

**Sexual maturity of female Norway lobster,
Nephrops norvegicus, in the central North Sea**

F. Redant

Fisheries Research Station
Ankerstraat 1, B-8400 Oostende, Belgium

ABSTRACT

Data on the maturity stages of female Norway lobster, *Nephrops norvegicus*, were collected from catches taken by a commercial trawler, operating in the Botney Gut - Silver Pit area (central North Sea). The maturity stages of about 3,800 females were identified, using criteria based on FARMER (1974).

The size at 50 % maturity was found to be 27.5 mm carapace length (CL). The smallest females with stage 4 ovaries measured 24 mm CL ; the smallest ovigerous females 25 mm CL. Peak maturity rates exceeding 95 % were observed around 32 mm CL. From this size onwards, maturity rates fell off again, to values of 85-90 % for the size class ≥ 46 mm CL.

The results are discussed in relation to the methodological problems which may arise when studying sexual maturity in female *Nephrops*.

This study was subsidized by the Institute for Scientific Research in Industry and Agriculture (ISRIA), Brussels, Belgium.

INTRODUCTION

For a number of years already the length based assessments on female Norway lobster, *Nephrops norvegicus*, are being made with separate growth curves for immature and mature animals, the transition length between the two groups being the size at 50 % maturity (see e.g. ICES, 1994a). Detailed information on female sexual maturity is also essential when calculating e.g. the spawning stock biomass or the reproductive potential of *Nephrops* stocks.

The aim of the present study, carried out in the margin of a research programme on gear selection and discarding in the Belgian *Nephrops* fishery, was to collect data on female sexual maturity in the Botney Gut - Silver Pit stock (central North Sea), and to provide estimates of the sizes at first and at 50 % maturity.

MATERIALS and METHODS

Data on the maturity stages of female *Nephrops* were collected on 7 and 8 September 1993, from catches taken by a commercial *Nephrops* trawler operating in the Botney Gut - Silver Pit area. Samples were collected from two hauls, viz. haul 56 (made on 7 September between 1.00 and 5.00 p.m.) and haul 60 (made on 8 September between 5.30 and 9.00 a.m.).

Samples of the largest size classes in the catches were taken after sorting of the catch by the ship's crew (see REDANT and POLET, 1994, for further information on the sorting process). *Nephrops* to be landed whole (mostly > 35 mm CL) and *Nephrops* to be tailed (mostly 30-40 mm CL) were sub-sampled, such that the fractions retained contained about 1,000 and 200 females respectively. The discards were sorted by the scientific crew, and then graded into three size categories, viz. "small" (< 30 mm CL), "medium" (25-35 mm CL) and "large" (> 30 mm CL). From these too sub-samples were taken, as a rule containing 200-300 females each.

The numbers of females measured per sorting category (small, medium and large discards, *Nephrops* to be tailed, and *Nephrops* to be landed whole), and per mm size class are shown in Tables 1 and 2.

This "stratified" sampling method was preferred over sampling of the unsorted catch, to make sure that as wide a range of size classes as possible was sampled in sufficient numbers, to allow the calculation of a maturity ogive extending into both the smallest and the largest size classes in the population.

After sorting, the females were measured (carapace length, CL, to the nearest mm), and their maturity stage was identified by external examination, using criteria based on FARMER (1974) :

Empty	:	no visible signs of ovary development (Farmer's stages 1 and 2).
Maturing	:	ovary pale green, visible through the carapace, but not extending into the abdomen (Farmer's stage 3).
Mature	:	ovary fully developed, dark green in colour and extending into the abdomen (Farmer's stage 4).
Ovigerous	:	with recently spawned, dark green eggs under the abdomen.
Hatching	:	with eggs close to hatching, or with remnants of recently hatched eggs under the abdomen.

For several reasons (time constraints, the necessity to leave the animals intact, etc.), it was impossible to examine other indicators of sexual maturity, such as ovary weight, developmental stage of the oocytes or the presence of spermatophores.

To calculate the proportions of females by maturity stage, the observed numbers-at-length in each sorting category were first raised to total numbers-at-length in the unsorted catch. The relative proportions of each maturity stage were then obtained by dividing the raised numbers-at-length for each stage by the total numbers-at-length of the females in the unsorted catch.

This method was preferred over straightforward summing across categories, mainly because fishermen's selection was found to be highly dependent on the maturity stage of the females (see REDANT and POLET, 1994, for further information on fishermen's selection and discarding). Many mature and ovigerous females in particularly the middle range of the size distribution are either tailed or discarded, and therefore their relative numbers varied substantially from one sorting category to another.

