International Council for the Exploration of the Sea

C.M. 1986 / H:60
Pelagic Fish Committee

FECUNDITY OF PERUVIAN ANCHOVY, ENGRAULIS RINGENS [1]

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ABSTRACT

The Peruvian anchovy is a serial spawner releasing several batches of eggs per spawning season. Batch fecundity was estimated applying the "Hydrated Oocytes Method". With the large data sets available the relationship between batch fecundity and female weight was determined for three different spawning peaks and two different populations. Relative fecundity, estimated for August/September 1981 (580 eggs/g female), October 1984 (604 eggs/g female) and August/September 1985 (556 eggs/g female), did not show interannual variation. A comparison of fecundity values from February and August/September 1985 indicated seasonal variation. Although the stock size of the Peruvian anchovy increased considerably from 1981 to 1985, relative fecundity at peak spawning time was the same in both years and a compensatory mechanism between changes in fecundity and stock size was not observed.

RESUME

La fécondité de l'anchois du Pérou a été determiné en 1981, 1984 et 1985 et sa variation interannuelle et saisonnère a été étudié.

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[1] Contribution No. 28 of the Alfred-Wegener-Institut for Polar and Marine Research

INTRODUCTION

The spawning season of the Peruvian anchovy, Engraulis ringens, usually lasts from July to March with two spawning peaks, in August/September and January/February.

The Peruvian anchovy is a batch (serial) spawning clupeoid species releasing several batches of eggs per year (ALHEIT et al. 1984). The number of eggs spawned by a female in one single spawning event, the batch fecundity, can be determined by the recently developed 'Hydrated Oocytes Method' (HUNTER et al. 1985), which, because of its rapidity, allows the collection of large data sets on fecundity in reasonable time. Considerable interannual (HUNTER et al. 1985) and intra-seasonal (ALHEIT 1986a) variation in batch fecundity is reported for other batch spawning clupeoid fish species. As several new large data sets on batch fecundity of the Peruvian anchovy are now available, the seasonal, annual and regional variation in batch fecundity of this species is investigated.

METHODS

Female anchovies were collected along the Peruvian coast by a research vessel and commercial purse seiners in August/September 1981, October 1984, February 1985 and August/September 1985. After they were caught, their body cavity (anus to pectoral fins) was immediately opened and they were preserved in a 4 % buffered formaldehyde solution (HUNTER 1985). In the laboratory, females with hydrated oocytes in their ovaries were separated and their weight (ovary-free) and that of their ovaries determined. Three pieces of tissue of ca. 50 mg were removed from different parts of their ovaries. The number of hydrated oocytes in each of these three subsamples was counted. Hydrated oocytes can easily be separated from all other types of oocytes, as they are translucent, have a much larger size, and as their surface is wrinkled due to formalin preservation. The total number of hydrated oocytes in the ovaries which corresponds exactly to the batch fecundity was calculated for each female based on the average number of hydrated oocytes per unit weight in the three subsamples. The samples from the central and northern stock of the Peruvian anchovy were divided into two groups, a central and a northern one. The borderline between these two groups was at 11°15' (latitude). Batch fecundity was expressed as relative fecundity (number of eggs spawned/ovary-free female weight) because it is a more convenient fecundity term when comparing fecundity of different populations or species. The gonadosomatic index (GSI) was determined by dividing the ovary weight by the ovary-free female weight.

RESULTS

Average relative fecundity of the entire central and northern stock of the Peruvian anchovy was estimated in August/September of 1981 and 1985 (Table 1). The results were very similar with 580 and 556 eggs/g female (ovary-free), respectively. When dividing the data into a central and a northern component, in 1981, the central population had a considerably higher fecundity, 637 eggs/g female, than the northern one, 502 eggs/g female, as reported by ALHEIT et al. (1983). In 1985, there was no difference in fecundity between the two parts of the stock (Table 1). In order to investigate possible latitudinal differences in fecundity in more detail, relative fecundity was calculated for the different weight classes of the females. There was a general trend of relative fecundity increasing with augmenting size (Fig. 1 and 2). In 1981, a large proportion (51 %) of the fecundity data of the northern population were gained from females of the four smallest size groups, whereas it was only 6 % in the central population. Thus the different size composition of the females in the two samples from the central and the northern stock explains some of the difference in the average relative fecundity in 1981. However, in most weight classes fecundity was considerably higher in the central part (Fig 1). Such a trend could not be observed in 1985 (Fig. 2).

