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Biological characteristics of Atlantic mackerel (*Scomber scombrus* L.) sampled along the Canadian coast between 1983 and 1991

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BIOLOGICAL CHARACTERISTICS OF ATLANTIC MACKEREL (*SCOMBER SCOMBRUS L.*) SAMPLED ALONG THE CANADIAN COAST BETWEEN 1983 AND 1991

by

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ABSTRACT

Data gathered by the program to sample commercial mackerel catches are used to assess the status of this resource. These data are also analysed to improve our understanding of the dynamics of this species. During the sampling period, it was noted that the 1982 year-class was dominant in almost all samples. This year-class is characterized by a greater number of males and by smaller growth. Annual variations in some biological parameters are linked to the presence and development of this strong year-class. Results presented here may be used in more theoretical studies on the biology of this species.

RÉSUMÉ

Les données recueillies dans le cadre du programme d'échantillonnage des captures commerciales de maquereau sont utilisées dans le processus d'évaluation de l'état de cette ressource. Ces données sont aussi analysées dans le but d'améliorer nos connaissances sur la dynamique de cette espèce. Lors de la période d'échantillonnage, il s'est avéré que la classe d'âge de 1982 était dominante dans presque tous les échantillons. Cette classe se caractérise par un plus grand nombre de mâles et par une croissance plus faible. Les variations annuelles de certains paramètres biologiques sont reliées à la présence et à l'évolution de cette forte classe d'âge. Les résultats qui sont présentés ici pourront être utilisés dans le cadre d'études plus théoriques sur la biologie de cette espèce.

INTRODUCTION

Assessing the abundance of a resource is one of the fundamental phases of managing a fishery. The assessment involves not only quantifying a biomass but also predicting the reactions of this biomass to different management options (Hilborn and Walters 1992). Since it is not possible to determine the size of an entire stock, a representative sample must be taken. Under ICNAF, member countries were responsible for taking their own samples. Catch sampling techniques and frequency thus varied from one country to another. Sampling protocols were standardized in 1974; however, since the extension of its jurisdiction over fisheries in 1977, the frequency and quality of sampling by Canada have increased considerably (Stevenson 1983). A large number of species, including Atlantic Mackerel (*Scomber scombrus L.*), are now included in a vast sampling program along Canada's coasts.

Such a large-scale program is justified by the fact that data from the sampling of commercial catches may be used as base calculations for making assessments of abundance. These data are used for example in analyses of catches at age using the methods of Paloheimo or Doubleday (Hilborn and Walters 1992), of virtual populations (Gulland 1965; Pope 1972) or those based on the decrease in abundance such as the methods proposed by Leslie or DeLury (Ricker 1975). For mackerel, the main data taken from samples are fork length, weight, gonad weight and maturity stage, sex and age. Annual weight-length relationships are used to determine the weight of fish samples measured. Age is used to determine growth, age structure and the construction of age-length keys to be used to convert length frequency distributions to age frequency distributions. In mackerel, these frequencies are not currently being used in analyses of virtual populations due to the low fishing mortality rate and the lack of a valid index of stock size (Grégoire 1992a). Assessment of the mackerel in the Gulf of St Lawrence is done by the total egg production method (Grégoire 1992b). This method requires knowledge of the weight of gonads and of females ready to release eggs.

This study analyses biological data collected between 1983 and 1991 by the sampling program for commercial catches of mackerel. The main objective is to update these data and observe annual variations. The main results presented here may be used as the basis for future studies on more theoretical aspects of the biology of this species.

MATERIALS AND METHODS

Mackerel were sampled at the wharf in the main landing ports. Sampling frequency depended on the intensity of fishing activity. The sampling protocol currently used requires that, if possible, a maximum of 250 fish chosen at random be measured to the nearest 0.5 cm. Of this number, two fish per 0.5 cm class were taken for laboratory analyses. Tables 1 and 2 show for each year the number of fish sampled per month, by Northwest Atlantic Fisheries Organization (NAFO) division (Figure 1) and subdivision. The number of fish caught and measured has decreased in recent years. This phenomenon is more pronounced in some areas, such as the Scotian Shelf for example, and requests have recently been presented for corrections to the sampling effort (Grégoire 1991, 1992b).

Age was determined by sagitta (otolith) readings, the use of which has been validated in mackerel (Steven 1952; MacKay 1967). Although the true birth date falls towards the end of June, it is considered by convention that this date is January 1. Thus, a fish born in a given year will be classified in Age Group One on the following January 1. For mackerel, it is relatively simple to determine age before age 12. Subsequently, readings become more difficult due to the curve of the margin and the narrowness of layers deposited. Poor calcification at the margin is also responsible for a decrease in the contrast observed between the hyaline and opaque layers (Dery 1988). Readings were taken at more than one location around the otolith to avoid considering growth anomalies as true annuli. Particular attention was paid to the rostrum since the spacing between the hyaline zones is greatest there. Delayed deposit was seen in fish from the age of three or four. A delay was also observed in fish of all ages from the east coast of Newfoundland.

Otolith readings were also used to obtain information on life-span and variations in recruitment, as well as on growth, which was estimated using the von Bertalanffy model (Ricker 1975) for length and weight at age. The parameters of the model were defined using the SAS NLIN procedure (SAS/STAT 1990), which uses the DUD iteration method. The growth model was calculated using all data and the Fisher test (Zar 1974) was used on residues to determine whether there were any differences in growth between males and females. The instantaneous growth rate for the 1982 to 1986 year-classes was calculated on the basis of linear relationships between the weight and age logarithms. These classes were chosen because of the presence of the earlier age groups for which growth is rapid and the desire to make calculations using at least five values to prevent biased results. A year-class is defined here as the birth year of a fish and is calculated as being the year of capture less the age of the fish. The mean lengths and weights for each age group were compared on an annual basis and between the dominant year-classes by a variance analysis (Kirk 1982). The instantaneous growth rate and the proportions of immature fish by age and by length class were calculated and compared between the most recent classes. Weight-length relationships were calculated and expressed logarithmically for each year. Equality of slopes and ordinates at the origin of relationships were compared (Zar 1974) with a view to checking whether it was possible to use only one relationship for all data.

Sex was determined by visual examination of gonads, since sex in mackerel cannot be determined, as in some species, on the basis of external morphological criteria. Once each specimen was thawed, the gonads were carefully removed and weighed. Equality in the sex ratio was checked for each age group with a chi-square test (Zar 1974). Fish over 12 years old were not included in these analyses due to uncertainty related to age determination. The hypothesis that each age group came from the same statistical population was verified by the chi-square heterogeneity test (Zar 1974).

The degree of gonad maturity was established on the basis of criteria proposed by Parrish and Saville (1965) for herring *(Clupea harengus harengus L.)*. These criteria were adapted for mackerel and eight stages established. The fifth corresponded to fish about to release eggs. It is at this stage that gonads reach their maximum size. The colour and relative size of male and female gonads in the abdominal cavity as well as the form, colour and size of ovules were the main criteria used to determine sexual maturity.

The mean values calculated for length and weight of fish, weight of gonads and the gonado-somatic index are presented for each stage of maturity. The purpose of this is to describe the variation patterns in these variables and determine which might enable us to best describe each stage of maturity without using the Parrish and Saville (1965) scale. The gonado-somatic index is also used to describe spawning seasons. Size at maturity as well as the degree of maturation between males and females were calculated for NAFO divisions where data is sufficient.

Length frequencies recorded annually were first sorted by month in order to present possible variations in size linked to seasonal migration of mackerel. Frequencies were also classified by type of gear (net, fixed or trap, line and seine) to describe and compare the main sizes caught by each.

RESULTS

SEX RATIO AND AGE STRUCTURE

The hypothesis of equality in the sex ratio was rejected on several occasions for some age groups (Table 3). In most cases, these groups were from the 1982 year-class when a larger number of males were observed. The presence of these significant differences in the sex ratio did not justify the use of the chi-square heterogeneity test. For other age groups where the equality hypothesis was rejected, there were almost as many cases where each of the sexes dominates alternately.

Age distributions of samples analysed in the laboratory were characterized by the dominance of the 1982 year-class (Figure 2). This class became the largest in the fishery from the age of two on. Despite the presence of other major classes, those of 1987 and 1988, the 1982 year-class was still the dominant year-class in samples in 1991. The presence and development over the years of these major classes also enabled us to compare and validate age readings. For example in 1986, summer growth in the 1982 class, then in Age Group 4, was very slow. The corresponding opaque zone, i.e. the fifth since birth, was almost invisible. A similar phenomenon was observed by MacKay (1979) for the 1959 year-class. Detection of this anomaly was only possible through annual monitoring, which would have led to an underestimation of true age and biasing of growth estimates.

Several modes were found in the size structure of fish aged in the laboratory, each of which corresponded to a year-class (Figure 3). When one class dominates significantly, like that of 1982 between 1985 and 1988, only one main mode was observed. Conversely, a multimodal distribution reflected the presence of several year-classes. Overlapping of modes encountered towards the end of distributions was due to a decline in growth encountered in older fish.

LENGTH AND WEIGHT AT AGE

Growth in mackerel, expressed in terms of length or weight at age, was very rapid during the early years (Figures 4 to 9). Towards age four, an annual difference in size was observed between males and females. In all cases, females had a length and weight at age significantly greater than males (Fisher Test, $P < 0.0001$). Brody growth coefficients calculated for both sexes decreased gradually between 1983 and 1988 (Tables 4 and 5). During this period, the 1982 year-class was increasingly found in both the fishery and in samples. These variations in values of Brody coefficients resulted in a decrease and an increase in the curve of corresponding growth relationships (Figures 5, 6, 8 and 9). The higher the Brody coefficient, the faster the decrease in the exponential growth which appeared at a certain point. In other words, this coefficient does not necessarily give an adequate indication of true growth. Moreover, since the growth relationships expressed by the von Bertalanffy model varied widely from year to year, a single model for each sex based on all data would not be appropriate, and growth in the population should be expressed using the most recent model.

Lengths and weights at age showed significant annual differences (Figures 10 and 11). No particular pattern was observed in annual changes in mean length at age. However, for certain years, a decrease then an increase were observed in mean weight at age for age groups 4 to 6. The lowest mean weight values for these ages were always found in the 1982 year-class.

WEIGHT/LENGTH RELATIONSHIPS

Annual weight-length relationships lined up exponentially (Figure 12). A logarithmic transformation was used to express these relationships, for males and females, using a linear regression (Table 6). The relationships were all significant ($P < 0.0001$) and in most cases, there was no difference between the two sexes in weight changes based on length (Table 6). There is thus no justification for making a distinction between the two sexes when calculating ratios. The slopes of annual relationships, males and females combined, were all significantly different ($F= 143.77$, $P < 0.0001$) (Figure 13). The weight of samples taken at the wharf can thus not be calculated based on a relationship including data for all years. By convention, the weight of samples for a given year should be calculated based on the previous year's ratio then adjusted once the biological data for the current year were analysed. The relationship must accordingly be calculated annually.

During this study, visual examination of weight-length relationships enabled us to detect any major errors made in base files when collecting or entering data.

MATURITY AND WEIGHT OF GONADS

The mean length by stage of maturity increased rapidly from the first stage to Stage 3 and then stabilized (Figure 14). This pattern, which is similar from one year to another, is linked to the rapid growth in the early years. Although there were not enough Stage 1 fish to draw conclusions, the size of immature Stage 2 fish in 1983 was larger than 300 mm. For subsequent years, it was around 250 mm, rising in 1991 to a value greater than 300 mm. A similar change was also observed in the case of mean weight (Figure 15). Thus at the time when the 1982 year-class was dominant, the size and weight of immature fish were smaller.

The mean weight of male and female gonads increased from Stage 1 to Stage 5 (Figures 16 and 17). It subsequently decreased because of the onset of spawning. Variances in mean values were higher for Stages 4 to 6. As opposed to the earlier stages, these variances were due to the presence of fish with a wider range of sizes. These high variances may also have been due to a difference in the length of each stage and possibly to errors in classification. Variances were much narrower in the case of the gonado-somatic index (Figures 18 and 19). The profile of variations in the index could be used to confirm the degree of maturity of a gonad.

At the beginning of each sampling season, values of the gonado-somatic index in males and females were greater than 10% (Figures 20 and 21). These values, which corresponded to Maturity Stage 5 (Figures 18 and 19), then decreased rapidly. This decrease in the index was due to the onset of spawning activities and variations observed may have corresponded to regional differences in spawning schedules. Spawning was basically over by Day 210, i.e. July 29, and the value of the index remained low until the end of the sampling season. Sampling carried out towards the end of the winter along the American coast and in early spring south of Nova Scotia might enable us to complete the ascending part of the cycle.

The profile of daily changes in the gonado-somatic index in 1983 was very different from that of other years (Figures 20 and 21). An attentive examination of the data base for 1983 enabled us to detect errors in the weight of gonads of fish sampled in Divisions 3K and 3L on the east coast of Newfoundland. The profile of values of the gonado-somatic index calculated using these data suggest a delay or cessation in the spawning process. This seems to be indicated by the high, stable values observed in the index towards the end of the season. Even though fish may be found late in the season with gonads of a certain size, as in the Magdalen Islands in September 1992 (Carole Turbide, pers. comm.), it would be unwise to suggest that such a striking delay in spawning really occurred in 1983.

In Stage 5 fish, i.e. those ready to spawn, it was often found that the median size of males was smaller than that of females (Figure 22). This was observed in 1983, 1984, 1987, 1988, 1989 and 1990 and is also in line with differences observed during these same years in growth between males and females.

The median length of Stage 5 male and female gonads decreased gradually from 1983 to 1988, i.e. during the passage of the 1982 year-class, increased until 1990 and then decreased once again in 1991 with the arrival of another probably significant class, that of 1988. In addition, the small number of observations made it impossible to present adequate conclusions on the speed of maturation between the sexes (Figures 23, 24 and 25).

PRELIMINARY DESCRIPTION OF YEAR-CLASSES

In the samples taken between 1983 and 1991, it was possible to find fish from year-classes as old as those of 1966 and 1967, that is, fish aged 16 and 17 at the time they were caught. The representativeness of these older year-classes was often biased because it has proved difficult to determine the age of fish older than 12 years. Since the first samples dated from 1983, year-old fish taken during this year were from the 1982 year-class (Tables 7 and 8).

Mean lengths at age (Table 7) and mean weights at age (Table 8) were, in most cases, significatively different from one year-class to another. With the exception of ages four and five, no trend in the profile of mean length variations was observed. In the case of these last two age groups, mean length decreased to the 1982 class and then increased. This profile is more pronounced in the case of mean weight at age. For Age Group 4, mean weight by class decreased from the 1979 year-class to that of 1982. It then increased until the 1986 class and declined again for that of 1987. For Age Group 5, mean weight decreased from the 1978 year-class to that of 1982 and then increased to the 1986 year-class. These variations between year-classes explain the variations in weight or length already observed in figures 10 and 11. In fact, the same fish were compared on the basis of year of capture or year-class.

Variations in length or weight of the main year-classes in a given year fluctuated widely (Figures 26 and 27). A decrease in length or weight could even be observed in the course of a year. The sampling may be responsible for this. It was carried out at the same time and at different locations and at the same location at different times. For example, a reduction in weight might be due to a reduction in the weight of gonads at spawning. Moreover, samples were taken from catches using different types of gear each with its own particular selectivity.

The linear relationships between logarithms of weight and age were all significant ($P < 0.001$). Instantaneous growth rates, i.e. the slopes of each linear relationship, increased from the 1982 year-class to that of 1986 (Figure 28). Growth rates were almost significantly different from one another ($F= 2.55$, $P < 0.0642$). The covariance analysis was also significant ($F= 2.81$, $P < 0.0435$). The number of observations decreased from one class to another and growth rates could again be compared with the addition of new annual values. Other growth models could also be used.

The mean lengths and weights of mature fish (Stage 5) in certain age groups were, in the case of 1982 year-class, smaller compared to the 1980, 1981, and 1983 to 1989 classes (Table 9). In all these classes, there does not appear to be a relationship between the proportion of immature or mature fish and age (Table 10). Conversely, it would appear that there is a relationship between the proportion of immature and size (Shaded areas, Table 11). For the 1982 year-class, the degree of maturity was more advanced in the smaller size fish.

LENGTH FREQUENCIES

Annual length frequency distributions recorded since 1984 show two different patterns. The first, found in 1984, 1990 and 1991 was characterized by multimodal distribution (Figure 29). The second pattern, found in other years, instead showed a unimodal distribution. Based on the characteristics observed in Figure 3, the form of length frequency distributions appears to be caused by the presence of one or more relatively dominant year-classes.

From May to June, there is a movement of the main modes towards smaller sizes (Figures 30 to 37). This observation, which was more pronounced in some years than in others, was noted by Hunt (1975) and MacKay (1979). Larger fish are thus caught early and late in the season. This may be due to the fact that mackerel movements are linked to size. The larger fish enter the Gulf first in the spring and leave it last in the fall.

Length frequency distributions, once classified by type of gear, were also characterized by the presence of one or more modes (Figure 38). When the distribution of frequencies for a given year showed only one mode, for example, the distributions encountered for each type of gear for this year showed a unimodal aspect. However, nets caught more larger fish. When there was more than one major mode, certain categories of gear such as fixed gear and lines caught smaller fish than others. The selectivity of fishing gear is also linked to different fishing activities and the migratory aspect of mackerel. For example, purse seines are used in the fall on the west coast of Newfoundland. At that time of year, this region is mainly characterized by the presence of large fish en route to the outer Gulf. The sizes found will not be representative of the range of sizes that can be caught with this type of gear.

DISCUSSION

The Atlantic Mackerel population in the Gulf of St Lawrence is characterized by the more or less regular appearance of a dominant year-class (1959, 1967, 1974, 1982). The strength of such a class may persist over several years. For example, that of 1959 was still being felt in 1973 (MacKay 1979). Dominance is such that the class may alone represent the majority of commercial catches over a certain number of years (Grégoire 1992b). What is observed annually in the population is closely related to the presence of such a class. During this study, it was found that variations in the sex ratio, mean length and mean weight at age, length frequency distributions and the selectivity of fishing gear were closely related to the presence and development of the 1982 year-class. Fish of this class showed lower growth at age. This observation was also noted by Overholtz (1989) for samples taken during research cruises, sport and commercial fishing (Polish) along the U.S. coast. The decline in growth was also seen in otoliths. The radius of the first annulus calculated for a certain number of otoliths from this class shows a smaller mean value than that calculated for other classes (F. Grégoire, unpublished data).

Maturity of a dominant year-class should be delayed because of the decline in growth. For example, the first fish in the 1959 year-class to mature did so only when they were three years old. Moreover, it was only at age five that all fish in this year-class and that of 1967 were mature (MacKay 1979). A relationship between density, growth and maturity was observed by Agnalt (1989) for North Sea mackerel. An increase in growth, together with an increase in fishing effort due to the arrival of modern seiners and a reduction in the biomass were responsible for this decrease in age at maturity. Length at maturity nevertheless remained the same. Maturity thus appears to be independent of age but dependent on size. The present data yield no such clear conclusions on the relationship between the age, growth and maturity of the 1982 year-class. The classes that preceded were represented only by older age groups, and it is impossible to assign them a median age or median size at maturity. For year-classes after 1982, the number of age groups decreased from one class to another and it is then difficult to make comparisons. Maturity could even be determined by a complex interaction between size and age. This study of maturity could be supplemented by the addition and analysis of new data from the annual sampling program.

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REFERENCES

Agnalt, A.-L. 1989. Long-term changes in growth and age at maturity of mackerel, *Scomber scombrus L.*, from the North Sea. J.Fish Biol. 35:305-311.

Dery, L.M. 1988. Atlantic mackerel (*Scomber scombrus L.*). in: J. Penttila and L.M. Dery (eds.), Age determination methods for Northwest Atlantic species, p 77-84. U.S. Dep. Commer. NOAA. Technical Report NMFS 72.

Grégoire, F. 1991. Analyse des captures de maquereaux bleus (*Scomber scombrus L.*) en 1990 pour les sous-régions 2 à 6 de l'OPANO et présentation de certaines caractéristiques biologiques. CAFSAC Research Document 91/78.

Grégoire, F. 1992a. Cycle de ponte, développement des ovocytes et résultats préliminaires concernant la fécondité en lots chez le maquereau (*Scomber scombrus L.*) du nord-ouest de l'Atlantique. CAFSAC Research Document 92/57.

Grégoire, F. 1992b. Suivi des captures de maquereau bleu (*Scomber scombrus L.*) en 1991 pour les sous-régions 2 à 6 de l'OPANO et évaluation de la biomasse reproductrice du golfe du St-Laurent. CAFSAC Research Document 92/53.

Gulland, J.A. 1965. Estimation of mortality rates. Annex to Arctic Fisheries Working Group Report. (ICES, C.M. 1965. Doc. No. 3. mimeographed).

Hilborn, R. and C.J. Walters. 1992. Quantitative fisheries stock assessment: Choice, Dynamics and Uncertainty. Chapman and Hall, Inc. New York. 570 p.

Hunt, J.J. 1975. Canadian mackerel catches (m.t.) and numbers at age in Subarea 4 for 1974. ICNAF Res. Doc. 75/92.

Kirk, R.E. 1982. Experimental Design: Procedures for the behavioral sciences. Brooks/Cole publishing Company. 911 p.

MacKay, K.T. 1967. An ecological study of mackerel *Scomber scombrus* (Linnaeus) in the coastal waters of Canada. Fish. Res. Board Can. Tech. Rep. 31, 127 p.

MacKay, K.T. 1979. Synopsis of biological data of the northern population of Atlantic mackerel (*Scomber scombrus*). Tech. Rep. Can. Fish. Mar. Ser., 885, 26 p.

Overholtz, W.J. 1989. Density-dependent growth in the northwest Atlantic stock of Atlantic mackerel (*Scomber scombrus*). J. Northw. Atl. Fish. Sci. Vol. 9: 115-121.

Parrish, B.B., and A. Saville. 1965. The biology of the northeast Atlantic herring populations. Oceanogr. Mar. Biol. Ann. Rev. 3.

Pope, J.G. 1972. An investigation of the accuracy of virtual population analysis using cohort analysis. Int. Comm. Northwest Atl. Fish. Res. Bull. 9: 65-74.

Ricker, W.E. 1975. Computation and interpretation of biological statistics of fish populations. Fish. Res. Board Can. Bull. No. 191.

SAS/STAT User's Guide. 1990. Version 6, Fourth Edition, Volume 2. SAS Institute Inc., Cary, NC, USA.

Steven, G.A. 1952. Contributions to the biology of the mackerel *Scomber scombrus* L. III. Age and growth. J. Mar. Biol. Assoc. U.K. 30:549-568.

Stevenson, S.C. 1983. A review of the sampling of commercial groundfish catches in Newfoundland, pp. 29-38. in: W.G. Doubleday and/et D. Rivard [ed./éd.] Sampling commercial catches of marine fish and invertebrates/L'Échantillonnage des prises commerciales de poissons et d'invertébrés marins. Can. Spec. Publ. Fish. Aquat. Sci./Publ. spéc. can. sci. halieut. aquat. 66.

Zar, J.H. Biostatistical analysis. 1974. Prentice-Hall, INC., Englewood Cliffs, N.J. 620 p.

TABLE 1. Number of mackerel sampled in the various NAFO divisions and subdivisions, 1983-1991.

DIVISION OR SUBDIVISION	YEAR									
	1983	1984	1985	1986	1987	1988	1989	1990	1991	Total
3K	481	1173	1018	1268	536	629	554	303	169	6131
3L	1438	374	680	644	367	290	556	212	95	4656
3Ps	192	81	50	184	101	158	109	56	145	1076
	2111	1628	1748	2096	1004	1077	1219	571	409	11863
4R	46	0	0	0	0	0	0	0	0	46
4Rb	0	0	22	0	86	60	90	119	265	642
4Rc	816	356	80	106	498	221	239	287	344	2947
	862	356	102	106	584	201	329	406	609	3635
4S	0	0	0	38	0	0	0	0	0	38
	0	0	0	38	0	0	0	0	0	38
4T	394	0	0	0	0	0	0	0	0	394
4Tf	0	823	772	619	383	468	640	673	452	4830
4Tg	98	847	446	259	355	0	133	75	40	2253
4Th	0	92	61	34	100	0	0	0	0	287
4Tj	0	0	231	0	0	0	0	0	0	231
4Tl	237	88	0	72	0	165	294	164	53	1073
4Tm	59	409	256	273	253	189	239	263	236	2177
4Tn	0	136	98	71	106	37	59	0	197	704
	788	2395	1864	1328	1197	859	1365	1175	978	11949
4VNA	46	155	0	0	50	101	145	158	0	655
	46	155	0	0	50	101	145	158	0	655
4Wd	172	67	0	0	216	26	66	23	0	570
	172	67	0	0	216	26	66	23	0	570
4Xm	150	63	95	0	68	0	251	0	0	627
4Xo	61	115	133	0	0	0	0	0	0	309
4Xq	0	0	28	0	0	0	0	0	0	28
4Xr	0	0	33	0	0	0	0	0	0	33
	211	178	289	0	68	0	251	0	0	997
TOTAL	4190	4779	4003	3568	3119	2344	3375	2333	2133[1]	29844

[1] 137 fish without the identification of the division or subdivision.

TABLE 2. Number of mackerel sampled monthly in the various NAFO divisions and subdivisions, 1983-1991.

Year	Division or Sub-division	MONTH								
		May	June	July	August	September	October	November	December	Total
83	3K					230	201	50		481
	3L			50	130	306	878	48	26	1438
	3Ps				122	30	40			192
	4R			46						46
	4Rc					816				816
	4T		141	253						394
	4Tg			38			60			98
	4Tl				237					237
	4Tm				40	19				59
	4VNA		46							46
	4Wd	45			91	36				172
	4Xm	23	42		33	52				150
	4Xo	26	35							61
		94	264	387	653	1489	1179	98	26	4190
84	3K		323	27	79	353	391			1173
	3L			30	34	152	158			374
	3Ps				47			34		81
	4Rc					308	48			356
	4Tf	22		283	178	230	110			823
	4Tg		51	80	436	224	56			847
	4Th		45	47						92
	4Tl		88							88
	4Tm		328		34	47				409
	4Tn			48	31	57				136
	4VNA	27				128				155
	4Wd	31			36					67
	4Xm	28			35					63
	4Xo	43	41		31					115
		151	876	515	941	1499	763	34		4779

TABLE 2. (cont'd).