RESULTS

The cumulated relative proportions of the maturity stages by size class are shown in Figures 1 and 2, for hauls 56 and 60 respectively.

In general, the graphs in Figures 1 and 2 are very similar, the main difference being a marked increase in the proportion of ovigerous females in almost all size classes, from haul 56 to haul 60. It is tempting to relate this increase to the time lapse between the two hauls, and to explain it as a result of the ongoing spawning activity. It should, however, be noted that the two hauls were made

in different parts of the Botney Gut - Silver Pit area, and therefore, that the difference may be just geographical.

The maturity ogives are shown in Figures 3 and 4, for hauls 56 and 60 respectively. The percentages of "mature" females in these graphs were obtained by summing the relative proportions of maturing, mature and ovigerous females in each size class. Thus, they should be seen as an estimate of the proportions of females which (may) take part in the ongoing spawning season, rather than as an estimate of the actual proportions of fully mature females at the time of sampling. The curves were plotted by means of a maximum likelihood routine for the left, more or less sigmoid part of the curve, and by calculation of a trend line for the right, linear part of the curve.

The overall shape of the two curves is very similar, and the lengths at 50 % maturity (viz. 27.3 and 27.4 mm CL) are almost identical.

The smallest female with fully mature gonads (Farmer's stage 4) measured 24 mm CL (in both hauls) ; the smallest ovigerous female 25 mm CL (in both hauls).

The graphs show two remarkable features :

- (a) even in the middle part of the size range (30-35 mm CL), where the highest maturity rates are found, none of the size classes shows a 100 % maturity rate ; and
- (b) from a size of about 32 mm CL, the maturity rates fall off almost linearly, to a value of 85-90 % for the size class ≥ 46 mm CL.

DISCUSSION

The choice of the period for collecting data on female sexual maturity in *Nephrops* is very important. If the measurements are made too early in the year (i.e. long before the onset of the spawning period), considerable proportions of the females well above the size at 50 % maturity may still be "empty", and this would result in an over-estimation of the size at 50 % maturity (DIAZ in ICES, 1994b).

If, on the other hand, the measurements are made too late in the year (e.g. at the peak of the spawning season or later), large proportions of the ovigerous females will be missed in the samples, mainly because, owing to their burrowing behaviour, ovigerous females are much less accessible to trawling. This

would again result in an over-estimation of the size at 50 % maturity (MORIZUR, 1979 ; DIAZ in ICES, 1994b).

In the Botney Gut - Silver Pit area, spawning usually takes place in September-November (Figure 5, taken from STERK and REDANT, 1989, and completed with the data for 1989-93). Since the samples for this study were taken early in September (i.e. at the very beginning of the spawning season), the problems of females not yet being mature, or of ovigerous females already having disappeared in the burrows, were largely avoided.

In previous studies on the sexual maturity of female *Nephrops*, several criteria have been used to define the size at 50 % maturity, such as the proportions of ovigerous females, the general appearance of the gonads (shape, colour, etc.), their volume or weight, the developmental stage of the oocytes, the presence of a spermatophore in the thelycum, or a combination of several of these criteria (see e.g. FIGUEIREDO and THOMAS, 1967 ; FARMER, 1974 ; HILLIS, 1976 ; MORIZUR, 1979 ; BAILEY, 1984 ; BRIGGS, 1988 ; FIGUEIREDO in ICES, 1994b).

Unless spawning is concentrated within a very short period of time - which, in most *Nephrops* stocks, is not the case - the ovigerous condition of the females seems to be the least reliable criterion to determine the size at 50 % maturity. By the time the "late spawners" appear in the samples, the "early spawners" will have disappeared in their burrows, which makes them inaccessible to sampling. This may result in a substantial under-estimation of the proportions of ovigerous females, and in an equally substantial over-estimation of the size at 50 % maturity.

Methods, such as the one used in this study, which are based on a combination of ovary stage (to identify those females which are likely to spawn within the next few weeks or months), and ovigerous condition, give a much closer approximation of the size at 50 % maturity.

