Stock Annex: Anchovy (*Engraulis encrasicolus*) in Division 9.a (Atlantic Iberian waters)

Stock specific documentation of standard assessment procedures used by ICES

Stock:	Anchovy
Working Group:	Working Group on Anchovy and Sardine and Southern Horse Mackerel (WGANSA)
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A. General

A.1. Stock definition

The distribution of anchovy in the Division 9.a is nowadays mainly concentrated in the Spanish waters of the Gulf of Cádiz (Subdivision 9.a-South, **Figure A.1.1**). Outside the main nucleus of the Gulf of Cádiz, resilient anchovy populations have been detected in all fishery independent surveys (ICES, 2007 b) and previous records on large catches in ICES areas 9.a North, Central North and South (Algarve) suggest that abundance in those areas have been high in early years of the time series. In the south, outside the Gulf of Cádiz anchovy is abundant to the East of the Strait of Gibraltar, in the Mediterranean Sea (GFCM, 2002) as well as in northern Africa, where a combined Spanish-Morocco fishery produces landings of up to 12 000 tn (Millán, 1992; García-Isarch *et al*., 2008).

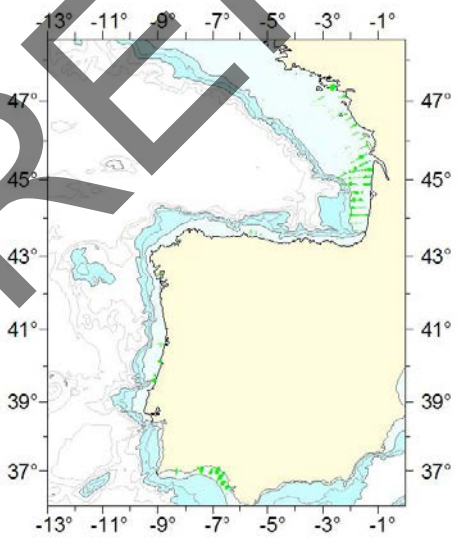

Figure A.1.1. Distribution of acoustic energy allocated to anchovy from the combined 2007 acoustic surveys off Iberia and the Armorican shelf (from ICES, 2009b).

A.2. Fishery

Anchovy harvesting along the Division 9.a is at present carried out by the following fleets:

- Portuguese purse-seine fleet
- Portuguese trawl fleet
- Portuguese artisanal fleet (although fishing with artisanal purse-seines)
- Spanish purse-seine fleet
- Spanish trawl fleet (in Subarea 9.a-South (Cádiz))

Purse-seine fleets are the main responsible for the anchovy fishery in the Division (usually more than 90% of total annual landings in the Division). Spanish fleets operate in Sub-divisions 9.a-North (Southern Galicia) and 9.a-South (Gulf of Cadiz), and the Portuguese ones along its national peninsular fishing grounds (Sub-divisions 9.a-Central North, -Central South and South (Algarve)). Most of the fishery for this anchovy stock in the Division takes place in Sub-division 9.a-South (C), where anchovy is the target species. The fleets in the northern part of Division 9.a (targeting sardine) occasionally target anchovy when abundant, as occurred in 1995.

Data on number and technical characteristics for the Portuguese fleets are available for 2006 (ICES, 2007 a). The Portuguese purse- seine fleet (n =121 in 2006) presently ranges in size from 10.5 to 27 m (mean vessel length = 20 m) and between 71 to 447 HP (mean = 249) in vessel engine power. Portuguese producers organisations traditionally agree a voluntary closure of the purse-seine fishery in the northern part (north of the 39º 42'' North) of the Portuguese coast. This closure usually lasted from the 1st of February to 31 of March. Since 2006, the closure, also lasting 2 months, may however be selected between 1st of February and 30th of April (*i.e*. boats stopped fishing in February to March or in March to April).

Since 1999 the number of Gulf of Cadiz purse-seiners operated by Spain has oscillated between 145 (in 2004) and 84 (in 2010) vessels, and the vessels within this fleet targeting anchovy between 76 (2010) and 135 (2004) vessels. As it has been previously reported (ICES, 2007 a), the observed fluctuations during this period were mainly motivated by the ending of the fifth EU-Morocco Fishery Agreement (in 1999, which affected the heavy-tonnage fleet in the following two years: acceptation of tie-up scheme in 2000 and 2001), the rising of the light-tonnage purse seiners on those dates, and the fluctuations showed by the multipurpose vessels. These vessels fishing for anchovy account for more than 85% of the whole fleet during the available series, evidencing the importance of anchovy as a target species in the Gulf of Cadiz purse-seine fishery. Since 2008 the EU–Morocco Fishery Agreement was renewed, and part of the fleet (the heavier/larger vessels) devoted to the anchovy fishing in the Moroccan grounds, which entailed an important reduction of the fishing effort in the Gulf of Cadiz.