For the investigation of possible seasonal or interannual differences in fecundity, four data sets were available for the northern part of the Peruvian anchovy stock (Table 1), ranging between 466 and 604 eggs/g female. The size of the October 1984 sample (11 females) was considered as too small to be used in a seasonal comparison. However, the value of 604 eggs/g female in October 1984 indicates that there probably was no dramatic change in fecundity at this time. The data from August/September 1981, February 1985 and August/September 1985 were grouped by weight (Fig. 3). In all these data sets it was obvious that the larger females had a higher relative fecundity. With exception of the weight group 30 - 32 g, the fecundity was always highest in the August/September 1985 samples. In February 1985, the relative fecundity was consistently lower than in August/September 1981 and 1985 in all weight classes.

A study of the seasonal and latitudinal variation of the gonadosomatic index (GSI) showed that it was highest in 1981, in the central part of the stock (Table 2). The lower GSI in the northern part in 1981 might partly be attributed to size class differences. In 1985, the GSIs in the central and in the northern part of the stock were nearly equal: 5.9 and 5.6, respectively. The lowest GSI was recorded in February 1985 with 3.2, although only females >20 g were considered. This low value was mainly due to many small females having inactive ovaries. When considering only females >25 g, the GSI rose to 4.4. Obviously, the larger females were actively spawning in February 1985, whereas a certain proportion of the smaller ones did not. Due to the size dependent spawning activity in February 1985, the comparison of the GSI does not indicate lower average relative fecundity in February 1985 coinciding with a smaller size of the ovaries. For this study, only females caught in the morning between 08.00 and 11.00 hours were used. At that time of day, the weight increase caused by hydration of the ovaries is negligible.

The GSI of females with hydrated ovaries was calculated for the three different seasons (Table 3). To ensure that all the females considered here were in the same state of hydration, only females caught between 16.00 and 17.30 hours in August/September and 19.00 and 19.30 hours in February were used. In February 1985, the GSI of the hydrated females was considerably lower than in August/September 1981 and 1985. Relative fecundity in February 1985 was also lower. Obviously, when the number of hydrated oocytes in the ovary decreases, then the proportion of the weight of the hydrated ovary to the female weight also decreases.

The relationship between batch fecundity (F) and ovary-free female weight (W) had the following form:

$\ln F = 5.34 + 1.34 \ln W$ $r = .74$ August/September 1981
$n = 249$ (central)

$\ln F = 5.16 + 1.34 \ln W$ $r = .90$ August/September 1981
$n = 191$ (northern)

$\ln F = 3.88 + 1.68 \ln W$ $r = .83$ February 1985
$n = 76$ (northern)

$\ln F = 4.29 + 1.64 \ln W$ $r = .78$ August/September 1985
$n = 58$ (central)

$\ln F = 5.39 + 1.29 \ln W$ $r = .63$ August/September 1985
$n = 190$ (northern)

DISCUSSION

The advantages of the 'Hydrated Oocytes Method' for determination of batch fecundity are that it is much faster than traditional methods and that it has a high accuracy (HUNTER et al. 1985) Its disadvantage is that females with hydrated oocytes suitable for fecundity estimates are encountered only at certain times of the day and that some effort is required to find them as they are patchily distributed in the population (ALHEIT et al. 1984). The method has been successfully applied to a number of other batch (serial) spawning fish species, such as northern anchovy, E. mordax, (HUNTER and GOLDBERG 1980), Peruvian sardine, Sardinops sagax sagax, (LO et al. 1986), Chilean sardine, S. sagax musica, (RETAMALES and GONZALEZ 1983), North Sea sprat, Sprattus sprattus, (ALHEIT 1986a), Pacific mackerel off Peru, Scomber japonicus peruanus, (PENA et al. 1986), and Peruvian hake, Merluccius gayi peruanus, (ALHEIT 1986b).