It should, however, be noted that not all females with ovaries in stage 3 (maturing), and maybe even stage 4 (mature), will eventually spawn within the next few months. Whether spawning can be successfully completed or not, depends on both ovary development and the presence of a spermatophore in the thelycum (FARMER, 1975). The combined use of these two criteria gives maturity ogives which are slightly shifted to the right as compared to those obtained from ovary stages only, but the resulting differences in the sizes at 50 % maturity are very small (MORIZUR, 1979 ; BAILEY, 1984).

The size at 50 % maturity of female *Nephrops* in the Botney Gut - Silver Pit area (viz. 27.5 mm CL) is slightly higher than the sizes reported for most other stocks in the ICES area (Table 3). Recent studies in the Clyde (West Scotland) have shown, however, that biological parameters such as growth rates and size

at 50 % maturity, can vary considerably on a small geographical scale (TUCK *et al.* in ICES, 1994b). Female sizes at 50 % maturity, derived from samples taken on 6 different locations within the Clyde, ranged from 23 to 30 mm CL, i.e. a range comparable to the one seen in the data for all *Nephrops* stocks in the NW European waters (Table 3).

The fact that, from a size of about 32 mm CL, the maturity rates fall off again, once more confirms the existence of a biennial spawning regime in northern *Nephrops* stocks (SYMONDS, 1972 ; BAILEY, 1984 ; REDANT, 1987 ; STERK and REDANT, 1989). Bearing in mind that part of the larger females with stage 3, and maybe even stage 4 ovaries, may not spawn, and eventually will resorb their ovaries (FIGUEIREDO, 1982), it cannot be excluded that the actual proportions of females skipping a spawning period may be larger than suggested by the maturity ogives.

LITERATURE CITED

BAILEY, N. (1984) : Some aspects of reproduction in *Nephrops*.
ICES, Shellfish Comm., CM 1984/K:33 (mimeo).

BRIGGS, R. (1988) : A preliminary analysis of maturity data for Northwest Irish Sea *Nephrops*.
ICES, Shellfish Comm., CM 1988/K:21 (mimeo).

FARMER, A.S.D. (1974) : Reproduction in *Nephrops norvegicus* (Decapoda : Nephropidae).
J. Zool., London, 174, 161-163.

FARMER, A.S.D. (1975) : Synopsis of biological data on the Norway lobster, *Nephrops norvegicus* (Linnaeus, 1758).
FAO Fisheries Synopsis, No. 112, 1-97.

FIGUEIREDO, M. (1982) : The occurrence of resorption in the ovaries of *Nephrops norvegicus* (L.) in Portuguese waters.
ICES, Shellfish Comm., CM 1982/K:28 (mimeo).

FIGUEIREDO, M. and THOMAS, H.J. (1967) : On the biology of the Norway lobster, *Nephrops norvegicus* (L.).
J. Cons. Int. Explor. Mer., 31 (1), 89-101.

HILLIS, J.P. (1979) : Growth studies on the prawn *Nephrops norvegicus*.
Rapp. Proc.-verb. Réun. Cons. Int. Explor. Mer, 175, 170-175.

ICES (1994a) : Report of the Working Group on the assessment of *Nephrops* and *Pandalus* stocks.

ICES, CM 1994/Assess:12 (mimeo).

ICES (1994b) : Report of the Study Group on *Nephrops* stocks.

ICES, Shellfish Comm., CM 1994/K:9 (mimeo).

MORIZUR, Y. (1979) : Utilisation de critères fonctionnels (présence de spermatophore, maturation des ovaires) pour la détermination de la taille et l'âge à maturité sexuelle de *Nephrops norvegicus* femelles dans la région Sud-Bretagne. ICES, Shellfish Comm., CM 1979/K:41 (mimeo).

REDANT, F. (1987) : Reproduction and seasonal behaviour of the Norway lobster, *Nephrops norvegicus*, in the Central North Sea.

ICES, Shellfish Comm., CM 1987/K:32 (mimeo).

REDANT, F. and POLET, H. (1994) : Results of a discard study on the Belgian *Nephrops* fishery in the central North Sea.

ICES, Shellfish Comm., C.M. 1994/K:44 (mimeo).

STERK, W. and REDANT, F. (1989) : Further evidence on biennial spawning of the Norway lobster, *Nephrops norvegicus*, in the Central North Sea. ICES, Shellfish Comm., CM 1989/K:2 (mimeo).

SYMONDS, D.J. (1972) : The fishery for the Norway lobster, *Nephrops norvegicus*, off the north-east coast of England.

Fish. Invest. (London), Series 2, 27, 1-35.

