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International Council for the Exploration of the Sea

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REPORT OF THE MACKEREL EGG PRODUCTION WORKSHOP

Fisheries Laboratory, Lowestoft, 24-28 June 1985

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REPORT OF THE MACKEREL EGG PRODUCTION WORKSHOP

1. INTRODUCTION

1.1 Terms of Reference

At the 72nd Statutory Meeting in Copenhagen it was decided (C.Res.1984/2:11) that a Mackerel Egg Production Workshop (Chairman: Dr. S J Lockwood) should meet at the Fisheries Laboratory, Lowestoft from 24 to 28 June 1985 to:

(i) Re-examine the fecundity of the North Sea and Western mackerel stocks, including the estimation of fecundity itself and the effect of within-season variations in the age structure and sex ratio of the spawning stocks on estimates of total egg production,

(ii) Review the statistical characteristics of previous surveys of egg production in Western and North Sea mackerel to specify appropriate sampling strategies and procedures for the analysis of survey data,

(iii) Having regard for (b), develop a programme for international surveys proposed for 1986, including the logistical requirements and the way in which they may be met.

In addition, the Mackerel Working Group asked for a review of all available data on the sexual maturation of mackerel, with a view to constructing a new maturity ogive (Anon, 1985). Participants were also asked to bring 10 x 100 ml "unsorted" plankton samples with them to exchange for an examination of the variability in mackerel egg identification.

1.2 Participation

The Workship met in Lowestoft with the following participants:

Coombs S H	UK(IMER)
Eltink A	Netherlands
Hopkins P	UK (Scotland)
Iversen S A	Norway
Joakimsson G	Federal Republic of Germany
Kirkegaard E	Denmark
Lockwood S J (Chairman)	UK (England and Wales)
Molloy J	Ireland
Nichols J H	UK (England and Wales)
O'Brien B	Ireland (UCG)
Walsh M	UK (Scotland)

Additional members of staff from the Fisheries Laboratory who attended parts of the meeting were: W A Dawson, J G Pope, L Woolner and M G Walker.

2. NORTH SEA PLANKTON SURVEYS

2.1 Results of the North Sea Stock Survey, 1984

During the period 22 May to 17 July 1984, the mackerel spawning area in the North Sea was surveyed six times. The investigations were carried out by Denmark, the Netherlands, Norway and Scotland.

The egg production was estimated by the methods described by Iversen and Westgaard (1984) and Pope and Woolner (1984). Both methods give estimates of confidence limits.

The total egg production was estimated between 78 and 88 x 10^{12} eggs. This was a reduction of about 50% of the production estimated in 1983. The confidence limits of the egg production estimate were about ± 30%. The egg production was converted to spawning stock biomass assuming a sex ratio of 1:1 and the weight-fecundity relationship given by Iversen and Adoff (1983). The variance on the fecundity estimate is unknown. A full account of the 1984 surveys will be presented at the ICES Statutory Meeting in 1985 (Iversen et al. 1985).

The results from the last three North Sea surveys (1982, 1983, 1984) were given equal weighting to estimate the 1984 fishing mortality rates in the North Sea (Anon., 1985).

2.2 Future Surveys in the North Sea

In the report of the Mackerel Working Group (Anon. 1984a), it was recommended that due to the low level of the North Sea stock, assessment by egg survey should be carried out every second year, which means that the next survey should be undertaken in 1986.

Due to the surveys on the Western stock in 1986, only two nations, Norway and Denmark, felt they would be able to participate, each for about 3 weeks. This gives a total of about 40 survey days compared with 75 in 1984. Consequently, the coverage both in time and area will be relatively low in 1986. However, it should be possible to cover the total spawning area in June, which is the main spawning period. The sampling strategy will be broadly that which has been described by Iversen and Westgaard (1984).

3. WESTERN AREA PLANKTON SURVEYS

3.1 The Western Sampling Area

The results from the previous three surveys, 1977, 1980, 1983, were discussed and it was agreed that the contribution to the total egg production from the area south of 45^0N was small. Consequently, the southern limit to the survey was moved to 45^0N. In contrast, it was agreed that the spawning north of 54^0N may be significant. As a routine, rectangles between 54^0 and 55^0N will be sampled and in May-June rectangles along the 200 m isobath between 55^0 and 56^0N will also be sampled. The western boundary to the grid remains virtually as it was in 1980 and 1983, but the eastern boundary is two or three rectangles further east. These new limits to the survey area are shown in Figure 1.

3.2 Statistical Sampling Strategy

Papers relevant to the design of the 1986 Western mackerel egg survey were available from Hopkins (1984) and Pope and Woolner (1985). The latter suggested fitting a quadratic surface of latitude, longitude and time to transformed survey results within time and area stratifications. The stratifications used (3 periods, 3 areas) were amalgamations of areas and times suggested as strata by Hopkins. The fitted response surfaces would then either be integrated over time and space to provide production estimates directly or used to interpolate the results of unsampled rectangles prior to raising by traditional approaches. The advantage of the response surface technique as opposed to a stratified random design is that it requires less stratification to obtain the same variance reduction effects and it avoids the need for the random station allocation. Consequently, stations can be conveniently worked by rows as on previous occasions. Additionally, the improved interpolation of the response surface should give a reduction in the variance of the final production estimate compared to the method adopted in 1983.

Further consideration of the previous survey results indicated that a higher proportion of the variance was contributed by the relatively few stations which include the majority of egg production. It is therefore desirable to allocate a higher proportion of the sampling effort to these stations.