ALHEIT et al. (1983) observed latitudinal variation in batch fecundity of the Peruvian anchovy studying a data set from 1981 and concluded that anchovies of higher latitudes might have a higher batch fecundity. The same findings were reported for the northern anchovy (LAROCHE and RICHARDSON 1980). A new data set gained in 1985 did not support the hypothesis of latitudinal variation in batch fecundity of Peruvian anchovy. Dividing the data into female weight classes revealed that some of the latitudinal variation observed in 1981 was due to relative fecundity being dependent on female weight, however, most of the variation cannot be explained in this way.

For the sprat, Sprattus sprattus, from Kiel Bay, it has been clearly shown that the batch fecundity of a serial spawner can vary considerably during the spawning season, e.g. it can double within a few weeks (HEIDRICH 1925, ALHEIT 1986a). As the 1981 data on the northern population of Peruvian anchovy were collected, on average, two weeks later than those from the central population, the observed differences, presumed to be regional, could very well be due to intraseasonal variation in batch fecundity.

In view of the high interannual variation of relative fecundity reported by HUNTER et al. (1985) for the northern anchovy and considering the potentially high intraseasonal variation in batch fecundity of serial spawning clupeoids (ALHEIT 1986a), the similarity of the fecundity values of the Peruvian anchovy gained in August/September 1981, October 1984 and August/September 1985 seems somewhat surprising. Only the low values from February 1985 indicate a seasonal variation in batch fecundity.

An interesting outcome of the analysis of the data from February 1985 is that mainly the larger females were spawning whereas the smaller ones had inactive ovaries. February is near the end of the Peruvian anchovy's protracted spawning season and the smaller females had probably already ceased spawning.

In August/September 1981, the spawning biomass of the central and northern stock of the Peruvian anchovy was estimated at 1.2 million tons (SANTANDER et al. 1984). In August/September 1985, the spawning biomass of the same stock was estimated at several million tons, a multiple of the biomass from 1981. Still, the average relative fecundity stayed about the same (Table 1). There is no indication of a compensatory mechanism between fecundity and stock size, such as fecundity decreasing with augmenting stock size, as reported e.g. for the South African pilchard (SHELTON and ARMSTRONG 1983). In any case, as batch fecundity can vary considerably during the spawning season (HEIDRICH 1925, ALHEIT 1986a) and as annual fecundity is a function of both average batch fecundity and number of spawnings per year, a proof of such a compensatory mechanism for batch spawners such as the anchovy would require a very high sampling effort over the entire spawning season.

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Table 1. Relative fecundity (nr. eggs/g female) of Peruvian anchovy.

Month	Year	Relative Fecundity	S.D.	n	Population
		580	±139	437	northern + central
Aug/Sep	1981	637	±134	254	central
		502	±103	183	northern
Oct	1984	604	±137	11	northern
Feb	1985	466	±128	76	northern
		556	±134	251	northern + central
Aug/Sep	1985	568	±153	58	central
		553	±128	191	northern

Table 2. Gonadosomatic Index (GSI) of non-hydrated females of Peruvian anchovy.

Month	Year	GSI	S.D.	n	Population
Aug/Sep	1981	6.5	±2.2	96	central
		4.1	±2.0	109	northern
Feb	1985	3.2	±1.9	90	northern, females > 20 g
		4.4	±1.5	49	northern, females > 25 g
Aug/Sep	1985	5.9	±1.9	234	central
		5.6	±1.9	211	northern

Table 3. Gonadosomatic Index (GSI) of hydrated females of Peruvian anchovy.

