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A software tool for monitoring legal minimum length of landings: Case study of a fishery in southern Spain

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ABSTRACT

The regulation of minimum legal size (MLS) of catches is a tool widely applied in the management of fisheries resources, although the MLS does not always coincide with the length at first maturity (LFM). The optimization of this management tool requires a series of quality control in fish markets and transportation. A software application has been developed to make the control of the landings of several target species easier and faster. In order to test and make this tool operational, six species of commercial interest were selected: four species of fish and two species of bivalves. It is proposed to estimate the proportion of illegal specimens in the studied lot from the proportion of illegal individuals found in the samples taken from this lot. The input data for the application are the minimum legal size (MLS) of the species and the total length (TL) of each specimen sampled. The output data is a statistical summary of the percentage of specimens of size less than the legal minimum ($TL \leq MLS$) within different confidence intervals (90%, 95% and 99%). The software developed will serve as a fast, efficient and easy to manage tool that allows inspectors to determine the degree of compliance on MLS control and to make a decision supported by statistical proof on fishing goods.

1. Introduction

Globally, fisheries are currently in a seriously degraded state. Many fisheries have collapsed in the last 50 years [1–3]. There has also been a trend towards seeking new fishery resources in an attempt to maintain the level of catches, although these resources were not exploited previously and markets for them did not even exist [4]. In addition to the above, several other factors contribute to creating a critical situation in the management of the fishing industry. For example, it is known that the statistics and information on catches are often false (smaller quantities are declared, species are incorrectly labeled, etc.); notice is rarely taken of soundly-based scientific recommendations, and 'climate change' is repeatedly blamed, without evidence, for the damage being done by human action [5].

The management and conservation of fisheries is a constant concern of many and varied international bodies; these international 'authorities' have proposed that the system for allowing access to fishery resources, the effort devoted to fishing, and the industry's fishing capacity should all be rigorously controlled. Proposals are made for monitoring, supervising and inspecting the performance of fishing operations [6,7] and protocols for strengthening the control of commercial fisheries are proposed and agreed [8]. However, despite all these proposals and agreements for more effective management and conservation, it is necessary that fishing vessels should take their catches in accordance with a series of operational directives, so that the exploitation of resources is sustainable in the long term. It is clearly impossible for every vessel to carry an inspector while fishing; therefore the involvement of stakeholders as co-managers in the enforcement of agreed fisheries regulations ([9–14] among others) will always be necessary.

Most importantly, across all fisheries, only the specimens of greater size and age should be fished: the smaller and younger specimens must be conserved as the reserve for the future [15]. Knowledge of the biology of species of commercial interest and the selectivity of fishing techniques and gear, jointly, provide tools for determining the maximum permitted catches and the minimum permissible size of the specimens caught. Studies of the

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selectivity of fishing techniques and gear are fundamental for the good management of fisheries [16]. There have been many studies on the selectivity of net-based gear, not only mesh size but also net morphology [17–19] (among others [20,21]), which have demonstrated the importance of effective selectivity.

Other lines of research have argued for the creation of protected marine areas as zones where fishing should be prohibited outright or partially limited, and that would function as exporters of biomass, since these would be areas where the juveniles of many fish species are reared [22]. Such protected areas also generate other types of recreational activity that can have a powerful impact on the local economy [23]. In any case, the need to establish protection zones is proposed as an important measure for the future management of fisheries; they would represent a relatively small cost at the local level but an important benefit at the global level, since they would preserve biodiversity, and an acceptable level of catches could be maintained [24].

In the EU (EU Regulation 1967/2006), and in the case of Spain (Spanish Royal Decrees RD 560/1995 and RD 1615/2005), the main focus has been on regulating the MLS (minimum legal size) with the object of safeguarding and protecting stocks by facilitating spawning and the survival of juveniles [25,26]. However, the MLS values, established legally as LMLs (legal minimum lengths) are not usually set in function of the biological information available [27].

Despite this, the capture of specimens of small size ($\leq$ MLS) continues to be a widespread practice. Whether through ignorance or due to conflicting socioeconomic interests, catches with sizes below the stipulated MLS continue to be landed [26,27]. The current state of fisheries resources subjected to exploitation has led the various governments, with capacity for regulating and controlling fishing activity, to develop a series of regulations or standards for the control and management of these resources. Among these regulations are the establishment of a corps of fishing inspectors who are charged with monitoring fish landings to ensure that they meet the stipulated MLS, and to prevent the purchase and sale of specimens below the legal size.