Following the arguments outlined above and in Hopkins (1984) and Pope and Woolner (1985), it is recommended that an optimal sampling strategy requires that:

(a) the survey duration is separated into three periods: March+April, May-mid June, mid June-mid July. Approximately equal effort should be allocated to the first and last survey periods and about two thirds of the total effort to the central period at the time of peak spawning. Allocation of several vessels to the survey during the central period will achieve this aim.

(b) the survey area is separated into two strata comprising stations of high and low abundance (Figure 1). The stations of high abundance account for about 80% of total egg production. The aim should be for something between a 1:1 and a 2:1 sampling advantage to the high area during each cruise or sampling period.

This sampling strategy is statistically sensible and is also a practical proposition. During a 3-week cruise, it should be possible to cover both strata by sampling all rectangles on alternate rows on the outward legs and sampling all rectangles in the high abundance stratum only on the return leg. This would give a sampling ratio of approximately 1:1. During a 4-week cruise, it might be possible to sample all high abundance rectangles on both the outward and return legs, thereby giving a ratio of about 2:1 between high and low strata.

Further reductions in variance might be achieved by taking two samples consecutively from each rectangle. When time is limiting, this double sampling intensity should be concentrated within the high abundance stratum. Every effort should be made to complete this level of sampling in Row M (40^0 15'N) which is to be analysed as an analogue of the whole spawning area production cycle.

Where three ship surveys are proposed, it is suggested that two ships proceed independently as indicated above and the third ship concentrates its sampling on the area of high production. The objective should be to obtain a robust design with sample numbers roughly in the ratio 1.5:1 in the high and low abundance areas. With the multiple ship surveys, cruise tracks should be staggered in time in order to sample all areas at as many distinct time points as possible. This is particularly important for the high area.

Common sense considerations suggest that:

(1) Designs should try to avoid correlation between time and latitude or time and longitude. This is best avoided by not sampling the southern area at appreciably different times from the northern area. Regular liaison between vessels should ensure that cruise tracks are suitably spread in time and area.

(2) "Zero" observations should be kept to the minimum. This would be achieved by discontinuing sampling along rows when very low numbers of eggs are observed in the sample.

(3) Because of the changing distribution of spawning through the season, some reduction of the survey area can be accepted if vessel time becomes limited. In particular, a) in March and April, the eastern and western limits of the survey area may be reduced when spawning is usually confined to a fairly narrow band adjacent to the shelf edge and b) from May onwards, high area sampling may be curtailed to the south of 48^0N when little further spawning takes place in that area.

(4) Where high abundance of eggs are observed outside the "high" stratum, they should be sampled at the same intensity as rectangles within the "high" stratum.

3.3 Research Vessel Availability

Compared with the surveys undertaken in 1980 and 1983, there is a shortage of research vessel time in 1986. There are only five research vessel cruises committed to the stock assessment programme:

R/V "Anton Dohrn"	ca 26 March-7 May (Federal Republic of Germany)
R/V "Cirolana"	ca 9 May-5 June (UK, England & Wales)
R/V "Scotia"	3 weeks early June (UK, Scotland) 3 weeks May
R/V "Tridens"	ca 2 June-19 July (Netherlands)

Both R/V "Anton Dohrn" and R/V "Tridens" will have mid-cruise breaks. The first half of the R/V "Anton Dohrn" cruise will be primarily fishing the spawning stock, with plankton sampling predominating later. During this later period, R/V "Anton Dohrn" will work in conjunction with R/V "Poseidon" (Institut für Meereskunde, Kiel) which will undertake a "patch" study.

The cruise dates outlined above will give minimum coverage of the spawning season to meet the sampling strategy outlined above. The participants also expressed their appreciation to their Dutch colleagues at RIVO (IJmuiden) for a late change in cruise scheduling to cover the later part of the spawning season.

3.4 Sampling Gear and Procedures

The use of modified Gulf III type samplers was considered adequate in 1980 and 1983 and no change in basic sampler type is recommended. However, improvement in depth monitoring and the concurrent collection of relevant physical data should be encouraged. Every effort should be made to maintain an even dive profile by careful monitoring of the time spent in each stratum. Ideally, equal volumes of water should be filtered per unit depth. Sample sizes from past surveys suggest that volumes filtered can be reduced considerably without seriously affecting the precision of the estimate. In view of proposed increases in sampling intensity in areas of high egg abundance, it is recommended that, where practicable, a reduction in the area of the sampler mouth opening can be made.

A mesh size of 500 micron aperture is adequate for sampling mackerel eggs. Historically, however, these surveys have also been used to sample other species using a 250/280 micron aperture net. It is recommended, therefore, to continue using mesh of 250/280 micron aperture unless serious clogging occurs, in which case a 500 micron aperture may be used.

Existing data on the vertical distribution of mackerel eggs indicate that, during the early spawning season, they may be found deeper than the routine maximum sampling depths of 100 m adopted for the 1977 and 1983 surveys. In order to reduce the potential undersampling from this source, it is recommended that, in the absence of a thermocline, sampling should be to the bottom or to 200 m, whichever is the shallower. In the presence of a thermocline of at least 2^0C over 10 m, in depth, sampling should be limited to 20 m below the thermocline. Under conditions of extreme and predictable stratification, ca 5^0C in 10 m, such as occur in the North Sea, sampling can be restricted to the mixed surface layer.

The standard fixative should continue to be 4% buffered formaldehyde in either distilled or fresh water to minimise shrinkage and distortion. This solution is approximately isosmotic with seawater and should be used in preference to 4% formaldehyde in seawater. The sample should not come into contact with formaldehyde strength in excess of 4%; the sample should be directly fixed with the addition of 4% formaldehyde in water to the sample.