Table 1 - Haul 56 : fractions sampled (FS) and numbers of females measured per category and per mm CL

	Discards small	Discards medium	Discards large	Landings tails	Landings whole
CL	FS = 1:2	FS = 1:4	FS = 1:2	FS = 1:1	FS = 1:1
<21	13				
21	4				
22	4	1			
23	16	2			
24	43	1			
25	64	13			
26	73	15			2
27	40	22			8
28	25	31			12
29	6	36			7
30		36	2		30
31		31	5		27
32		36	15		87
33		13	21		84
34		6	21		105
35		1	11		107
36		1	6		85
37		1	9		104
38			2		76
39			3		75
40			3		84
41			-		70
42			1		50
43			-		41
44			-		56
45			-		25
>45			1		46
Tot	288	246	100	1,181	

Total no. of measurements	1,815
Raised to nos. in unsorted catch	2,941

Table 2 - Haul 60 : fractions sampled (FS) and numbers of females measured per category and per mm CL

	Discards small	Discards medium	Discards large	Landings tails	Landings whole
CL	FS = 1:1	FS = 1:2	FS = 1:1	FS = 1:6	FS = 1:2
<21	28				
21	11				
22	9				
23	14				
24	32	1			
25	49	4			
26	57	19		1	
27	70	38		1	1
28	29	58		6	-
29	5	40		10	2
30		30	1	8	8
31		24	13	10	8
32		7	31	35	8
33		7	38	39	12
34		2	33	36	22
35		-	23	31	41
36		1	23	13	64
37		-	15	20	65
38		1	11	13	114
39			14	6	102
40			5	1	102
41			4	1	124
42			1		81
43			1		84
44			2		63
45			1		36
>45			1		58
Tot	304	232	217	231	995

Total no. of measurements	1,979
Raised to nos. in unsorted catch	4,361

Table 3 - Sizes at 50 % maturity (in mm CL) of female <i>Nephrops</i> in NW European waters (*)			
Area	Size 50 % maturity	Criteria used	Reference
Skagerrak and Kattegat	28.0	Ovary stage + ovigerous	Ulmestrand, pers. comm.
Clyde	27.0 27.0	Ovary stage Ovary stage + spermatophore	Bailey, 1984
Clyde	23.0-30.0	Ovary stage	Tuck, et al., in ICES, 1994b
Sound of Jura	23.0	Ovary stage	Bailey, 1984
W Irish Sea	25.0-26.0	Ovary stage + ovigerous	Hillis, 1979
NW Irish Sea	23.5	Ovary stage + ovigerous	Briggs, 1988
Bay of Biscay data for 1977	23.0-23.5 23.5-24.0 24.0	Spermatophore Ovary stage Ovary stage + spermatophore	Morizur, 1979
Bay of Biscay data for 1978	22.0-22.5 23.0 23.0	Spermatophore Ovary stage Ovary stage + spermatophore	Morizur, 1979
SW Portugal	30.0	Ovary stage + ovigerous	Figueiredo, in ICES, 1994b
Botney Gut	27.5	Ovary stage + ovigerous	This study

(*) Sizes at 50 % maturity derived from the proportions of ovigerous females only, are not included in this table (see text, Discussion section).