The need to carry out the inspections in the shortest time possible and covering as many landings as possible, before the fresh fish reach the market, creates a situation of tension between all the parties involved—fishermen, carriers, traders and the authorities responsible for the management and conservation of the fisheries resources. Therefore, in response to the importance of minimizing the time that the fresh fish are retained for inspection, a software tool has been developed to aid in this task. The result is a computer application that is fast, efficacious and easy to use that enables the inspector to determine the degree to which a batch of fresh fish, shellfish, etc. complies with the regulations on MLS, and then to take the correct decision on whether that batch should be seized or embargoed.

2. Materials and methods

To develop a useful tool suitable for generalized use, a process in two phases was planned:

a) Developing the actual tool and its protocol of use.
b) Checking that it works well in a real operational context.

2.1. Development of the tool

To inspect all the fish unloaded from every vessel is an impossible task. Therefore what is needed first is a procedure for taking samples that would allow decisions of the maximum possible reliability to be taken, when the findings are extrapolated from the sample to the totality of the catch subject to supervision and control. The first task is to determine the size of sample required that would allow the technician responsible to perform the inspection and take the corresponding decision in the shortest time possible.

The determination of the sample size involves estimating and making inferences in respect of the parameters governing the distribution of the size, prior to analysis of the distribution of the data. Hence, the starting point is a pilot sample, of more than 30 units, which is the number of individuals that allows use to be made of the relevant statistical and mathematical techniques, such as the central theorem of limit, in search of a normal distribution of the data with respect to length in the different species; the approximation of this distribution will be more accurate and true with the greater the size of the sample. Consequently, the size of any sample that is intended to be used to infer and decide on the population analyzed must, in no case, be less than 30 individuals. Working from this premise, it is proposed that the inspection protocol should stipulate sampling sizes of between 100 and 200 individuals from any one batch or cargo.

To define the confidence intervals, and from there the desired sample size, the following equation is used:

$$IC(\mu) = \left(\overline{X} - Z_{1-\frac{\pi}{2}} \frac{S_c}{\sqrt{n}}, \overline{X} + Z_{1-\frac{\pi}{2}} \frac{S_c}{\sqrt{n}}\right)$$

where μ is the populational mean of the data; $\overline{X}$ is the mean sampling of the data; S_c is the standard deviation of the data; Z corresponds to the Normal Typified distribution of probability; n is the sample size, in numbers and α is the level of significance demanded in the estimation.

From an interval of confidence, with a predetermined level of significance, and a fixed error in the estimation (e), we can obtain the sample size required:

$$n = Z^{1}_{1-\frac{\pi}{1}} \frac{S^{1}_{2}}{e^{1}}$$

The sample size necessary for estimating the parameters of the population is directly proportional to the variance or heterogeneity in the length of individuals of the species.

It is necessary to perform separate analyses according to the species since, in the samples, it is evident that mean lengths and variances differ between species. Then the corresponding inferential study is conducted to determine that the interspecies variance of the length is different, and to reject homoscedasticity.

Since the interest of the study is focused in determining if the batch of merchandise inspected, originating from the fish wharf or market (often already loaded for transport), complies with the stipulated MLS, based on taking a significant sample, the detailed objective can be stated as estimating the proportion of individuals of a defined population that do not exceed the minimum permitted length.

Confidence intervals will be obtained for the object parameter (the proportion of the population) from the value obtained in the sample (p), of number of individuals (n), at different significances (α):

$$IC(\pi) = \left(p - Z_{1-\frac{\pi}{2}} \sqrt{\frac{p(100-p)}{n}}, p + Z_{1-\frac{\pi}{2}} \sqrt{\frac{p(100-p)}{n}}\right)$$

This expression estimates the percentage of illegals that exist in the population (i.e. in the total fish comprising the batch of merchandise being inspected) when the percentage of illegals in the sample is known. The accuracy of the estimation made depends closely on two factors: first, the level of significance required, and second, the sample size required, since the larger the sample size, the more accurate the estimation.

It is proposed to establish that the lower limit of the confidence interval, for proportions of a unilateral estimation, is equivalent to the permitted tolerance when the inspection is made; in this context, tolerance is understood as the maximum legally-permitted percentage of specimens of length smaller than the MLS in the set of individuals (i.e. in the batch of merchandise) subject to inspection. Thus, the problem is reduced to determining the maximum permitted proportion of illegals that will coincide with the value of p in the expression, given that L_1 is the tolerance:

$$(L_1,L_2)=\left(p-Z_{1-\pi}\sqrt{\frac{p(100-p)}{n}},\infty\right)$$

In addition, it is necessary to know the percentage of tolerance that is legally permitted for each of the species to be inspected. This means that, if the tolerance is set at 0%, the detection of only one illegal individual in the sample will oblige the inspector to seize or embargo the entire batch of merchandise. The three variables that will differentiate one species from another are the % tolerance permitted, the sample size required (in number of individuals to be measured) and the MLS.