Year	Division or Sub-division	May	June	July	August	September	October	November	December	Total
85	3K			110	189	270	126	323		1018
	3L				155	132	152	170	71	680
	3Ps				50					50
	4Rb				22					22
	4Rc			56	24					80
	4Tf	35	52	117	425	143				772
	4Tg		47	73		241	85			446
	4Th		61							61
	4Tj		112	100	19					231
	4Tm		192	64						256
	4Tn		47	51						98
	4Xm	38		26	31					95
	4Xo	25	108							133
	4Xq			28						28
	4Xr				33					33
		98	619	625	948	786	363	493	71	4003
86	3K			39	188	528	384	47	82	1268
	3L			50	190	183	110	111		644
	3Ps			34	49	55		46		184
	4Rc				106					106
	4S					38				38
	4Tf	43	66		206	304				619
	4Tg		33	50	176					259
	4Th			34						34
	4Tl		72							72
	4Tm		152	121						273
	4Tn		30	41						71
		43	353	369	915	1108	494	204	82	3568

TABLE 2. (cont'd).

Year	Division or Sub-division	May	June	July	August	September	October	November	December	Total
		MONTH								
87	3K			40	105	176	215			536
	3L			54	154	110	49			367
	3Ps					101				101
	4Rb					86				86
	4Rc			164	190	108	36			498
	4Tf		115	48	118	67	35			383
	4Tg		18	97	152		88			355
	4Th		64			36				100
	4Tm		165	65		23				253
	4Tn		28		52	26				106
	4VNA				50					50
	4Wd	79	81		56					216
	4Xm				68					68
		79	471	468	945	733	423			3119
88	3K			56	267	148	98	60		629
	3L				29	153	54	54		290
	3Ps				54	81	23			158
	4Rb					60				60
	4Rc				160	27	34			221
	4Tf	29	101	39	172	127				468
	4Tl		165							165
	4Tm		189							189
	4Tn		37							37
	4VNA	29	26		25	21				101
	4Wd		26							26
		58	544	95	707	617	209	114		2344

TABLE 2. (cont'd).

Year	Division or Sub-division	MONTH								
		May	June	July	August	September	October	November	December	Total
89	3K			50	152	142	210			554
	3L		50	138	45	104	169			556[1]
	3Ps				60	49				109
	4Rb					90				90
	4Rc			58	40		141			239
	4Tf	33	91		336	180				640
	4Tg		37	50		46				133
	4Tl	69	133	92						294
	4Tm		133	25	34	47				239
	4Tn		26		33					59
	4VNA					95	50			145
	4Wd			35	31					66
	4Xm			29	172					251[1]
		102	470	477	903	753	570			3375
90	3K				48	5	200	50		303
	3L			50		112		50		212
	3Ps			56						56
	4Rb						119			119
	4Rc			146		92	49			287
	4Tf		90	53	294	186	50			673
	4Tg				30	45				75
	4Tl		164							164
	4Tm		156	107						263
	4VNA	44	29		42	43				158
	4Wd	23								23
		67	439	412	414	483	418	100		2333

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[1] 50 fish without the knowledge of the month.

TABLE 2. (cont'd).

Year	Division or Sub-division	MONTH								
		May	June	July	August	September	October	November	December	Total
91	3K				69			100		169
	3L						95			95
	3Ps			55	40		50			145
	4Rb						265			265
	4Rc				78	115	151			344
	4Tf		116	50	151	135				452
	4Tg			40						40
	4Tl		53							53
	4Tm		77	40	93	26				236
	4Tn		197							197
	?		26			33	78			137
			469	185	431	309	639	100		2133
TOTAL		692	4505	3533	6857	7777	5058	1143	179	29844

TABLE 3. **Annual number of males and females by age group for mackerel sampled, 1983-1991.**

YEAR	AGE	MALE	FEMALE	CHI-SQUARE	DF	Pr> CHI-SQUARE
83	1	167	137	2.794	1	Pr < 0.10
	2	226	137	22.697	1	Pr < 0.001
	3	229	202	1.575	1	Pr < 0.25
	4	65	71	0.184	1	Pr < 0.75
	5	279	259	0.671	1	Pr < 0.50
	6	30	24	0.468	1	Pr < 0.50
	7	41	51	0.891	1	Pr < 0.50
	8	142	158	0.752	1	Pr < 0.50
	9	395	428	1.246	1	Pr < 0.50
	10	169	209	4.069	1	Pr < 0.05
	11	42	67	5.578	1	Pr < 0.025
	12	20	31	2.056	1	Pr < 0.25
Total of Chi-Squares				42.981	12	Pr < 0.001
Pooled Chi-Square		1805	1774	0.252	1	
Heterogeneity C.-S.				42.729	11	Pr < 0.001
84	1	3	6	0.500	1	Pr < 0.50
	2	772	695	3.948	1	Pr < 0.05
	3	720	699	0.282	1	Pr < 0.75
	4	110	94	1.109	1	Pr < 0.50
	5	38	39	0	1	Pr < 0.999
	6	94	98	0.047	1	Pr < 0.90
	7	14	15	0	1	Pr < 0.999
	8	20	17	0.109	1	Pr < 0.75
	9	83	87	0.053	1	Pr < 0.90
	10	151	171	1.126	1	Pr < 0.50
	11	72	73	0	1	Pr < 0.999
	12	7	12	0.904	1	Pr < 0.50
Total of Chi-Squares				8.078	12	Pr < 0.90
Pooled Chi-Square		2084	2006	1.450	1	
Heterogeneity C.-S.				6.628	11	Pr < 0.90

TABLE 3. (cont'd).

YEAR	AGE	MALE	FEMALE	CHI-SQUARE	DF	Pr> CHI-SQUARE
85	1	81	67	1.153	1	Pr < 0.25
	2	27	19	1.099	1	Pr < 0.50
	3	1122	889	27.129	1	Pr < 0.001
	4	372	424	3.282	1	Pr < 0.10
	5	33	39	0.349	1	Pr < 0.75
	6	13	14	0	1	Pr < 0.999
	7	49	63	1.533	1	Pr < 0.25
	8	8	8	0.063	1	Pr < 0.90
	9	15	12	0.150	1	Pr < 0.75
	10	43	33	1.085	1	Pr < 0.50
	11	55	60	0.140	1	Pr < 0.75
	12	20	30	1.688	1	Pr < 0.25
Total of Chi-Squares				37.671	12	Pr < 0.001
Pooled Chi-Square		1838	1658	9.189	1	
Heterogeneity C.-S.				28.482	11	Pr < 0.005
86	1	23	19	0.216	1	Pr < 0.75
	2	125	86	7.086	1	Pr < 0.01
	3	109	83	3.316	1	Pr < 0.10
	4	1021	746	43.543	1	Pr < 0.001
	5	274	235	2.854	1	Pr < 0.10
	6	21	20	0	1	Pr < 0.999
	7	13	11	0.042	1	Pr < 0.90
	8	18	19	0	1	Pr < 0.999
	9	4	4	0.125	1	Pr < 0.75
	10	11	8	0.216	1	Pr < 0.75
	11	15	18	0.123	1	Pr < 0.75
	12	17	17	0.029	1	Pr < 0.90
Total of Chi-Squares				57.550	12	Pr < 0.001
Pooled Chi-Square		1651	1266	51.446	1	
Heterogeneity C.-S.				6.104	11	Pr < 0.90

TABLE 3. (cont'd).

YEAR	AGE	MALE	FEMALE	CHI-SQUARE	DF	Pr> CHI-SQUARE
87	1	69	44	5.360	1	Pr < 0.025
	2	130	132	0.004	1	Pr < 0.95
	3	124	100	2.390	1	Pr < 0.25
	4	60	58	0.008	1	Pr < 0.95
	5	659	635	0.409	1	Pr < 0.75
	6	170	147	1.535	1	Pr < 0.25
	7	9	9	0.056	1	Pr < 0.90
	8	8	12	0.469	1	Pr < 0.50
	9	5	9	0.700	1	Pr < 0.50
	10	5	3	0.133	1	Pr < 0.75
	11	8	7	0	1	Pr < 0.999
	12	7	13	1.374	1	Pr < 0.25
Total of Chi-Squares				12.438	12	Pr < 0.50
Pooled Chi-Square		1254	1169	2.916	1	
Heterogeneity C.-S.				9.522	11	Pr < 0.75
88	1	18	2	31.250	1	Pr < 0.001
	2	61	18	31.730	1	Pr < 0.001
	3	43	28	2.890	1	Pr < 0.10
	4	48	42	0.279	1	Pr < 0.75
	5	49	28	5.612	1	Pr < 0.025
	6	671	594	4.583	1	Pr < 0.05
	7	144	150	0.085	1	Pr < 0.90
	8	3	12	6.666	1	Pr < 0.01
	9	6	8	0.073	1	Pr < 0.90
	10	14	11	0.162	1	Pr < 0.75
	11	5	8	0.325	1	Pr < 0.75
	12	4	7	0.393	1	Pr < 0.75
Total of Chi-Squares				84.048	12	Pr < 0.001
Pooled Chi-Square		1066	908	12.568	1	
Heterogeneity C.-S.				71.480	11	Pr < 0.001

TABLE 3. (cont'd).

YEAR	AGE	MALE	FEMALE	CHI-SQUARE	DF	Pr> CHI-SQUARE
89	1	82	75	0.230	1	Pr < 0.75
	2	372	308	5.889	1	Pr < 0.025
	3	125	126	0	1	Pr < 0.999
	4	67	68	0	1	Pr < 0.999
	5	53	43	0.853	1	Pr < 0.50
	6	26	17	1.556	1	Pr < 0.25
	7	629	507	13.038	1	Pr < 0.001
	8	73	79	0.165	1	Pr < 0.75
	9	7	13	1.374	1	Pr < 0.25
	10	5	5	0.10	1	Pr < 0.90
	11	3	6	0.50	1	Pr < 0.50
	12	-	-	-	-	- -
Total of Chi-Squares				23.705	11	Pr < 0.025
Pooled Chi-Square		1442	1247	14.070	1	
Heterogeneity C.-S.				9.635	10	Pr < 0.50
90	1	11	11	0.045	1	Pr < 0.90
	2	125	117	0.203	1	Pr < 0.75
	3	271	249	0.850	1	Pr < 0.50
	4	69	66	0.029	1	Pr < 0.90
	5	39	38	0	1	Pr < 0.999
	6	37	23	2.979	1	Pr < 0.10
	7	15	12	0.150	1	Pr < 0.75
	8	423	358	5.281	1	Pr < 0.025
	9	17	32	4.413	1	Pr < 0.05
	10	-	-	-	-	- -
	11	-	-	-	-	- -
	12	-	-	-	-	- -
Total of Chi-Squares				13.950	9	Pr < 0.25
Pooled Chi-Square		1007	906	5.242	1	
Heterogeneity C.-S.				8.708	8	Pr < 0.50

TABLE 3. (cont'd).

YEAR	AGE	MALE	FEMALE	CHI-SQUARE	DF	Pr> CHI-SQUARE
91	1	37	12	15.892	1	Pr < 0.001
	2	61	42	3.257	1	Pr < 0.10
	3	140	165	1.902	1	Pr < 0.25
	4	199	219	0.866	1	Pr < 0.50
	5	33	49	2.853	1	Pr < 0.10
	6	24	35	1.756	1	Pr < 0.25
	7	32	28	0.150	1	Pr < 0.75
	8	29	23	0.488	1	Pr < 0.50
	9	303	329	0.991	1	Pr < 0.50
	10	10	22	4.40	1	Pr < 0.05
	11	-	-	-	-	- -
	12	3	3	0.166	1	Pr < 0.75
Total of Chi-Squares				32.721	11	Pr < 0.001
Pooled Chi-Square		871	927	1.681	1	
Heterogeneity C.-S.				31.040	10	Pr < 0.001

TABLE 4. **Annual growth parameters for length at age (von Bertalanffy model) of male and female mackerel sampled, 1983-1991.**

YEAR	SEXE MALE		FEMALE	
	Parameter	**Std. Error**	**Parameter**	**Std. Error**
1983	$L\infty$ = 402.9843 K = 0.5440 t_o = -0.9697	0.5633 0.0099 0.0421	$L\infty$ = 410.2206 K = 0.5215 t_o = -1.0313	0.5225 0.0094 0.0437
1984	$L\infty$ = 408.1137 K = 0.4311 t_o = -1.1792	1.0460 0.0116 0.0804	$L\infty$ = 416.1333 K = 0.4158 t_o = -1.1612	1.0821 0.0110 0.0791
1985	$L\infty$ = 421.8304 K = 0.2855 t_o = -2.2204	2.0855 0.0085 0.1069	$L\infty$ = 426.4489 K = 0.2933 t_o = -2.0212	1.9857 0.0084 0.1009
1986	$L\infty$ = 426.2365 K = 0.2109 t_o = -3.8354	4.3080 0.0115 0.2392	$L\infty$ = 445.4948 K = 0.1941 t_o = -3.7723	4.1699 0.0093 0.2162
1987	$L\infty$ = 454.5346 K = 0.1487 t_o = -5.3278	8.1596 0.0107 0.3119	$L\infty$ = 459.1206 K = 0.1499 t_o = -5.2614	7.2233 0.0098 0.2960
1988	$L\infty$ = 459.8759 K = 0.1301 t_o = -6.7090	11.4371 0.0142 0.5927	$L\infty$ = 476.8843 K = 0.1048 t_o = -8.8159	13.8983 0.0148 1.0734
1989	$L\infty$ = 385.6357 K = 0.4954 t_o = -1.2755	1.1001 0.0188 0.0999	$L\infty$ = 394.2558 K = 0.4739 t_o = -1.2061	1.3468 0.0189 0.1026
1990	$L\infty$ = 398.2361 K = 0.3758 t_o = -2.0036	2.0546 0.0251 0.2474	$L\infty$ = 409.8929 K = 0.3335 t_o = -2.2235	2.5983 0.0230 0.2618
1991	$L\infty$ = 409.8751 K = 0.2798 t_o = -3.0787	2.2054 0.0146 0.2271	$L\infty$ = 417.9615 K = 0.2718 t_o = -3.0233	2.5143 0.0165 0.2830

TABLE 5. Annual growth parameters for weight at age (von Bertalanffy model) of male and female mackerel sampled, 1983-1991.

YEAR	SEXE MALE		SEXE FEMALE	
	Parameter	Std. Error	Parameter	Std. Error
1983	L∞ = 829.4225 K = 0.3601 t_o = 0.2204	5.3581 0.0110 0.0429	L∞ = 875.9432 K = 0.3582 t_o = 0.2274	4.9741 0.0104 0.0430
1984	L∞ = 802.3183 K = 0.3519 t_o = 0.5826	5.8497 0.0109 0.0433	L∞ = 879.7313 K = 0.3146 t_o = 0.5665	6.9443 0.0101 0.0450
1985	L∞ = 955.7709 K = 0.1856 t_o = 0.1661	17.1800 0.0083 0.0701	L∞ =1013.0967 K = 0.1773 t_o = 0.1830	19.5325 0.0083 0.0752
1986	L∞ =1045.3115 K = 0.1258 t_o = -0.5554	46.3604 0.0110 0.1467	L∞ =1164.2966 K = 0.1172 t_o = -0.3495	51.8831 0.0101 0.1457
1987	L∞ =1415.5697 K = 0.0762 t_o = -1.0902	143.1283 0.0117 0.1753	L∞ =1492.3185 K = 0.0715 t_o = -1.2442	153.7687 0.0114 0.1997
1988	L∞ =1294.8654 K = 0.0865 t_o = -1.5034	- 0.0153 0.1794	L∞ =1339.0388 K = 0.0800 t_o = -2.2109	151.7724 0.0182 0.5958
1989	L∞ = 774.3119 K = 0.2957 t_o = 0.0637	17.4764 0.0244 0.1048	L∞ = 860.0942 K = 0.2602 t_o = 0.1276	22.9661 0.0217 0.1008
1990	L∞ = 762.7261 K = 0.3153 t_o = 0.1914	17.8317 0.0336 0.1819	L∞ = 840.9328 K = 0.2876 t_o = 0.2614	22.0616 0.0301 0.1671
1991	L∞ = 912.0043 K = 0.1642 t_o = -0.6254	38.2335 0.0189 0.2168	L∞ = 846.3706 K = 0.2714 t_o = 0.1144	45.4890 0.0626 0.4766

TABLE 6. Annual linear regression parameters between logarithms (Base 10) of weight and length for male and female mackerel sampled, 1983-1991.

YEAR	SEXE	N	SLOPE	INTERCEPT	R^2	Pr > F
1983	Male	2031	3.3339	-5.7864	0.9608	0.0001
	Female	1979	3.2261	-5.5054	0.9576	0.0001
1984	Male	2329	3.1545	-5.3377	0.9559	0.0001
	Female	2180	3.1981	-5.4442	0.9624	0.0001
1985	Male	1946	3.2694	-5.6377	0.9457	0.0001
	Female	1721	3.2479	-5.5822	0.9485	0.0001
1986	Male	1989	3.3989	-5.9717	0.9295	0.0001
	Female	1504	3.3468	-5.8417	0.9273	0.0001
1987	Male	1602	3.4528	-6.1011	0.9310	0.0001
	Female	1453	3.3758	-5.9066	0.9256	0.0001
1988	Male	1253	3.3571	-5.8440	0.9012	0.0001
	Female	1068	3.2614	-5.5952	0.8557	0.0001
1989	Male	1660	3.4602	-6.1034	0.9491	0.0001
	Female	1394	3.4875	-6.1727	0.9620	0.0001
1990	Male	1192	3.3865	-5.9289	0.9334	0.0001
	Female	1082	3.3628	-5.8633	0.9482	0.0001
1991	Male	933	3.4132	-6.0130	0.9368	0.0001
	Female	963	3.4082	-5.9944	0.9393	0.0001

HOMOGENEITY OF SLOPES			ANALYSIS OF COVARIANCE	
1983	F = 25.31	Pr > F = 0.0001	--------	--------
1984	F = 5.00	Pr > F = 0.0254	--------	--------
1985	F = 0.71	Pr > F = 0.3999	F = 0.85	Pr > F = 0.3567
1986	F = 2.69	Pr > F = 0.1009	F = 4.75	Pr > F = 0.0293
1987	F = 5.01	Pr > F = 0.0252	--------	--------
1988	F = 3.42	Pr > F = 0.0644	F = 2.34	Pr > F = 0.1265
1989	F = 1.02	Pr > F = 0.3135	F = 0.05	Pr > F = 0.8196
1990	F = 0.45	Pr > F = 0.5044	F = 8.94	Pr > F = 0.0028
1991	F = 0.02	Pr > F = 0.9001	F = 9.82	Pr > F = 0.0018

TABLE 7. **Mean length at age for the various year-classes present in mackerel sampled, 1983-1991.**

AGE GROUP

Year-Class		1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17
66	n																	1
	$\bar{x}$																	423.00
	s																	-
67	n																8	5
	$\bar{x}$																419.50	426.00
	s																10.13	8.57
68	n															4	2	
	$\bar{x}$															408.00	425.50	
	s															11.66	43.13	
69	n														7	1	1	
	$\bar{x}$														418.14	399	407	
	s														11.71	-	-	
70	n													15	4			
	$\bar{x}$													421.87	408.75			
	s													12.26	4.50			
71	n												49	13	2			
	$\bar{x}$												414.92	412.62	427.50			
	s												12.76	10.15	10.61			
72	n											108	19	12		1		
	$\bar{x}$											408.07	412.26	416.25		428		
	s											13.63	12.71	6.37		-		

TABLE 7. (cont'd).

AGE GROUP

Year-Class		1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17
73	n										376	143	50	14	1		1	
	$\bar{x}$										406.62	409.01	414.22	420.93	430		417	
	s										11.11	11.11	11.07	15.41	-		-	
74	n									810	320	111	34	11	9	1		
	$\bar{x}$									403.36	406.80	410.77	414.94	419.64	421.67	421		
	s									11.14	12.28	11.70	12.08	11.42	10.39	-		
75	n								296	171	72	32	21	14	6	3		
	$\bar{x}$								403.67	407.36	410.60	415.94	419.19	418.36	418.50	438.67		
	s								12.10	11.27	13.23	12.04	7.75	9.05	42.84	27.54		
76	n							93	37	26	19	15	11	2	1	2		
	$\bar{x}$							403.57	406.05	408.15	401.63	415.40	422.36	443.50	433	435.50		
	s							13.09	12.39	11.91	31.27	7.81	11.25	26.16	-	6.36		
77	n						53	29	16	8	8	13	1		4			
	$\bar{x}$						393.83	395.52	402.63	416.88	417.75	418.31	423.00		439.50			
	s						12.97	8.20	11.99	8.89	8.24	12.55	-		9.40			
78	n					533	189	110	35	14	25	9	3	4				
	$\bar{x}$					388.33	394.66	399.65	406.83	416.36	416.24	424.22	433.67	423.75				
	s					12.00	9.93	12.52	11.19	9.68	8.02	16.57	5.51	10.59				
79	n				136	75	28	24	20	14	10	5	6					
	$\bar{x}$				378.45	388.32	395.21	405.83	408.60	413.14	422.50	423.60	428.50					
	s				17.07	13.93	23.14	11.22	12.38	13.17	12.43	9.71	10.03					

TABLE 7. (cont'd).

AGE GROUP

Year-Class		1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17
80	n			429	201	72	41	18	15	20	3	3						
	x̄			359.89	370.39	373.44	381.63	393.89	403.67	401.35	405	418.33						
	s			15.19	14.48	18.23	19.84	18.38	18.48	26.82	13.23	15.28						
81	n		364	1383	773	508	316	294	148	49	35							
	x̄		323.38	340.00	354.44	361.50	376.15	389.65	394.14	402.51	411.29							
	s		20.46	14.50	16.03	16.32	15.12	13.18	18.40	18.38	16.09							
82	n	370	1506	1981	1751	1294	1264	1108	775	655								
	x̄	265.61	304.62	325.38	343.58	355.94	371.81	379.52	390.94	397.00								
	s	16.82	19.88	16.55	13.74	15.06	14.76	16.42	18.06	17.79								
83	n	28	50	185	116	77	44	27	54									
	x̄	234.46	325.82	342.81	349.71	361.79	381.20	385.74	395.83									
	s	18.62	19.37	13.63	15.27	16.25	14.39	15.77	15.79									
84	n	228	212	223	91	96	60	65										
	x̄	252.86	302.74	329.44	351.20	367.79	379.78	386.11										
	s	17.97	12.55	13.06	12.82	13.63	16.28	16.62										
85	n	51	265	70	135	77	63											
	x̄	254.76	304.57	337.20	355.60	372.66	380.25											
	s	10.94	14.90	12.89	15.60	23.39	12.59											
86	n	127	79	256	133	85												
	x̄	272.53	322.72	345.73	363.14	374.13												
	s	14.16	17.54	15.66	17.09	14.09												

TABLE 7. (cont'd).

AGE GROUP

Year-Class		1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17
87	n	30	722	522	456													
	$\bar{x}$	266.63	307.74	338.17	355.30													
	s	15.40	19.83	20.18	15.31													
88	n	222	256	377														
	$\bar{x}$	254.76	304.18	333.76														
	s	20.79	21.23	16.14														
89	n	25	142															
	$\bar{x}$	287.48	310.02															
	s	16.89	15.98															
90	n	73																
	$\bar{x}$	276.77																
	s	16.03																

TABLE 8. Mean weight at age for the various year-classes present in mackerel sampled, 1983-1991.

AGE GROUP

Year-Class		1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17
66	n																	1
	$\bar{x}$																	938
	s																	-
67	n																8	6
	$\bar{x}$																860.64	909.88
	s																106.57	102.95
68	n															4	2	
	$\bar{x}$															851.50	906.15	
	s															74.36	288.99	
69	n														7	1	1	
	$\bar{x}$														875.19	797.90	779.70	
	s														55.29	-	-	
70	n													15	4			
	$\bar{x}$													975.66	806.38			
	s													115.75	53.58			
71	n												51	13	2			
	$\bar{x}$												882.12	828.01	991.95			
	s												127.11	84.06	14.07			
72	n											109	19	12		1		
	$\bar{x}$											860.64	840.92	867.36		1041.50		
	s											98.81	87.24	78.13		-		

TABLE 8. (cont'd).

AGE GROUP

Year Class		1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17
73	n										377	145	50	14	1		1	
	$\bar{x}$										822.37	803.88	847.62	853.32	783.80		856.30	
	s										88.20	86.65	106.39	79.59	-		-	
74	n									817	326	116	34	11	9	1		
	$\bar{x}$									805.08	795.60	816.70	834.31	901.05	872.79	874.60		
	s									91.36	98.22	105.50	106.27	130.02	125.42	-		
75	n								299	171	76	33	19	14	6	3		
	$\bar{x}$								804.40	801.23	826.04	811.49	879.58	892.51	931.45	975.53		
	s								84.90	92.12	117.76	109.99	85.00	95.29	293.65	189.90		
76	n							92	37	27	19	14	11	2	1	2		
	$\bar{x}$							785.77	767.96	814.77	791.14	835.91	914.20	1055.90	926.80	1020.55		
	s							111.60	104.68	102.97	99.26	80.22	110.60	138.45	-	44.76		
77	n						54	29	16	8	8	13	1		4			
	$\bar{x}$						766.47	734.93	808.88	831.64	869.75	889.78	979.50		964.08			
	s						103.38	83.34	104.19	96.32	84.68	132.74	-		82.60			
78	n					537	192	113	37	14	25	9	3	4				
	$\bar{x}$					706.27	718.09	746.09	782.29	857.39	850.59	939.27	1015.53	987.08				
	s					92.36	80.27	94.17	96.87	125.83	80.51	162.13	122.20	75.54				
79	n				137	77	28	24	20	14	10	5	6					
	$\bar{x}$				656.56	694.38	716.46	776.76	793.19	828.76	900.85	902.34	913.75					
	s				103.91	100.02	118.02	105.03	77.03	124.61	84.48	71.35	118.70					

TABLE 8. (cont'd).

AGE GROUP

Year-Class		1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17
80	n			434	205	72	41	18	15	20	3	3						
	x̄			537.00	578.44	588.67	652.69	687.58	794.70	801.60	786.93	927.70						
	s			86.40	84.05	90.51	124.45	155.55	96.51	161.12	118.94	136.77						
81	n		372	1426	802	510	317	295	152	49	35							
	x̄		377.75	458.23	501.27	537.17	619.86	717.78	755.38	774.01	835.38							
	s		86.80	69.61	83.92	86.55	106.92	100.16	135.02	157.39	147.25							
82	n	378	1549	2071	1771	1301	1265	1146	782	655								
	x̄	214	318.62	383.03	448.08	519.01	622	678.02	714.13	733.94								
	s	59.81	68.51	67.18	70.67	95.64	98.71	118.43	135.73	136.70								
83	n	32	50	193	118	77	45	27	54									
	x̄	133.04	367.72	448.66	496.43	558.46	695.07	645.70	728.74									
	s	36.54	70.03	69.49	88.21	97.41	112.28	104.85	123.62									
84	n	234	212	223	91	96	60	65										
	x̄	160.01	285.24	399.06	506.28	615.57	664.46	663.12										
	s	44.24	43.77	71.52	78.50	108.13	121.51	120.37										
85	n	51	265	71	136	77	63											
	x̄	158.21	305.57	436.46	540.47	636.44	636.64											
	s	26.27	53.60	58.49	108.53	130.92	104.22											
86	n	127	79	257	135	85												
	x̄	204.49	385.17	494.01	575.69	601.68												
	s	41.87	109.83	100.29	125.44	108.50												

TABLE 8. (cont'd).

