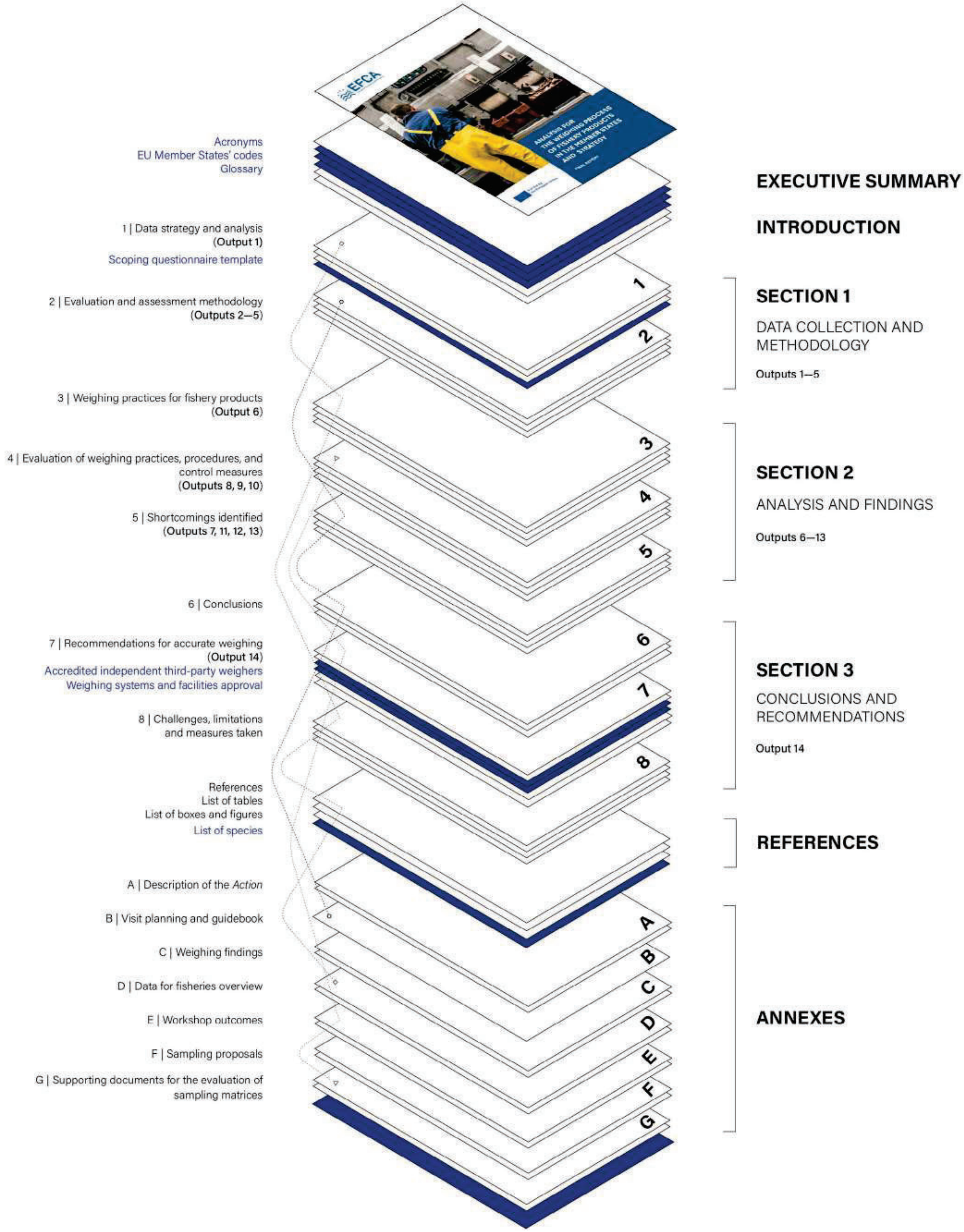

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Sveriges lantbruksuniversitet
Swedish University of Agricultural Sciences

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Department of Aquatic Resources

2023-10-25

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Ordering supporting documents in the framework of the CFP Advisory Project

15. Risk analysis control – Basis for sampling plans for pelagic landings

<u>Question/Order</u>

Supporting documentation for drawing up sampling plans for the weighing of pelagic fisheries on landing.

Details of the documentation need to be designed in a continuous discussion between HaV and SLU- Aqua. Questions that HaV initially assesses need to be discussed below.