2.2. Checking the operational performance of the software tool

The starting point for the empirical test is the choice of a sample of n individuals from each of the populations selected for this study, in this case six target species characteristic of the littoral of Andalusia. The sample must be sufficiently large and representative. Four target species of fish were selected. These were as follows: *Engraulis encrasicholus* (Linnaeus 1758) (European anchovy), recorded landings of which totaled 4,400 and 4,100 t, respectively, in 2008 and 2009; *Merluccius merluccius* (Linnaeus 1758) (European hake), with landings of 1,009 and 1,287 t, respectively, in 2008 and 2009; *Mullus surmulletus* (Linnaeus 1758) (Red mullet) with landings of 406.3 and 487.8 t, respectively, in 2008 and 2009 and *Solea vulgaris* (Quensel 1806) (Common sole), no landed catch data available for 2008 or 2009. With respect to shellfish two target species were selected: *Venus gallina* (Linnaeus 1758) (Striped venus clam) with landings of 2,878 and 3,178 t, respectively, in 2008 and 2009 and *Donax trunculus* (Linnaeus 1758) (Wedge shell), with no landed catch data available for 2008 or 2009. (Data of landed tonnages in 2008 [28] and 2009 [29].) A random sampling protocol was defined to obtain the required data as rapidly and efficiently as possible.

The samples originated from different interventions of the fishing inspectors, and in each case the total quantity inspected (in kg) was known. This gave us the required data on the size of the batch of merchandise inspected, and the provenance of the batch (Table 1).

Two ichthyometers and two calipers, Teckniker™, calibrated by ENAC, certified for the measurement of fishes and shellfish, respectively, were used to measure the lengths of the sample specimens. The measurements made for LT are to the nearest mm for the fishes and to the nearest tenth of a mm (0.1 mm) for the shellfish.

The biological and commercial minimum lengths used are those stipulated in the pertinent legislation for these species (Spanish Royal Decrees RD 560/1995 and RD 1615/2005; EU Regulation 1967/2006) (Table 2, [30–33]); it is significant that all these minimum lengths are less than the range of lengths of first maturation (LFM), except in the case of *Solea vulgaris* (Table 2).

The sampling was carried out taking into account the packaging in which the different species are loaded for transport and sale. In the case of *Merluccius merluccius* and *Engraulis encrasicholus* which are packed in boxes of expanded polystyrene, one box was selected at random and the entire content of individuals was measured, to determine the characteristics of the population and to establish the control set prior to the sampling. The rest of the boxes were sampled respecting the principles of systematic random sampling; that is, the various boxes sampled were not

Table 1
Composition of sample of six different species of fish and shellfish.

Species	Total	Weight
Engraulis encrasicholus[a] (European anchovy)	3805	43.4
Merluccius merluccius[a] (European hake)	799	42
Solea vulgaris[a] (Common sole)	104	6
Mullus surmulletus[a] (Red mullet)	407	7.8
Donax trunculus[b] (Wedge shell)	3401	30
Venus gallina[b] (Striped venus clam)	1981	63.5

Total = number of specimens measured. Weight = Total weight of samples, in kg.

[a] Fish.
[b] Shellfish.

Table 2
Species studied: Legal minimum length origin of the species, and length at first maturity. (LML: Legal minimum length (in mm); LFM: Length at first maturity (in mm); LMW: Legal minimum weight (g/unit); FG: Fishing ground of origin; T: Tolerance (i.e. percentage of individuals of less than legal size permitted by law.) ND: no defined tolerance).

Species	FG	LML	LMW	*T* (%)	LFM
Engraulis encrasicholus[a]	Mediterranean	90	8	10	110.9♂ 112.0♀[b]
	Atlantic	100			
Merluccius merluccius[a]	Mediterranean	200	150	15	328♂ 450♀[c]
	Atlantic	270	200		
Solea vulgaris[a]	Mediterranean	150	120	10	148♂ 152♀[d]
	Atlantic	240			
Mullus surmulletus[a]	Mediterranean	110		10	150♂ 168♀[e]
	Atlantic	150			
Donax trunculus[f]	Atlantic	30		ND	
Venus gallina[f]	Mediterranean	24		ND	
	Atlantic	25		ND	

[a] Fish.
[b] Gulf of Cadiz (Millan, 1999) [24].
[c] Northwest Atlantic from the Iberian Peninsula (Piñero & Sainz, 2003) [25].
[d] Iskenderun Bay, Turkey (Türkmen, 2003) [26].
[e] Balearic Islands (Reñones et al., 1995) [27].
[f] Shellfish.

all from the same row or the same column, and from each box four sub-samples were obtained, with individuals selected from the length and width of the entire box, always according to a vertical and not horizontal model. In the case of *Solea vulgaris* and *Mullus surmulletus* it was decided to measure all the samples, since the numbers of individuals were notably less than for the species previously mentioned.

