Working Document presented to WGHANSA, Bilbao, 24-29 June 2017

Preliminary adults results for the IEO Sardine DEPM survey 2017 ICES 9a North, 8c and 8b

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1. Background

The IEO (Insituto Español de Oceanografía) carries out DEPM surveys every three years to estimate the sardine spawning stock biomass within the Atlanto-Iberian stock area. DEPM surveys consisted of ichthyoplankton, adults and hydrographic sampling and are internationally coordinated and planned under the framework of ICES WGACEGG. Fishing hauls are undertaken for estimation of adult daily fecundity parameters (sex ratio, female weight, batch fecundity and spawning fraction) within the mature component of the population.

In 2017, the Spanish survey took place in March/April covering the northern stock area from the river Minho to the south of the Armorican shelf in French waters (ICES areas 9a North and 8c). Division 8b in the Bay of Biscay, beyond the boundaries of Atlanto-Iberian sardine stock, has also been covered by the IEO in the inner part of the Bay of Biscay (8b up to a maximum of 45°N)

The Spanish DEPM survey (SAREVA0417) was undertaken using two vessels; RV Vizconde de Eza (from 24 March to 14 April), for ichthyoplankton sampling mainly and RV Miguel Oliver for adult samples which were collected during the acoustics survey (PELACUS0317) from 14 March to 16 April.

This document provides a description of the survey, laboratory analyses and estimation procedures used to obtain preliminary adults parameters (mean female weight, sex ratio, batch fecundity and spawning fraction) for the 2017 DEPM applied to the Atlanto-Iberian sardine stock. The laboratory tasks for processing samples are still underway, and therefore estimates presented for the batch fecundity and spawning fraction are preliminary at this meeting.

2. Methodology

2.1 Surveying

Fishing hauls for estimation of adult parameters were undertaken from PELACUS acoustic survey which was carried out concurrently with RV Vizconde de Eza. Fishing hauls were conducted by pelagic trawling following sardine schools detection by the echo-sounder. The number of samples and its spatial distribution was scheduled to ensure a good and homogeneous coverage of the survey area (Figure 1).

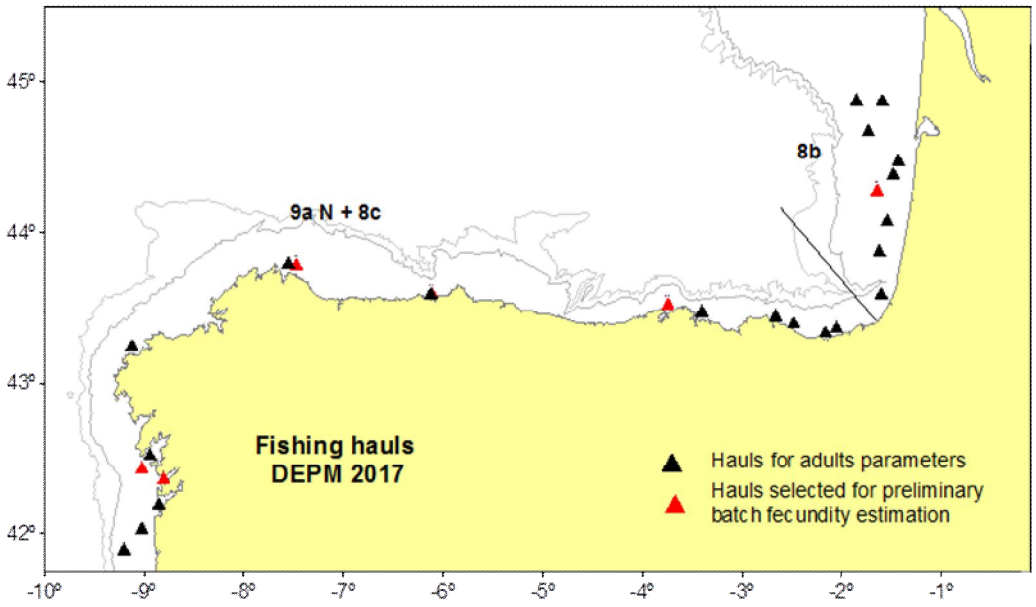


Figure 1. Spatial distribution of fishing hauls. Hauls selected for preliminary batch fecundity estimation (triangle in red).