AGE GROUP

Year-Class		1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17
87	n	30	755	525	456													
	x̄	192.32	323.10	450.89	545.03													
	s	52.72	87.31	105.15	427.88													
88	n	227	259	377														
	x̄	171.36	308.93	432.15														
	s	53.06	80.72	321.98														
89	n	25	142															
	x̄	249.99	322.51															
	s	56.18	53.87															
90	n	73																
	x̄	209.51																
	s	31.38																

TABLE 9. **Length, weight and mean gonado-somatic index for Maturity 5 mackerel in 1980 to 1989 year-classes.**

		LENGTH (mm)			WEIGHT (g)			GSI (%)		
Class	Age	N	X	STD.	N	X	STD.	N	X	STD.
80	2	-	-	-	-	-	-	-	-	-
	3	9	360.33	15.76	9	557.40	72.62	7	9.41	2.78
	4	43	368.81	10.94	43	565.58	58.87	43	11.44	3.32
	5	27	380.48	11.13	27	641.69	68.32	27	11.41	3.42
	6	7	388.71	23.29	7	731.19	145.50	7	15.14	3.57
81	2	6	328.00	26.23	6	402.17	89.64	5	11.26	2.80
	3	86	337.44	13.03	87	429.53	61.31	87	10.07	2.25
	4	133	358.08	15.11	135	518.77	88.29	135	11.72	2.91
	5	38	369.92	15.61	38	595.07	81.06	38	12.98	2.67
	6	52	373.88	17.77	52	579.49	89.06	52	10.16	3.51
82	2	3	302.67	5.13	3	309.67	20.50	3	9.01	3.03
	3	107	327.06	19.21	108	383.39	76.08	106	10.17	2.63
	4	61	345.43	16.22	61	465.18	81.12	61	12.40	2.94
	5	203	353.03	16.98	203	489.05	82.31	203	10.78	3.04
	6	87	362.54	14.28	87	559.71	76.90	87	12.79	3.11
83	2	6	317.83	10.26	6	351.25	29.17	6	9.55	3.82
	3	2	334.00	5.66	2	399.10	48.51	2	11.18	0.72
	4	10	349.10	13.32	10	474.16	49.47	10	10.32	4.56
	5	13	354.54	18.86	13	529.61	109.75	13	12.80	2.02
	6	4	387.25	19.92	4	695.65	95.21	4	11.86	2.69

TABLE 9. (cont'd).

		LENGTH (mm)			WEIGHT (g)			GSI (%)		
Class	Age	N	X	STD.	N	X	STD.	N	X	STD.
84	2	-	-	-	-	-	-	-	-	-
	3	13	330.92	10.39	13	384.62	46.16	13	9.00	2.13
	4	8	347.13	10.05	8	480.39	55.88	8	13.10	1.83
	5	8	357.50	7.76	8	545.26	58.82	8	13.23	2.70
	6	12	376.92	15.48	12	596.34	86.05	12	10.72	2.72
85	2	-	-	-	-	-	-	-	-	-
	3	9	329.56	7.21	9	399.53	47.55	9	10.04	1.36
	4	3	352.00	15.87	3	506.43	47.93	3	12.75	1.58
	5	23	363.22	16.30	23	538.29	78.82	23	10.71	2.30
	6	2	377.00	11.31	2	577.10	6.51	2	14.05	4.40
86	2	4	313.25	6.18	4	340.55	60.03	4	7.55	2.30
	3	-	-	-	-	-	-	-	-	-
	4	31	356.26	16.15	31	498.74	64.69	31	11.40	3.50
	5	2	369.00	0.00	2	527.30	16.12	2	8.67	0.44
87	2	-	-	-	-	-	-	-	-	-
	3	60	333.42	13.26	60	407.83	49.37	60	10.46	2.60
	4	24	349.38	9.78	24	454.60	40.57	24	10.45	2.52
88	3	46	332.67	14.87	46	396.64	76.59	46	11.33	7.21
89	2	10	320.90	12.49	10	369.87	66.94	10	8.78	2.14

TABLE 10. Proportion (%) by age of immature mackerel (Stage 1 and 2 gonads) in 1980 to 1989 year-classes.

YEAR-CLASS	AGE	% IMMATURE
80	2	-
	3	21.00
	4	1.48
	5	0.00
	6	0.00
81	2	55.24
	3	2.33
	4	0.25
	5	0.00
	6	0.00
82	2	27.28
	3	0.75
	4	0.06
	5	0.15
	6	0.00
83	2	4.35
	3	0.00
	4	0.00
	5	0.00
	6	0.00
84	2	2.84
	3	0.45
	4	0.00
	5	0.00
	6	0.00
85	2	17.94
	3	0.00
	4	0.00
	5	0.00
	6	1.69
86	2	5.06
	3	0.79
	4	0.00
	5	3.66
87	2	16.47
	3	1.35
	4	8.61
88	2	9.13
	3	15.05
89	2	43.56

TABLE 11. Proportion (%) by length class of immature mackerel (Stage 1 and 2 gonads) in 1980 to 1989 year-classes.

Length class (mm)	YEAR-CLASSES 80	81	82	83	84	85	86	87	88	89
[215-224] 220	-	-	-	-	-	-	-	-	-	-
[225-234] 230	-	-	-	-	-	-	-	-	-	-
[235-244] 240	-	-	-	-	-	-	-	-	-	-
[245-254] 250	-	-	85.71	-	-	-	-	40.00	-	-
[255-264] 260	-	-	78.38	-	-	-	-	50.00	-	-
[265-274] 270	-	-	82.44	-	-	80.00	-	46.67	50.00	-
[275-284] 280	-	80.00	57.70	-	-	61.54	-	50.00	8.33	-
[285-294] 290	-	45.45	37.32	-	10.26	35.71	-	36.08	10.53	62.50
[295-304] 300	-	37.50	16.59	-	1.23	17.19	-	13.04	6.67	56.52
[305-314] 310	50.00	29.55	10.41	0.00	2.78	12.50	9.09	9.55	5.71	37.50
[315-324] 320	28.57	23.01	3.54	0.00	0.00	0.00	4.76	4.37	14.29	28.00
[325-334] 330	16.67	11.66	1.03	0.00	0.00	0.00	1.47	2.33	15.48	60.00
[335-344] 340	24.24	5.74	0.00	0.00	0.00	0.00	1.11	4.59	15.38	16.67
[345-354] 350	26.32	3.29	0.10	0.00	0.00	0.00	1.96	6.11	9.09	0.00
[355-364] 360	15.82	0.95	0.00	0.00	0.00	0.00	0	5.34	7.41	-
[365-374] 370	7.57	0.53	0.15	0.00	0.00	2.17	1.61	2.17	0.00	-
[375-384] 380	0.95	0.00	0.23	0.00	0.00	0.00	0.00	0.00	0.00	-
[385-394] 390	0.00	0.00	0.44	0.00	0.00	0.00	0.00	0.00	0.00	-
[395-404] 400	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	-
[405-414] 410	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	-	-
[415-424] 420	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	-	-

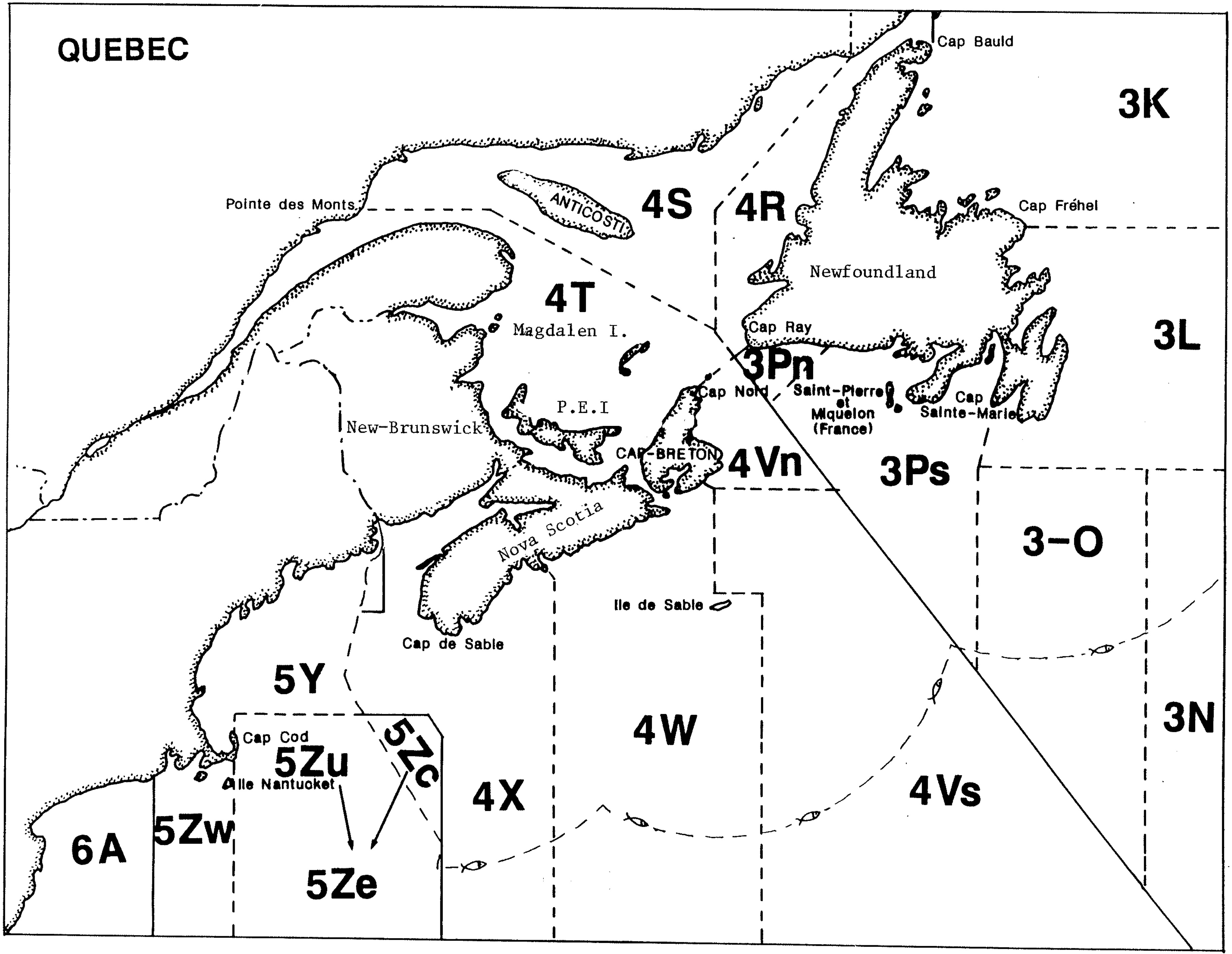


Figure 1. Map of NAFO divisions.

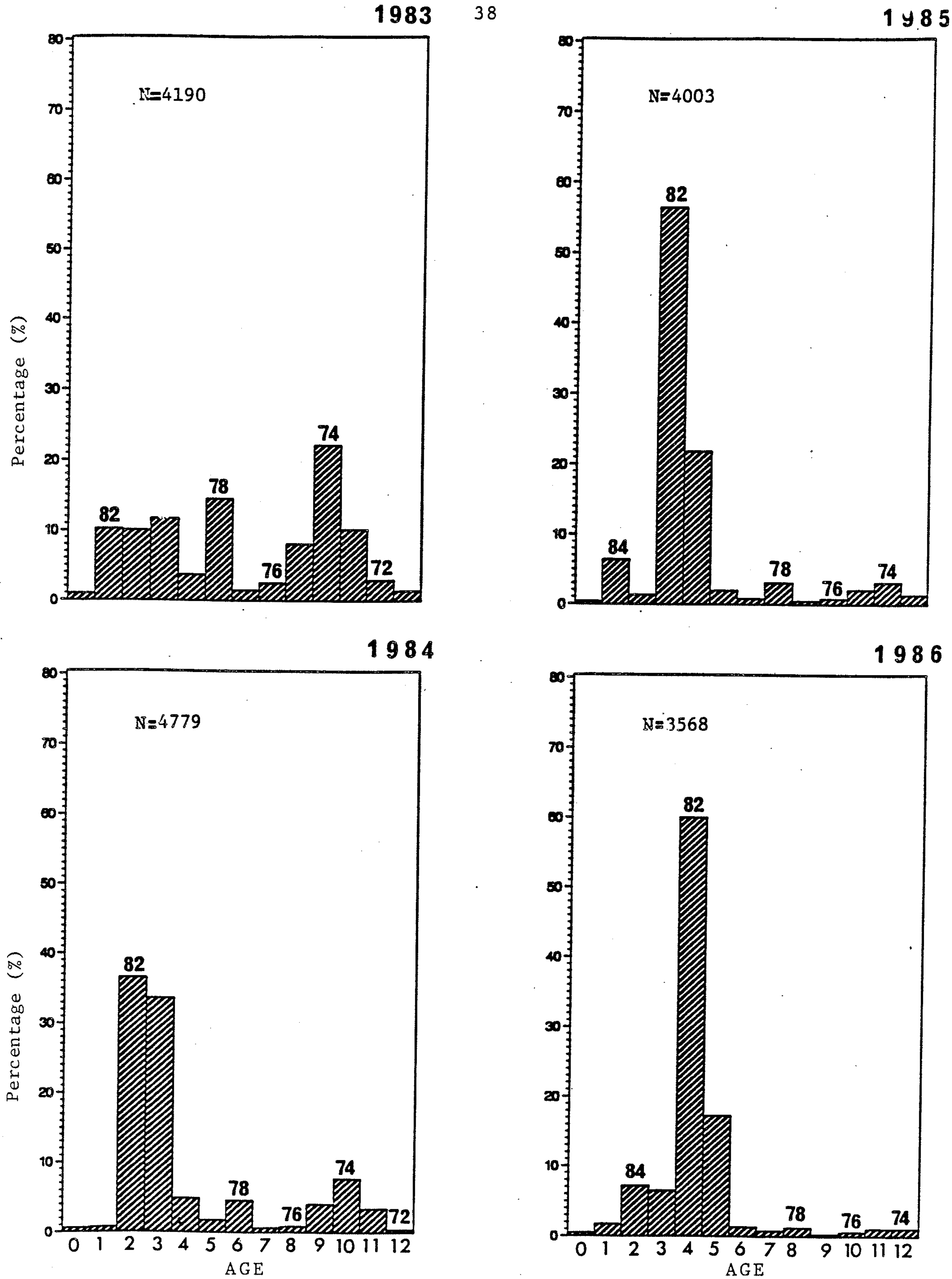


Figure 2. Annual frequency distributions (%) of age of mackerel sampled, 1983-1991.

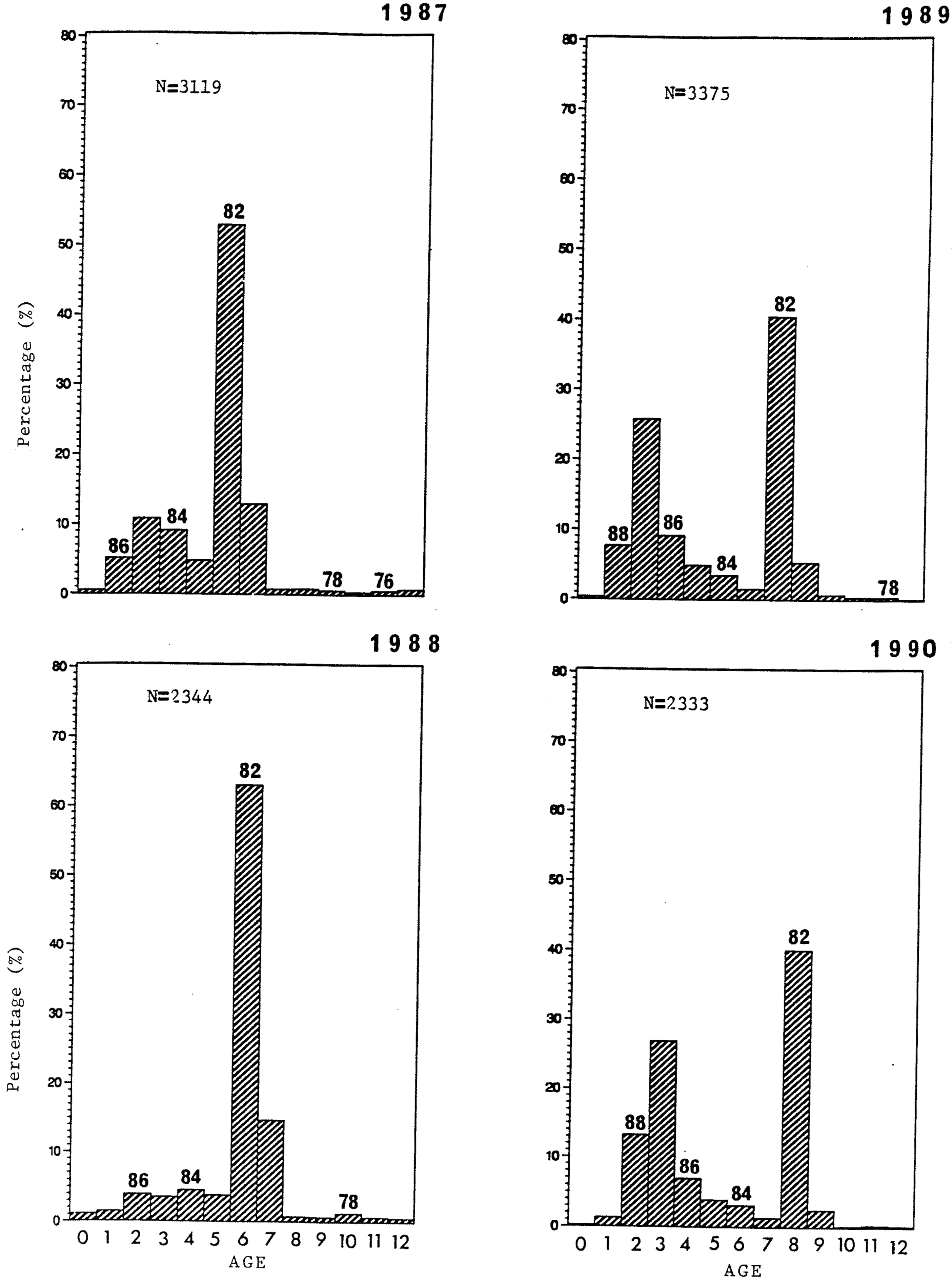


Figure 2. (cont'd).

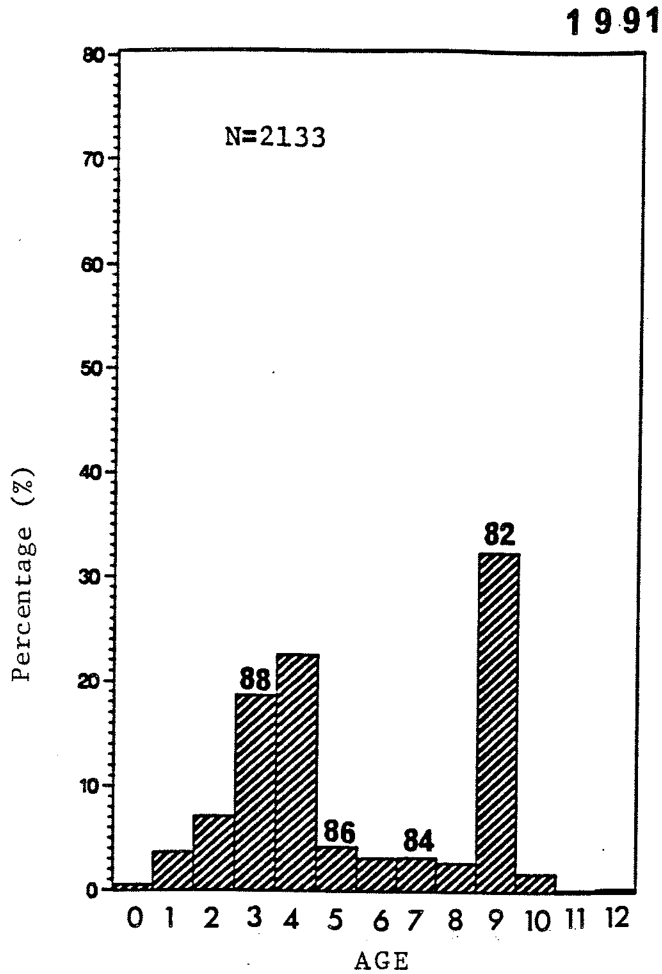


Figure 2. (cont'd).

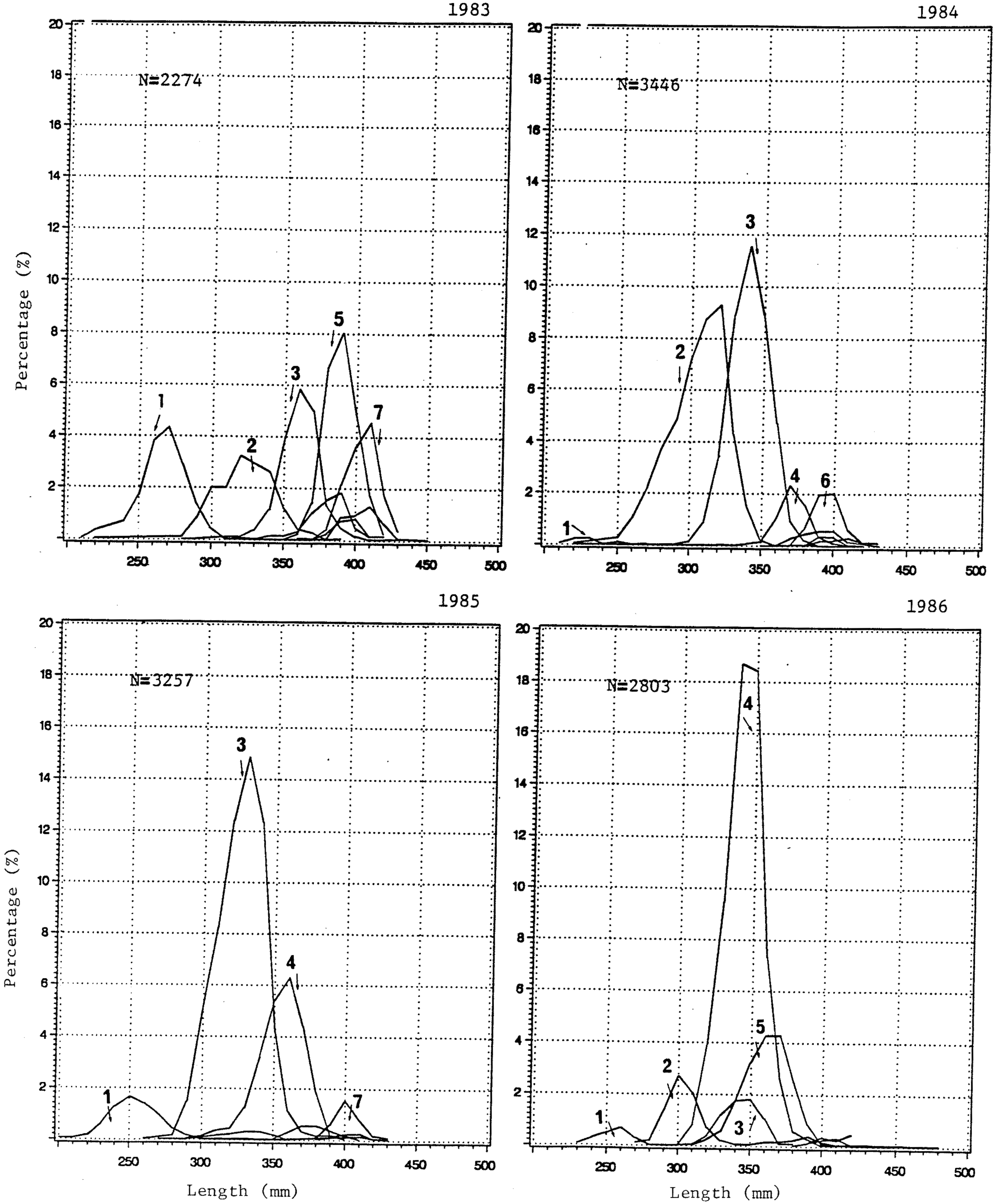


Figure 3. Annual frequency distributions (%) of length of mackerel sampled, 1983-1991.

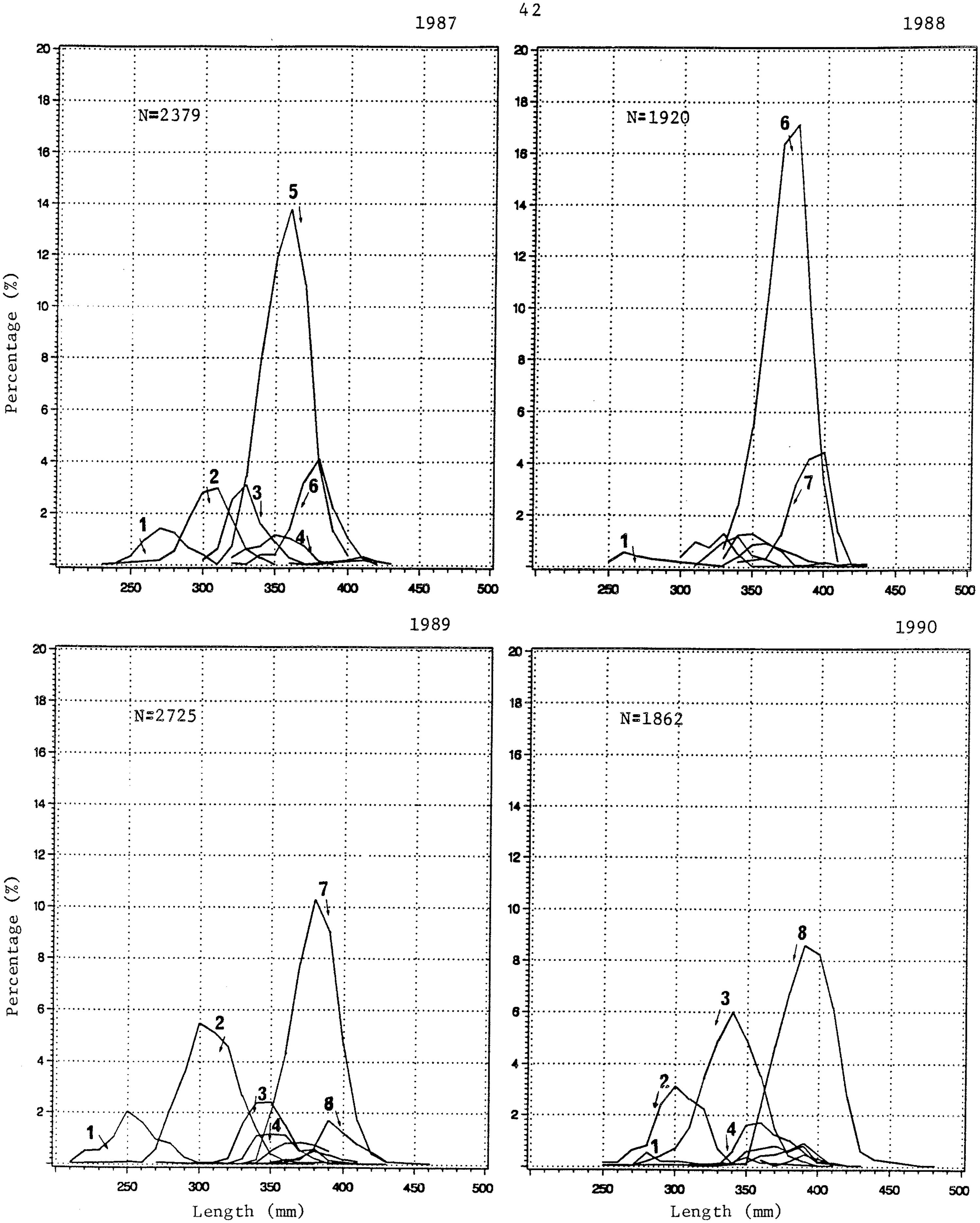


Figure 3. (cont'd).