In the case of shellfish that are packaged for sale in net bags, a different procedure was adopted, since in the majority of cases the packaging process involves placing a cylinder in the central zone where the length of the specimens is usually less than in the peripheral zones. For each species the entire content of one of the net bags was measured to estimate the adequate sample size, and in the other net bags 4 sub-samples were measured. When the actual sampling was performed, the mesh was cut and the contents were allowed to fall into an expanded polystyrene box, in which all the specimens were well-mixed and the samples were extracted randomly.

As this is intended to be a tool to be used widely by persons of differing technical competence, and with the object of demonstrating the existence of possible bias in the sampling, an experiment was devised in which the various sub-samples of specimens of each species were measured twice, by two technicians independently. Information was gathered on the mean size, the standard deviation and the minimum and maximum lengths obtained in the measurements made on the same individual specimens by the two technicians.

3. Results

Measurements were made of a total of 5023 specimens of fishes belonging to the four species of fish selected, three of them originating from the Atlantic fishing grounds and one species from the Mediterranean fishing grounds, and a total of 5382 specimens of two species of shellfish, both originating from the Atlantic fishing grounds.

The results obtained in the double measurement experiment conducted with two different technicians on the same specimens (Table 3) have demonstrated that, despite the existence of small differences in the measurements made by the two technicians, these differences were not statistically significant ($p < 0.001$; test of Levene) (Fig. 1).

A test of equality of variances with respect to length between the species gave a p-value of < 0.001 (test of Levene); this leads us to state that an identical behavior does not exist in the variability of length according to the species. *Engraulis encrasicholus*, *Solea vulgaris* and *Mullus surmulletus* are found to be less disperse with respect to their length than *Merluccius merluccius*, *Venus gallina*, and *Donax trunculus* (Fig. 2). These results indicate that a larger sample size is required to represent reliably the population of *Merluccius merluccius*, *Venus gallina* and *Donax trunculus*, compared with *Engraulis encrasicholus*, *Solea vulgaris* and *Mullus surmulletus*.

In this study, for each case, the sample size required for estimating the proportion of illegals in the population, and for estimating the mean populational size, was determined from the data obtained in a selection of possible illegals.

With the object of grouping and establishing a pattern of behavior from the results shown, accepting a possible margin of error in the measurement in function of the species and depending on the level of confidence required (90%, 95%, 97% or 99%), the minimum sample sizes necessary range between 30 and 200 specimens, depending on the dispersion of lengths of each species and on the minimum permissible error (MPE) (Table 4).

3.1. Operating protocol

Based on the results obtained, an operating protocol was devised for decision-making in function of the presentation of the merchandise (in boxes, packs or as loose specimens) according to the legal tolerance permitted and at different levels of confidence.

Step 1. The person holding the merchandise (seller, purchaser, carrier, etc.) will be informed that the shipment is going to be submitted to inspection with the object of checking that the

Table 3
Summary statistics of the measurements (TL in mm) made independently by the two technicians (T1 and T2). AVGL: Average length; SE: Standard error; MNL: Minimum length; MXL: Maximum length.

Species	*n*	AVGL		SE		MNL		MXL	
		T1	T2	T1	T2	T1	T2	T1	T2
Engraulis encrasicholus	92	85.05	84.96	6.40	6.66	70.00	66.00	101.00	101.00
Merluccius merluccius	57	169.75	169.03	24.49	24.55	129.00	128.00	242.00	242.00
Solea vulgaris	44	206.27	206.682	11.22	11.18	179.00	179.00	224.00	224.00
Mullus surmulletus	25	121.52	120.84	20.34	20.11	89.00	88.00	158.00	158.00
Venus gallina	89	24.84	24.79	0.87	0.87	22.70	22.60	26.80	26.80
Donax trunculus	50	24.20	24.25	2.12	2.17	20.00	20.10	30.00	30.00