Onboard the RV, and for each haul with sardine catches, a minimum of 60 sardines (males and females) were randomly selected and biologically sampled. For reproductive parameters, a minimum of 30 females per haul was required, thus, in some occasions, the random sampling was complemented with additional directed sampling in order to get females enough for histological analysis, and/or fecundity estimations. Individual biological information (length, total weight, sex, maturity state, gonad weight) was recorded for all fish, the ovaries were preserved for histology (with a 4% buffered formaldehyde) and the otoliths removed for age determination. The biological sampling and ovaries fixation were always carried out in fresh material. Details on the methodologies used on board, during laboratory work and data analyses are summarized in Table 1.

Table 1. Sampling, processing and analyses carried out in sardine adults samples.

SURVEY ADULTS	Divisions 9a N + 8c + 8b
Biological sampling:	On fresh material, on board of the R/V
Sample size	60 indiv randomly (30 mature female); extra if needed and if hydrated found
Sampling for age	Otoliths from random males and females
Fixation	4% buffered formaldehyde
Preservation	4% buffered formaldehyde
Sex ratio (R) estimation	The observed weight fraction of females
Mean female weight (W)	Individual total weight of hydrated females corrected by a linear regression between total weight of non-hydrated females and their corresponding gonad-free weight
Spawning fraction (S) : preliminary estimation	Quotient between the total number of random hydrated females (macroscopically classified) and the total random mature females in the haul.
Batch fecundity (F): preliminary estimation	On hydrated females (without checking histologically POFs absence), according to Pérez et al. 1992b

2.2 Laboratorial analyses

In order to report a preliminary batch fecundity estimate, a total of 52 hydrated females with total length between 157 and 245 mm were selected from six hauls over a total for 26 positive sardine hauls from 65 performed during Pelacus0317 survey (Table 2 and Figure 1).

At the laboratory, the individual batch fecundity (number of hydrated oocytes in the gonad) was estimated by the gravimetric method, on 1-3 whole mount sub-samples per ovary of 50-150 mg (Hunter et al. 1985).

Table 2. Description of selected hauls and samples used to estimate preliminary batch fecundity.

ICES area	Lat	Long	Date	Depth (m)	Time	Females No.
9a N+ 8c	42.43	-9.02	2017/03/17	82	12:29	12
9a N+ 8c	42.36	-8.8	2017/03/18	35	13:14	3
9a N+ 8c	43.78	-7.47	2017/03/27	126	11:05	1
9a N+ 8c	43.59	-6.11	2017/03/29	58.5	16:10	12
9a N+ 8c	43.52	-3.74	2017/04/05	46	16:40	12
8b	44.27	-1.64	2017/04/12	106.5	13:08	12

2.3 Data analysis

Adult parameters (W, R, F, and S) are estimated independently for each fishing haul, using only the mature fraction of the population (macroscopic maturity stages 2-6).

Before the estimation of the mean female weight per haul (W), the individual total weight (Wt) of the hydrated females was corrected by a linear regression between the total weight of non-hydrated females and their corresponding gonad-free weight (Wnov).

The sex ratio (R) in weight per haul was obtained as the quotient between the total weight of females on the total weight of males and females based on random samples.

The expected individual batch fecundity (Fexp) for all mature females (hydrated and non-hydrated) was estimated by modelling the 52 observed individual batch fecundity (Fobs) with their gonad-free weight (Wnov) by a GLM.

The preliminary daily spawning fraction of females (S) was determined, for each haul, as the ratio between hydrated females (macroscopically determined) and the total number of mature females from random samples. No histological correction (presence of recent POFs) was taking into account to estimate the preliminary spawning fraction.

$$S = \frac{\sum_{i} H}{\sum_{i} Mat}$$

where H is the number of hydrated females in the haul (i), and Mat the number of mature females in the haul (i).

The mean and variance of the adult parameters was obtained according to Picquelle and Stauffer 1985 (weighed means and variances).

Those hauls containing less than 30 fish sampled were excluded from the mean and variance calculations.