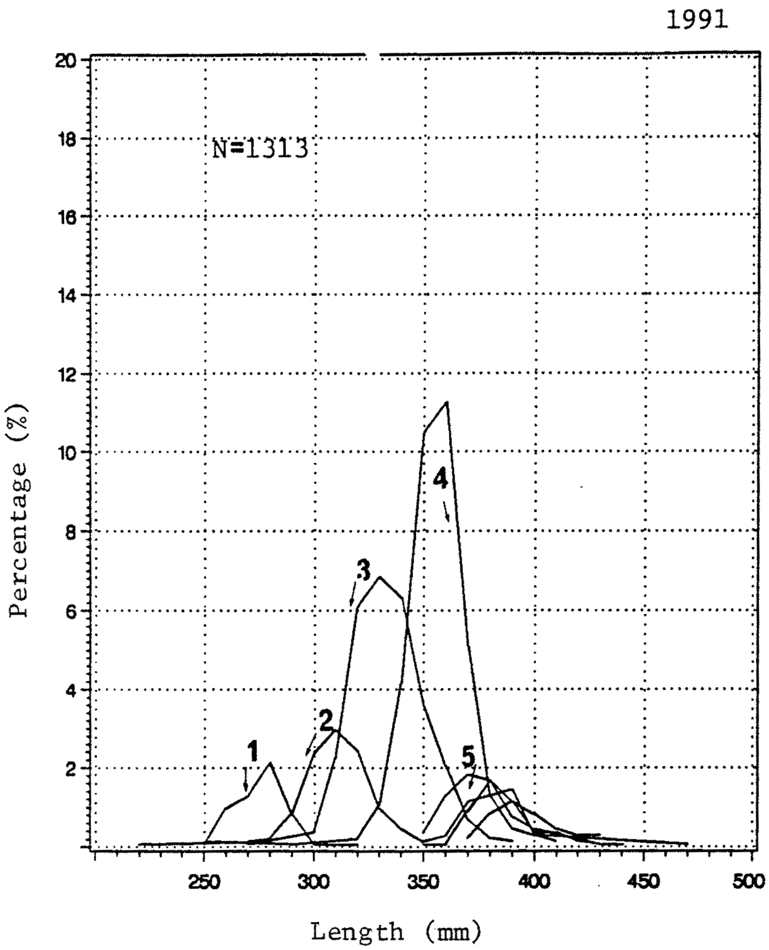


Figure 3. (cont'd).

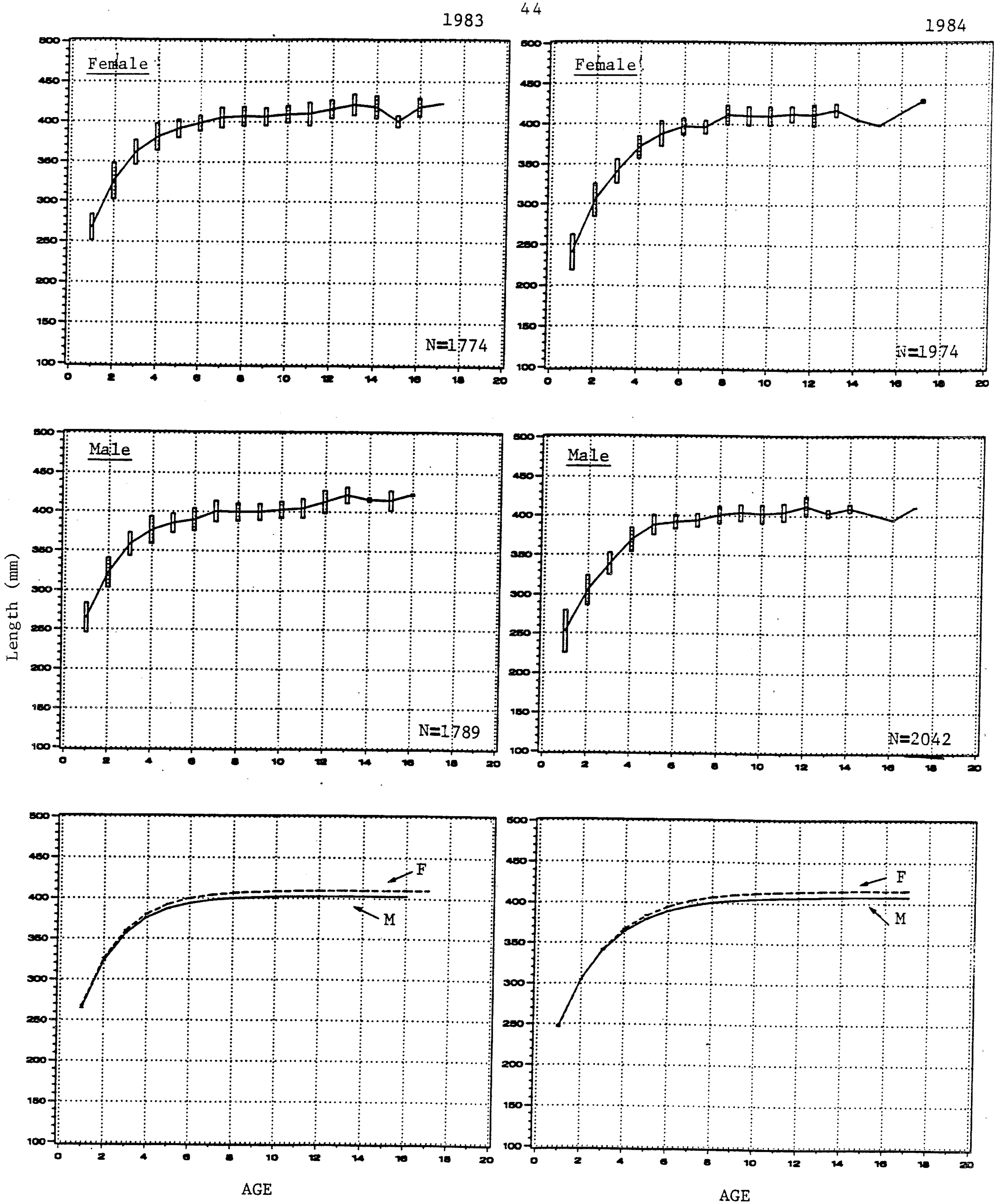


Figure 4. Lengths at age observed and predicted using the von Bertalanffy model for male and female mackerel sampled, 1983-1991.

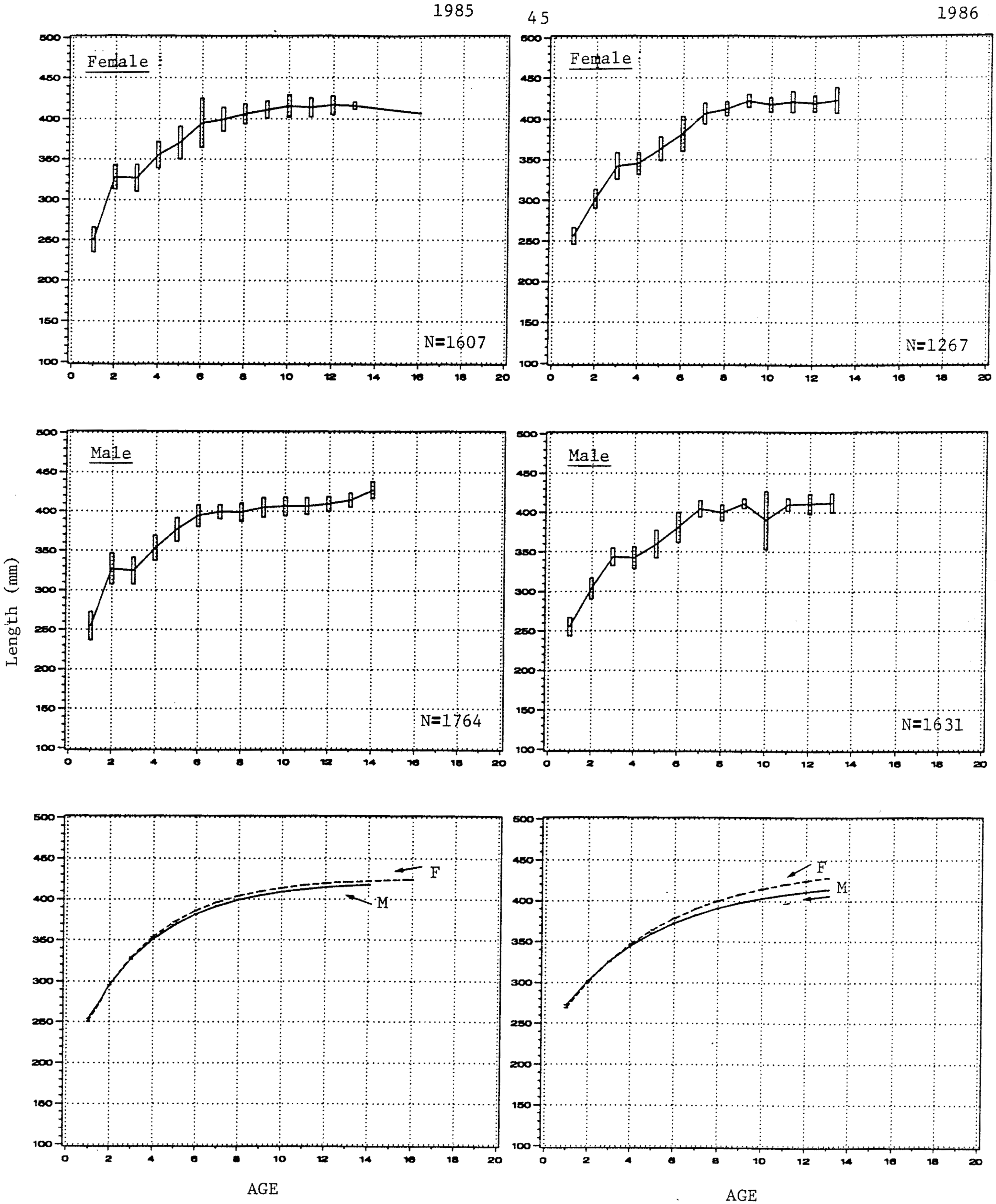


Figure 4. (cont'd).

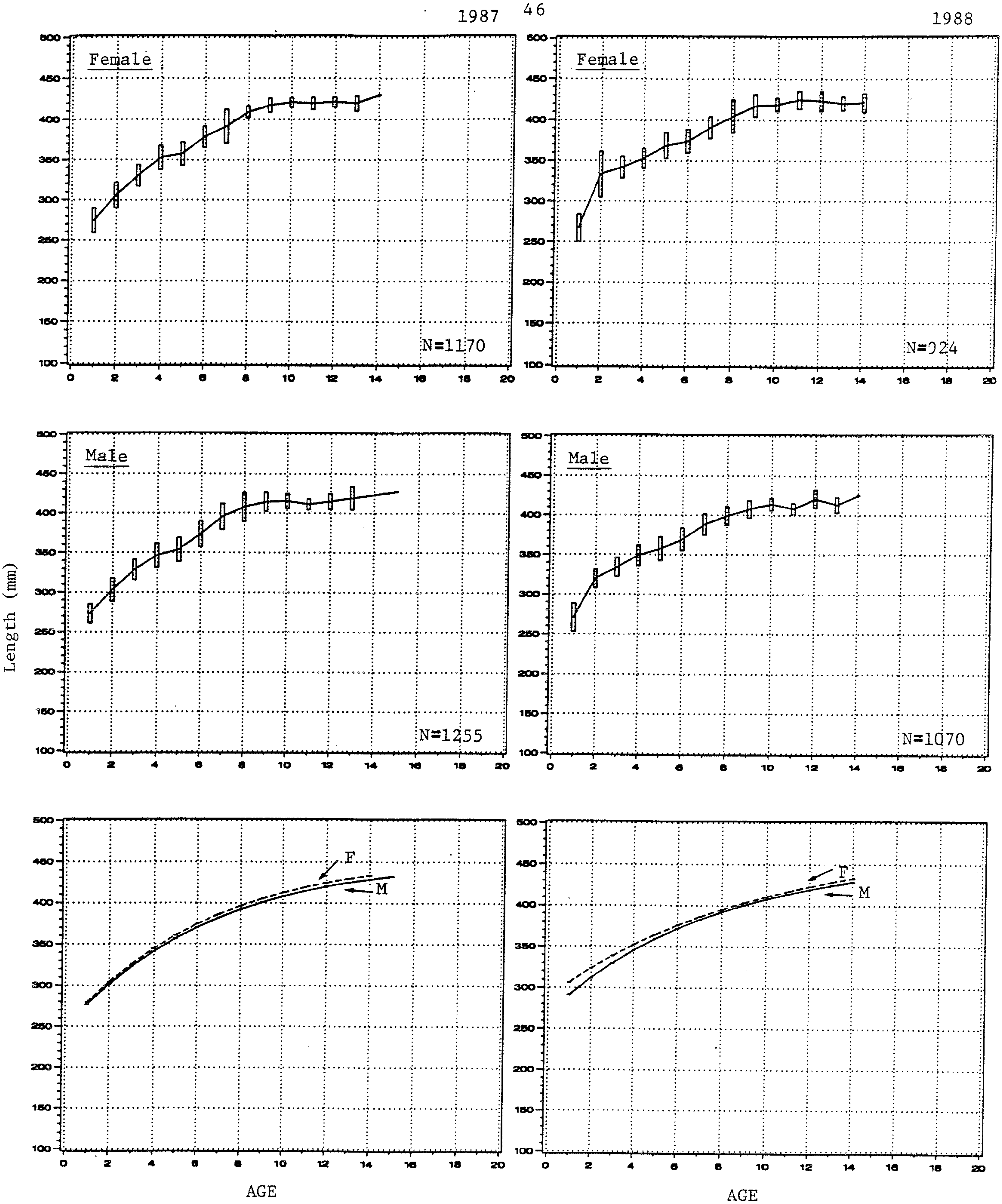


Figure 4. (cont'd).

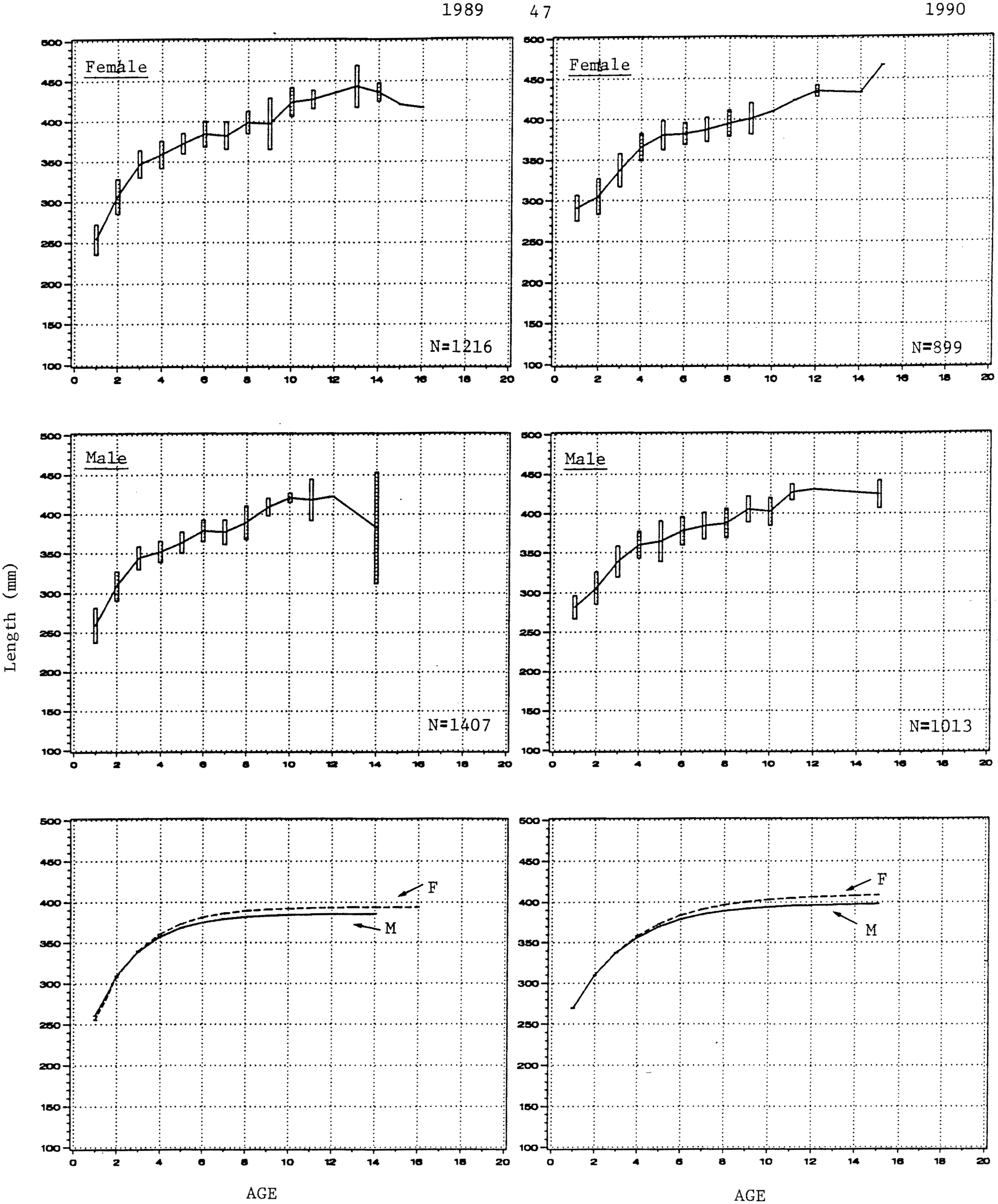
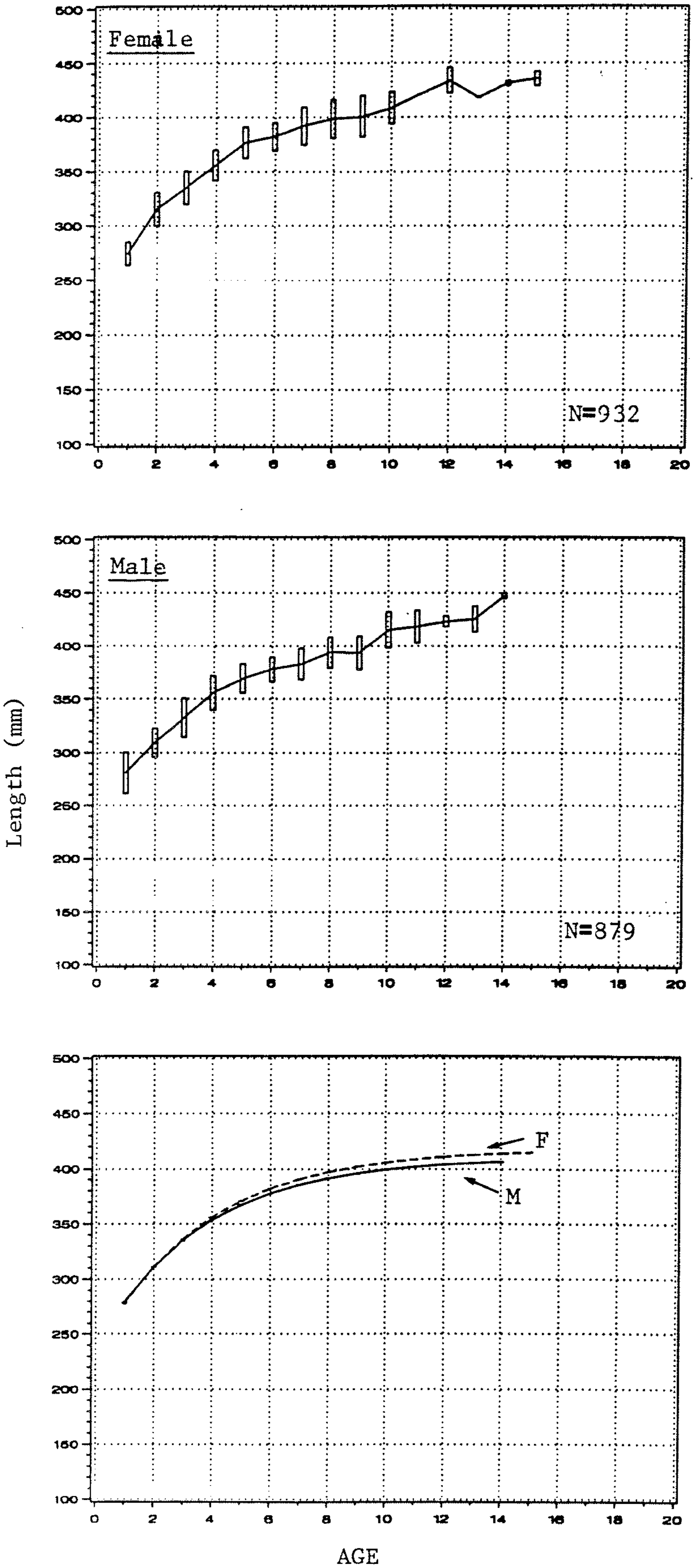


Figure 4. (cont'd).



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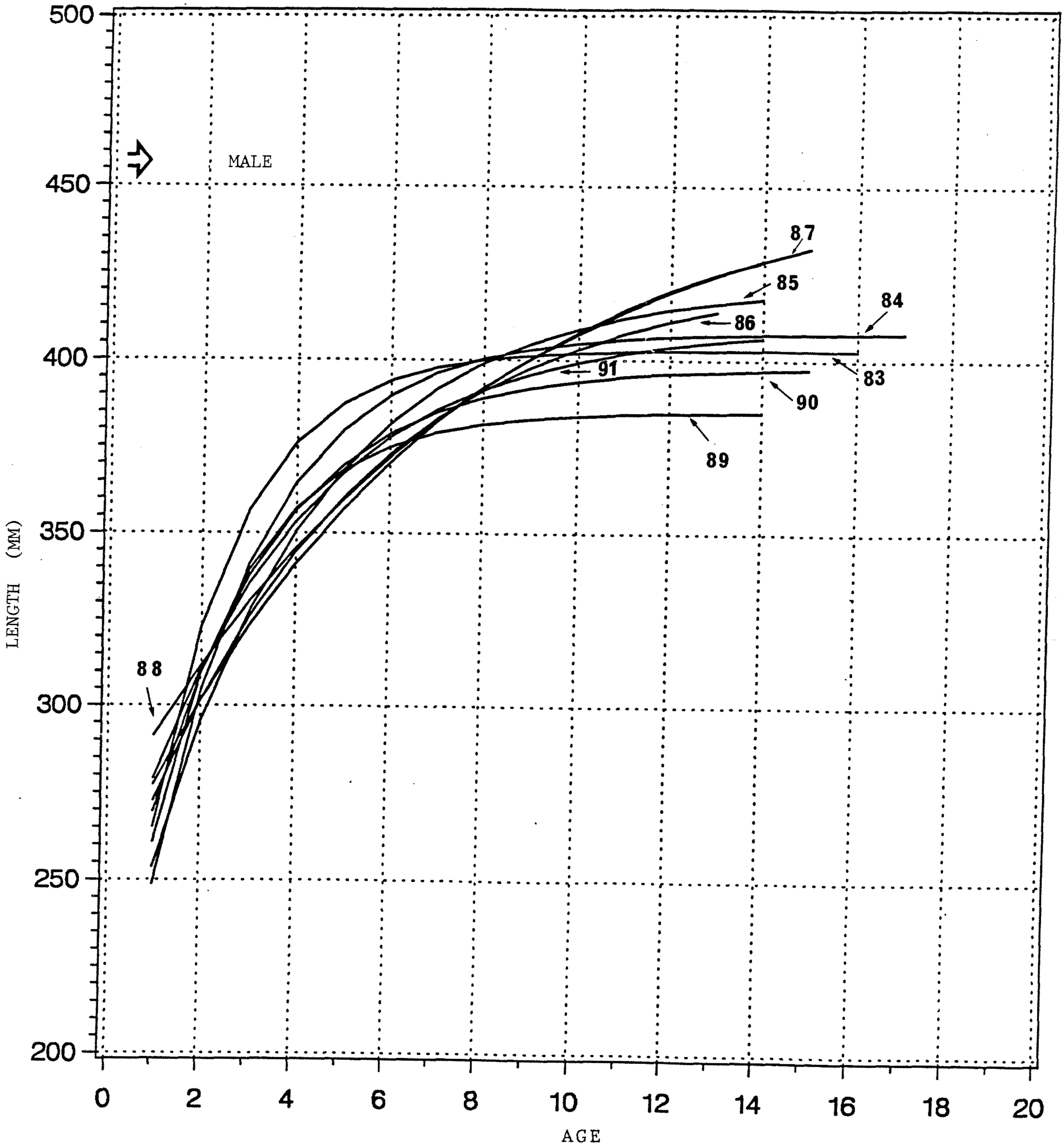


Figure 5. Annual lengths at age predicted using the von Bertalanffy model for male mackerel sampled, 1983-1991.