The 4% formaldehyde should be made up as follows: 40% formaldehyde as purchased, 1 part; distilled (or fresh) water 9 parts; plus an appropriate buffer to pH 7-8.

The plankton volume must never exceed 50% of the volume of the jar; excess sample should be fixed separately in additional jars.

When calculating egg abundance as Nm^{-2}, the egg densities (Nm^{-3} must be integrated over the maximum sampler depth. Mackerel eggs should be identified and staged; only stage 1 (Lockwood, Nichols & Dawson, 1981a) should be counted for the assessment. Egg production rates will be estimated from:

$$\ln \text{Time (hours)} = 1.61 \ln (T^0C) + 7.76$$

(Lockwood, Nichols & Dawson, 1981a).

All sample analysis and data preparation should be completed by the end of October 1986.

3.5 Additional Sampling

3.5.1 Collection of environmental and other data

All participants should attempt to record temperature-depth profiles concurrent with the plankton tow. The temperature at 20m depth should be used to calculate egg stage duration. Where this is not available, then the sub-surface (ca 3 m) temperature can be used. The measurement of sub-surface temperature at each sampling station, is, therefore, the minimum requirement from these surveys.

Sub-surface salinity should be measured at each sampling station as a minimum requirement from ICES. These measurements can be taken with CTDs or by sample collection for subsequent laboratory analysis. Where possible, vertical profiles of salinity should be taken, provided this does not seriously affect the progress of the plankton survey.

All participants are encouraged to monitor sub-surface temperature and chlorophyll "a" fluorescence continuously throughout each survey. When this is done, regular calibrations by acetone extract of chlorophyll and phaeophytins from sub-surface samples should be made. The results of continuous monitoring of temperature and chlorophyll "a" fluoresence should be data logged in a format which can be made available to other participants.

Highest egg abundances in previous surveys have been found consistently along Row M ($49^0$15'N) and, in particular, in rectangle M19 ($10^0$15'W). In order to monitor the shape of the production curve in time more closely, every opportunity should be taken for additional sampling along Row M and, in particular, in rectangle M19 when a research vessel is in the vicinity.

During the surveys, a simple measure of the settled volume of each sample should be made about six hours after collection. As a minimum, an approximate apportioning of the sample to the major phyla present should be made. More specific analysis of the major components should be done where sufficient expertise is available.

3.5.2 Parallel research programmes

As a complementary part of the 1986 Western mackerel egg survey, the Institut für Meereskunde, Kiel (IFMK, Federal Republic of Germany) and the Institute for Marine Environmental Research (IMER, UK) intend to undertake additional research sampling to study the spawning environment and recruitment processes in relation to mackerel eggs and larvae.

The objectives of the programmes of IFMK and IMER are similar and include specific topics of direct relevance to the stock estimation programme:

- egg mortality rates
- vertical distribution of eggs, in particular in the early part of the spawning season
- fine-scale distribution of eggs within standard survey rectangles
- diel periodicity of spawning

Included in the broader, biological aims are the following:

- to determine the detailed horizontal and vertical distribution of eggs and larvae and available food

- to characterize the hydrographic regime and its influence on the above distributions

- to determine the growth and mortality of eggs and larvae in relation to environmental conditions.

The Institut für Meereskunde has allocated R/V "Poseidon" to its programme for the period mid-April to mid-May, during which time it will have the opportunity to work in conjunction with R/V "Anton Dohrn", which will be carrying out the standard egg survey at the same time. It is proposed that the main effort of R/V "Poseidon" will be directed towards a patch study in the main area of spawning (Great Sole Bank).

IMER will be participating in the R/V "Poseidon" cruise. Additionally, they will be manning two other of the participating vessels to extend their studies over a wider area and to cover the remainder of the spawning season. IMER will be responsible for the detailed analysis of all data collected from Row M. Additional data, as outlined in Section 3.5.1, will be incorporated in the results processed by IMER also.

4. <u>FECUNDITY</u>

4.1 <u>Definition of Fecundity</u>

All mackerel fecundity estimates incorporated in ICES stock assessments hitherto have been estimates of potential, not effective or absolute fecundity, i.e., the potential fecundity estimated was the maximum number of maturing oocytes which might become fully developed and be shed. No adjustment, allowance or corrections have been made for pre- or post-spawning resorption of developing oocytes (atresia) or for oocytes which are shed but are not fertilized subsequently.

4.2 <u>Review of Available Fecundity Estimates</u>

In recent years, three fecundity relationships have been discussed in relation to ICES stock assessments. In the Western area, only one relationship has been published:

Potential fecundity = $8.8L^{3.02}$ (Lockwood, Nichols and Dawson 1981a).

This has been used in all Western stock plankton assessments hitherto.

Two studies of fecundity have been made in the North Sea area:

Potential fecundity = $560\ (g)^{1.14}$ (Iversen and Adoff 1983)

Potential fecundity = 1942 + 1062 (g) (Walsh, 1983).

As Walsh's samples were collected from around Shetland and Iversen and Adoff's samples came from nearer the centre of spawning, Iversen and Adoff's fecundity regression has been the one incorporated into the North Sea assessments hitherto.

Since their review (Anon, 1984b), there have been no new insights into the reasons for the differences between the regressions given above, and the Workshop saw no benefit to be gained in discussing them further. Instead, it was agreed to put increased effort into the 1986 surveys to obtain more accurate fecundity data. In discussing these proposals, due note was taken of a small pilot programme recently completed by Mariduena (1984) which shows that:

a) occasionally there may be 100% pre-spawning atresia;

b) atresia in spent fish ranges from 2% in 28 cm fish to about 15% in 45 cm fish;

c) the onset of vitellogenesis is probably in larger oocytes than previously recorded by Macer (1976).