All estimations and statistical analysis were performed using the R software. Final adult parameters include individual estimates for the 9a N+ 8c, and 8b areas, with two independent estimates.

3. Results

In total, 26 fishing hauls positive for sardine were performed during the survey (Figure 1). A total of 2358 sardines were sampled (Table 3), 818 ovaries were collected and preserved for histological analysis and otoliths were removed for age determination. A total of 229 hydrated females were caught for batch fecundity estimation and 52 hydrated females selected from them to obtain a preliminary estimate. Mean female weight (W) and sex ratio (R) were based on samples collected in the total area (26 hauls), therefore, preliminary spawning fraction (S) has been estimated from 17 hauls in which hydrated females were found.

Table 3. General sardine adult sampling DEPM 2017.

ADULTS	**9a N + 8c**	**8b (up to 45ºN)**	**Total area**
Number (+) trawls	18	8	26
Date	15.03 - 10.04	10.04 - 14.04	15.03 – 14.04
Depth range (m)	35-127	55-111	35-127
Time range	07:00 – 17:00		07:00-17:00
Total sardine sampled	1534	824	2358
Length range (mm)	145-245	137-226	137-245
Weight range (g)	23.3-117.7	18.4-85.6	18.4-117.7
Hydrated females	190	39	229

The same linear regression (Table 4 and figure 2) between the non-hydrated females Wt and their corresponding Wnov was used for the whole surveyed area (Wt = - 1.39 + 1.09 * Wnov, R^2 = 0.993).

Table 4. Coefficients from the linear regression model between gonad-free-weight and total weight fitted to non-hydrated females.

Parameter	Estimate	Standard error	Pr(>|t|)
Intercept	-1.388696	0.183165	1.4e-13***
Slope	1.096860	0.003855	<2e-16***

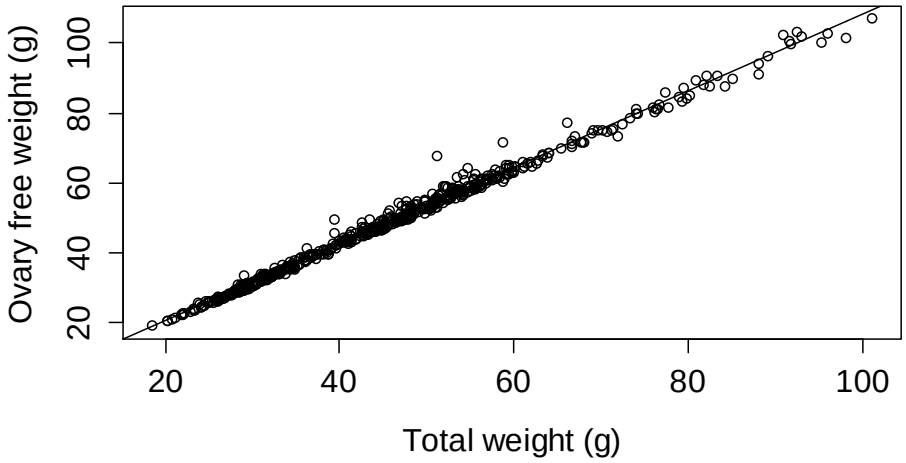


Figure 2. Linear regression model between gonad-free-weight and total weight fitted to non-hydrated females.

Minimum mean female weight (Figure 3) by haul was observed in the French coast (27 g) and maximum in Galicia (87 g). Mean female weight (W) was 51.06 g in the 9a N + 8c area and 40.06 in 8b area. Female mean weight observed in 2017 in 8b area is the minimum of the serie. Regarding 9a-8c area, female mean weight is slightly higher than in 2014 but significantly lower than those observed between 1996 and 2011 (Figure 4).

