DAILY EGG PRODUCTION SPAWNING BIOMASS OF THE NORTH-WESTERN MEDITERRANEAN ANCHOVY DURING 1993 (CATALAN SEA, GULF OF LIONS AND LIGURIAN-N TYRRHENIAN SEAS)

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Research carried out by HUNTER AND GOLDBERG (1980) on the reproductive aspects of the northern anchovy off California Engraulis mordax, showed that many small pelagic species, mainly clupeiforms were batch spawners. Subsequently, an ichthyoplankton based method (LASKER, 1985), the Daily Egg Production Method, was developed that allowed the spawning biomass estimate of Clupeoids. The first applications of DEPM in European waters were carried out in the coasts of the Atlantic Iberian peninsula on the Iberian sardine, *Sardina pilchardus* (GARCÍA *et al.*, 1992) during 1988, and on the Bay of Biscay anchovy, *Engraulis encrasicolus* (SANTIAGO and SANZ, 1992). The first Mediterranean DEPM survey was carried out by PALOMERA and PERTIERRA (1993) on the anchovy from the Catalonian coasts. Within the framework of a an EU financed FAR project, the northwestern Mediterranean anchovy biomass was estimated through DEPM (MPH-MED-93) aboard the R/V García del Cid during July, 1993. This survey was combined spatially and temporally with the echo-acoustic survey, PELMED-93 on board the R/V Thalassa, with the purpose providing the anchovy echo-integration biomass estimates and allowing to estimate DEPM parameters related to the adult stock. The DEPM sampling and data treatment methodology in relation to the egg and adults survey are described in GARCÍA (1994). In summary, the basic scheme of egg sampling stations was based on a 5 by 5 nautical mile track, with transects perpendicular to the coastline. A total of 602 CalVET net (150 µ mesh) vertical tows of 100 m depth were done, representing a coverage of 59,981 km^2 of sea surface. Catalán Sea accounted for 292 plankton hauls, whereas the Gulf of Lions and Ligurian Sea accounted for 138 and 172, respectively.