1. How should a sampling be carried out to determine with a given certainty (95 % confidence) species composition in unsorted pelagic catches (industry)?
    1. Does quantity matter?
    2. Does the species or number of species matter?
    3. Does the number of tanks that fish are stored in any role affect?
    4. Are there other factors that affect safety? For example, how long the fish have been stored in the tanks.

2. How should a sampling be carried out to determine with a given certainty (95 % confidence) species composition in pelagic catches (human) sorted by size? Before you start with this issue, we should have a reconciliation meeting so that we have the same picture of how this type of landing is done.

3. How should the fisherman's sampling on board be carried out in order to estimate with a given certainty (95 % confidence) species composition in pelagic catches?

Background

The basic rule in fisheries control is that all catches landed should be weighed by species on landing, (EC) 1224/2009, species 60. These data shall then form the basis for different reports and are used, among other things, in quota monitoring and stock assessments. It is therefore of paramount importance that the system of weighing of catches works well.

As there are difficulties in weighing all catches per species, there are possibilities to have sampling plans allowing sampling of catches to determine species composition. These plans shall be approved by the Commission.

In the case of a pelagic unsorted catch today, a sampling is made where a species distribution is determined. Weighing of the total catch since weighting of by-catches sorted out.

Today, there are different ways to do sampling:

- 100 kg or 0.5 permille evenly distributed over catch
- After sorting
- Sampling in tanks on board in accordance with Regulation on market standards 3703/85.

Format

Brief description of the sampling methodology.

Table of the number of samples.

Matrix for the number of samples to be taken depending on the size of the catch.

Comments SLU-Aqua

During the preparation of the data, a number of meetings have been held between the client and the performer where preliminary results have been discussed and presented. This has meant that the content of the final documentation in parts has changed based on the original order. For example, the basis includes sampling needs based on several different levels of acceptable margin of error.

The documentation is delivered after agreement with the client as an appendix.

Sveriges lantbruksuniversitet
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Determination of sample size for pelagic catch sampling

Annica de Groote, Nuno Prista, Katja Ringdahl

Introduction

This document presents preliminary calculations of the required sample size for the sampling of pelagic catches from a fishing trip. Data from a survey of pelagic fisheries in the Baltic Sea 2021-2023 (total of 20 trips) are used as the basis for the calculations. In addition to selection of sample size, we also discuss the choice of sample volume (shock size) and compare samples ashore with selections on board the vessels.

Data and sampling method

Data comes from a total of 20 fishing trips carried out in the Baltic Sea during quarters 1 and 4 2021, quarters 1 and 4 2022, and quarters 1 and 2 2023. The fishing has been carried out on pelagic trawlers of between 18-63 meters and 83-1568 gross tonnes. The average size was 45 m and 870 gross tonnes. During the fishing trips, scientific observers have been on board. Observers have systematically sampled all hauls during the fishing trip as well as during the landing of the catch in order to estimate catch composition. In this analysis, we are based on the data collected by sampling from the landed catch.

Data from a landing consists of a number of five litre buckets of fish, where the buckets were selected with systematic sampling from the catch during on-shore pumping. For each selected bucket, the total catch was weighed in the bucket. For each bucket, the contents were sorted and the different species were weighed separately. We ignore in our calculations that, during a few trips, some buckets were collected before the catch passed water separators at the landing site and others after. This was done during the first trips because there were thoughts that the passing of the catch through the water separator would affect the ability to determine the species. There were indications that this would be the case from at least one trip where the proportion of fish that were unidentifiable increased to some extent in the samples taken after the water separator. For the present analysis, it was assessed that it was better to include all samples from the fishing trips as this amount of unidentifiable fish was still small in relation to species-defined herring and sprat.

Results

Table 1 presents the number of five litre buckets needed to estimate the weight share of herring and sprat for four possible levels of acceptable margin of error. Possible levels of acceptable margin of error to be presented in this report have been established during the meeting meetings held with the control unit of the Swedish Agency for Marine and Water Management during the preparation of this analysis and report. Margin of error refers to half the width of a confidence interval or, in other words, the number added or deducted from an excise estimate when forming a confidence interval. This is based on a 95 % confidence interval. *Examples:* We want to estimate the weight share of herring for a fishing trip. Based on a sample of buckets from the landed catch, we estimate the weight share to be 0.75 (75 %) with a margin of error of 0.05 (5 percentage points). With 95 % certainty, the true weight share of herring is between 70 and 80 percent.