Month	Year	GSI	S.D.	n	Population
Aug/Sep	1981	14.2	±3.3	82	northern + central
Feb	1985	7.4	±1.6	77	northern
Aug/Sep	1985	11.9	±2.6	56	northern + central

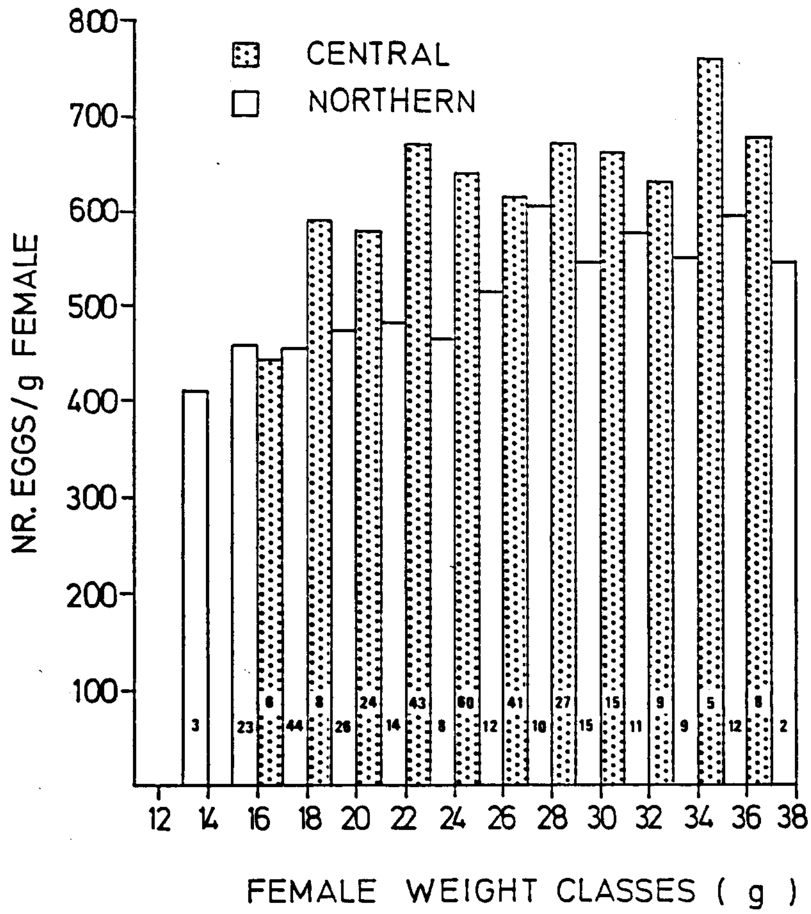

Fig. 1. Relative fecundity of Peruvian anchovy in August/ September 1981.