Adult anchovies were sampled in 34 positive anchovy hauls (13 in Catalonian waters, 13 in the Gulf of Lions and 8 in the Ligurian-N Tyrrhenian) with an epipelagic trawl. The period of trawls ranged from 7:30 A.M. to 22:30 P.M. (GMT). 1,034 ovaries were collected, where 210 corresponded to hydrated females. The model (LASKER, 1985) is based on the following equation, where B = spawning biomass in metric tons, Po= daily egg production (number of eggs per sampling unit, 0.05 m^2), W = average weight of mature females (grams), R = sex ratio (fraction mature of females by weight), F = batch fecundity (mean number of eggs per mature female per spawning), A = total survey area (in 0.05 m^2 sampling units). S = fraction of mature females spawning per day. Plankton stations are post-stratified by location (negative and positive strata) with the purpose of decreasing variance and by geographic criteria based on the spawning area distribution (GARCÍA, 1994). Eggs were staged according to their embryonic degree of development and subsequently aged, taking into account an specific temperature-dependent egg development model, through the program STAGEAGE. Egg production, Po, is estimated by fitting the exponential mortality function using a weighted nonlinear least squares regression to the data egg file. This model was fit to the data from stratum 1 for each of the regions. In consequence, each region has an estimate of Po1 (intercept) and a corresponding egg mortality, z (slope). The final stratified estimate of Po by regions was calculated as the weighted average of the two strata. In reference to the adult parameters estimates, W, F, S and R, mean and variance were estimated following PICQUELLE and STAUFFER's (1985) weighing procedure, calculating weighted averages albeit the number of sampled individuals are not equal in each of the tows. W, the mean weight of mature females per trawl was adjusted for those females which were in the hydrated condition, through the following regression, W = -0.3261 + 1.1012W* (ovary-free weight of non-hydrated females). F, batch fecundity, is estimated by regressing batch fecundity on ovary-free weight of hydrated females, without post-ovulatory follicles. A total of 83 hydrated females were obtained. The resulting linear regression is : y = 1848,3 + 499,57 x R = (0.92). Weights of the females used ranged from 3.6 to 30.6 g, while sizes ranged from 9.1 to 17.5 cm. S, fraction of mature females spawning per day, is determinated by the histological analysis of post-ovulatory follicles. These were assigned ages according to the following: Day-0 PO = 0-7 hours; Day-1 PO = 8-31 hours; Day-2 PO = > 31 hours. Day-1 PO has been used in the estimate of S, since Day-0 PO are oversampled during the daily spawning period in anchovy (ALHEIT, 1985). R, sex ratio, is calculated as the fraction in weight of mature females. Based on the geographical distribution of the anchovy population and the spawning grounds distribution, the defined stratified regions were : Catalán Sea and Gulf of Lions, which have common geographical, hydrographical and environmental characteristics, as opposed to the Ligurian-N Tyrrhenian Sea, which presents a distributional barrier along the Provençal coasts, probably due to the narrow shelf limits. The results of all the DEPM parameters estimate and the final anchovy spawning biomass estimate are in following table. When comparing by regions the different parameters estimate, no great differences are observed between the adult parameters. However, in comparison to the Bay of Biscay anchovy, it should be remarked that the average female weight is much lower and consequently, batch fecundity (aproximately 30 g and 15 000 eggs/batch, respectively). Nevertheless, spawning fraction is within the same range (0.30). Daily egg production over the surveyed regions are in the same order of magnitude, but with high mortality (z), specially in the Ligurian-N Tyrrhenian Sea, in comparison to Bay of Biscay anchovy estimates (SANTIAGO and SANZ, 1992). Higher Mediterranean temperatures account for the faster egg development rates that eventually result in shorter egg durations. The temporal and spatial simultaneous coverage of both surveys have contributed to the similarities in the biomass estimates, except the case of the Italian waters in which daily egg production probably is over-estimated.

DEPM Parameters	Catalan Sea-Gulf of Lions	Ligurian-N Tyrrhenian Sea
Po1	3.215	4.998
c.v.	0.145	0.223
z	1.063	1.551
c.v.	0.136	0.260
Po	2.382	2.715
c.v.	0.258	0.229
A(in 0.05 m^2)	6.911×10^{11}	3.085×10^{11}
A(in km^2)	44.567	15.420
W (g.)	14.31	14.17
c.v.	0.074	0.058
F	4668	4894
c.v.	0.11	0.10
S	0.31	0.32
c.v.	0.13	0.11
R	0.65	0.63
c.v.	0.05	0.05
Biomass (MT)	30.565	12.129
c.v.	0.33	0.30
Acoustic Biomass (MT)	32.831	6.459

REFERENCES

ALHEIT, J., 1985. *Technical Rep.* NMFS 36:59-62.
GARCÍA, A. (Ed.), 1994, Final Report Study Contract FAR Proyect MA 3.730, U.E. DG XIV
GARCÍA, A., N. PÉREZ, N.C.H. LO, A. LAGO DE LANZÓS and A. SOLA, 1992. *Bol. Inst. Esp. Oceanogr.*, V. 8, N° 1: 123-138.
HUNTER, J.R. and S.R. GOLDBERG, 1980. *Fish. Bull.* U.S. 77: 641-652.
LASKER, R. (Editor), 1985.*NOAA Technical Rep.* NMFS 36: 99 p.
PALOMERA, I. and PERTIERRA, J.P., 1993. *Sci. Mar.*, 57(2-3): 243-251.
PICQUELLE, S.J. and G. STAUFFER, 1985. *NOAA Technical Rep.* NMFS 36:7-16.
SANTIAGO, J. and A. SANZ, 1992.*Bol. Inst. Esp. Oceanogr.*, V. 8, N° 1: 225-230.

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