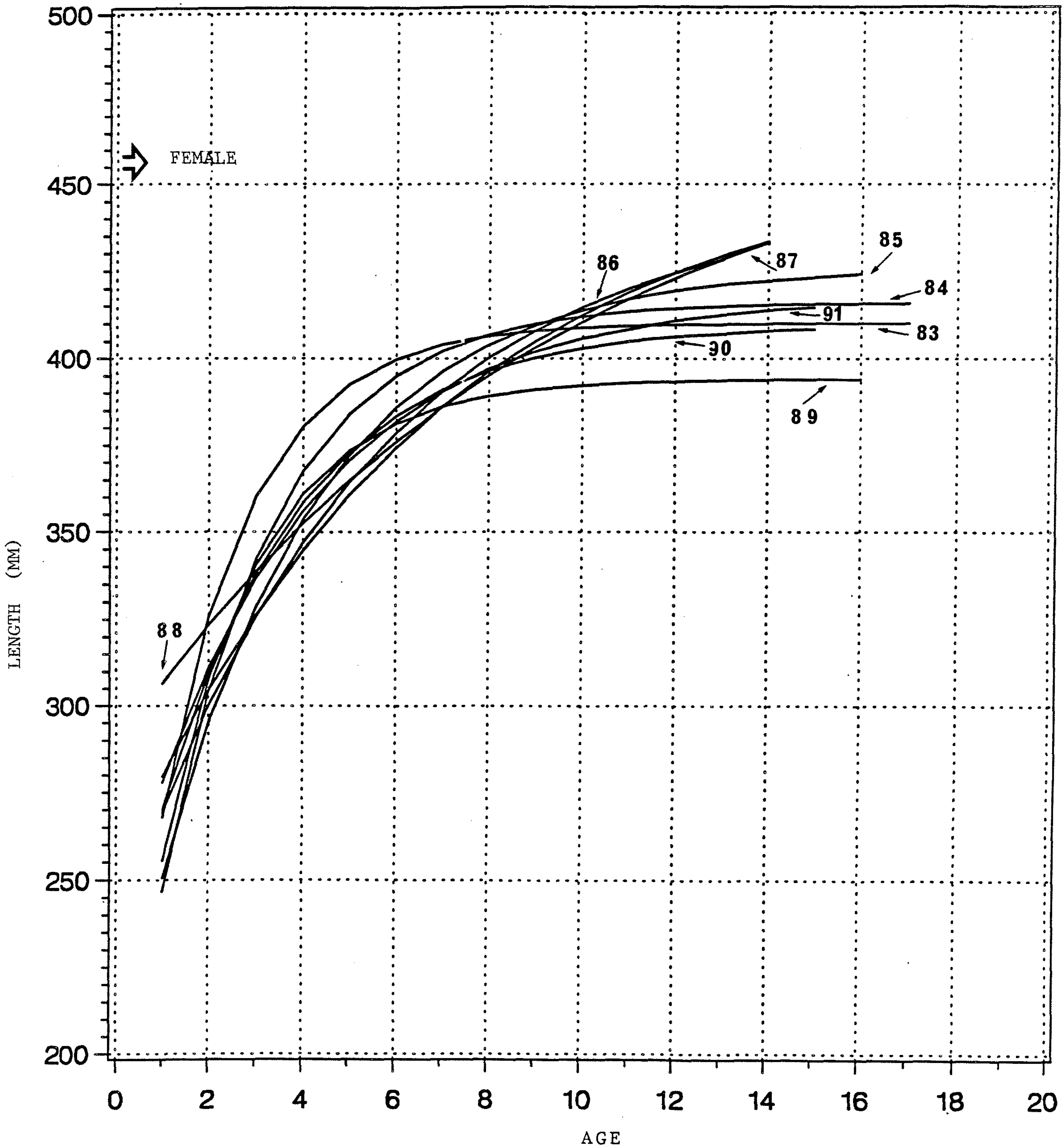


Figure 6. Annual lengths at age predicted using the von Bertalanffy model for female mackerel sampled, 1983-1991.

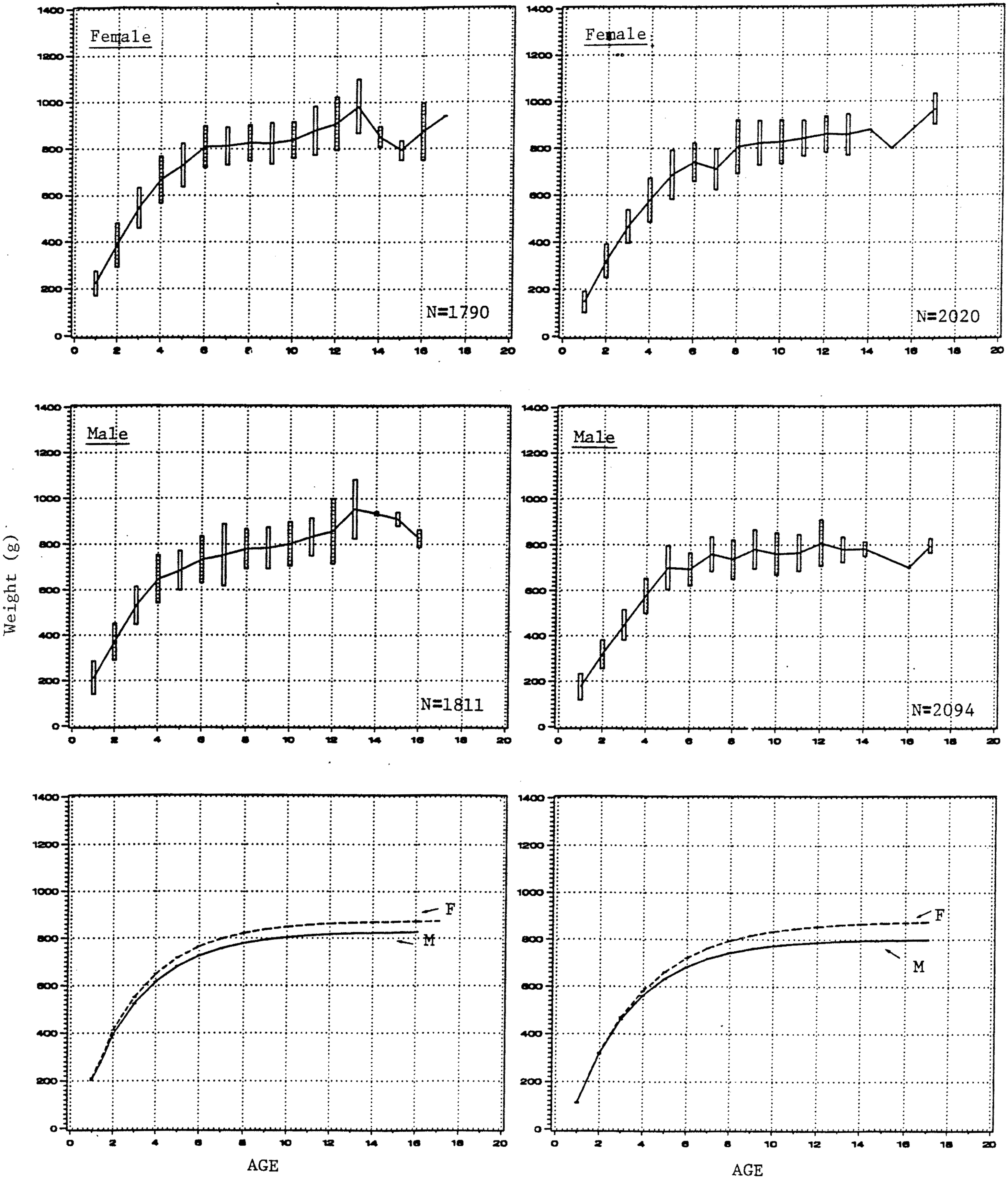
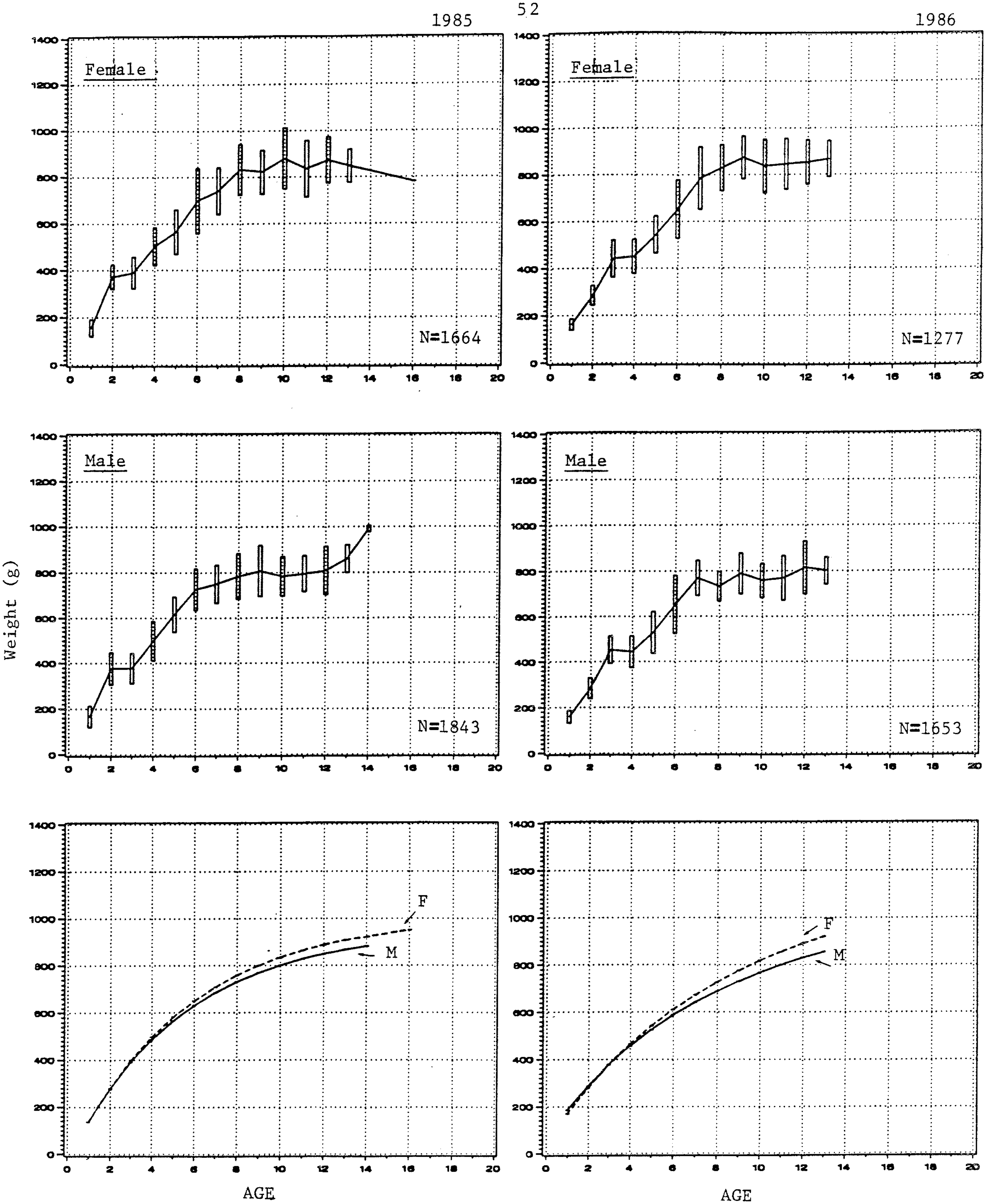


Figure 7. Weights at age observed and predicted using the von Bertalanffy model for male and female mackerel sampled, 1983-1991.



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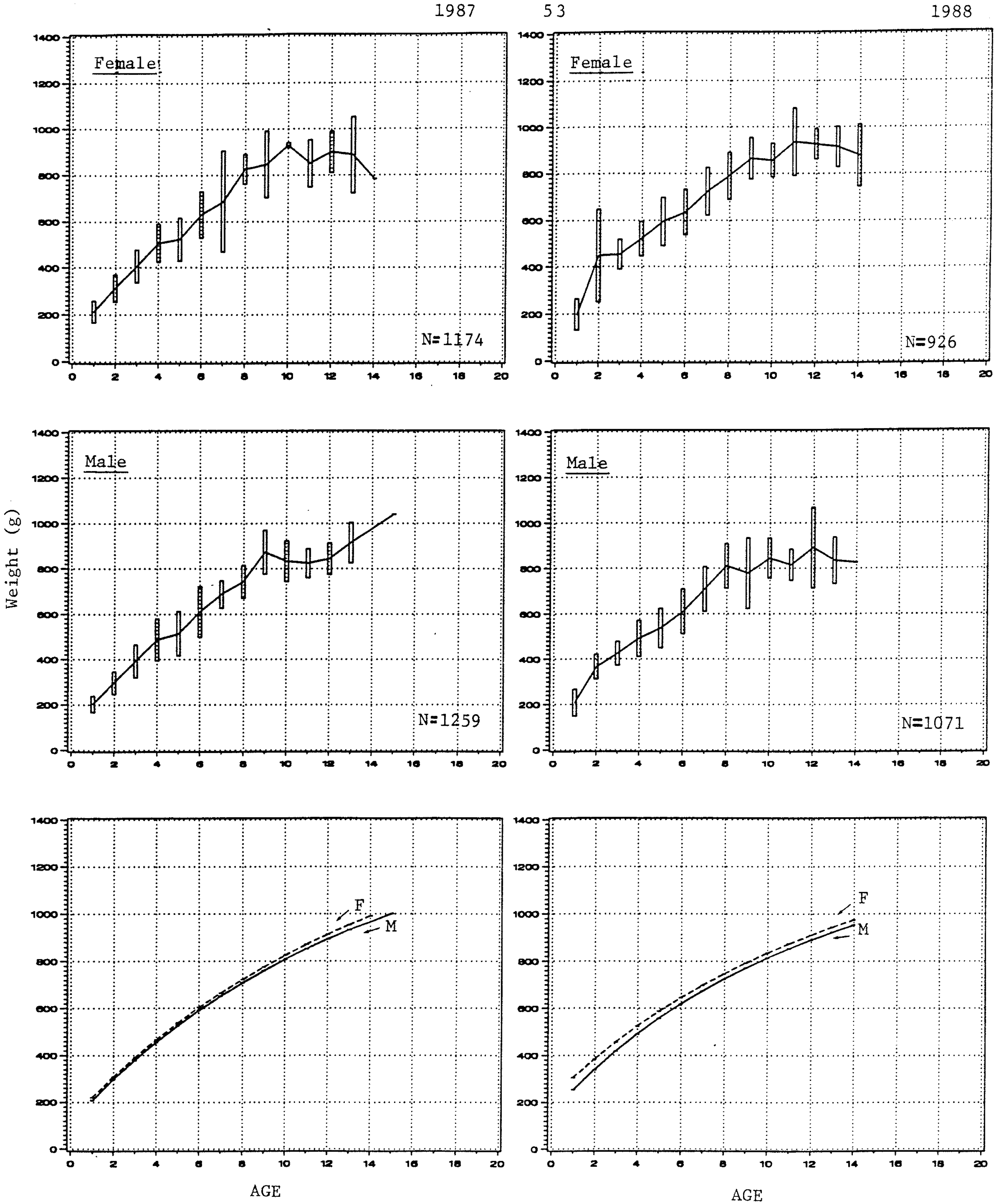

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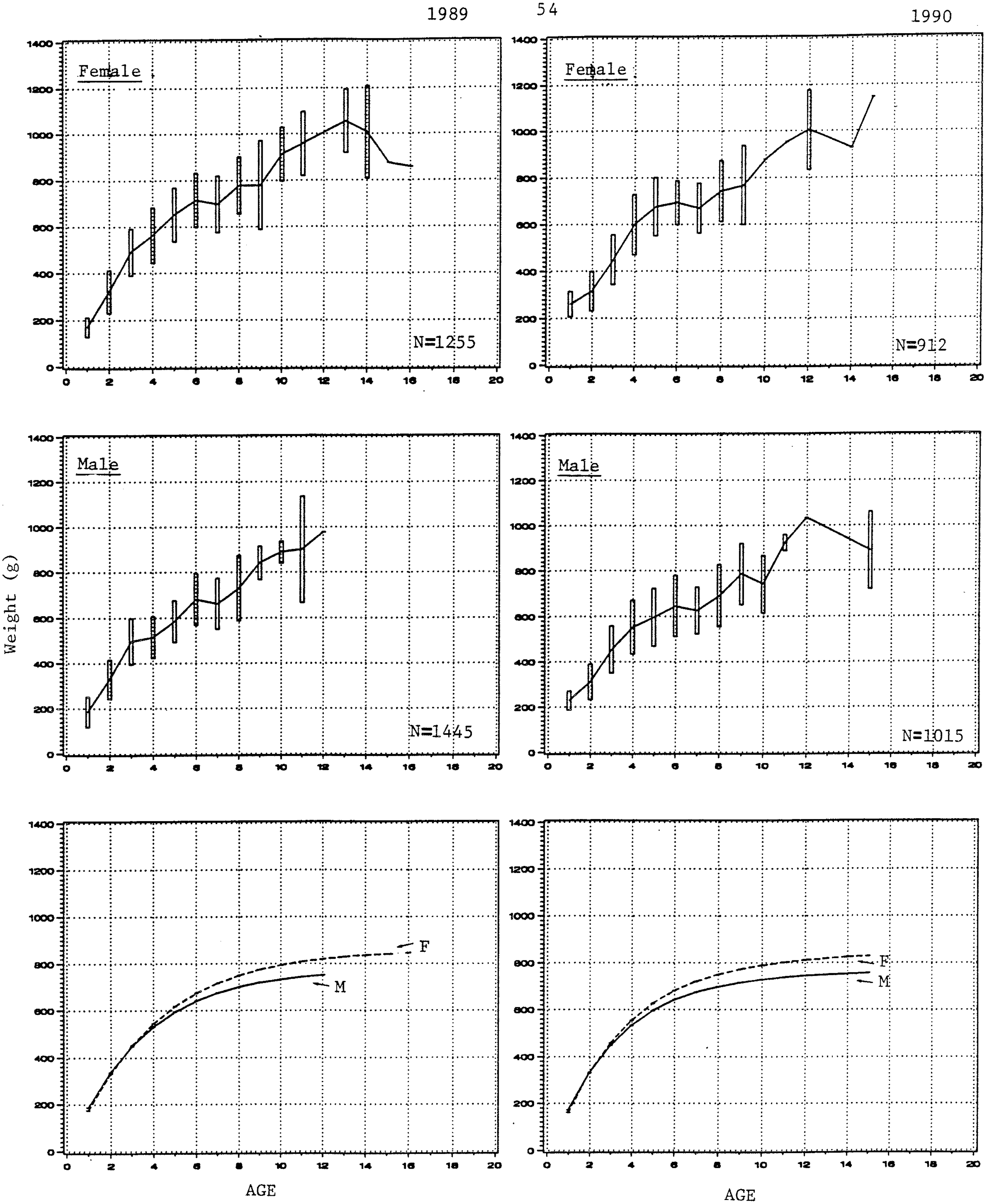

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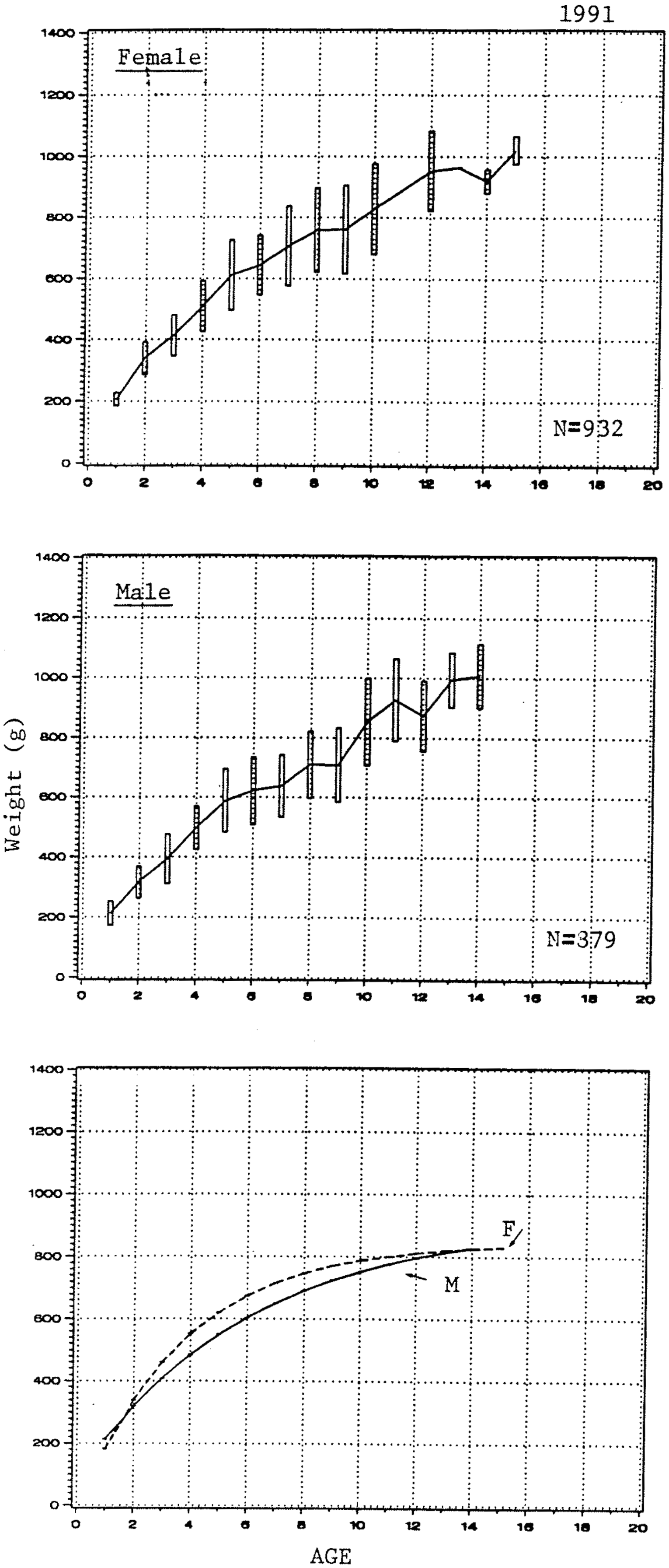

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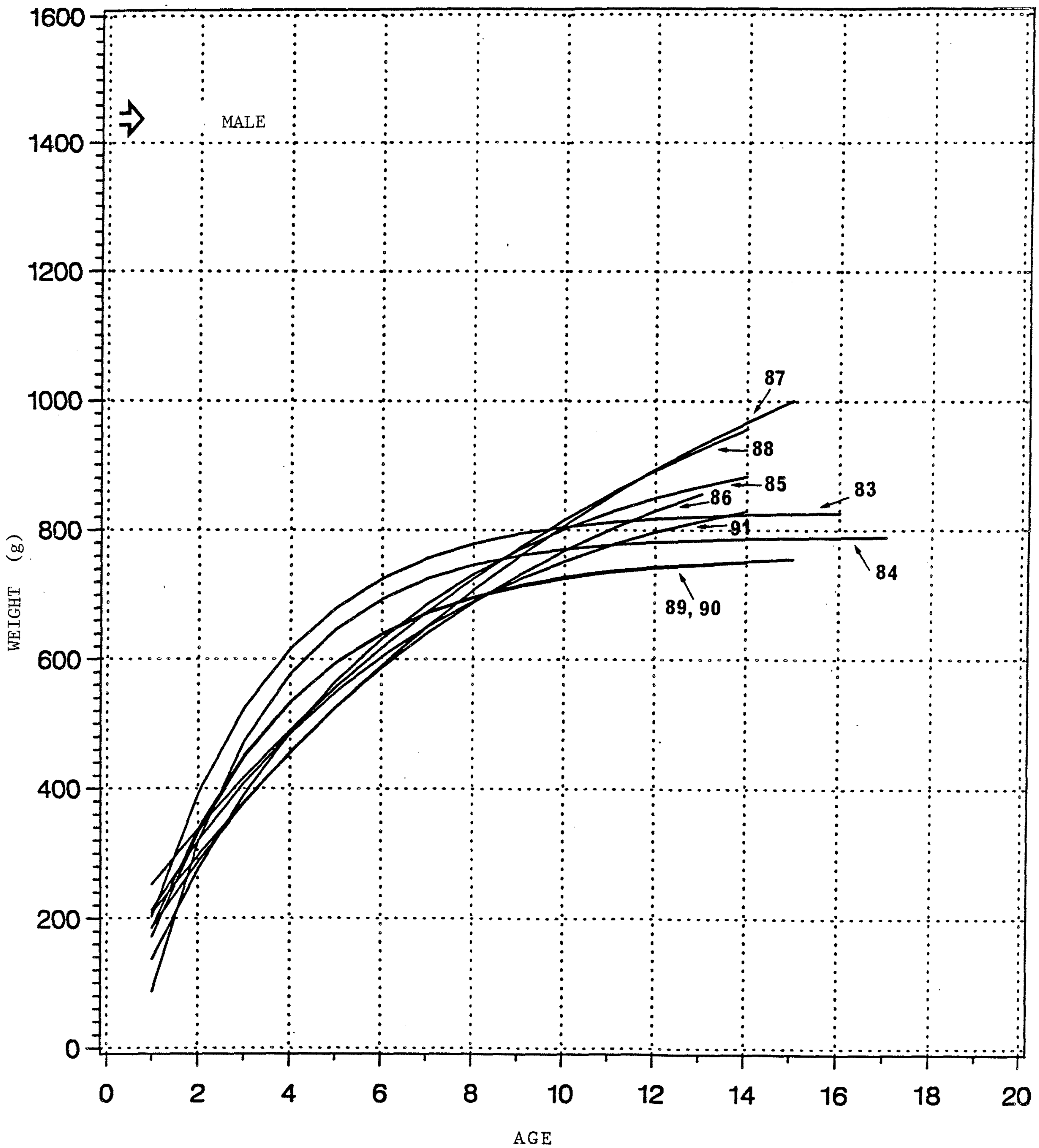


Figure 8. Annual weights at age predicted using the von Bertalanffy model for male mackerel sampled, 1983-1991.