A first attempt of identifying *métiers* in this last fleet/fishery was presented in the 2007 WGMHSA meeting (ICES, 2007 a). This study (see also Silva *et al*., 2007, for details) focused on the application of a non-hierarchical clustering data-mining technique (*CLARA*, *C*lustering *LAR*ge *A*pplications) for classifying the fishing trips from 2003 to 2005. The classification of individual trips was only based on the species composition of landings from logbooks, hence the preliminary character of this study. Up to four clusters (catch profiles) were identified from each of the annual datasets according to

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the targeted species: 1) trips targeting anchovy, 2) trips targeting sardine; 3) trips targeting a mackerel (*Scomber* spp.) species mixture; and 4) trips targeting an anchovy and sardine mixture. The first three groupings were considered as clearly identifiable *métiers* according to the knowledge on the fishery. At present no comparable information on Portuguese *métiers* is available.

The regulatory measures in place for the Spanish anchovy purse-seine fishing in this Division were the same as for the previous years and are summarized as follows:

- Minimum landing size: 10 cm total length;
- Minimum vessel tonnage of 20 GRT with temporary exemption;
- Maximum engine power: 450 h.p;
- Purse-seine maximum length: 450 m;
- Purse-seine maximum depth: 80 m;
- Minimum mesh size: 14 mm;
- Fishing time limited to 5 days per week, from Monday to Friday;
- Cessation of fishing activities from Saturday 00:00 hr to Sunday 12:00 hr;
- Fishing prohibition inside bays and estuaries.

Until 1997, the Spanish purse-seine fleet voluntary closed the fishery each year from December to February in the Gulf of Cadiz (Subdivision 9.a-South(C)). Since 2004, two complementary sets of management measures have been in force in this part of the Sub-division. The first one is the new "*Plan for the conservation and sustainable management of the purse-seine fishery in the Gulf of Cadiz National Fishing Ground*". This plan is in force during 12 months from 30th October and includes a fishery closure (basically aimed to protect the anchovy recruitment) of either 45 days (between 17th of November to the 31st of December in 2004 and 2005), two months (November and December in 2006) or three months (mid November 2007 to mid-February 2008; 1st December 2008 to 28th February 2009), accompanied by a subsidized tie-up scheme for the purse-seine fleet. The expected subsidized 3-month closure from 2009 mid-autumn to the 2010 mid-winter was restricted to one month only, in December 2009, although the fishery was practically closed since November 2009 until February 2010 for persistent bad sea conditions during all these months. This same scheme was accomplished for the 2010-2011 autumn/winter closure. This plan also includes additional regulatory measures on the fishing effort (200 fishing days/vessel/year as a maximum) and daily catch quotas per vessel (6000 kg of sardine-anchovy mixing, but the catch of each of these species cannot exceed 3000 kg). A new regulation approved in October 2006 establishes that up to 10% of the total catch weight may contain fish below the established minimum landing size (10 cm), but fish must always be ≥9 cm.

The effort exerted by the entire purse-seine fleet since 1997 has been high (even with the fishing closures since 2004 on). While the effects of the fishery closures have not been formally evaluated, it appears that they have limited a further expansion of effort.

The second management action in force since 15th of July 2004 is the delimitation of a marine protected area (fishing reserve) in the mouth and surrounding waters of the Guadalquivir river, a zone that plays a fundamental role as nursery area of fish (including anchovy) and crustacean decapods in the Gulf (Figure A.2.1). Fishing in the reserve is only allowed (with pertinent regulatory measures) to gill-nets and trammel-nets, although in those waters outside the riverbed. Neither purse-seine nor bottom trawl fishing is allowed all over this MPA. The effects of such closures and MPA in the Gulf of Cádiz anchovy recruitment are not still possible to be directly assessed. In any case, the implementation of both of these measures should benefit the stock.

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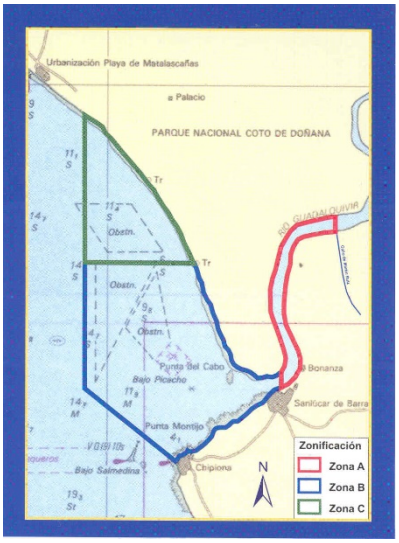

Figure A.2.1. Anchovy in Division 9.a. Limits of the Fishing Reserve off the Guadalquivir river mouth (Spanish Gulf of Cadiz. Sub-division 9.a South).