Results are reported per trip, by average per weight class, and on average for all trips. The weight classification is based on the estimated weight of the total catch in tonnes. All sample sizes are rounded up to the nearest integer. Please note that a sample size of at least two is needed to estimate the variance (and the margin of error is calculated). For details on how the calculations in the table are done, see appendix 1.

Please note that the results should be used with great care. On the one hand, the data is small and, on the other hand, we do not know how representative the sample of sampled fishing trips is for all voyages carried out by the fleet. If the landed catch from a trip is dominated by a fish species, a large sample is not required, but we do not know in advance (the dominance of the trips included in Table 1 is shown in Appendix 2). If the sample size is selected solely on the basis of the results in Table 1, there is a high risk that estimates will become more uncertain than expected.

Estimated total weight, t	Journey No.	**HERRING**				**SPRAT**			
		e=0.03	e=0.05	e=0.07	e=0.10	e=0.03	e=0.05	e=0.07	e=0.10
t < 25	7	1	1	1	1	1	1	1	1
t < 25	21	18	7	4	2	17	6	4	2
t < 25	25	23	9	5	3	23	9	5	3
Means		14	6	4	2	14	6	4	2
25 ≤ t & 200	8	2	1	1	1	2	1	1	1
25 ≤ t & 200	17	12	5	3	2	9	4	2	1
25 ≤ t & 200	20	60	22	11	6	60	22	11	6
25 ≤ t & 200	26	20	8	4	2	23	9	5	3
Means		24	9	5	3	24	9	5	3
t ≥ 200	1	620	224	114	56	621	224	114	56
t ≥ 200	2	70	26	13	7	83	30	16	8
t ≥ 200	3	248	90	46	23	264	95	49	24
t ≥ 200	4	82	30	15	8	85	31	16	8
t ≥ 200	5	147	53	27	14	119	43	22	11
t ≥ 200	6	132	48	25	12	134	48	25	12
t ≥ 200	10	1	1	1	1	1	1	1	1
t ≥ 200	11	5	2	1	1	304	110	56	28
t ≥ 200	16	40	15	8	4	40	15	8	4

t ≥ 200	18	214	77	40	20	233	84	43	21
t ≥ 200	19	53	19	10	5	68	25	13	7
t ≥ 200	23	3	1	1	1	5	2	1	1
t ≥ 200	24	320	115	59	29	358	129	66	33
Means		149	54	28	14	179	65	34	17
Means all classes		104	38	20	10	123	45	23	12

Table 1. Number of five litre buckets needed to estimate the weight share of herring and sprat in mixed pelagic catches for different levels of margin of error (e) and landing sizes.

Table 1 answers questions of the type: if, for a large catch, you want to estimate the weight share of herring with a margin of error of not more than 0.03 (3 percentage points), how many buckets do you need to take? According to our results, an average of 104 buckets are needed.

Sample volume selection

Our data and calculations assume that five litre buckets are used for sampling. In other similar studies, ten litre buckets are often used. How can one reason about the choice of bucket size?

In this context, a bucket, whether it holds five or ten liters, represents a *cluster* of fish (which make up our population elements). We assume a sampling based on drawing a sample of buckets and examining all fish in selected buckets. In the literature on statistical sampling-methodology, such a procedure is called one-step cluster selection or simply cluster selection. In the vast majority of cases, the use of cluster selection leads to a decrease in precision in estimates compared to the same number of elements (here: fish) randomly from the entire population (here: the whole catch). This is because elements within the same cluster tend to resemble each other more than elements randomly selected from the entire population (see further Lohr, 2010, sec 5.2.2). Cluster selection can nevertheless be a necessary and well-motivated method, for example if it facilitates data collection, but it is important to try to counteract the deterioration of precision by drawing a sufficiently large sample.