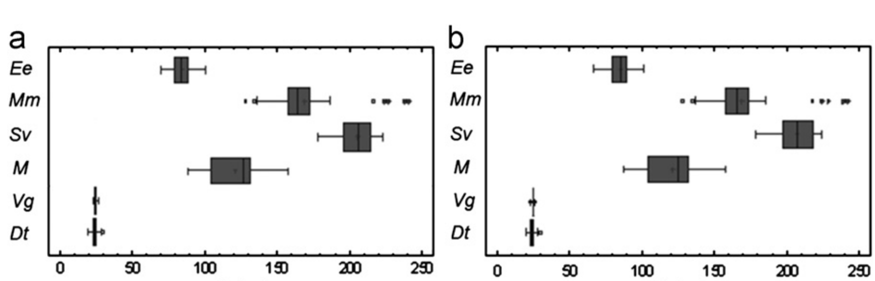


Fig. 1. Comparison of the measurements (TL in mm) made independently by the first (a) and second (b) technicians. (Ee: *Engraulis encrasicholus*; Mm: *Merluccius merluccius*; Sv: *Solea vulgaris*; M: *Mullus surmulletus*; Vg: *Venus gallina*; Dt: *Donax trunculus*.)

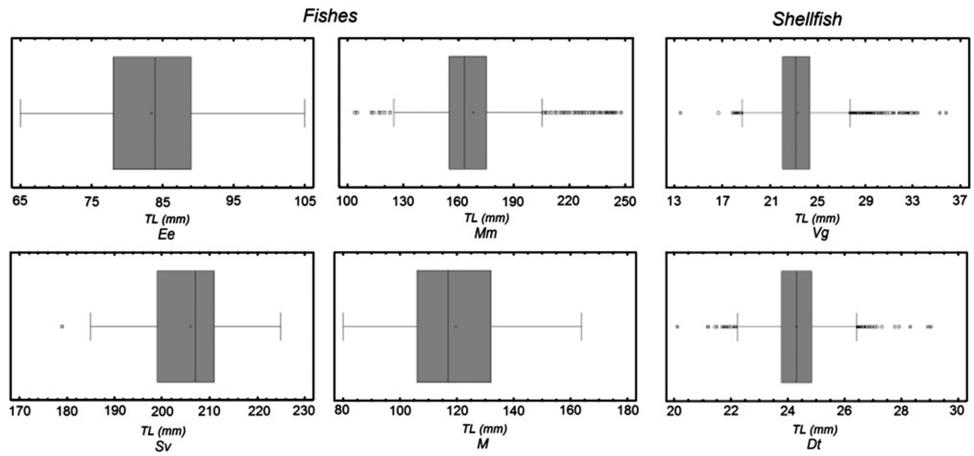


Fig. 2. Comparison of the dispersion in TL between the different species studied. (Ee: *Engraulis encrasicholus*; Mm: *Merluccius merluccius*; Sv: *Solea vulgaris*; M: *Mullus surmulletus*; Vg: *Venus gallina*; Dt: *Donax trunculus*.)

Table 4
Minimum sample size, in number of specimens, necessary for each of the species studied, at three alternative confidence levels, and the minimum permissible error (MPE mm) in measuring individual specimens.

Species	MPE (mm)	Confidence level		
		90%	95%	99%
Engraulis encrasicholus	3–4	30	40	50
Merluccius merluccius	5–7.5	60	90	130
Solea vulgaris	3–4	30	40	50
Mullus surmulletus	3–4	30	40	50
Venus gallina	0.3–0.4	50	55	70
Donax trunculus	0.4–0.5	80	110	200

merchandise in question complies with the required legal minimum length, according to the species.

Step 2. In the light of the merchandise, the boxes/packs selected randomly from the total will be physically separated. The previous experience of the inspector should provide useful information relevant to performing the sampling. A batch will be constituted for each species with the same provenance and characteristics.

Step 3. A random sample will be taken from each batch, in accordance with Table 5 or similar, for the different tolerances.

3.1. The boxes/packs must be chosen respecting the principles of systematic random sampling ([34–36], among others).

3.2. In each box/pack, specimens will be taken according to the number proposed (Table 5) in accordance with the tolerance (maximum percentage of illegal permitted in the sample) and the level of confidence chosen; individual specimens will be selected from the full length and width of the box/pack according to a vertical model.

Step 4. The inspector will measure the specimens using the instruments and techniques authorized; as they are measured, the inspector will separate out those specimens that do not reach the legal minimum length. Data will be recorded in the corresponding official report.

Step 5. The inspector will decide whether to release or hold the shipment in function of the number of specimens whose TL is $\leq$ MLS.