A.3. Ecosystem aspects

Anchovy is a prey species for other pelagic and demersal species, and for cetaceans and sea-birds. The recruitment depends strongly on environmental factors. Ruíz *et al*. (2006, 2007) evidenced the clear influence that meteorological and oceanographic factors have on the distribution of anchovy early life stages in shelf waters of the north-eastern sector of the Gulf of Cadiz. The shallowness of the water column, the influence of the Guadalquivir River, and the local topography favor the existence of warm and chlorophyll-rich waters in the area, thus offering a favorable environment for the development of eggs and larvae. However, spring and early summer easterlies bursts may cause: a) a decrease of the water temperature by several degrees, b) generate oligotrophic conditions in the area, and c) force the offshore transport of waters over this portion of the shelf, advecting early life stages away from favorable conditions. These negative influences on the development conditions of anchovy eggs and larvae can impact on the recruitment of this species in the Gulf of Cadiz and subsequently in the anchovy fishery.

The anchovy population in Subdivision 9.a-South appears to be well established and relatively independent of populations in other parts of the Division. These other populations seem to be abundant only when suitable environmental conditions occur.

B. Data

B.1. Commercial catch

Portuguese annual landings from their respective Sub-divisions are available since 1943. Spanish landings started to be available since 1989.

No information on anchovy discarding in the Division 9.a has been available until 2005. That year several pilot surveys for estimating discards in the Gulf of Cadiz Spanish fisheries (trawl, purse-seine and artisanal) were conducted by an IEO observer's programme onboard commercial vessels lasting five months and covering the whole study area. Preliminary results (average estimates from 6 purse-seine trips –13 hauls –, not raised to total annual landings) from these pilot surveys were described in ICES (2006 a) although there were concerns about the reliability of such estimates and the ratios derived from them due to their extremely high associated CVs. On the other hand,

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discarded anchovies were of commercial and legal size, between 10 and 15 cm (mode at 12.5 cm), but reasons for discarding anchovy were not reported to that WG. Anchovy catches in sampled trips from the bottom otter-trawl fleet were negligible. Slipping practices are probable but not directly evidenced by sampling onboard. New data on anchovy discarding have started to be gathered since 2009 on within the Spanish National Sampling Scheme framed into the EC Data Collection Regulation (DCR).

B.2. Biological

Annual and quarterly length compositions of anchovy landings in Division 9.a are routinely provided by Spain for its Sub-division 9.a-South(C). This series dates back to 1988. Length distributions for the Spanish fishery in Sub-division 9.a-North are only available for the 1995-1999 period and they were characterized, with the exception of 1998, by fish larger than 12.5 cm (ICES, 2007 a). At present, Portugal does not provide either length distributions or catches at age of their anchovy landings in Division 9.a due to their scarce catches.

Catches at age from the whole Division 9.a are only available from the Spanish Gulf of Cadiz fishery (Sub-division 9.a South (C)). Problems with ageing/reading Gulf of Cádiz anchovy otoliths still persist.

The age composition of the Gulf of Cadiz anchovy in Spanish landings is available since 1988 (see ICES, 2007 a, for tabulated data from years not shown in this report). The catch-at-age series shows that 0, 1 and 2 age groups support the Gulf of Cadiz anchovy fishery and that the success of this fishery largely depends on the abundance of 1 year-old anchovies. The contribution of age-2 anchovies usually accounts for less than 1% of the total annual catch (except in 1997, 1999, the 2001-2003 period and since 2008 on, with contributions oscillating between 2% and 14%).Likewise, age-3 anchovies only occurred in the first quarter in 1992 and since 2008 on, but the importance of this age class in the total annual catch those years was insignificant. Inter-annual variations in the contribution of each age group in landings throughout the historical series are described in ICES (2007 a, 2008 a). Weights at age in the stock for the Gulf of Cádiz anchovy correspond to yearly estimates calculated as the weighted mean weights-at-age in the catches for the second and third quarters (throughout the spawning season).