Nephrops : Female sexual maturity
Maturity stages by size class : Haul 56

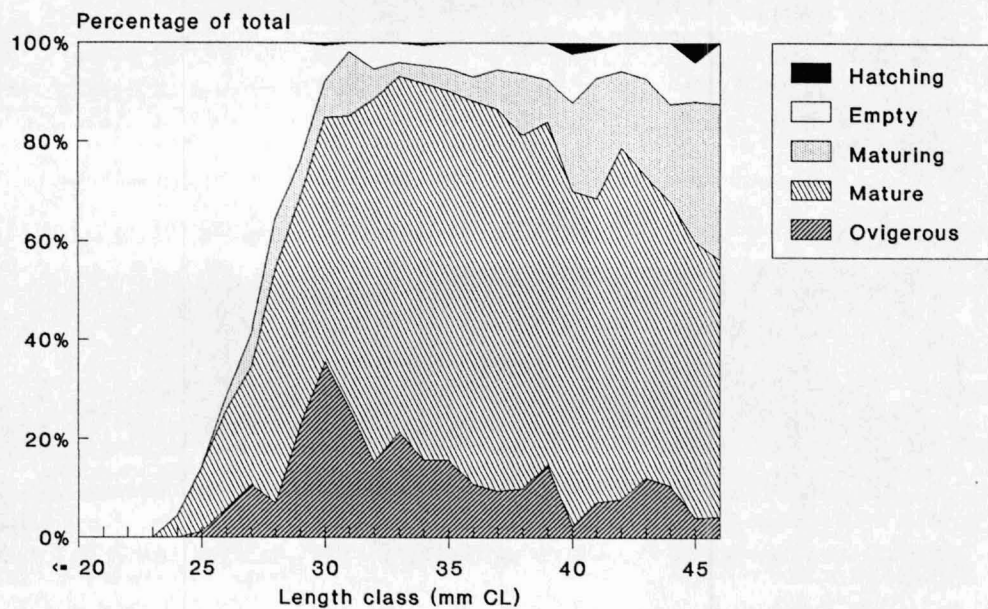


Figure 1

Nephrops : Female sexual maturity
Maturity stages by size class : Haul 60

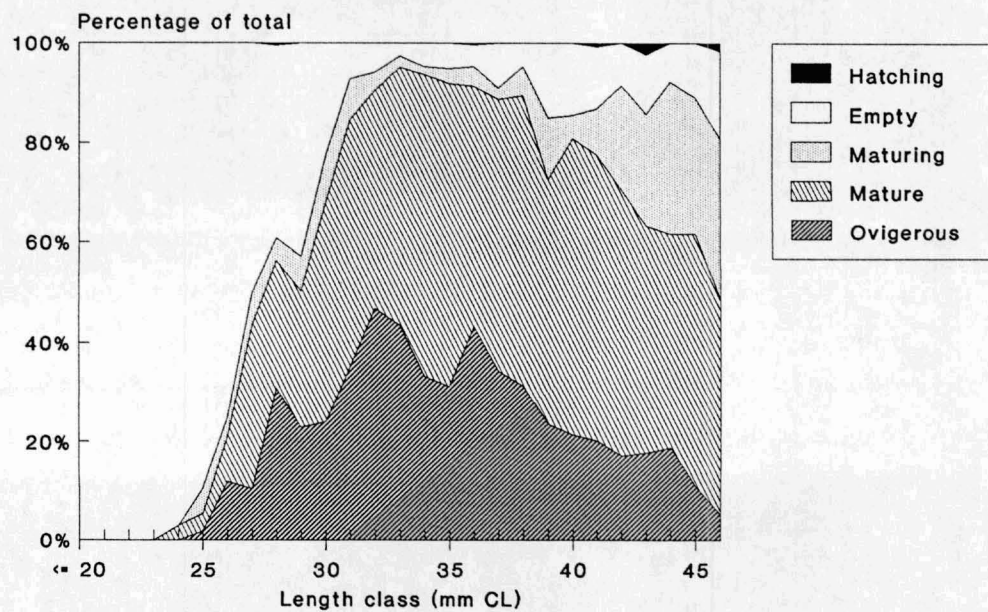


Figure 2

Nephrops : Female sexual maturity