With the object of simplifying and speeding up the tasks of monitoring and managing landings of fish and shellfish, a computer application has been designed. This application should serve as a tool to allow an inspector to obtain intuitively, easily and rapidly, all the statistics, estimations and, in general, the information necessary, so that the inspector or person analyzing

Table 5
Protocol for taking the decision to release or detain the batch of merchandise inspected, for species packed in boxes, expressed in number of specimens, for a case where the tolerance (i.e. the maximum percentage of "illegals" permitted in the sample) is 10%. (NTC: Number of boxes (in the batch being inspected); NTS: Number of boxes to be sampled; NES: Number of specimens in the sample to be taken from each box; SS: Sample size (i.e. total number of specimens to be measured); CL: Confidence level; LIMIT: Maximum number of specimens of less than legal minimum length/weight permitted in the sample).

Tolerance: 10%	NTC	NTS	NES	SS	CL (1−−)%	INM (np/SS)
	1	All	100	100	90	14
	2		50			
	3		33–34		95	16
	4		25			
	5–12	5	20		97	17
	13–20	10	10		99	19
	21–40	15	10	150	90	20
					95	22
					97	23
					99	25
	> 40	20	10	150	90	26
					95	28
					97	29
					99	32

the information obtained in respect of a particular sample can take the correct decisions on the population that the sample represents. The reliability of the results obtained are ensured providing the inspector respects the basic principles of good sampling and works with samples comprising the minimum number of individuals.

The application itself generates the appropriate messages for the interpretation of the results. It takes the form of a closed spread sheet in which only the data corresponding to the following should be introduced (Fig. 3):

1. Species submitted to inspection/study.
2. Condition of the **legal** specimen, expressed as **"TL $\geq$ Minimum legal size (*MLS*)".**
3. Condition of the **illegal** specimen, expressed as **"TL $<$ Minimum legal size (*MLS*)".**
4. The measurements (TL, in mm) made, introduced in the column headed MEASUREMENTS.

The output obtained consists of the percentage of illegal specimens (TL $\leq$ MLS), the confidence levels and the statistical summary (Fig. 3).

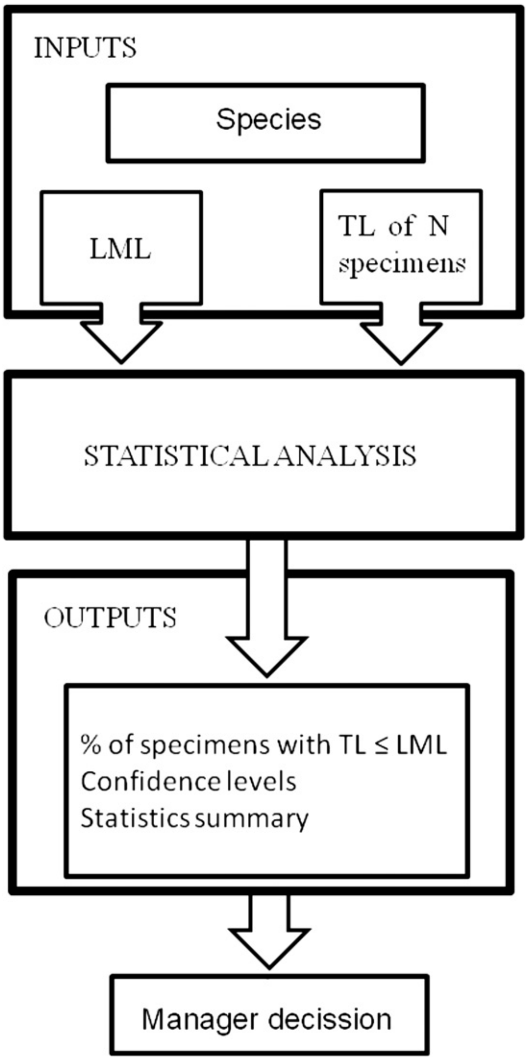


Fig. 3. Flow diagram of the operation of the computer software.

When a trial inspection was made of one box from a landing of European anchovy, a sample of 45 specimens was taken (Fig. 4); this number sampled exceeds, by 15 individuals, the minimum established for the tolerance applicable to this species (10%) (Table 5). It was found that the number of illegal specimens in the sample was 29; consequently the proportion of illegal specimens in the population landed will range between 52.71% and 76.18% with a mean of 55.30%, for the 90% confidence level. For the 95% confidence level, the range will be between 50.56% and 78.43%, with a mean of 55.30%, and for the 99% confidence level, the range will be between 46.06% and 82.82%, with a mean of 47.84%. The box to which the sample corresponds should therefore be withdrawn and not sent to the market.