Catches at age from the Spanish fishery in Sub-division 9.a North are presently not available since commercial landings used to be negligible. Mean length- and mean weight-at-age data are only available for Gulf of Cadiz anchovy catches. The analysis of small samples of otoliths from Subdivision 9.a North in 1998 and 1999 rendered estimates of mean sizes at ages 1, 2 and 3 of 15.5 cm, 17.6 cm and 17.9 cm respectively (ICES, 2000, 2001). A sample of 78 otoliths from the same area was collected during the *PELACUS 0402* acoustic survey. Mean lengths at age 1 and 2+ were 13.7 cm and 17.0 cm (Begoña Villamor, pers. comm.). Comparisons of these estimates with the ones from the Gulf of Cadiz anchovy indicate that southern anchovies attain smaller sizes at age.

Previous biological studies based on commercial samples of Gulf of Cadiz anchovy (Millán, 1999) indicate that its spawning season extends from late winter to early autumn with a peak spawning time for the whole population occurring from June to August. Length at maturity was estimated in that study at 11.09 cm in males and 11.20 cm in females. However, it was evidenced that size at maturity may vary between years, suggesting a high plasticity in the reproductive process in response to environmental changes. Annual maturity ogives for Gulf of Cadiz anchovy are routinely provided to ICES. They represent the estimated proportion of mature fish at age in the total catch

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during the spawning period (second and third quarters) after raising the ratio of mature-at-age by size class in monthly samples to the monthly catch numbers-at-age by size class.

Natural mortality is unknown for this stock. By analogy with anchovy in Subarea 8, natural mortality is probably high (M=1.2 is used for the data exploration).

B.3. Surveys

B.3.1. Acoustic surveys

The IPIMAR's Portuguese surveys series (*SAR* and *SARNOV* series, carried mainly out with the RV *Noruega*) correspond to those ones routinely performed for the acoustic estimation of the sardine abundance in Division 9.a off the Portuguese continental shelf and Gulf of Cadiz, during March-April (sardine late spawning season) and November (early spawning and recruitment season). Since 2007 on, the spring surveys are being planned as 'pelagic community' surveys. This shift in planning mainly entailed, as compared with previous years, a substantial increase in the number of fishing stations in the Sub-division 9.a-South, where the species diversity is higher, changing the series its former name by the one of *PELAGO* surveys. Anchovy estimates from these survey series started to be available since November 1998.

Spanish 'pelagic community' acoustic surveys have been conducted by IEO in Subdivision 9.a North and Division 8.c since 1983 (the spring *PELACUS* series with the R/V *Thalassa*). Results from these surveys for the Sub-division 9.a North have shown the scarce presence or even the absence of anchovy in this area (Carrera, 1999, 2001; Carrera *et al*., 1999). This situation still continues in the most recent years (surveys in the 2003-2010 period, see Porteiro *et al*., 2005; Iglesias *et al*., 2007).

Spanish acoustic surveys in the Gulf of Cadiz waters (Sub-division 9.a-South) have been sporadically conducted by IEO from 1993 to 2003. A consistent yearly series of early summer acoustic surveys (*ECOCÁDIZ* series) estimating the anchovy abundance in the Subdivision 9.a South (Algarve and Gulf of Cadiz) started in 2004. Surveys in this new series are also planned under the 'pelagic community' approach. Unfortunately, this series may show some gaps in those years coinciding (same dates and surveyed area) with the conduction of the (initially triennial) anchovy DEPM survey because of the available ship time (RV *Cornide de Saavedra*). In 2009 two additional surveys to the conventional one were also conducted, but mainly restricted to the Spanish waters. So, in July 2009 a complementary and almost synchronous survey to the *ECOCÁDIZ 0609* conventional survey was carried out with a small-draught vessel, R/V *Francisco de Paula Navarro*, aiming to survey shallower waters than 20 m depth not sampled by no vessel, either Spanish or Portuguese, routinely surveying the study area (*ECOCÁDIZ-COSTA 0709* survey). The acoustic estimates from this survey were separately given in the 2010 WG report from its conventional survey awaiting an intercalibration of data for a further merging of estimates if possible.

In October 2009 a new autumn survey (*ECOCÁDIZ-RECLUTAS 1009*, RV *Emma Bardán*), aimed to acoustically estimate the abundance and biomass of Gulf of Cádiz anchovy recruits, was planned to be conducted throughout the easternmost Portuguese waters and those waters off the central part of the Spanish Gulf of Cádiz, waters that supposedly include the main Gulf of Cádiz anchovy recruitment area. Unfortunately, the shortness of the available ship-time to cover a more intensive acoustic sampling grid (*i.e*. 4 nm spaced transects from 100 to 7-10 m depth) than the conventionally planned in standard surveys and some other unforeseen circumstances (e.g., a one-day

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technical stop for crew replacement, 2-day military manoeuvres just in the middle of both the survey area and calendar) prevented finally from covering the whole survey area. For the above reasons, the surveyed area was restricted to a relatively small central area in front the Guadalquivir river mouth rendering a very probable underestimation of the recruits abundance. Continuity of this survey in following years will necessarily depend on external (EC) funding.