Suppose that a survey has the opportunity to choose between different cluster sizes (in our case: different bucket sizes). Two factors that are usually taken into account in the choice of size are cost and precision. The cost can be measured in different ways, for example, in "the number of litres of fish that can be observed in one hour". In some duringsearches, larger clusters mean a saving (you might be able to short travel times or the like). In this case, however, the cost (measured in the number of observed liters of fish per hour) is about the same for the two bucket sizes. It may take a little longer to stack small buckets than large ones, but this time is kept down by storing the samples in stackable boxes – see Figure 1. In terms of precision, many small clusters usually provide better precision in estimates than few large clusters. This is because the variance generally increases as the number of samples (shocks) decreases so that clustersize can increase. Therefore, for larger clusters to be preferred, they need to provide clear costsavings, which we do not expect here. If you want to take this informal comparison further and count on which bucketsize is "best", this is quite possible (see, for example, Cochran, 1977, Sec 9.2). Such an analysis, which would require data on cost and variance for different bucket sizes, would be interesting to do.

Picture 1. Storage of the contents of selected five-litre buckets.

In summary, the use of five litre buckets rather than ten litre buckets makes it possible to take more samples (and thereby improve the accuracy of estimates) at relatively unchanged cost (measured in terms of total volume of fish analysed). In addition, the complex structure of the landing flow – where species composition can suddenly change when the different fish tanks are emptied – means that it is particularly important that the sample is large enough to ensure a good representation of the catch.

Selection by land or on board

An alternative to sampling the catch ashore is to do so on board the vessels. Which method is preferable from a precision point of view?

When sampling on board, it is possible to sample buckets separately for each haul. This corresponds to making a stratified selection of buckets, where the haul represents strata. Stratified selection is generally precision raising if strata are reasonably internally homogeneous with respect to what is measured (here: species composition), which appears to be the case for haul with pelagic catches (see Hilvarsson et al, 2021). This means that you probably need a smaller sample of buckets if you sample on board than if you sample ashore to get the same precision in the estimates.

The above reasoning is supported by compilations of estimates of variation in species composition from sampling of 5 voyages (Travel No 1-5 in Appendix 2) on board and at landing (Hilvarsson et al (2021), Figures 7 and 8) as well as by preliminary results from a simulation study (in prep). In the simulation study, the same five trips were analysed: for each trip, three buckets per haul were taken on board or about the same number of buckets combined ashore. It turned out that the on-board sampling resulted in much higher precision estimates, see Table 2 below. We know that for trips that are very heterogeneous in terms of species composition (e.g. trip 1 in Table 1), very large samples are required ashore in order to calculate estimates with good precision. A significantly smaller sample would be required if the sample was carried out on board instead.

Journey No.	Total stick sample-size*	Margin of error**
1	33	1.1 %
2	39	1.8 %
3	23	0.8 %
4	30	0.8 %
5	36	2.3 %

Table 2. Estimates of the weight share of herring based on on-board sampling with a sample of three buckets per hal. Preliminary results based on data from Q1 2021. *Total number of selected buckets for the trip. **Based on a 95 % bootstrap confidence interval.

References

Cochran, W. G. (1977). Sampling Techniques. Wiley.

Hilvarsson, A., Prista, N., de Groote, A. and Ringdahl, K. (2021). Knowledge supply pelagic fishing Baltic Sea. SLUID: Slu.aqua.2020.5.2-308.

Lohr, S. (2010). Sampling: Design and Analysis, 2nd edition. Brooks/Cole.

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Appendix 1: Determination of sample size

Consider a given fishing trip. For this fishing trip, we define a fictitious population of N standard buckets full of fish, numbered in "pump order" from 1 to N. Together, the N buckets hold all the fish pumped ashore. From this population, a sample of buckets n is drawn with systematic sampling. On the basis of this sample, the weight shares of different fish species of the total weight of the catch landed would be estimated. For details of the estimates used in the survey, see Annex 3 in Hilvarsson et al (2020).

Consider the unknown weight percentage of a fish species d. This parameter, which we designate, R_d is defined as a ratio of two population totals:

$$R_d = \frac{t_{y_d}}{t_y} \tag{1}$$

it t_{y_d} denotes the total weight of fish species d and t_y the total weight of the total catch landed. We R_d refer to the current point estimate of$\hat{R}_d$. The $\hat{R}_d$ excise estimate is a random variable (because it is based on a random sample) and therefore has a variance. We denote this variance $V(\hat{R}_d)$.

We want to determine a sample size so n that we get some precision in the estimation $\hat{R}_d$ ofR_d. This requirement can be formulated as a probability (see, for example, Lohr, 2010, sec 2.6):

$$P\left(\left|\hat{R}_d - R_d\right| \leq e\right) = 1 - \alpha \tag{2}$$

there e is the desired margin of error and α the chosen confidence level. In our calculations, we use the confidence level $\alpha = 0{,}05$.