4. Discussion

It is evident that the assessment of fisheries must be founded on biological knowledge of the target species and of the ecosystem that is exploited globally [2], data for such assessments should be obtained avoiding sources of bias and errors, so that the standards of reliability established by international and national working groups are achieved. However, despite attempts to regulate landings through the imposition of MLS or LML, these have been revealed as incomplete and insufficient, if not largely ineffective, since the length of individual stipulated as minimum in the legislation is less than the length of first maturation (LFM) for most species [26,27,37]; the same is found for the species studied in this work, with the exception of *Solea vulgaris* (Table 2). This implies that many individuals of most commercial species are being landed and sold before they have reached the length of first maturation.

The basis for all sampling schemes is a decision on the species to be sampled [8]. This decision will be generally determined by the commercial importance of the species (or group of species) and, in the case of the resources exploited by more than one country, by the requirements of the various countries concerned. These studies require significant investments in the long term by governments and official bodies. The ideal system would be to manage fisheries adequately, based on comprehensive regulation of the fishing effort and effective monitoring of the selectivity of fishing techniques and gear, together with other measures such as the creation of marine reserves, legislation and adequate enforcement that would protect the structure of the population and, thereby, the future of the fishery.

Despite these premises, in many cases when the authorities wish to apply such regulation and monitoring, the fishing activity has already taken place and often the catches have already been landed in port. Therefore an approach involving inspection of the catch for compliance with minimum length of individual becomes very useful; however, it must be realized that, currently, minimum length is often not based on the length of first maturation of the species (Table 2).

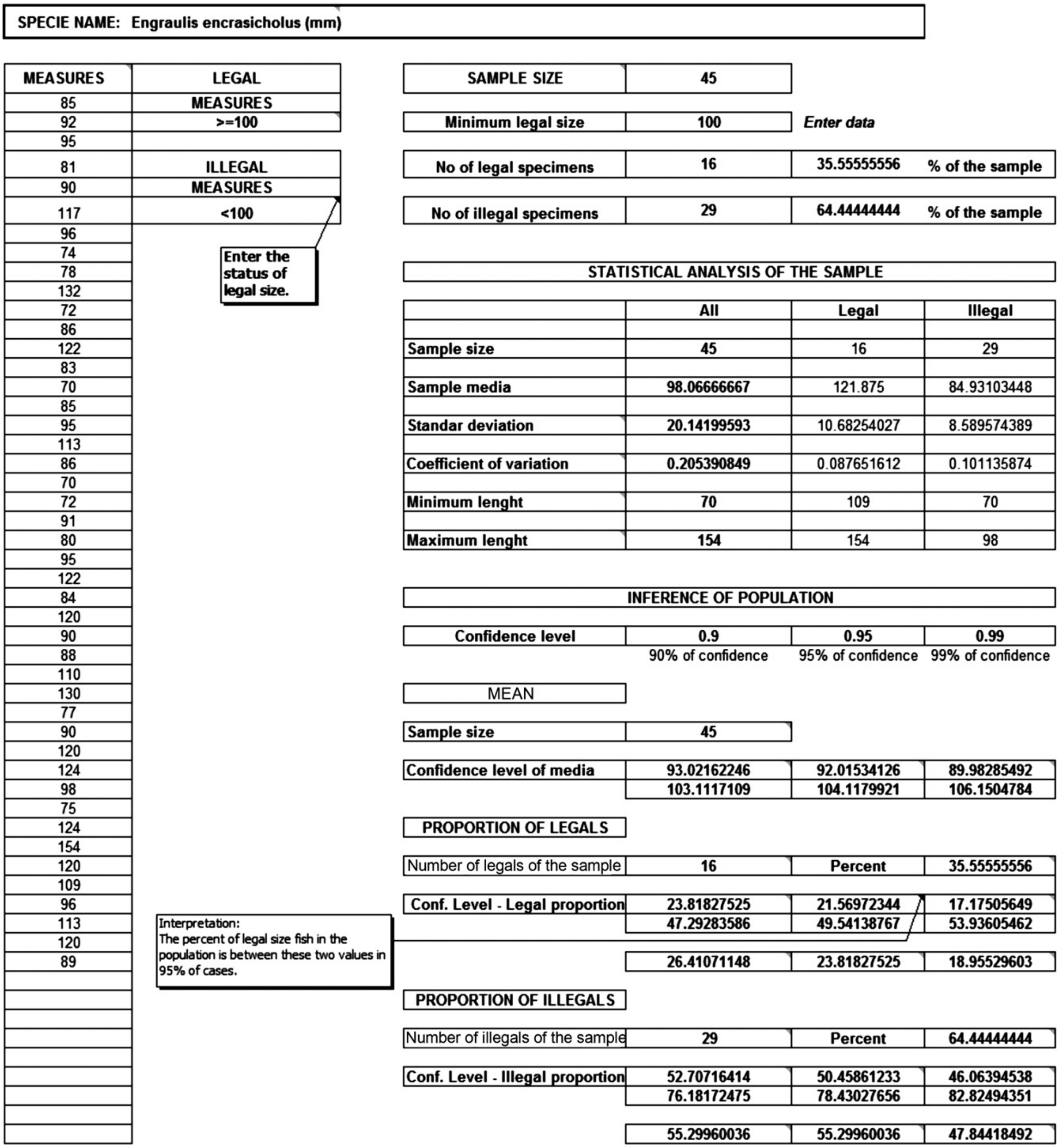
To achieve and optimize that essential level of control, and to recognize and respect the minimum lengths, it is not a simple matter of issuing information: what is required is a system for the objective observation of quality on fish wharfs and when merchandise is loaded for onward transport. This is an arduous task requiring the professional efforts of a great number of inspectors. The computer application developed in this study is intended to facilitate that essential work.