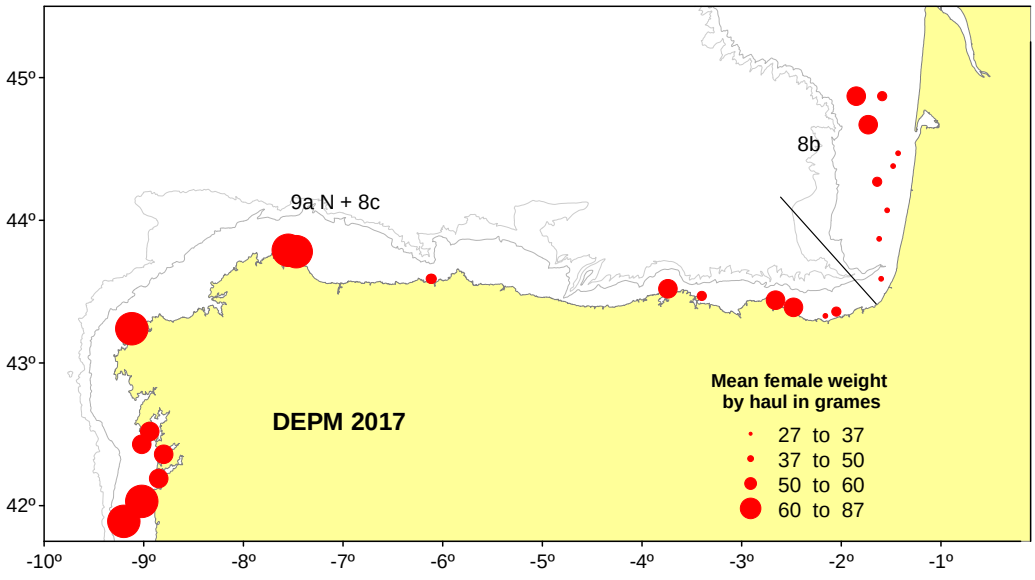


Figure 3. Spatial distribution of mean female weight (g) by haul.

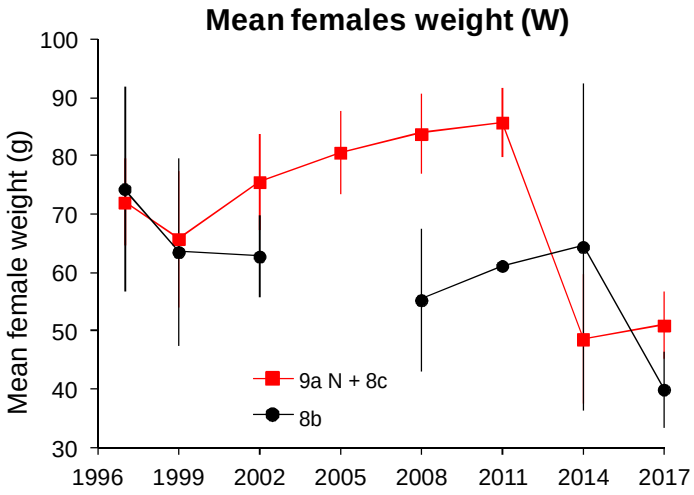
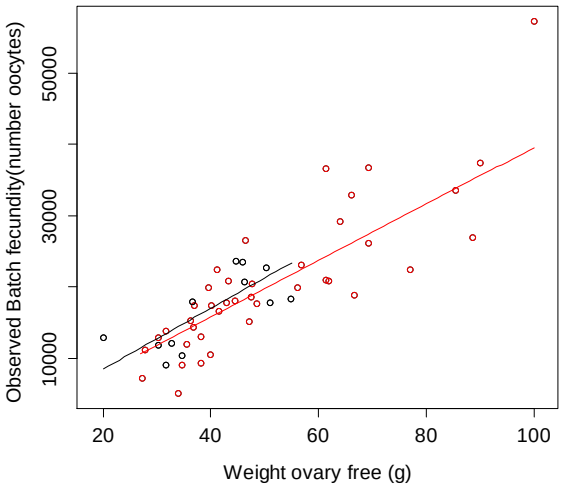


Figure 4. Mean females weight (W) in grams for 9a N+8c area in red and 8b area in black. Vertical lines correspond to 95% confidence intervals (i.e., ± 2 standard-deviations)

The geographical distribution of female weight (Figure 3) and mean observed batch fecundity (Fobs = 19010 and 16305 eggs/female, respectively, for 9a N + 8c and 8b strata) suggest the need for a spatial stratification in view of the parameters estimation. Fobs data were thus modelled against the Wnov and the Stratum (GLM: Fobs ~ -1 + Wnov:Stratum, negative binomial distribution and identity link) with two different strata, and the model obtained was statistically significant (Figure 5).