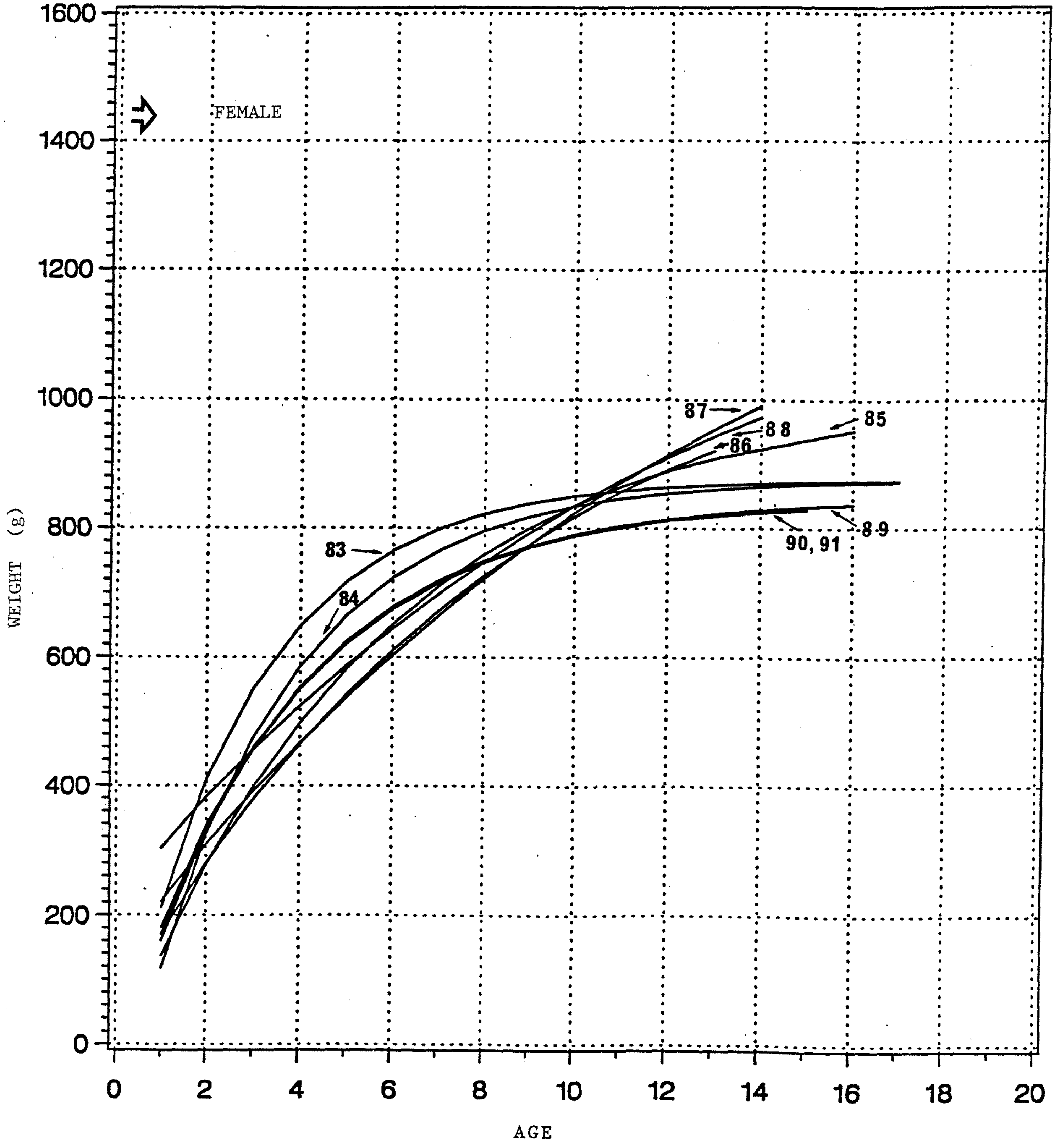


Figure 9. Annual weights at age predicted using the von Bertalanffy model for female mackerel sampled, 1983-1991.

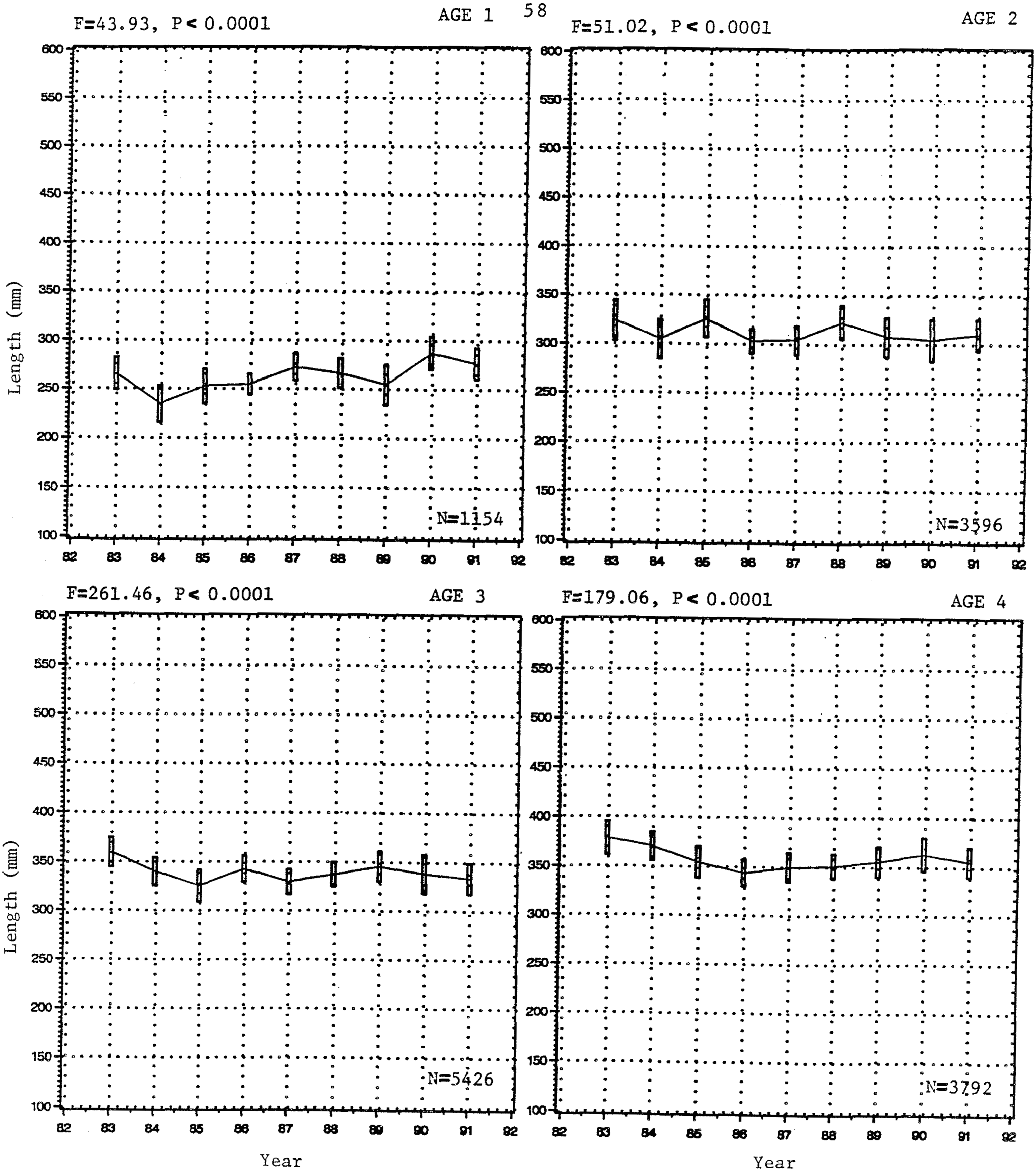
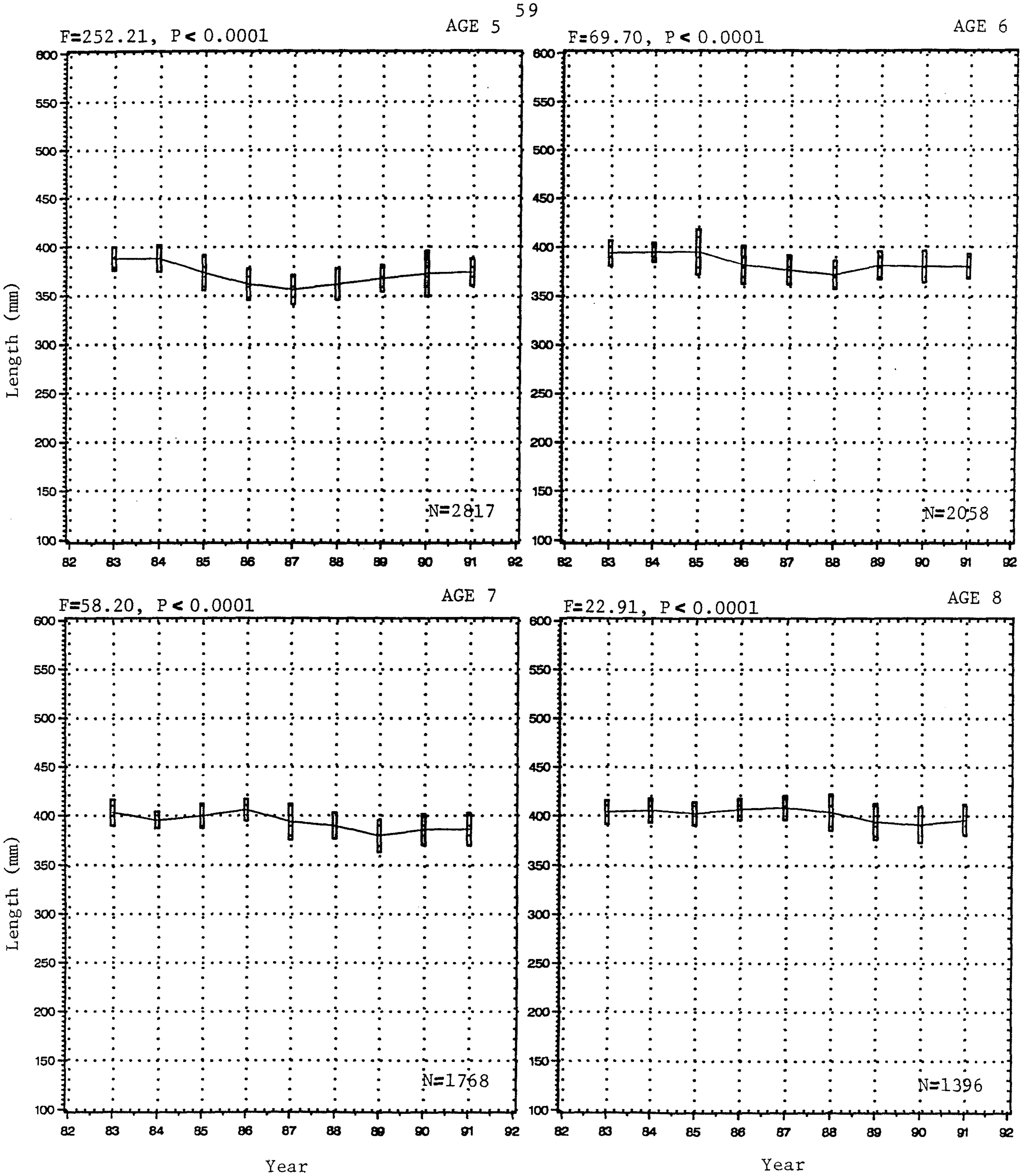


Figure 10. Mean annual lengths for mackerel sampled in 1 to 16 year age groups, 1983-1991.



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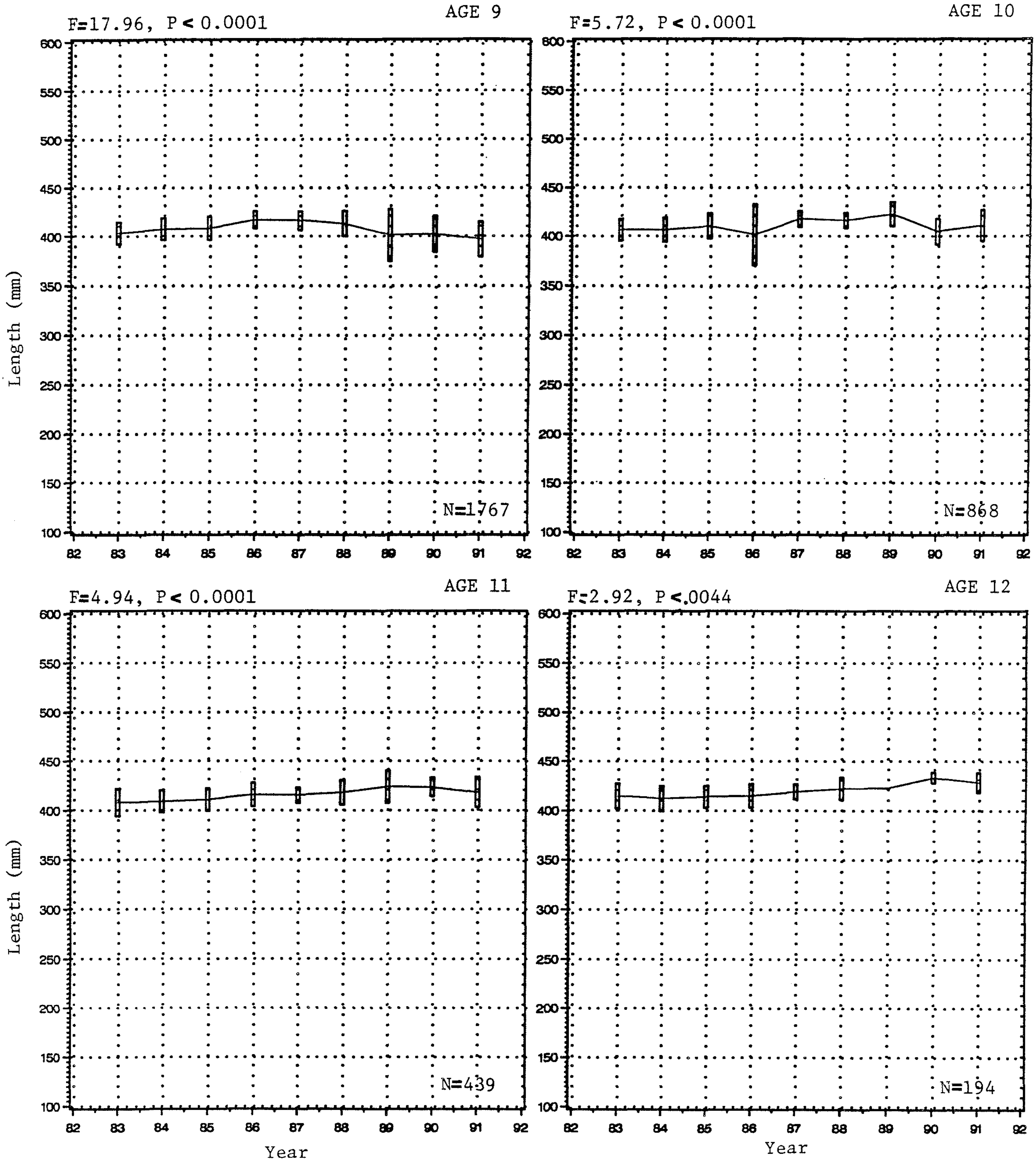

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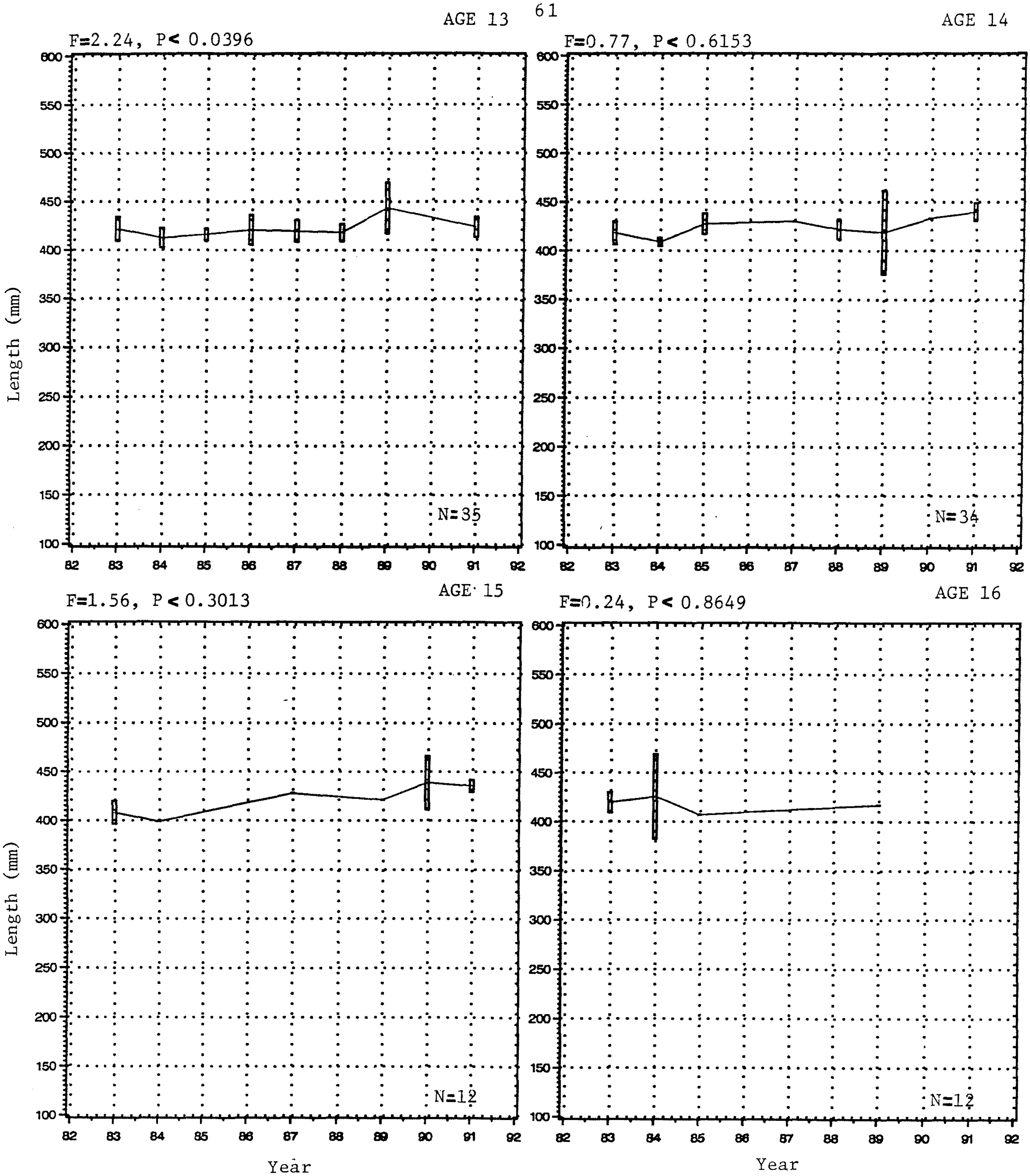

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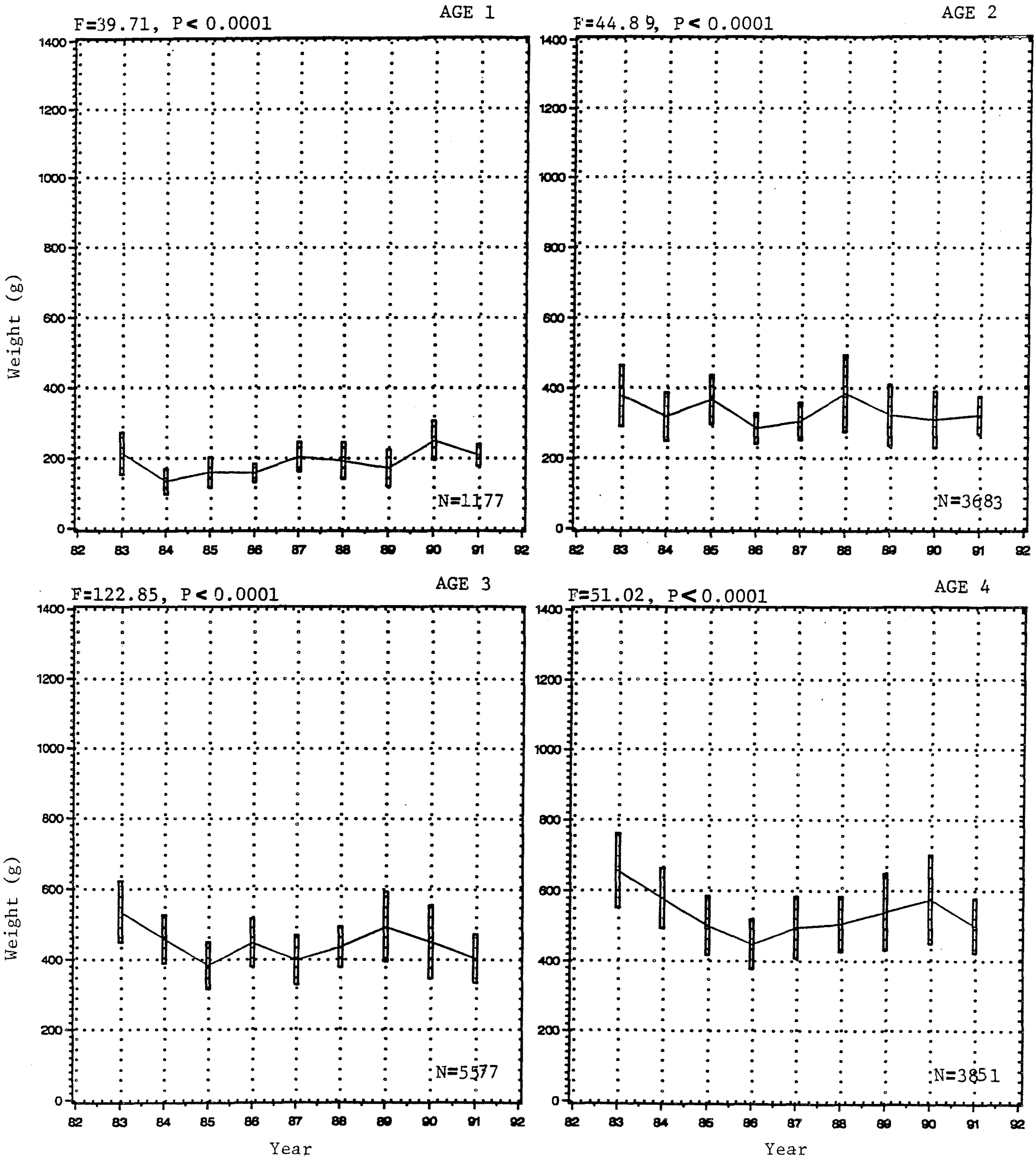
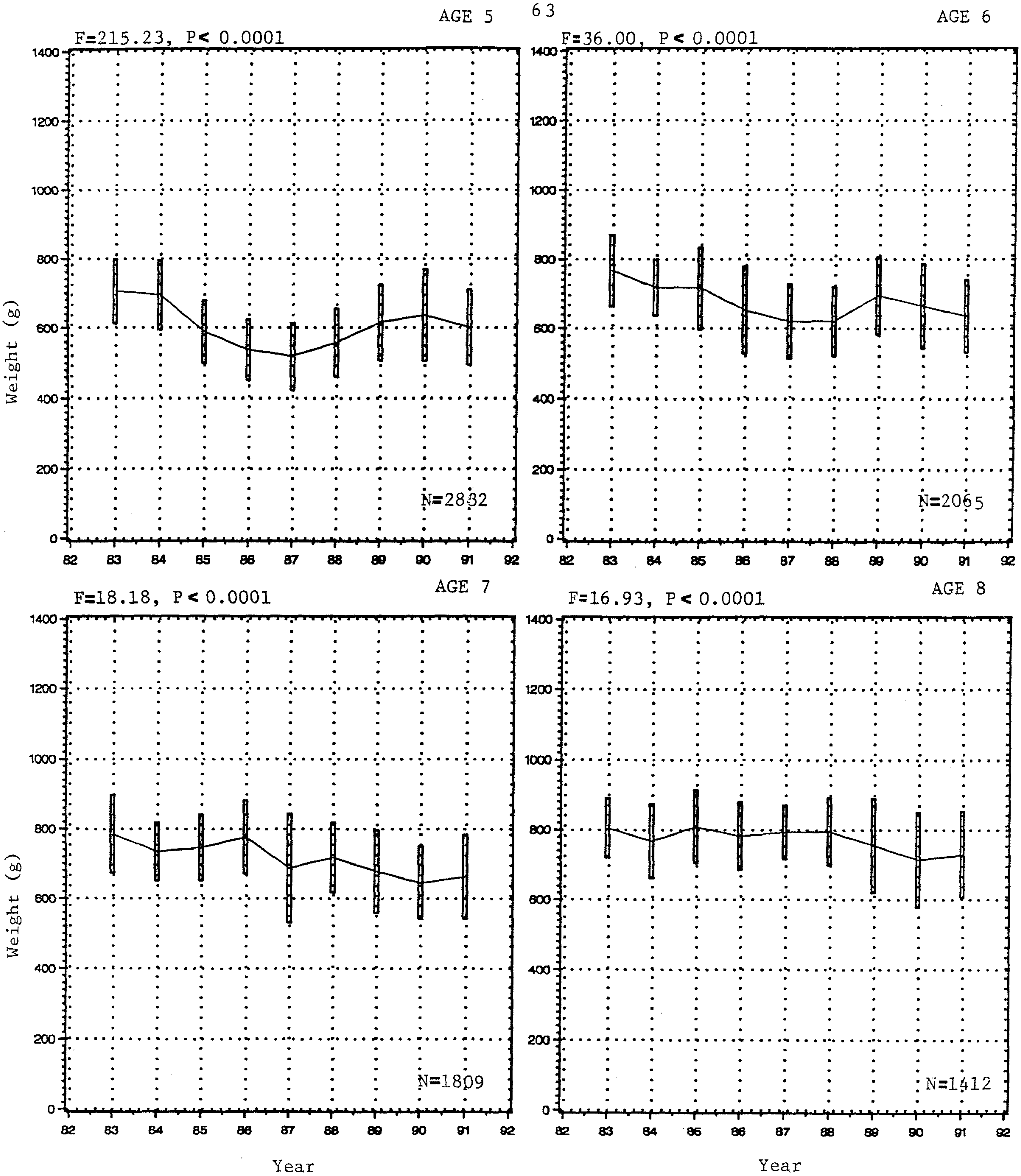


Figure 11. Mean annual weights for mackerel sampled in 1 to 16 year age groups, 1983-1991.