In the years 2008, 2009 and 2010, the Regional Department of Agriculture and Fishing of the Regional Government of Andalusia imposed 1551, 1865 and 1641 legal sanctions, respectively, on companies and persons for the transport and/or intention to sell individual fish, shellfish, etc., of below the legal minimum length (personal communication). The integral management that involves all the sectors and government at the appropriate level is essential and will greatly contribute to the achievement of sustainable development for many important marine species. Facilitating the work of the technical staff who assess the legality of the fisheries resources landed and transported that are intended for sale in the market, thus also becomes a necessary task.

5. Conclusions

In this study a basic methodology is proposed for the determination of the minimum sample size necessary. This proposal also takes into account possible sources of bias and variation in the ruling legislation; the result obtained is a software tool that can be applied to any landed catch of fisheries resources.

This tool is very intuitive and easy to use in any situation or location, since it can be run on any computer or similar portable device (PDA, iPhone, tablet). It enables the user to know the real data of any particular sample very rapidly, and makes the tasks of inspection more efficacious and efficient by allowing the user to optimize the work of inspection. Because the decision regarding the approval of such merchandise for release to the market can be made so rapidly, the use of this innovation will contribute to ensuring that handling and transport times are minimized and, as a result, the merchandise will reach the consumer in the maximum conditions of freshness and quality.



SPECIE NAME: Engraulis encrasicholus (mm)

MEASURES
85
92
95
81
90
117
96
74
78
132
72
86
122
83
70
85
95
113
86
70
72
91
80
95
122
84
120
90
88
110
130
77
90
120
124
98
75
124
154
120
109
96
113
120
89

LEGAL
MEASURES
>=100
ILLEGAL
MEASURES
<100

Enter the status of legal size.

SAMPLE SIZE	45		
Minimum legal size	100	Enter data	
No of legal specimens	16	35.55555556	% of the sample
No of illegal specimens	29	64.44444444	% of the sample

STATISTICAL ANALYSIS OF THE SAMPLE

	All	Legal	Illegal
Sample size	45	16	29
Sample media	98.06666667	121.875	84.93103448
Standar deviation	20.14199593	10.68254027	8.589574389
Coefficient of variation	0.205390849	0.087651612	0.101135874
Minimum lenght	70	109	70
Maximum lenght	154	154	98

INFERENCE OF POPULATION

Confidence level	0.9	0.95	0.99
	90% of confidence	95% of confidence	99% of confidence
MEAN			
Sample size	45		
Confidence level of media	93.02162246	92.01534126	89.98285492
	103.1117109	104.1179921	106.1504784
PROPORTION OF LEGALS			
Number of legals of the sample	16	Percent	35.55555556
Conf. Level - Legal proportion	23.81827525	21.56972344	17.17505649
	47.29283586	49.54138767	53.93605462
	26.41071148	23.81827525	18.95529603
PROPORTION OF ILLEGALS			
Number of illegals of the sample	29	Percent	64.44444444
Conf. Level - Illegal proportion	52.70716414	50.45861233	46.06394538
	76.18172475	78.43027656	82.82494351
	55.29960036	55.29960036	47.84418492

Interpretation: The percent of legal size fish in the population is between these two values in 95% of cases.

Fig. 4. Screen shot of the computer software spreadsheet applied to *Engraulis encrasicholus*.

It is also necessary to legislate again the MLS to be superior than the LFM of the target species to protect them from overfishing and unify the terms MLS and LML in different countries, in order to avoid misunderstandings, especially if more than one country implicate in the exploitation of that resource.

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