All these surveys followed the standard methodology adopted by the Planning Group for Acoustic Surveys in ICES Subareas 8 and 9 (ICES, 1986; 1998) and recommendations given by the WGACEGG (ICES, 2006 b,c). The methodological differences between these recent surveys are not considered by the WGACEGG as important as to prevent from any comparison between their results, such differences being basically due to:

- The echo-sounder and working frequencies used (IPIMAR surveys: Simrad EK 500 working at 38 and 120 KHz; IEO surveys since 2007 onwards: Simrad EK 60 working at 18, 38, 70, 120, and 200 KHz).
- The fishing gear used as sampler for echo-trace identification/confirmation and gathering biological data (IPIMAR surveys: bottom and pelagic trawl gears; IEO surveys: pelagic trawl).
- The software used for data storage and post-processing (IPIMAR surveys: Movies+ software; IEO surveys: SonarData EchoView software).
- The set of species-specific TS-length relationships: at present, the new IPIMAR spring survey series, *PELAGOS*, takes into account the same agreed species-specific TS values than the IEO surveys, but for mackerel (b_{20} IPIMAR= – 82.0 vs b_{20} IEO= – 84.9).

Regarding their respective objectives, the *SAR* Portuguese November surveys, as presently planned, are mainly aimed at the mapping of the spatial distribution of sardine *Sardina pilchardus*, and anchovy *Engraulis encrasicolus*, and the provision of acoustic estimates of their abundance and biomass by length class and age groups, speciallly the computation of a sardine recruitment index (for the time being age-structured estimates are only available for sardine).

Although the main objective of the *ECOCÁDIZ* Spanish surveys was formerly the mapping and the size-based and age-structured acoustic assessment of the anchovy SSB, and hence the survey's dates, mapping and acoustic estimates of all of those species susceptible of being assessed (according to their occurrence frequency and abundance levels in fishing stations) are also obtained. This same 'multi-species' or 'pelagic community' approach has also been adopted in the new *PELAGO* Spring Portuguese survey series, at least, for the time being, for the southern area (Subarea 9.a South), which has involved a substantial increase in the number of fishing stations as compared with previous surveys. In any case, the progressive inclusion of alternative (continuous and discrete) samplers for collecting ancillary information on the physical and biological environment (including top predators) are shaping these surveys as true 'pelagic ecosystem surveys'.

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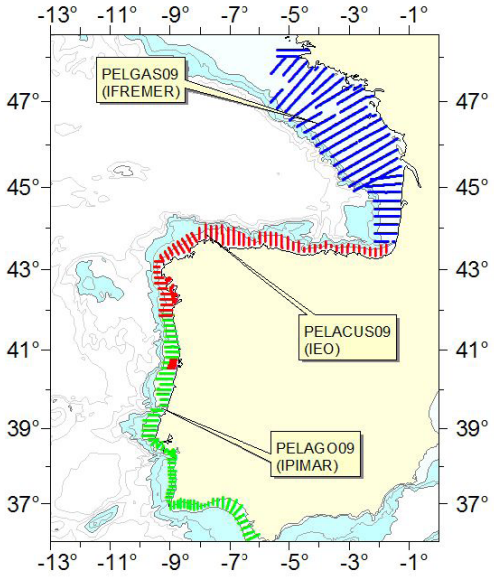

Figure B.3.1.1. Transects surveyed by the Spring *PELAGO*, *PELACUS* and *PELGAS* surveys. The early Summer *ECOCÁDIZ* surveys samples the same area that the *PELAGO* one in the Gulf of Cádiz waters (from Cape San Vicente to Cape Trafalgar).

B.3.2. DEPM Surveys

The Daily Egg Production Method (DEPM) for estimation of anchovy spawning biomass of the Gulf of Cádiz (South-Atlantic Iberian waters) is conducted every three years by IEO (Spain) since 2005. The first survey of this series was in 2005 (*BOCADEVA 0605*) and the second one in 2008 (*BOCADEVA 0608*). As described for the acoustic surveys, methods adopted for Gulf of Cádiz anchovy DEPM surveys follow the standards and recommendations given. Figure B.3.2.1 shows the grid of egg sampling with the PairoVET sampler. TableB.3.2.1 summarises the methodology used in these surveys (*BOCADEVA 0608* used as example) in order to obtain the eggs and adults samples.