Maturity ogive : Haul 56

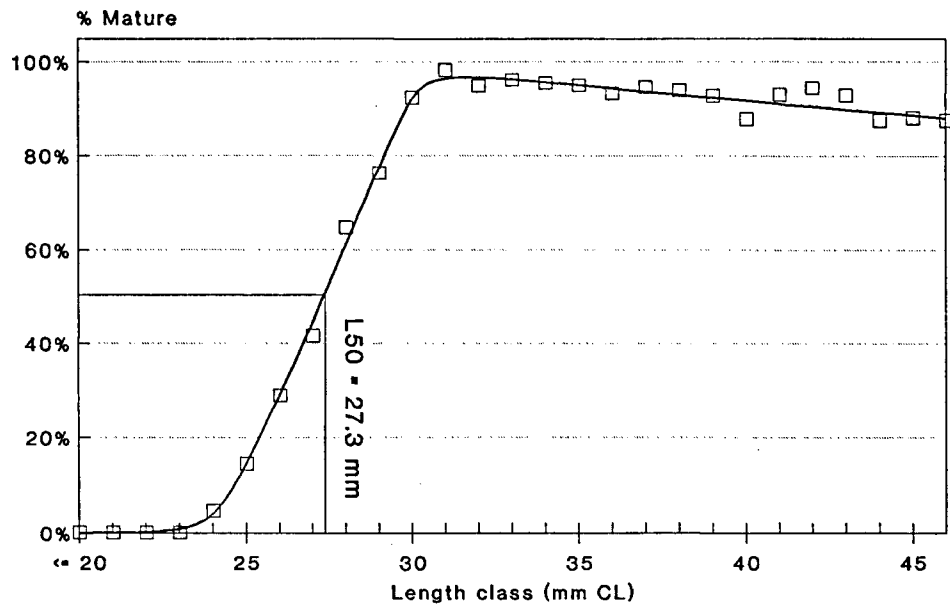


Figure 3

Nephrops : Female sexual maturity
Maturity ogive : Haul 60

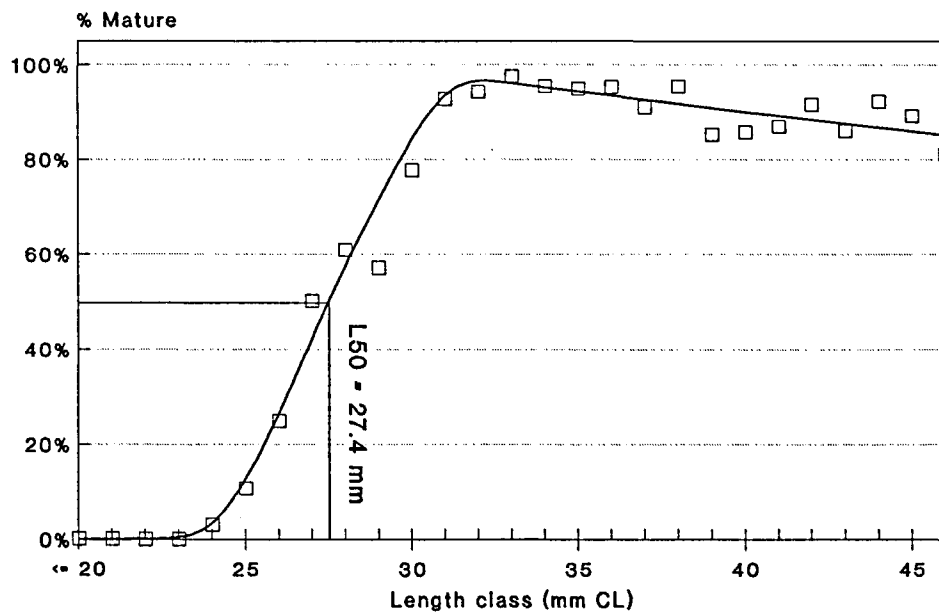


Figure 4

Nephrops : Reproduction cycle
Monthly percentages of ovigerous females

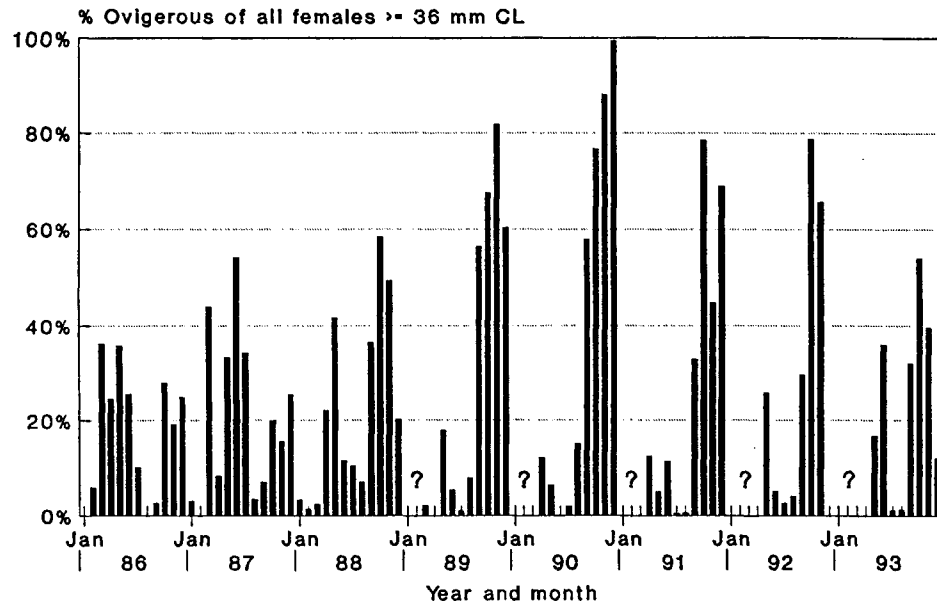


Figure 5