The sample size n that meets the requirement of formula (2) is $\alpha = 0{,}05$ obtained by redeeming n from the margin of error formula;

$$e = z_{0{,}025}\sqrt{V(\hat{R}_d)} \tag{3}$$

there $z_{0{,}025} = 1{,}96$ is the 0.975 percentile for a standard normal distribution. (We assume in formula (3) that, n N and $N - n$ are "sufficiently large" so that the central limit rate applies.)

Since the weight R_d ratio is a quotient, there is no exact expression of the variance of $\hat{R}_d$. When using formula (3), we instead use an approximate formula for $V(\hat{R}_d)$ extracted from Särndal et al (1992, Ex 5.6.2). The formula approximates the variance that $\hat{R}_d$ would have if the selection of buckets had been made with unbound random sampling (OSU) rather than systematic sampling. The formula includes a finite correction that we can ignore because n is much less than N. Insertion of the approximate variance formula (without finite correction) into formula (3) results in the expression

$$e = 1{,}96\sqrt{\frac{1}{\bar{y}_U^2}\frac{S_{t_EU}^2}{n}} \tag{4}$$

where $\bar{y}_U = t_y/N$ is the average catch per bucket in the population $S_{t_EU}^2 = \sum_{i=1}^{N}\left(t_{y_di} - R_d t_{yi}\right)^2 / (N-1)$,$t_{y_di}$, is the total weight of fish d $i$in bucket st_{yi}, and is the total weight of all catch in bucket $i; i = 1, \ldots, N$.

Now we are ready to calculate which sample size is needed. By redeeming n out of formula (4), we get:

$$n = \frac{1}{\bar{y}_U^2}\left(\frac{1{,}96 \times S_{t_EU}}{e}\right)^2 \tag{5}$$

In practice, we do not feel $\bar{y}_U$ and S_{t_EU} because they are defined for the entire population. When we calculate using n formula (5), we instead use the corresponding sample quantities, which we retrieve from the collected data: $\bar{y}_U$replaced by, $\bar{y}_s = \sum_{i=1}^{n} t_{yi}/n$i.e. the average catch per bucket in the sample, and $S_{t_EU}^2$ replaced by $S_{t_es}^2 = \sum_{i=1}^{n}\left(t_{y_di} - \hat{R}_d t_{yi}\right)^2/(n-1)$.

Appendix 2: More about selected fishing trips

Estimated total weight, *t*	Journey No.	Number of buckets	**HERRING** Point estimate	Margin of error	**SPRAT** Point estimate	Margin of error	Dominance
t < 25	7	15	0.998	0.001	0.002	0.001	HighDomHER
t < 25	21	13	0.325	0.035	0.669	0.034	DomSPR
t < 25	25	23	0.603	0.029	0.391	0.029	DomHER
25 ≤ t & 200	8	22	0.968	0.007	0.026	0.008	HighDomHER
25 ≤ t & 200	17	23	0.942	0.021	0.042	0.019	HighDomHER
25 ≤ t & 200	20	25	0.197	0.046	0.786	0.046	DomSPR
25 ≤ t & 200	26	16	0.799	0.033	0.170	0.036	DomHER
t ≥ 200	1	31	0.428	0.134	0.530	0.134	NoOrLittleDom
t ≥ 200	2	27	0.170	0.048	0.696	0.052	DomSPR
t ≥ 200	3	18	0.152	0.111	0.821	0.115	DomSPR
t ≥ 200	4	24	0.119	0.055	0.851	0.056	DomSPR
t ≥ 200	5	25	0.515	0.073	0.422	0.065	NoOrLittleDom
t ≥ 200	6	47	0.177	0.050	0.808	0.050	DomSPR
t ≥ 200	10	29	0.005	0.003	0.991	0.004	HighDomSPR
t ≥ 200	11	51	0.039	0.009	0.709	0.073	DomSPR
t ≥ 200	16	48	0.226	0.027	0.760	0.027	DomSPR
t ≥ 200	18	21	0.199	0.096	0.741	0.100	DomSPR
t ≥ 200	19	19	0.156	0.050	0.767	0.056	DomSPR
t ≥ 200	23	52	0.028	0.006	0.960	0.009	HighDomSPR
t ≥ 200	24	47	0.269	0.078	0.696	0.083	DomSPR