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Table B.3.2.1 *BOCADEVA 0608* Gulf of Cádiz anchovy DEPM survey. General sampling.

Parameters	Anchovy DEPM survey *BOCADEVA0608*
Survey area	(36°18'- 36°75'N – 6°22'- 8°92'W)
R/V	*Cornide de Saavedra*
Date	21/06-03/07
Eggs	
Transects (Sampling grid)	21 (8x3)
Pairovet stations (150 µm)	127
Sampling maximum depth (m)	100
Hydrographic sensor	CTD SBE25 and CTD SBE37
Flowmeter	Yes
CUFES stations	121
CUFES (335µm)	3 nmiles (sample unit)
Environmental data	Fluorescence(surface only),Temperature, Salinity
Adults	
Gears	Pelagic trawl
Trawls	26
Trawls time	During the daylight hours
Biological sampling:	On fresh material, on board of the R/V
Sample size	60 indiv randomly (30 female minimum); extra if needed and if hydrated found
Fixation	Buffered formaldehyde 4% (distilled water)
Preservation	Formalin

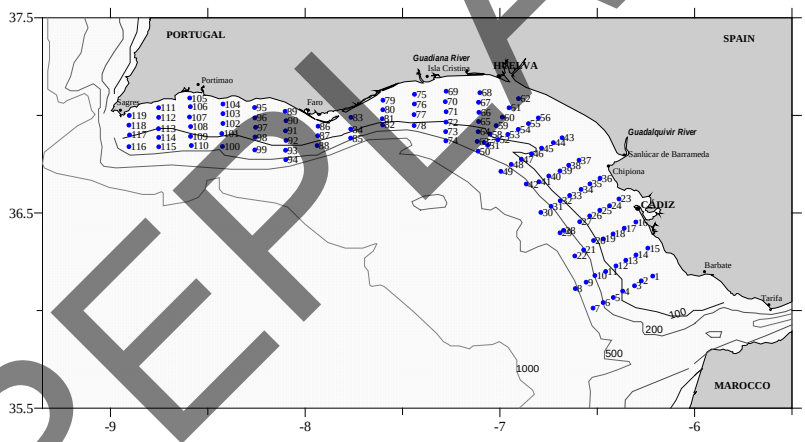

Figure B.3.2.1. Sampling grid adopted in the *BOCADEVA* anchovy DEPM surveys series.

Anchovy biomass estimation from these surveys was based on procedures and software adapted and developed during the WKRESTIM that took place between 27-30/04/2009 in Madrid (with e-participation of IPIMAR members from Lisbon), and validated by the WGACEGG. All calculations for area delimitation, egg ageing and model fitting for egg production (P_0) estimation were carried out using the R packages (*geofun, eggsplore and shachar*) available at *ichthyoanalysis* (http://sourceforge.net/projects/ichthyoanalysis). The surveyed area (*A*) was calculated as the sum of the area represented by each station. The spawning area (*A+*) was delimited with the outer zero anchovy egg stations, and was calculated as the sum of the area represented by those stations. The model of egg development with temperature was derived from the incubationexperiment carried out in Cádiz in July 2007 (Duarte*et al*., 2007). A multinomial model was applied (Ibaibarriaga *et al.*, 2007, Bernal *et al.* 2008) considering only the interaction Age*Temp (other interactions were not significant). Egg ageing was achieved by amultinomial Bayesian approach described by Bernal *et al*. (2008) and using *in situ* SST;

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a normal probability distribution was used with peak spawning assumed to be at 22:00h with 2h standard deviation. This method uses the multinomial development model and the assumption of probabilistic synchronicity (assuming a normal distribution). Daily egg production (P_0) and mortality (z) rates were estimated by fitting an exponential mortality model to the egg abundance by cohorts and corresponding mean age. The model was fitted using a generalized linear model (GLM) with negative binomial distribution. The ageing process and the GLM fitting were iterative until the value of z converged. Finally, the total egg production was calculated as: $P_{tot} = P_0 A+$