As Mariduena's sampling level was small, compared to the rest of the plankton assessment sampling and previous fecundity studies, the Workshop did not think that it was appropriate to incorporate his results directly at this stage.

4.3 Fecundity Sampling Programme 1985 and 1986

In view of the importance of fecundity estimates to stock size estimation, it was agreed that increased effort would be devoted to fecundity estimation in 1986 in both the North Sea and Western area. This will involve a much greater histological input than previously in order to confirm the validity of the maturity stage classification, to quantify the extent of atresia, and to establish with greater precision the egg size threshold at which vitellogenesis occurs.

With regard to the Western stock, sampling during the 1986 egg surveys should be based, as in the past, on Maturity Stage 4 (after Macer, 1976) mackerel. Target sampling levels should be 10 fish per cm during the first survey ("Anton Dohrn") when the greatest proportion of Stage 4 fish are expected in the survey area, and 5 fish per cm during subsequent surveys. An experienced histology technician from the UK (England) will sail on "Anton Dohrn", if required. If there is a serious shortfall of material following the first survey, Ireland will attempt to supplement this from their commercial fishery landings in April/May, or Norway from their Celtic Sea tagging programme. Samples should be taken, if possible, from the main spawning area (Figure 1).

All fish from which ovaries are taken for fecundity estimation should be frozen individually and returned to the laboratory for weighing (Ireland will mount a parallel sampling programme to measure the weight loss following frozen storage of eviscerated mackerel).

In addition to the stage IV ovaries, additional samples should be taken on each cruise for estimating atresia. Five fish at maturity stage V-VIII should be preserved from each of four length groups: <30 cm, 31-35 cm, 36-40 cm, >40 cm.

Details on treatment of ovaries at sea will be circulated by Dr.M G Walker (Lowestoft) closer to the time of the surveys. The task of working up the data will be carried out jointly by Lowestoft and Aberdeen with the possibility of some input from Kiel. The initial aim will be for Lowestoft and Aberdeen each to examine 3 fish per cm, or approximately 50 fish each. Depending upon the variability of the data, more fish might be examined subsequently. The aim should be to complete the work and the analysis by the end of October 1986 for presentation of results with those from the egg survey at the end of the year.

With regard to the North Sea stock, Norway provided Scotland with mackerel ovaries collected at Ekofisk in May 1985 for fecundity analysis. These samples are awaiting analysis. In 1986, there will be a similar programme to that outlined above for sampling North Sea mackerel ovaries, both from the commercial fishery and research vessels. These samples will be analysed in Norway.

4.4 Sex Ratio

It is well established that the sex ratio of mackerel populations in the North Sea and Western area is 1:1 (Iversen, 1981; Lockwood et al., 1981b; Dawson, in prep; Eltink, in prep.). Taking all fish on the spawning grounds at all maturity stages throughout the spawning season, the sex ratio is 1:1 (Figure 2). However, the sex ratio of running fish (maturity stage 6) on the Western spawning grounds varies during the spawning season. At the start of the season, males are in the majority, more than 2:1, but by the peak of spawning, the ratio is down to unity (Figure 2).

The changing sex ratio during the spawning season and the differences in mean weights between males and females (Figure 3) mean that care must be taken in raising spawning stock biomass from egg production data. Toward the end of the spawning season and out of the spawning season, males and females have the same mean weights (Figures 3 and 4); therefore, the male stock biomass equals female stock biomass. However, from March to June, the female average weight is greater than the average male weight by about 10%. Thus, at this time, females' biomass exceeds an equal number of males' biomass, but the shortfall is more than compensated for by the higher number of males present on the spawning ground.

In any month, March to June, on the spawning ground, male biomass exceeds female biomass, but over the season, the real difference is minimised by males remaining longer on the spawning ground than females. It is assumed, therefore, that all differences in mean weights and sex ratio can be accounted for adequately by working with female weight data only. The stock number and biomass should be calculated from the egg production curve and mean weights of spawning females only. These estimates can then be doubled to estimate the total spawning stock biomass and number.

5. MATURITY

5.1 Definition of Maturity

Hitherto, it was assumed that fish which were at maturity stage III (early developing, Macer, 1976) were assumed to be maturing prior to spawning in the current spawning season and fish at stage VII (spent) were assumed to have spawned in the current spawning season (Lowckwood _et al._, 1981b). In the review below, this definition has been extended to include maturity stage VIII (recovering spent).

5.2 Western Mackerel Stock Maturity Ogive

It has been suggested that the maturity ogive for the Western mackerel stock currently used by the Mackerel Working Group overestimates the percentage mature one year olds and underestimates the older age groups (Eltink, 1984). This may be because the samples used previously (Lockwood _et al._, 1981) were not representative of the whole Western stock (Anon., 1985 and Eltink, 1984). Three revised soures of maturity data are now available: Dutch commercial samples from ICES Divisions VIIb,e,f,g,h,j, Division VIa south of 57^{0}N and Sub-area VIII from March through to August for the years 1977-84; Irish data based on commercial samples from the southwest of Ireland, Divisions VIIb and j, only, collected during April and May for the years 1982-84; and English research vessel samples covering Divisions VIIIa-c and VIIb,c,g,h,j during March through to May for the years 1977-84

The Dutch data were accepted as the most representative samples which were well distributed throughout the spawning ground and the juvenile area. Also, these commercial samples were considered to reflect the relative abundance of the exploited population.