Though the model obtained with the two strata was statistically significant, in 2017, the relationship between the Fobs and the female Wnov was very similar for the two areas considered, i.e., that the batch fecundity estimated for a fish of the same weight would be similar off the North, West and South coasts (Figure 5). Similarly to the mean weight, mean batch fecundity estimate (F) was lowest off the French coast (8b).




```
> batch_S_0_3.glm <- glm.nb(Fobs ~ -1 + Wnov:Stratum, link=identity,
data=adults.dat, na.action="na.omit")

Deviance Residuals:
   Min     1Q  Median     3Q    Max
-3.2824 -0.6478  0.0541  0.5740  1.7489

Coefficients:
                  Estimate Std. Error z value Pr(>|z|)
Wnov:9aN + 8c   395.62     15.86   24.95   <2e-16 ***
Wnov:8b         425.85     31.16   13.66   <2e-16 ***
---
Signif. codes: 0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1

(Dispersion parameter for Negative Binomial(15.5768) family taken to be 1)

   Null deviance:   Inf on 52  degrees of freedom
Residual deviance: 52.564  on 50  degrees of freedom
  (2306 observations deleted due to missingness)
AIC: 1030.3
Number of Fisher Scoring iterations: 1
          Theta:  15.58
      Std. Err.:  3.03
2 x log-likelihood: -1024.274
```

Figure 5. Preliminary observed batch fecundity vs. gonad free weight of the 52 hydrated females, the regression line of the corresponding model for the two geographical areas (black: 8b stratum, red: 9a N + 8c) (left panel) and results of the GLM obtained (right panel).

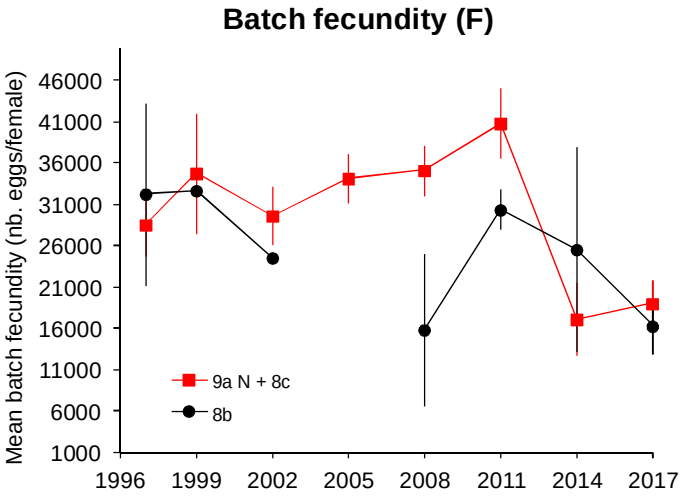


Figure 4. Batch fecundity (F) in number of eggs by female for 9a N+8c area in red and 8b area in black. Vertical lines correspond to 95% confidence intervals (i.e., ± 2 standard-deviations)

Preliminary S for the Northern Spanish coast (9a N + 8c) was 0.170, the highest in the historical series (Figure 5) and similar to those estimated in 1996; nevertheless the preliminary S estimated in the French coast (8b), 0.082, was similar to those obtained during the 2014 survey. In any case, as preliminary S has been estimated without considering females with other evidence of recent spawning (POFs), present results could over or underestimate S values. Thus, results have to be interpreted with caution until final estimates based on histological analysis be available.