The adult parameters estimated for each fishing haul considered only the mature fraction of the population (determined by the fish macroscopic maturity data). Before the estimation of the mean female weight per haul (*W*), the individual total weight 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. The expected individual batch fecundity for all mature females (hydrated and non-hydrated) was estimated by modelling the individual batch fecundity observed (*Fobs*) in the sampled hydrated females and their gonad-free weight (*Wnov*) by a GLM. The fraction of females spawning per day (*S*) was determined, for each haul, as the average number of females with Day-1 or Day-2 POF, divided by the total number of mature females (the number of females with Day-0 POF was corrected by the average number of females with Day-1 or Day-2 POF, and the hydrated females were not included). The mean and variance of the adult parameters for all the samples collected was then obtained using the methodology from Picquelle and Stauffer (1985; i.e., weighted means and variances). All estimations and statistical analysis were performed using the R software. The spawning biomass was computed according to:

$$SSB = \frac{P_0 * Area +}{(F * S * R)/W}$$

The high uncertainty associated to the estimates (especially to those ones related to the egg sampling in the 2005 survey) was matter of concern for the 2009 WGANSA and it was recommended that the appropriateness of the egg sampling scheme were revised in the 2009 WGACEGG. It was concluded by this last working group that reducing the variance in future surveys can probably be attained by increasing the number of stations in the actual positive spawning areas (adaptive sampling) and perhaps by applying GAM based estimators.

B.4. Commercial CPUE

The annual series of both nominal fishing effort (number of fishing trips) and CPUE indices of anchovy in Division 9.a are available for the Gulf of Cadiz Spanish purse-seine fishery since 1988. The data series from the Spanish purse-seine fishery off southern Galician waters (Sub-division 9.a North) only comprise the 1995-1999 period whereas no data from the Portuguese purse-seine fisheries along the Division are available. Causes for this scarcity or even absence of data from the later fisheries must be found in their low anchovy annual catches during the last 3-4 decades and mainly by the fact that these fisheries target sardine.

Regarding the Gulf of Cadiz anchovy Spanish fishery, data on annual values of nominal effort (fishing trips targeting on anchovy) and CPUE by fleet type have routinely been provided to ICES. The series of effective effort and CPUE from all of the Spanish fleets exploiting the Gulf of Cadiz anchovy were provided for the first time to the

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WGMHSA in 2004. For such a purpose, vessels from single-purpose fleets were additionally differentiated according to their tonnage in heavy- (≥30 GRT) and light- (<30 GRT) tonnage vessels, rendering a total of 11 fleet types.

The standardisation procedure was performed in the last years by fitting quarterly log-transformed CPUE's from fleet types composing the fishery to a GLM (Robson, 1966; Gavaris, 1980) which only included the effects of quarter and fleet type (without any interaction), (ICES, 2007 a). Since 2008 the GLM fitting is performed with the following modifications to the original version: (a) the effect of missing values in the nominal CPUE data was smoothed by adding a constant value to data before their log-transformation (ICES, 2008 b). In this case, this constant was computed as the 10% of the average value for the whole nominal CPUE series resulting in log(CPUE adjusted) data. (b) the model includes year, quarter, fleet type and first order interaction effects. Reference fleet (*métier* or fleet type), year and season used in the standardisation were the Barbate's single-purpose high-tonnage fleet, the first year in the series, 1988, and the first quarter in the year, respectively. The updated series of standardised effort and CPUE from all of the fleets exploiting the fishery is provided to the WG each year. Annual and half-year standardised CPUE series for the whole fleet are computed from the quotient between the sum of raw quarterly catches and that of standardised quarterly efforts within each of the respective time periods.

According to literature, CPUE indices have been considered, as not reliable indicators of abundance for small pelagic fishes (Ulltang, 1982, Csirke 1988, Pitcher 1995, Mackinson *et al.* 1997). At present, the series of CPUE indices is only used for interpreting the fleet's dynamics.

B.5. Other relevant data

C. Historical Stock Development

Model used:

For the time being, no analytical assessment model has been successfully applied. An exploratory assessment was under development until 2008. This exploratory assessment carried out so far was only performed for the anchovy population nucleus in the Gulf of Cádiz (Sub-division 9.a-South: Algarve + Cádiz zones), the remaining resilient anchovy populations along the Atlantic Iberian façade of the Division being out of the scope of this assessment. The model used was an *ad hoc* seasonal separable model implemented and run on a spreadsheet for data exploration of anchovy catch-at-age data in 9.a South since 1995 onwards. Given the nature of stock, short-lived, data in this model were analysed by half-year-periods, those from the Algarvian anchovy being previously compiled by applying Gulf of Cadiz ALKs.Weights at age in the catches were estimated as usual, whereas weights at age in the stock corresponded to yearly estimates calculated as the weighted mean weights-at-age in the catches for the second and third quarters (reproductive season). The model was fitted to the updated half-year catch-at-age data until the assessment's last year and to the available acoustic estimates of anchovy aggregated biomass from the spring Portuguese surveys series only (including the acoustic estimate one year ahead of the assessment's last year).