Consequently, the Dutch data were used to construct a maturity ogive for both sexes combined. Figure 5 and Table 1 show the number of mature and immature fish which were used for constructing this maturity ogive, by age and by Division. The estimated and smoothed percentage mature fish for the Western stock are the same.

The effect of this new maturity ogive on current stock assessments was compared with that used by the Mackerel Working Group (Anon., 1985). An SVPA similar to, but not identical with, that run by the Mackerel Working Group was run using all the Working Group basic data and assessment parameters (Anon.,1985), including the maturity ogive. The SVPA was then rerun, incorporating the revised maturity ogive. The net effect of the change was to reduce the estimated 1983 spawning stock biomass 5% (spawning stock in number held constant at about 6950 million fish). This net reduction results from the significant rise in the number of 2 and 3 year old fish now included in the spawning stock; these reduce the average weight per fish in the mature stock.

5.3 North Sea Stock Maturity Ogive

No further analysis of maturation data from this area has been carried out. The maturity ogive used by the Mackerel Working Group in recent years is considered to be the best available.

6. COORDINATION AND COMMUNICATION OF DATA

During 1986, only Denmark and Norway will participate in a North Sea mackerel plankton survey. The coordination of this programme will be by direct communication between the principal participants.

Coordination of the 1986 Western mackerel plankton survey will be through the Workshop Chairman (Dr. S J Lockwood). As soon as the information is available, participants should notify the Chairman:

(1) the dates on which cruises will start and finish

(2) the proposed dates and place of mid-cruise breaks

(3) the name of the scientist in charge of the cruise

(4) the times at which ship's officers maintain radio watches

(5) a list of (5-6) preferred working frequencies, both VHF and MF, for ship-to-ship communications. (NB. 2431 kHz is allocated for preferential use by research vessels.)

Towards the end of a cruise or immediately after returning home, the scientist in charge of a homeward ship should contact the scientist in charge of the next outward ship and advise him of the results from the cruise just completed.

When two ships are on the spawning grounds simultaneously, the scientists in charge should maintain regular radio contact. They should coordinate their joint sampling programme to optimise the coverage of the spawning.

After cruises, every effort should be made to work up the results as soon as possible. The primary objective is to produce estimates of number of stage 1 eggs per metre square per day (N m^{-2} d^{-1}). Production rates will be calculated from the regression:

$$\ln \text{Time (hours)} = 1.61 \ln (T^0C) + 7.76$$

(Lockwood, Nichols and Dawson, 1981a).

with temperature (T^0C) to be recorded at 20 m below the surface.

When completed, a copy of the production estimates by rectangles should be sent to the Chairman who will arrange for them to be exchanged and logged on a database. Production estimates for Row M and rectangle M19 should <u>also</u> be sent directly to S H Coombs, IMER, Plymouth.

While the primary objective of these plankton surveys is to assess mackerel spawning stock biomass in both the North Sea and Western area, it is recognised that the samples have wider utility than this. Countries participating in the Western area survey are urged also to work up the horse mackerel data to the same level at the same time.

Participants should endeavour to complete all sample analysis and estimation of egg production by 31 October 1986. With this aim in mind, the Workshop recommends that ACFM convene another meeting of the Workshop in November-December 1986 to assess the results. As the results are to be logged on a database, the Workshop agreed that the meeting should be at the laboratory of a participating country and that the Fisheries Laboratory, Lowestoft is convenient for this purpose.

7. PLANKTON SAMPLE EXCHANGE

Ten small plankton samples were supplied by England, Scotland, Norway, Holland and Denmark with which to check for variability in mackerel egg identification and staging between laboratories. Each sample contained mackerel eggs which had been counted and staged but which were still unsorted.

The samples were distributed between those 5 countries, plus Ireland and the Federal Republic of Germany. Each laboratory received a selection from other countries, but not from their own (Table 2). These mixed samples were taken back to participating laboratories to count and stage the mackerel eggs.

The results are to be returned to the Chairman for comparison with the originals, in order to identify any discrepancies.

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Table 1 The number of immature and mature MACKEREL, the percentage mature, and the mean length of immature, mature and both combined for the Western MACKEREL by age and by area in April, May, June, July and August from 1977-1984 according Dutch samples from mainly commercial freezer trawlers and some from research vessel "Tridens"

A R E A S	AGE						
	1	2	3	4	5	6	7+
Division VIa South of 57^0N							
Number immatures	2	17	11	4	7	1	-
Number matures	3	62	160	173	144	82	354
% Mature	60	78	94	98	95	99	100
Mean length Imm.	27.5	29.3	31.3	31.8	33.4	32.6	-
Mean length Mat.	29.2	29.9	32.1	33.5	34.6	36.3	38.2
Mean length all	28.5	29.8	32.0	33.4	34.5	36.3	38.2
Division VIIb							
Number immatures	2	19	5	-	-	-	-
Number matures	2	42	105	78	71	80	245
% Mature	50	69	95	100	100	100	100
Mean length Imm.	24.1	27.9	30.2	-	-	-	-
Mean length Mat.	28.8	28.5	31.7	32.8	34.1	35.6	37.6
Mean length all	26.4	28.3	31.7	32.8	34.1	35.6	37.6
Division VIIe							
Number immatures	27	82	41	6	3	1	2
Number matures	-	27	99	52	37	22	76
% Mature	0	25	71	90	93	96	97
Mean length Imm.	23.8	26.3	28.6	29.3	31.2	31.5	32.2
Mean length Mat.	-	27.6	29.9	31.7	32.3	33.3	36.4
Mean length all	23.8	26.7	29.6	31.5	32.2	33.3	36.3
Division VIIf							
Number immatures	31	39	32	6	3	1	-
Number matures	-	28	134	60	48	39	126
% Mature	0	42	81	91	94	98	100
Mean length Imm.	23.7	26.4	28.6	29.8	29.7	30.1	-
Mean length Mat.	-	28.7	30.0	31.2	32.1	32.9	35.6
Mean length all	23.7	27.4	29.7	31.0	32.0	32.8	35.6
Division VIIg							
Number immatures	123	91	19	10	6	1	2
Number matures	9	88	91	60	56	13	79
% Mature	7	49	83	86	90	93	98
Mean length Imm.	25.8	28.0	30.2	31.0	31.0	33.2	33.4
Mean length Mat.	27.2	28.0	30.2	31.2	32.2	32.5	35.0
Mean length all	25.9	28.0	30.2	31.1	32.1	32.6	34.9