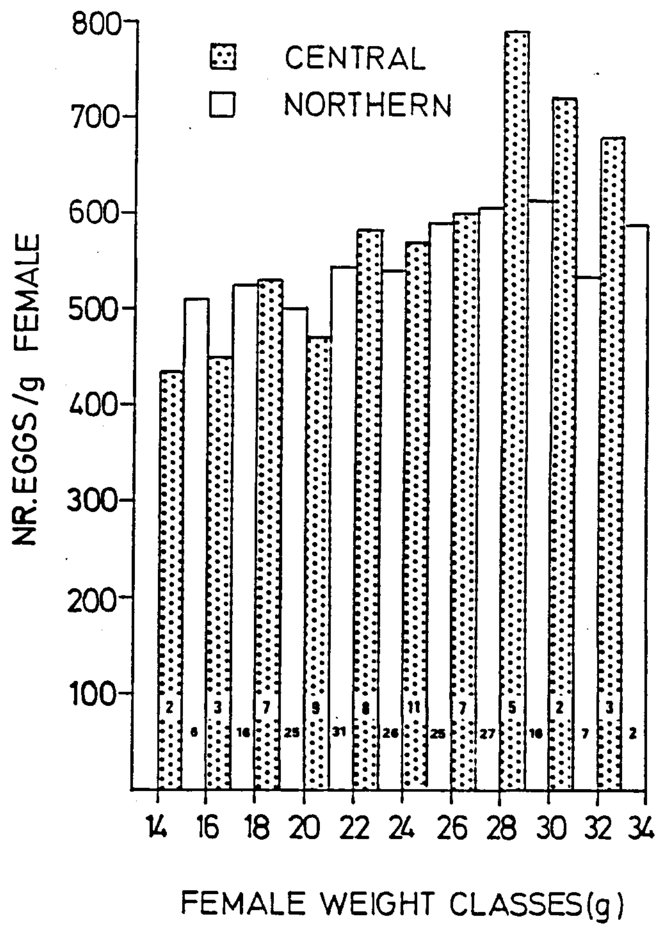

Fig. 2. Relative fecundity of Peruvian anchovy in August/ September 1985

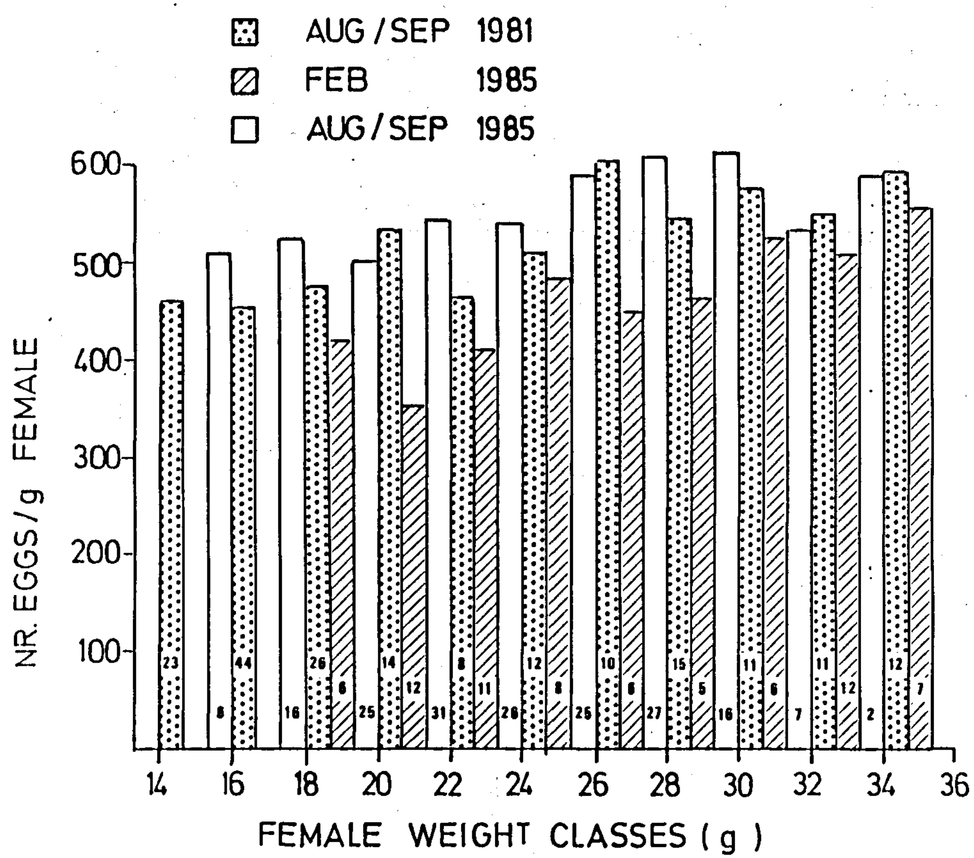

Fig. 3. Relative fecundity of northern subpopulation of Peruvian anchovy.