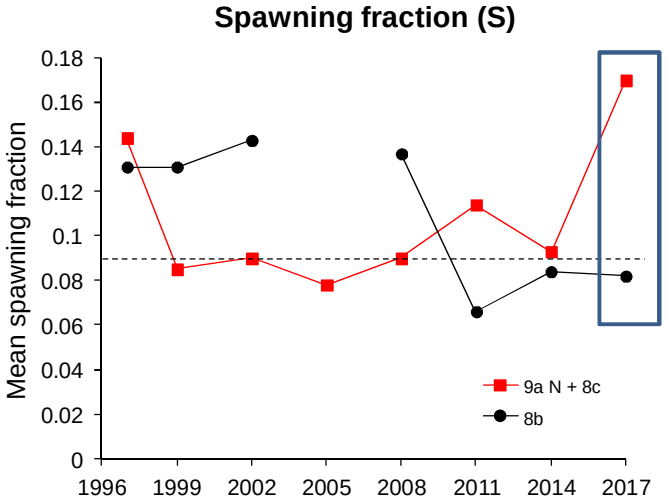


Figure 5. Spawning fraction (S) for 9a N+8c area in red and 8b area in black. The blue rectangle shows the preliminary spawning fraction estimated in 2017 using hydrated females without histological correction.

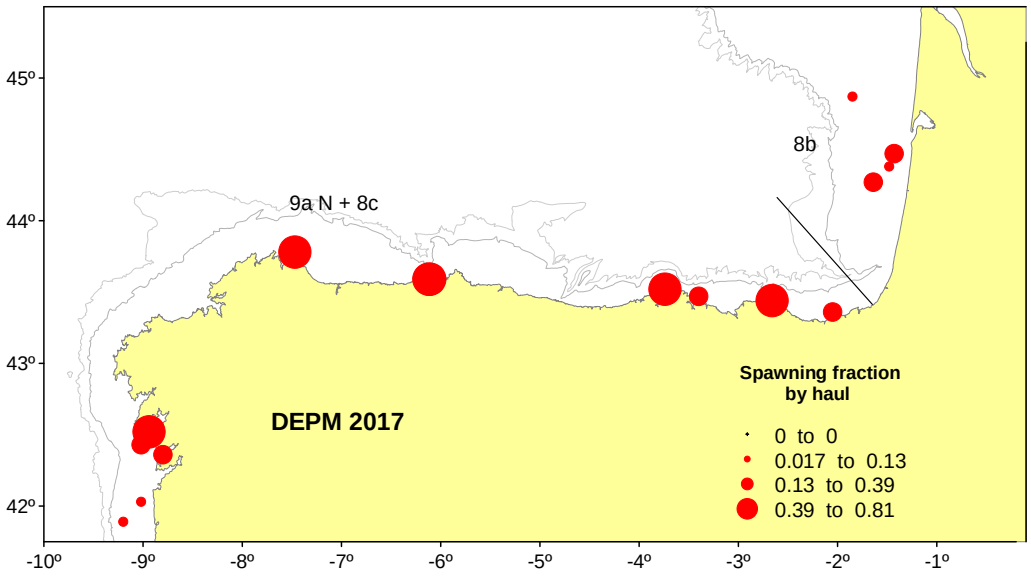


Figure 6. Spatial distribution of mean spawning fraction by haul.

The four adults parameters needed to estimate Spawning Stock Biomass in the 2017 Sardine DEPM survey are summarised in table 5.

Table 5. Sardine adults parameters for the total surveyed area and by ICES divisions. In brackets coefficient of variation in percentage.

2017	IEO	IEO	IEO
Sardine DEPM	9a N + 8c	8b (up to 45ºN)	Total area
Female Weight (g)	51.06 (5.6)	40.06 (8.1)	47.55 (5.1)
Batch Fecundity (eggs/female)	19010 (7.5)	16305 (10.3)	18090 (6.6)
Sex Ratio	0.505 (6.3)	0.434 (13.2)	0.48 (6.0)
Spawning Fraction	0.170 (32)	0.082 (47.2)	0.142 (27.3)

Final remarks

- All laboratory tasks for histological processing and microscopical analysis are still in progress.
- The expected individual batch fecundity (Fexp) for all mature females (hydrated and non-hydrated) was estimated by modelling 52 selected individual batch fecundity observed (Fobs) in the sampled hydrated females.
- Preliminary spawning fraction estimated as the quotient between the total number of random hydrated females in the haul and the total random mature females. No histological correction was taking into account to estimate the preliminary spawning fraction.
- Observed decrease on mean females weight and batch fecundity estimates in 9a N + 8c area in 2014 sardine DEPM survey are also maintained in 2017**.**
- For the first time in the historical series, the minimum mean female weight (W) was obtained for the 8b area.