(cont'd)

Table 1 (cont'd)

AREAS	AGE 1	2	3	4	5	6	7+
Division VIIh							
Number immatures	-	-	-	-	-	-	-
Number matures	-	1	10	8	2	2	2
% Mature	-	100	100	100	100	100	100
Mean length Imm.	-	-	-	-	-	-	-
Mean length Mat.	-	30.7	32.9	34.7	32.5	37.3	37.2
Mean length all	-	30.7	32.9	34.7	32.5	37.3	37.2
Division VIIj							
Number immatures	10	46	6	1	1	1	-
Number matures	3	183	440	384	330	271	1,374
% Mature	23	80	99	100	100	100	100
Mean length Imm.	26.1	27.8	30.7	33.8	29.9	33.8	-
Mean length Mat.	27.6	28.7	31.7	33.8	35.1	36.2	39.2
Mean length all	26.4	28.5	31.7	33.8	35.0	36.1	39.2
Sub-area VIII							
Number immatures	19	-	-	-	-	-	-
Number matures	1	1	12	20	10	-	62
% Mature	5	100	100	100	100	-	100
Mean length Imm.	22.0	-	-	-	-	-	-
Mean length Mat.	23.5	32.9	32.3	34.9	35.9	-	40.0
Mean length all	22.1	32.9	32.3	34.9	35.9	-	40.0
All Areas							
Number immatures	214	294	114	27	20	5	4
Number matures	18	432	1,051	835	698	506	2,318
% Mature	8	60	90	97	97	99	100
Mean length Imm.	24.9	27.4	29.3	30.6	31.6	32.2	32.8
Mean length Mat.	27.6	28.7	31.3	33.2	34.3	35.6	38.5
Mean length all	25.1	28.1	31.1	33.1	34.2	35.6	38.5

Table 2 The origins and distribution of fifty small plankton samples exchanged to examine identification and staging of mackerel eggs

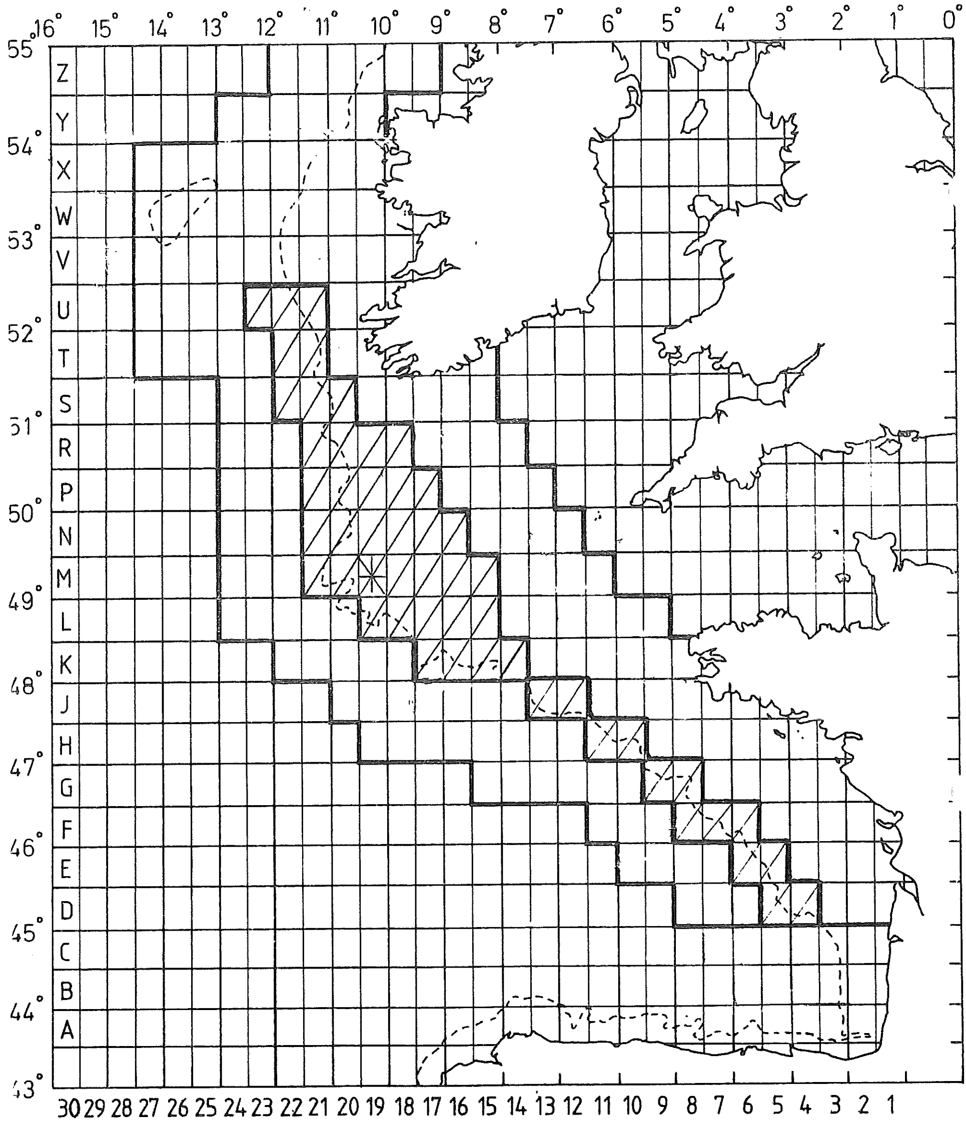
	Origin of Sample									
	England		Scotland		Norway		Holland		Denmark	
England	-		1	2	1	2	1	2	1	2
Scotland	1	2	-		3	4	3	4	3	
Norway	3	4	3	4	-		5	6	4	
Holland	5	6	5	6	5		-		5	6
Denmark	7		7	8	6	7	7	8	-	
Germany, Fed.Rep.	8	9	10		8		9		7	8
Eire	10		9		9	10	10		9	10