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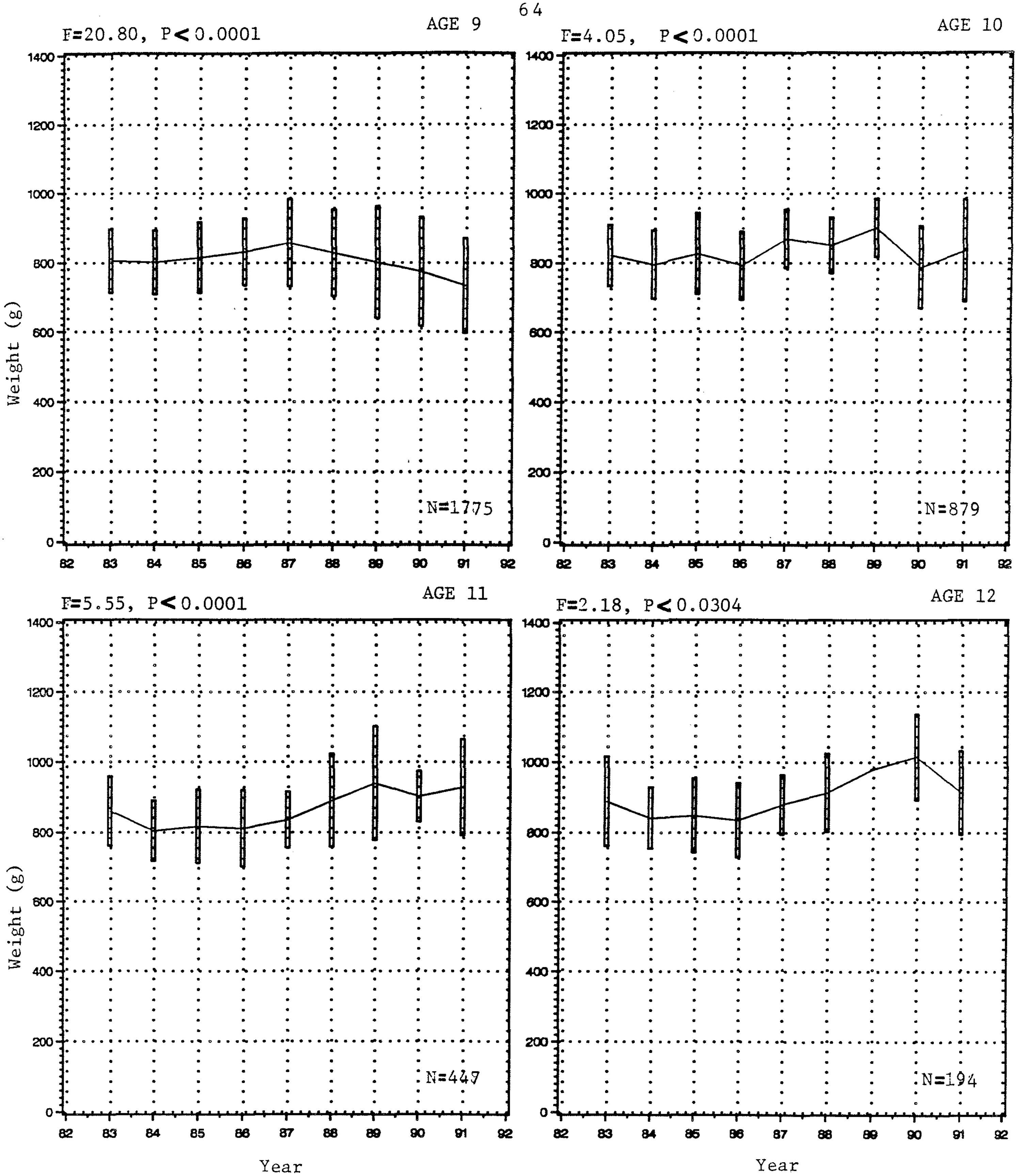

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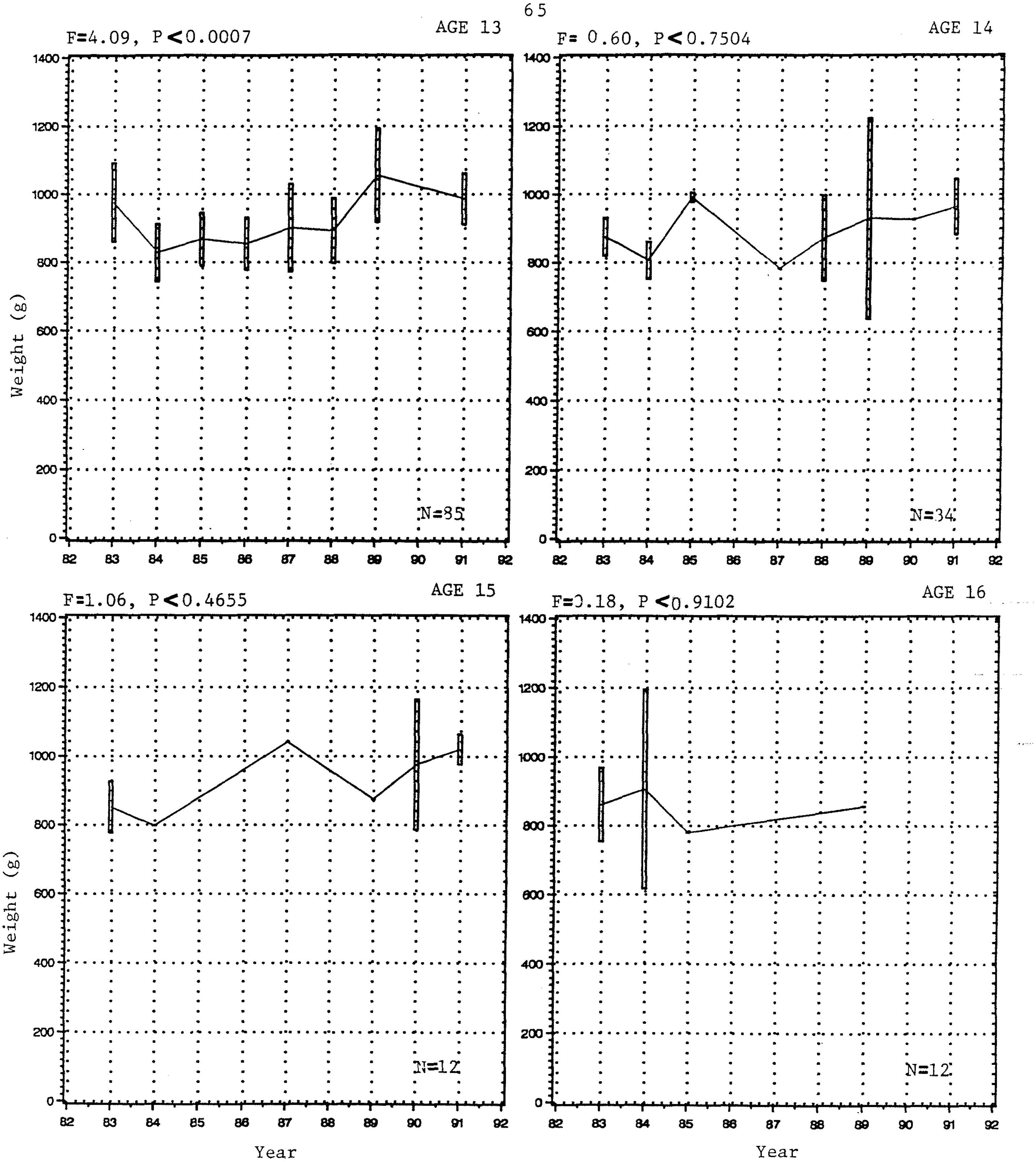

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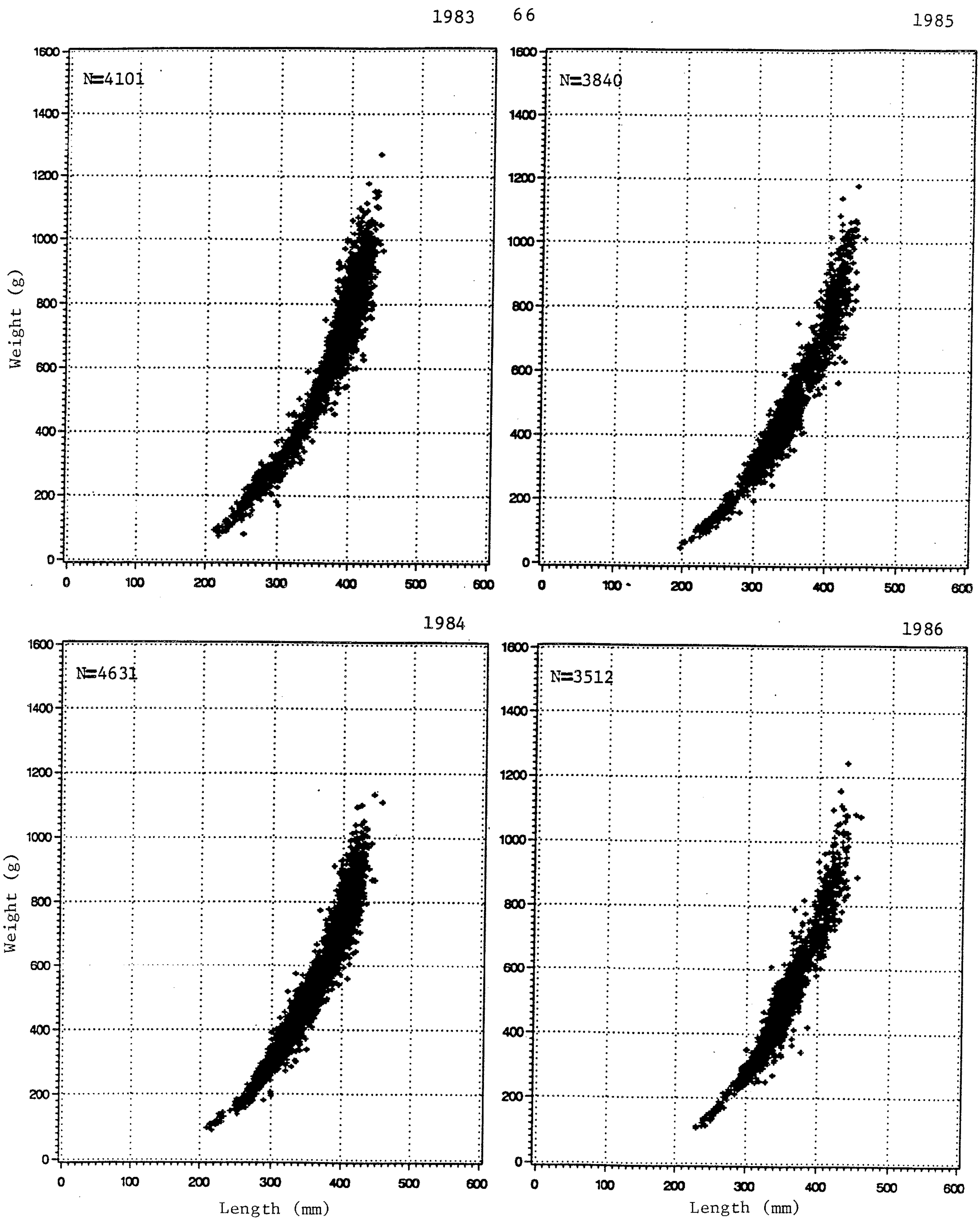
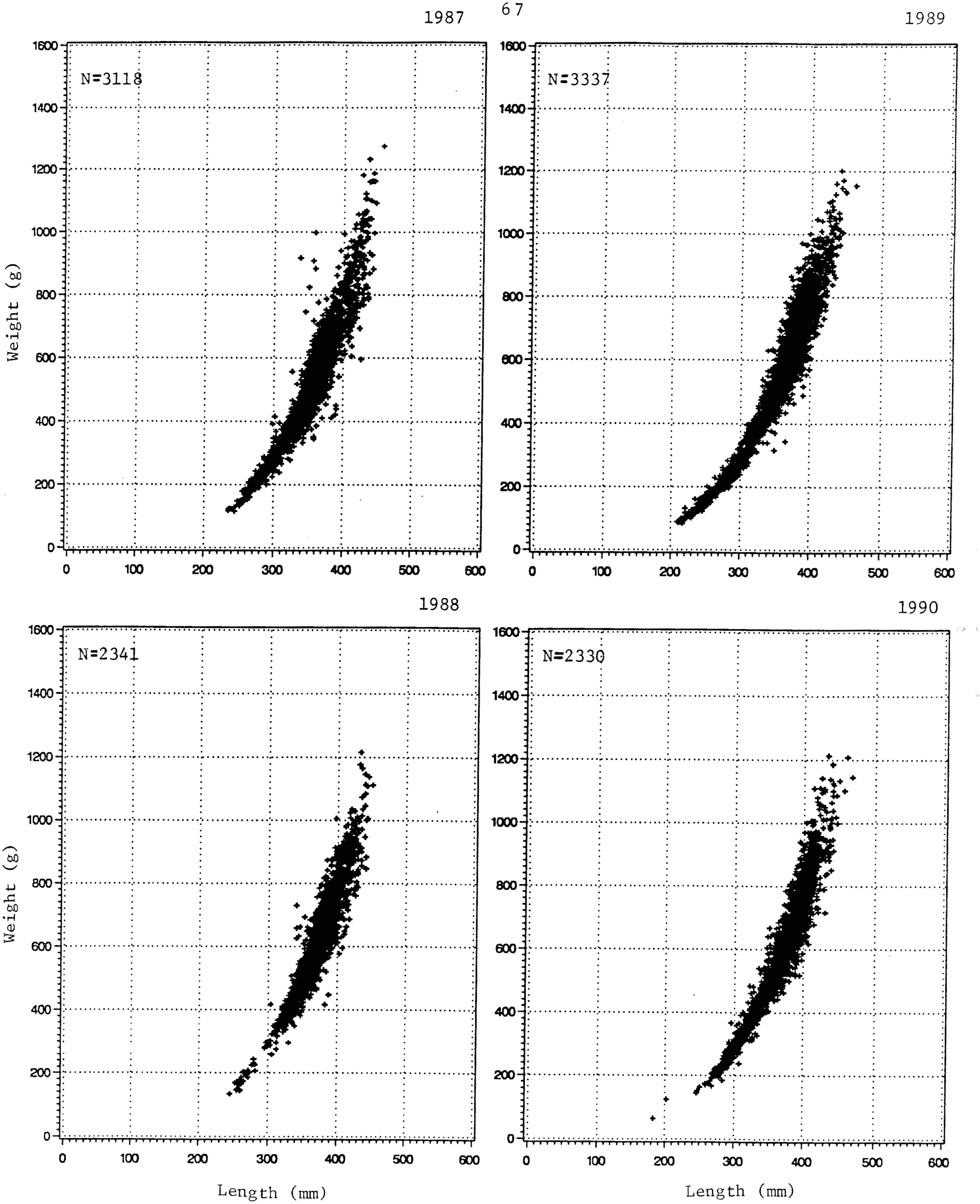


Figure 12. Annual weight-length relationships in mackerel sampled, 1983-1991.



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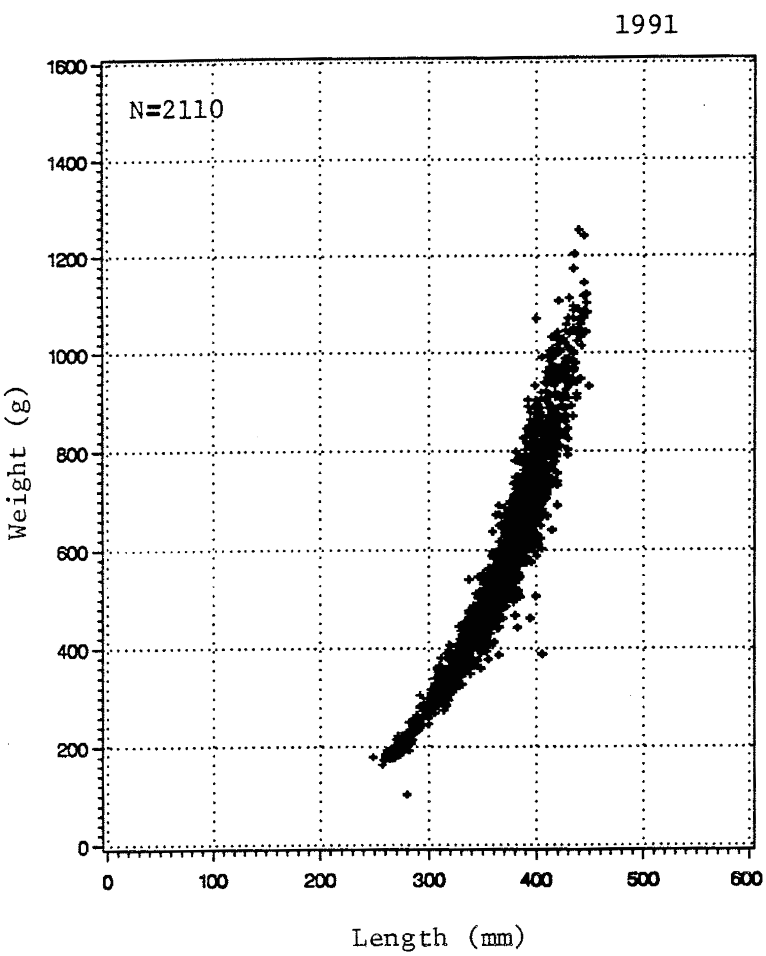

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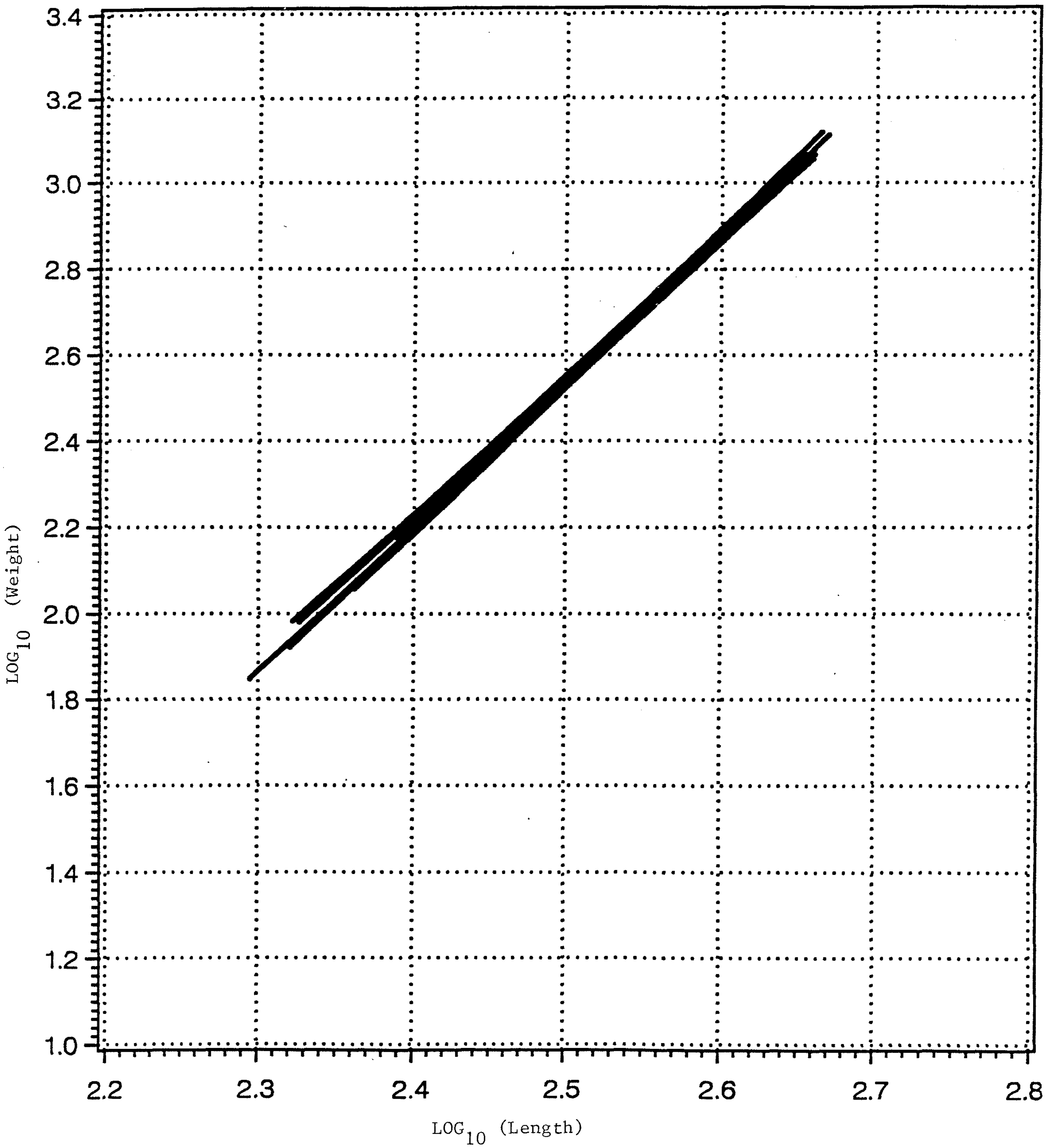


Figure 13. Annual linear relationships between logarithms of weight and length for mackerel sampled, 1983-1991.

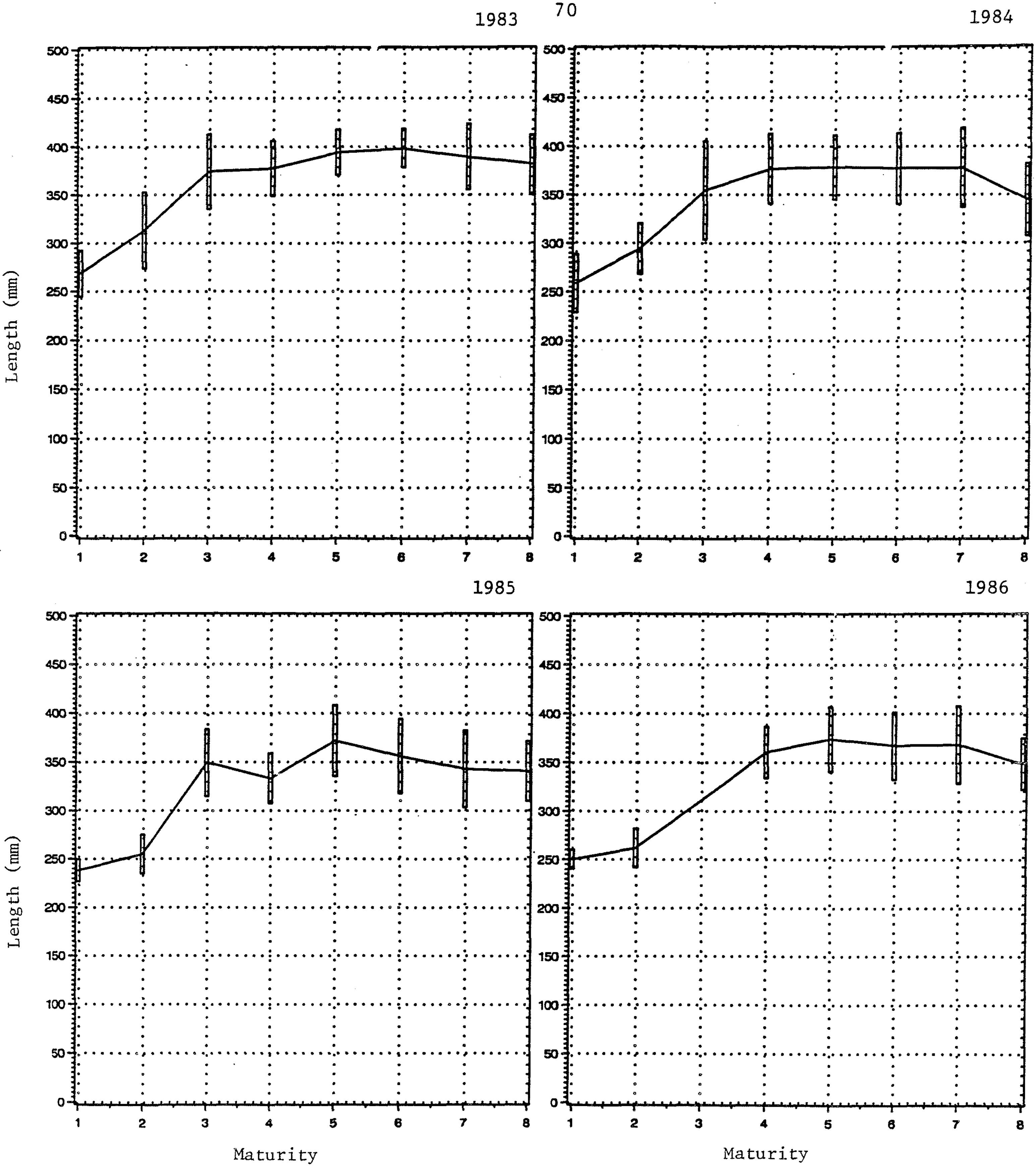
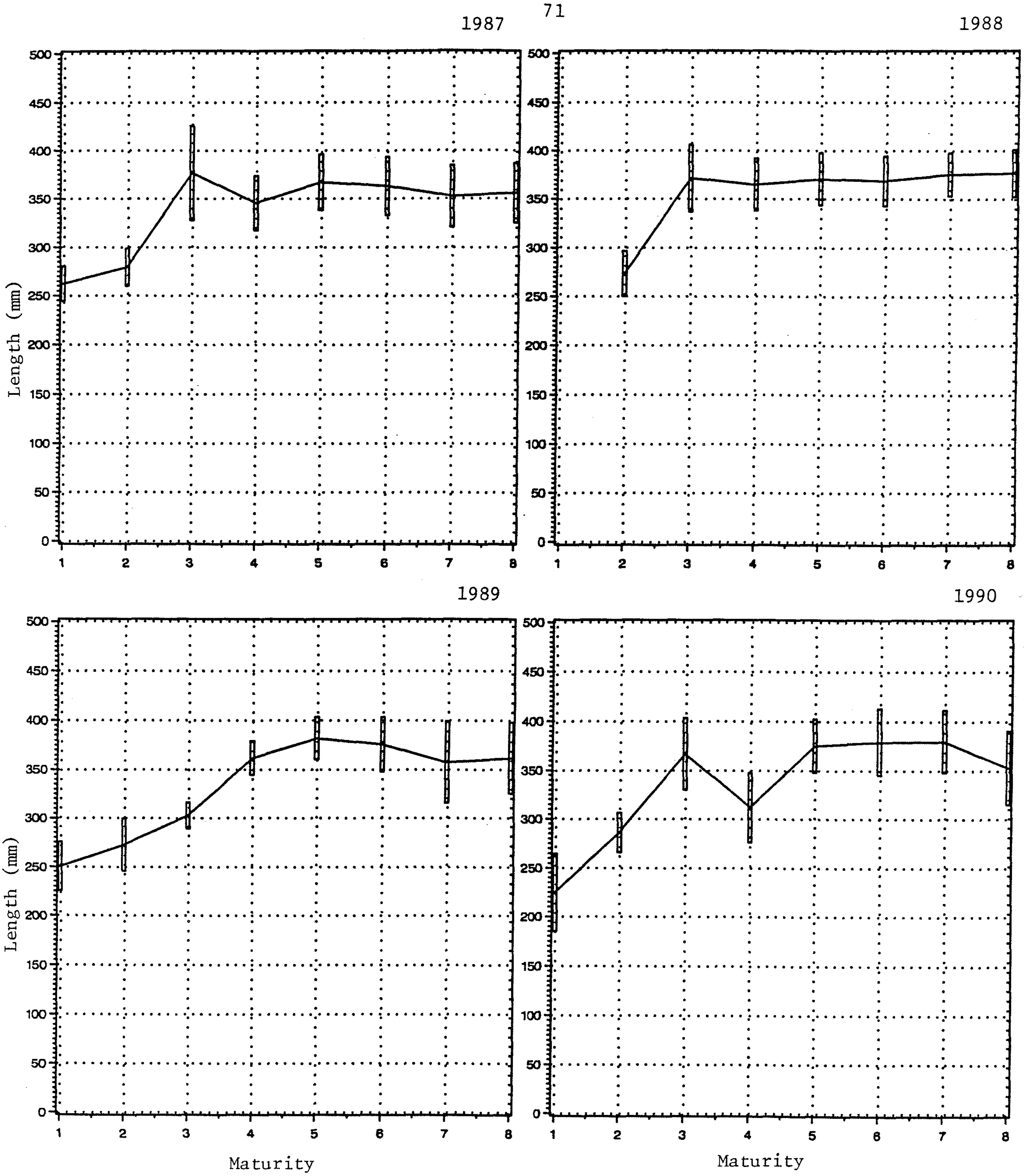


Figure 14. Mean annual lengths by gonad maturity stage in mackerel sampled, 1983-1991, stages identified using the scale proposed by Parrish and Saville (1965).