Reasons for the choice of the above tuning index were: (a) the Spanish acoustic survey series (2004, 2006, 2007), was not used as a tuning index because of its shortness; (b) neither the DEPM-based anchovy SSB was considered since it has only 1 data point until the last year, but it was provided for comparison with the acoustic and model-predicted biomass estimates; (c) both Portuguese acoustic surveys series (spring and

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autumn surveys) were used as tuning indices in the past, assuming the same catchability coefficient. However, each survey series cover different fractions of the population so, the assumption of same catchability is probably inappropriate. Given that the model is unlikely to be able to estimate the extra parameter and that the spring survey series has a better coverage both in space and time, only this survey series was recently used.

The exploratory runs were recently performed under the following assumptions:

–Assessment only tuned by Spring Portuguese acoustic surveys (for the reasons above).

–Catches at age are assumed by the model to be linked by the Baranov catch equations.

–The relationship between the index series and the stock sizes is assumed linear.

–A constant selection pattern is assumed for the whole period.

–F values for 1995 (assessment's first year) are computed as an average of the Fs in subsequent years.

–F in the 2nd half-year in the assessment's last year estimated as a ratio of the F estimated in the 1st half by applying the ratio of seasonal Fs in the previous year (affected by a closure as well in the last years).

–No available Cages for the first half in the year ahead of the assessment's last year: assumed as the same ones that in first half in the assessment's last year.

–Wagesstock in the year ahead of the assessment's last year: average of the estimates in the 3 last years in the assessment.

–F in the 1st half year of the assessment's last year: average of estimated 1st half-year Fs counterparts for the same period of years.

– Log-residuals of Cages in the year ahead of the assessment's last year excluded from the minimisation routine whereas the residuals from the biomass acoustic estimate in the year ahead of the assessment's last year are included in the model fitting.

Runs explored last years consisted in:

- **RUN 1**: Acoustic surveys as a relative tuning index and a weighting factor= 1.
- **RUN 2**: Acoustic surveys as a relative tuning index and a weighting factor= 6.
- **RUN 3**: Acoustic surveys as an absolute tuning index and a weighting factor= 1.

An upweighting factor of 6 for the acoustic estimates in RUN 2 was selected in order to balance the influence of their annual residuals in relation to those from catches at age (3 age groups x 2 semesters in a year). The rational for RUN 3 is the similarity between the estimates by the Portuguese survey and the Spanish DEPM in 2005 (around 14,000 tonnes).

Parameters estimated are selectivity at age for both half-year-periods in relation to the reference age (age 1), recruitment, an average SSB, survey catchability (Q) and annual F values per half-year-period. Parameters are estimated by minimising the sum of squares of the log-residuals from the catch-at-age and the acoustics biomass data.

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The exploratory assessments performed so far with this *ad hoc* model have not been recommended as a basis for predictions or advice. The immediate reason is that it usually estimated a large drop in fishing mortality and rapid increase in stock abundance in recent years, which is not supported by the data or the development of the fishery. The residuals showed large clusters over time, indicating that the selection may not be constant, one of the model's assumptions. Migration between the main nucleus in the Gulf of Cádiz and adjacent areas might be one of the causes explaining the discrepancies found in the assessment and it should be properly studied. The exploratory model utilised so far does not provide any reliable information about the true levels of both the stock, F and Catch/SSB ratios since the assessment is not still properly scaled.

For all the above reasons in 2009 was preferred to do not perform any exploratory assessment with this model. Instead of this, the provision of advice relies in an update of the qualitative assessment carried out in 2008 and accepted by the Review Groups of the 2008 and 2009 WGANC (RGANC). This qualitative assessment is based on the joint analysis of trends showed by the available data, both fishery-dependent and –independent information (*i.e.*, landings, fishing effort, cpue, survey estimates).

Advice is framed in a precautionary manner to limit exploitation and, accordingly, the basis for advice is average catches over a reference period.

Software used: the exploratory model was implemented and run in a MicroSoft Excel spreadsheet.

Model Options chosen:

Input data types and characteristics:

Type	Name	Year range	Age range	Variable from year to year Yes/No
Caton	Catch in tonnes			
Canum	Catch at age in numbers			
Weca	Weight at age in the commercial catch			
West	Weight at age of the spawning stock at spawning time.			
Mprop	Proportion of natural mortality before spawning			
Fprop	Proportion of fishing mortality before spawning			
Matprop	Proportion mature at age			
Natmor	Natural mortality			

Tuning data:

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Type	Name	Year range	Age range
Tuning fleet 1			
Tuning fleet 2			
Tuning fleet 3			
….			

D. Short-Term Projection

E. Medium-Term Projections

F. Long-Term Projections

G. Biological Reference Points

H. Other Issues

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