Numbers refer to sample bottle

Reading across the rows, the English laboratory, for example, will count and stage samples 1 and 2 from the other 4 supplying countries.

Reading down the columns, the 10 English samples are spread between the other 6 participants.

Figure 1 The Western MACKEREL stock plankton survey grid for 1986. The outer bold lines and coast lines define the outer limits to the grid. The inner bold line enclose the areas (hatched rectangles) of highest egg production. Rectangle M19 (starred) is close to the epi-centre of peak egg production.



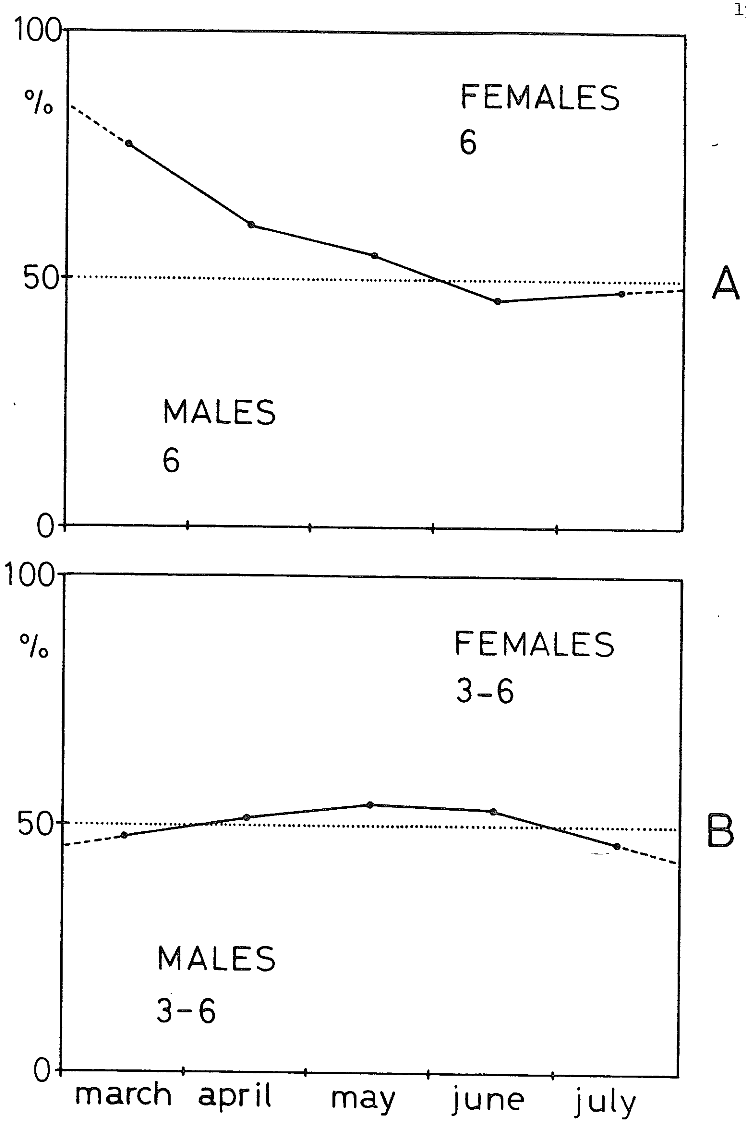


Figure 2 The percentage male and female MACKEREL in maturity stage 6 (A) and in maturity stages 3-6 combined (B) by month in ICES Division VII; in 1981-1983.

Figure 3 The mean weight, mean length and mean size of MACKEREL in maturity stage 6 by month, by sex and sexes combined in ICES Division VII; in 1981-1983.

Mean weight = solid line
Mean length = dashed line
Mean age = dotted line

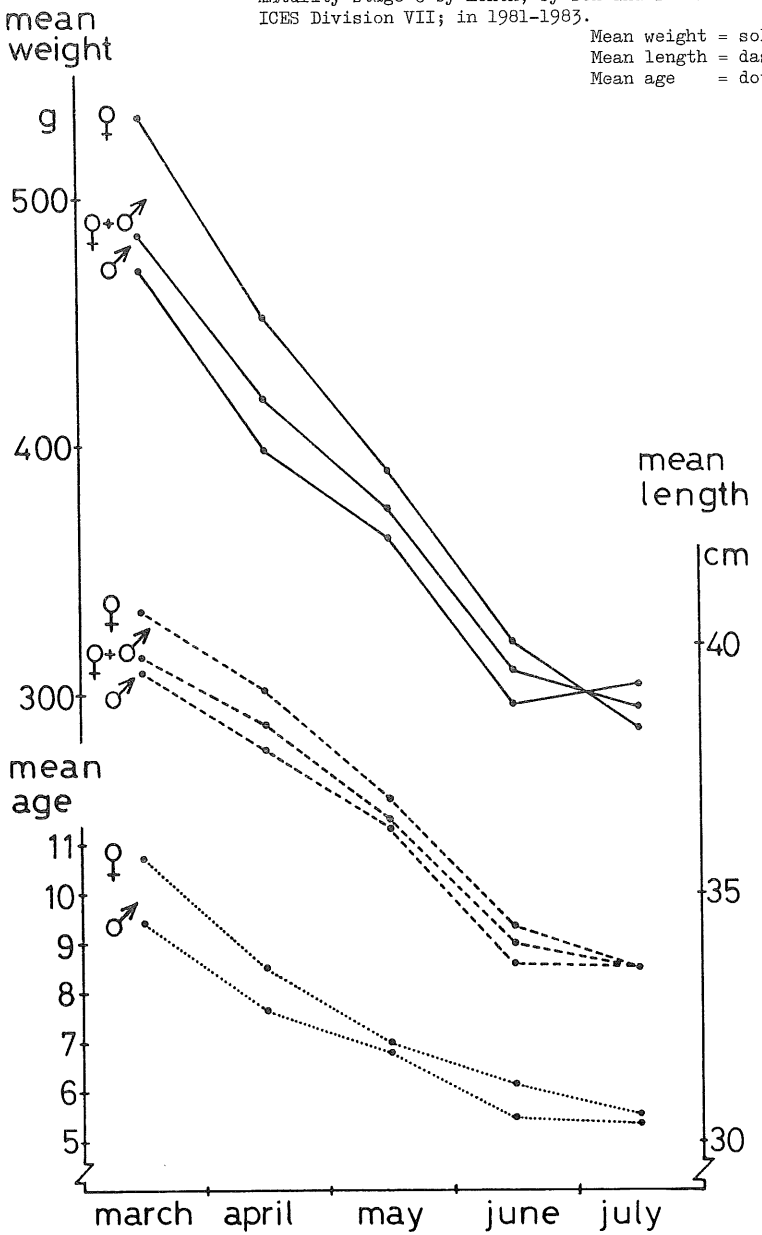


Figure 4 Mean weight by age and mean length by age of male and female MACKEREL in maturity stage 6 in ICES Division VII; in 1981-1983.

Mean weight = solid line
Mean length = dashed line

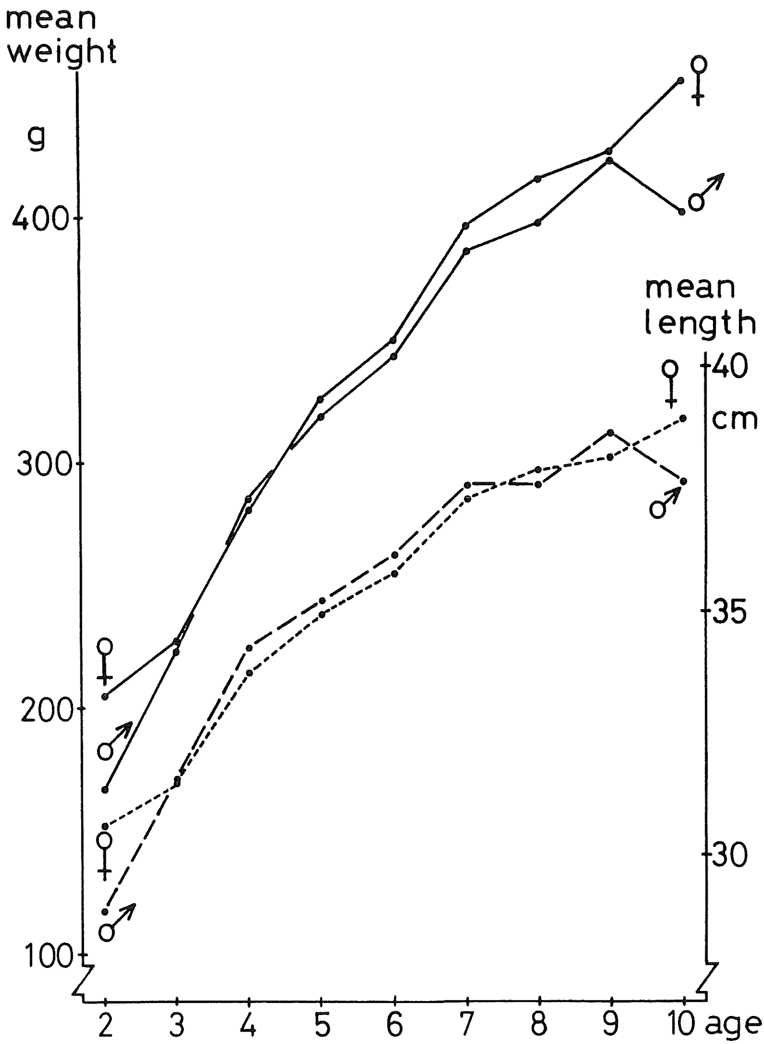


Figure 5 Western MACKEREL stock maturity ogive fitted to the percentage maturity data summarised in Table 1, all areas combined