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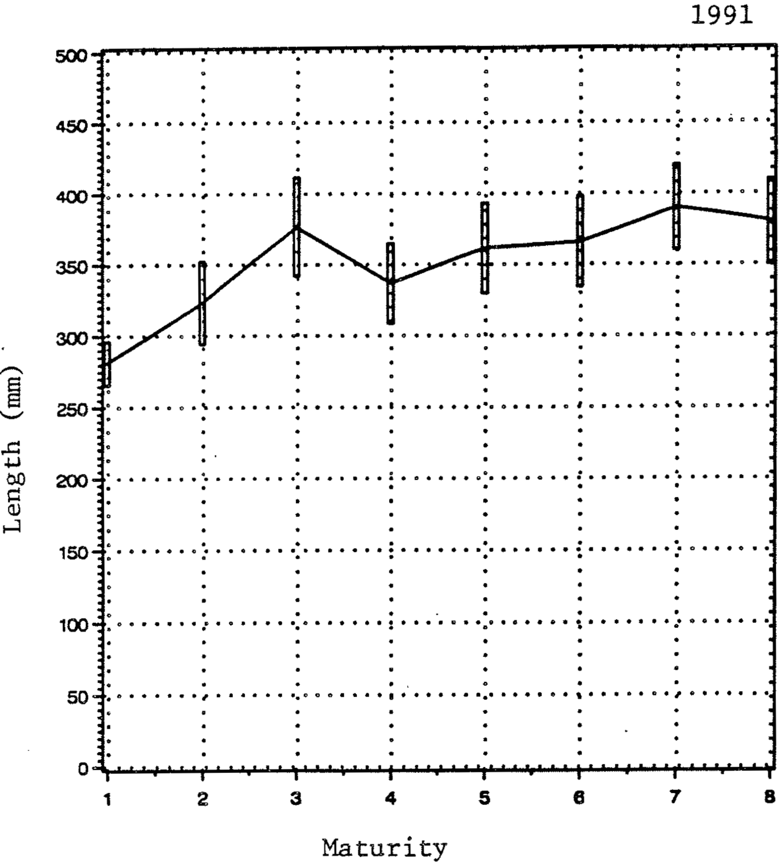

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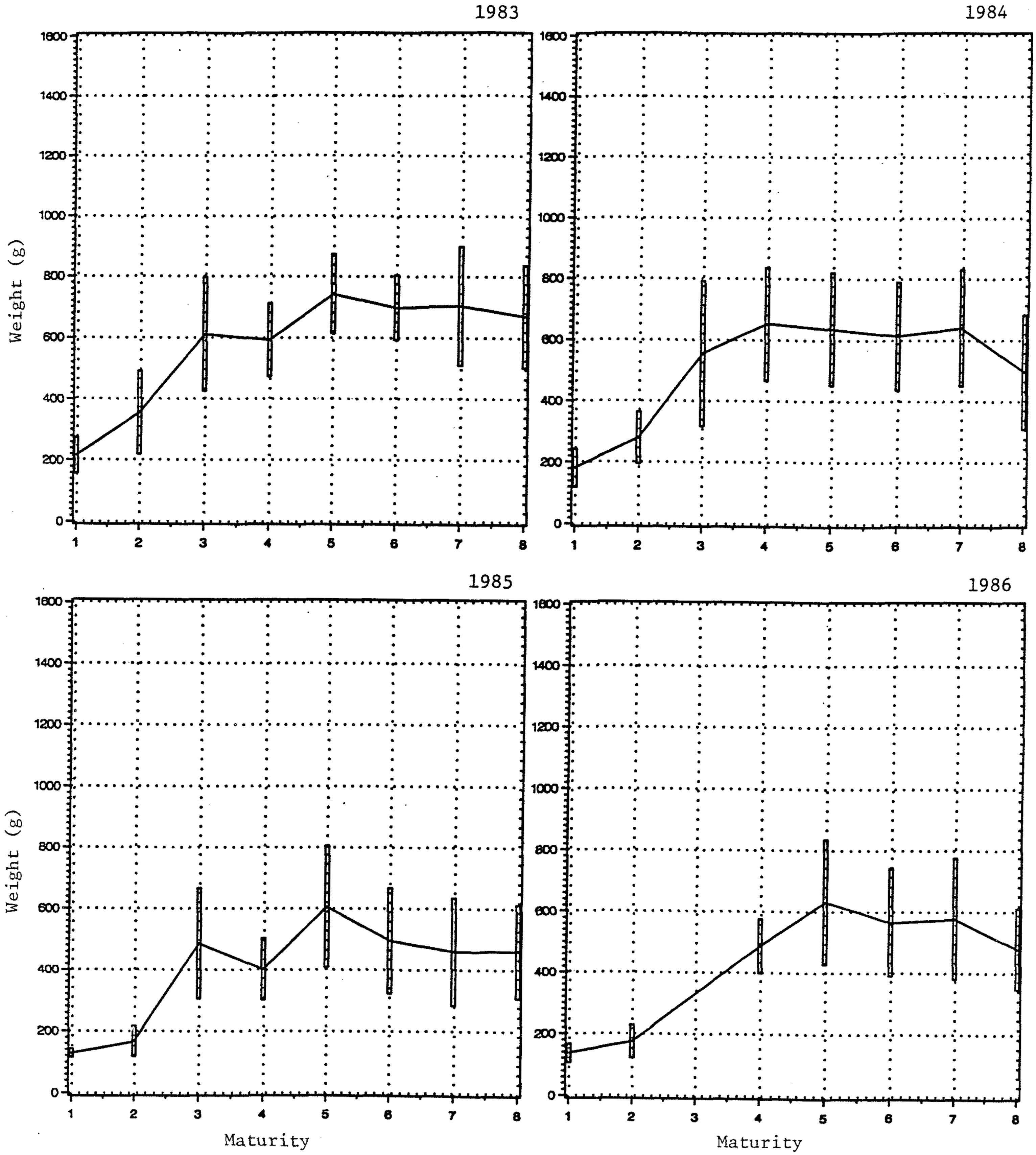


Figure 15. Mean annual weights by gonad maturity stage in mackerel sampled, 1983-1991.

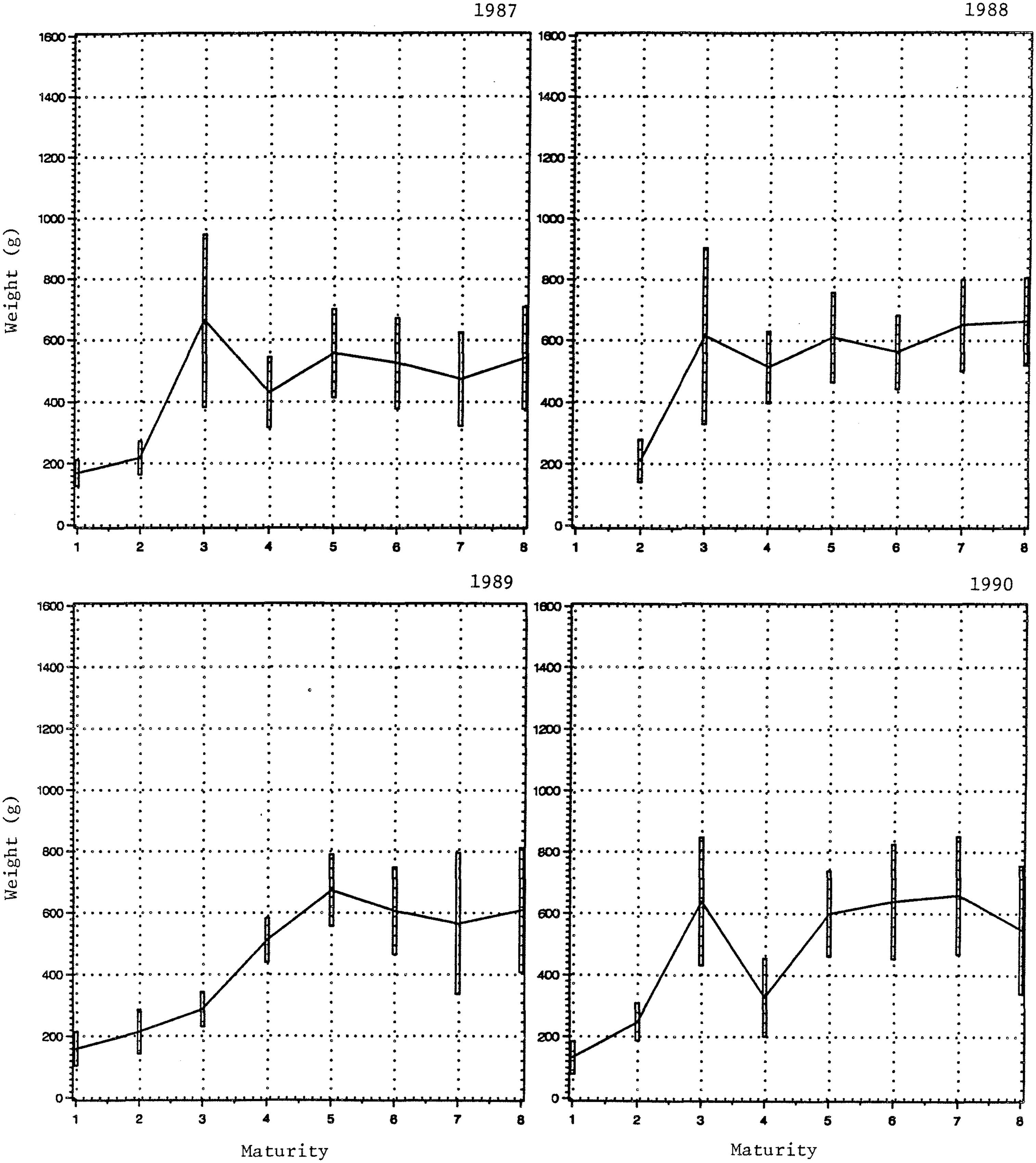
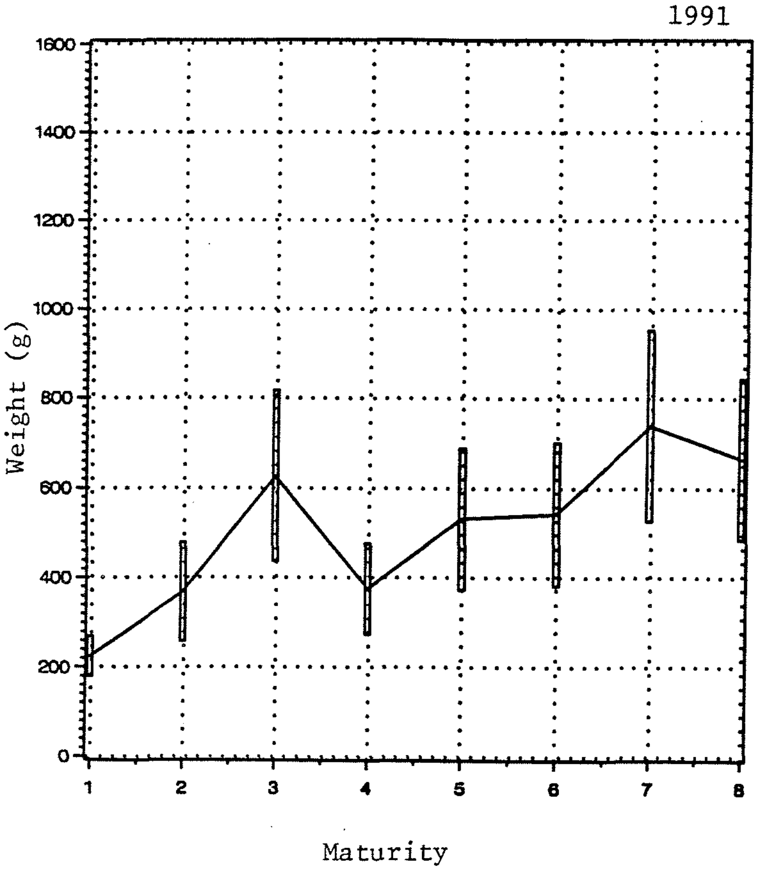


Figure 15. (cont'd).



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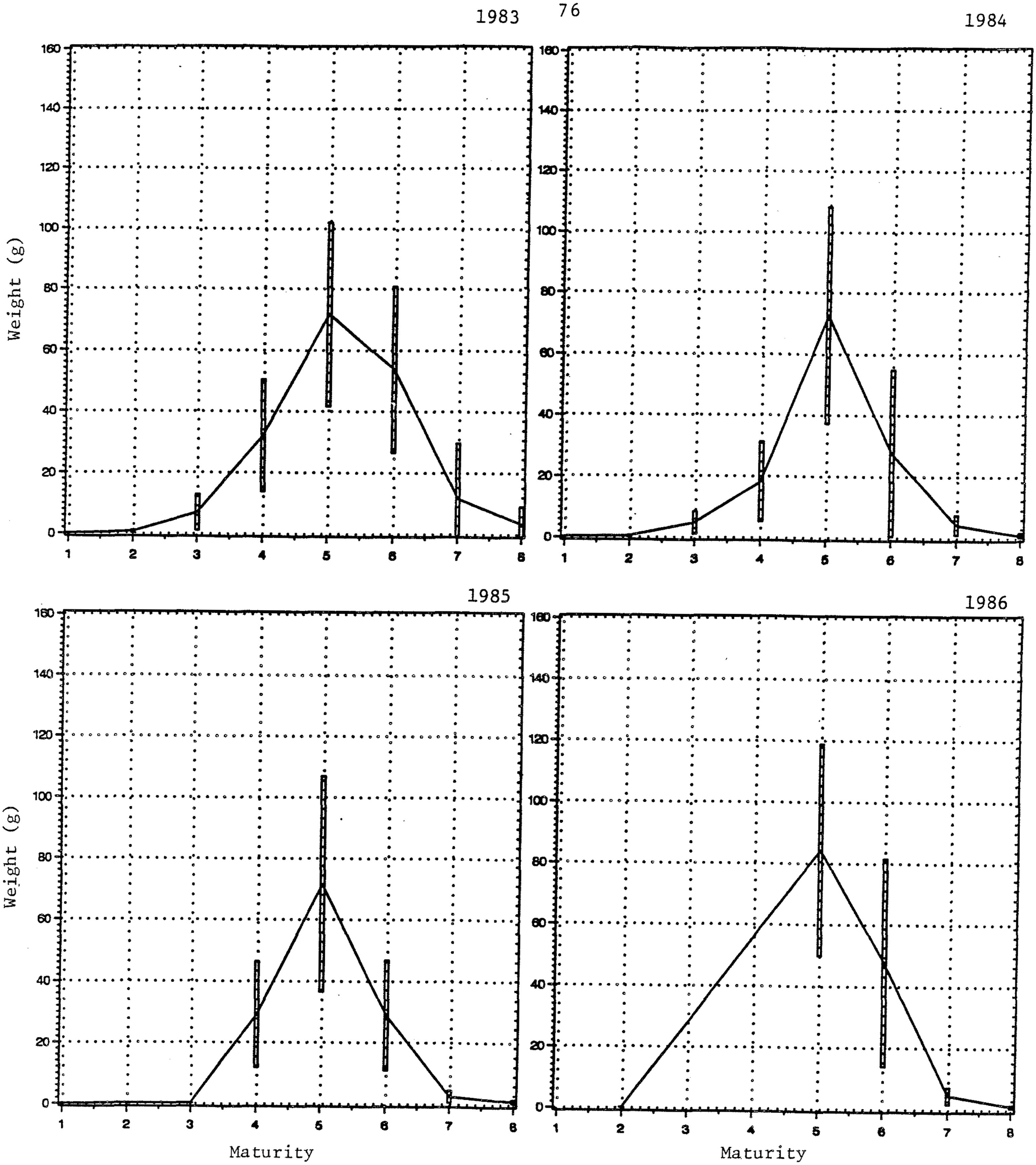


Figure 16. Mean weight of gonads by stage of maturity in male mackerel sampled, 1983-1991.

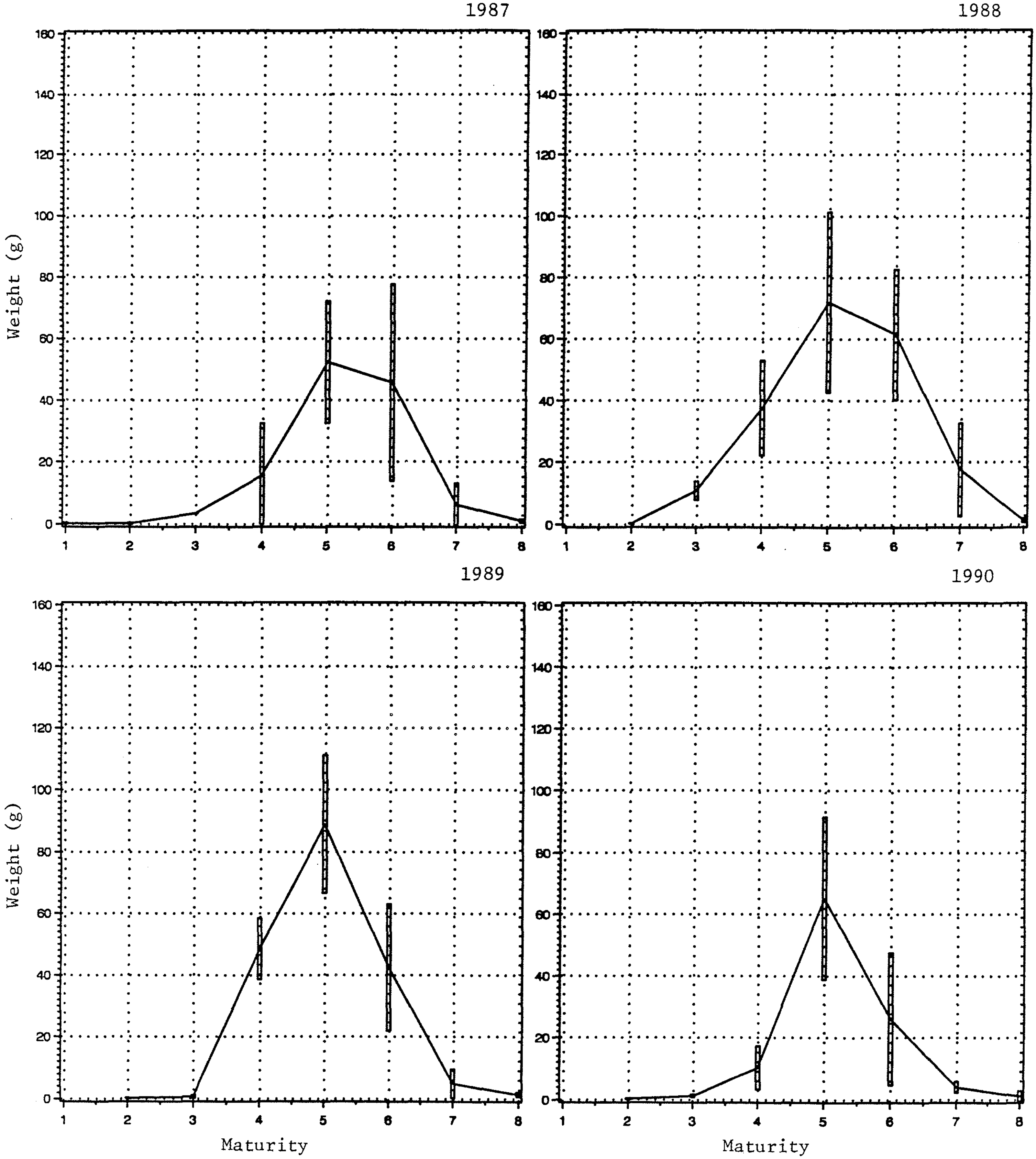


Figure 16. (cont'd).

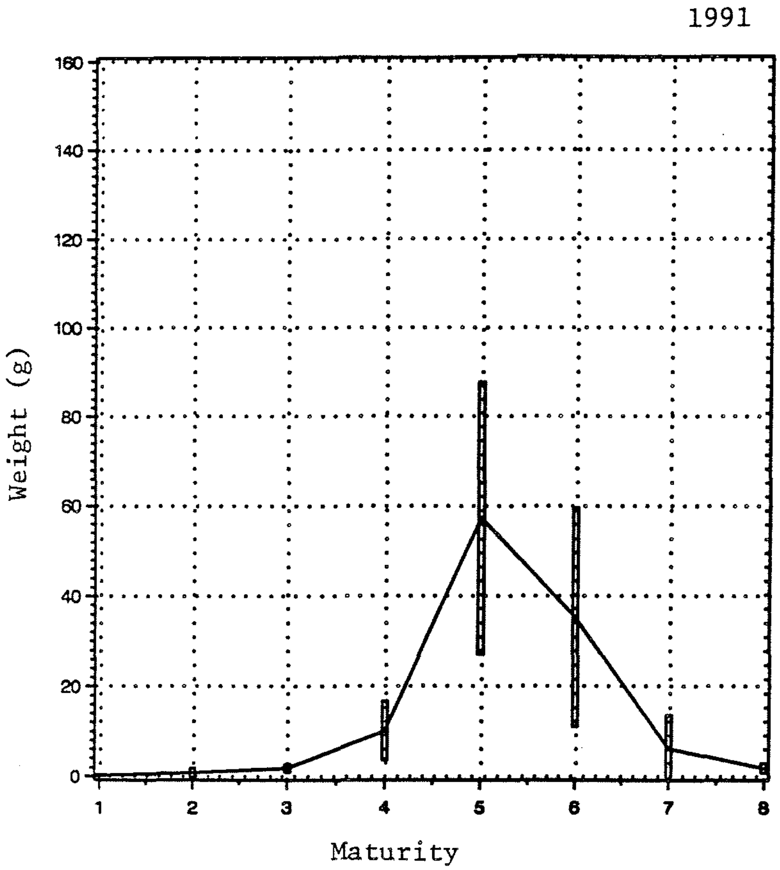


Figure 16. (cont'd).

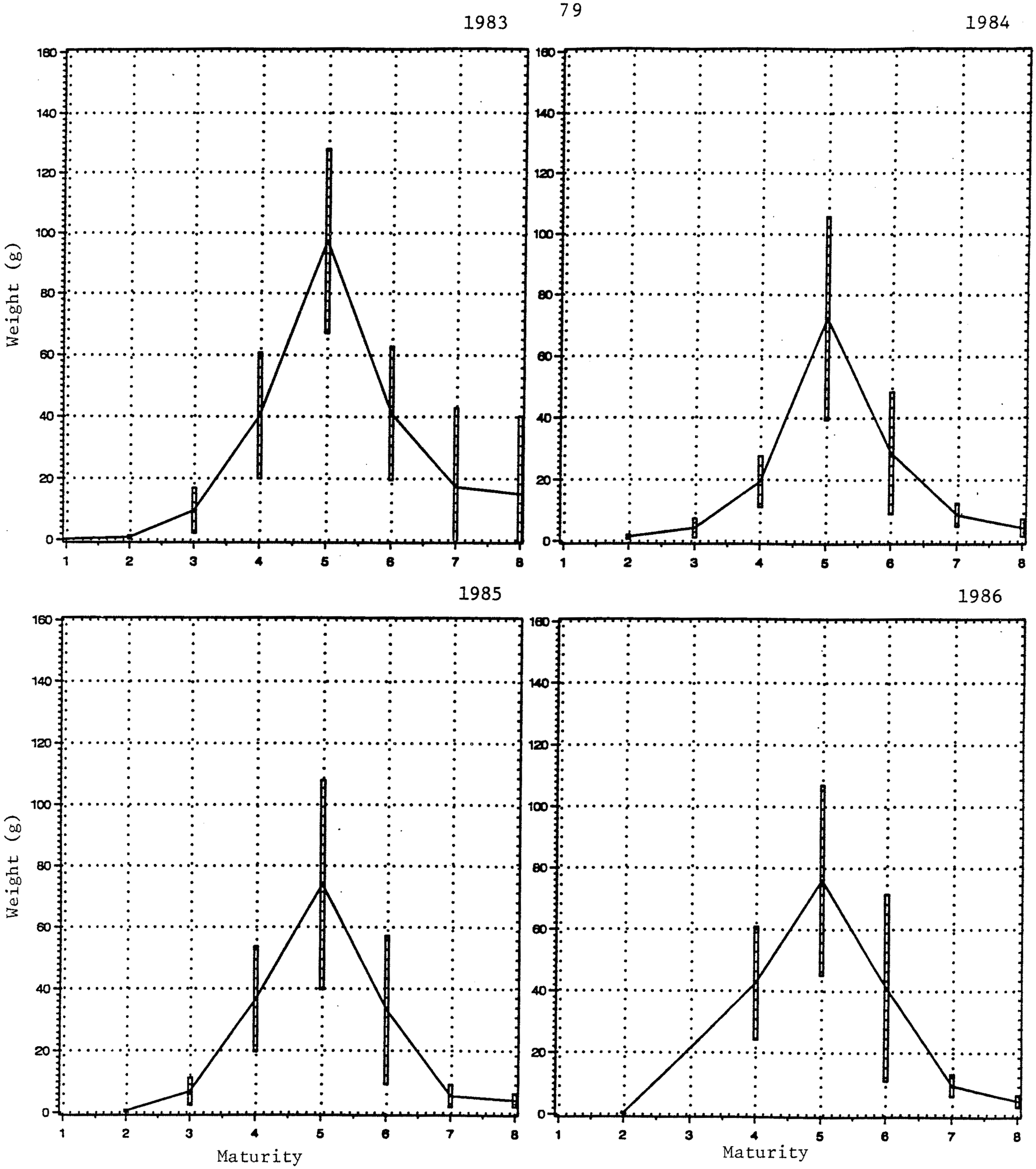
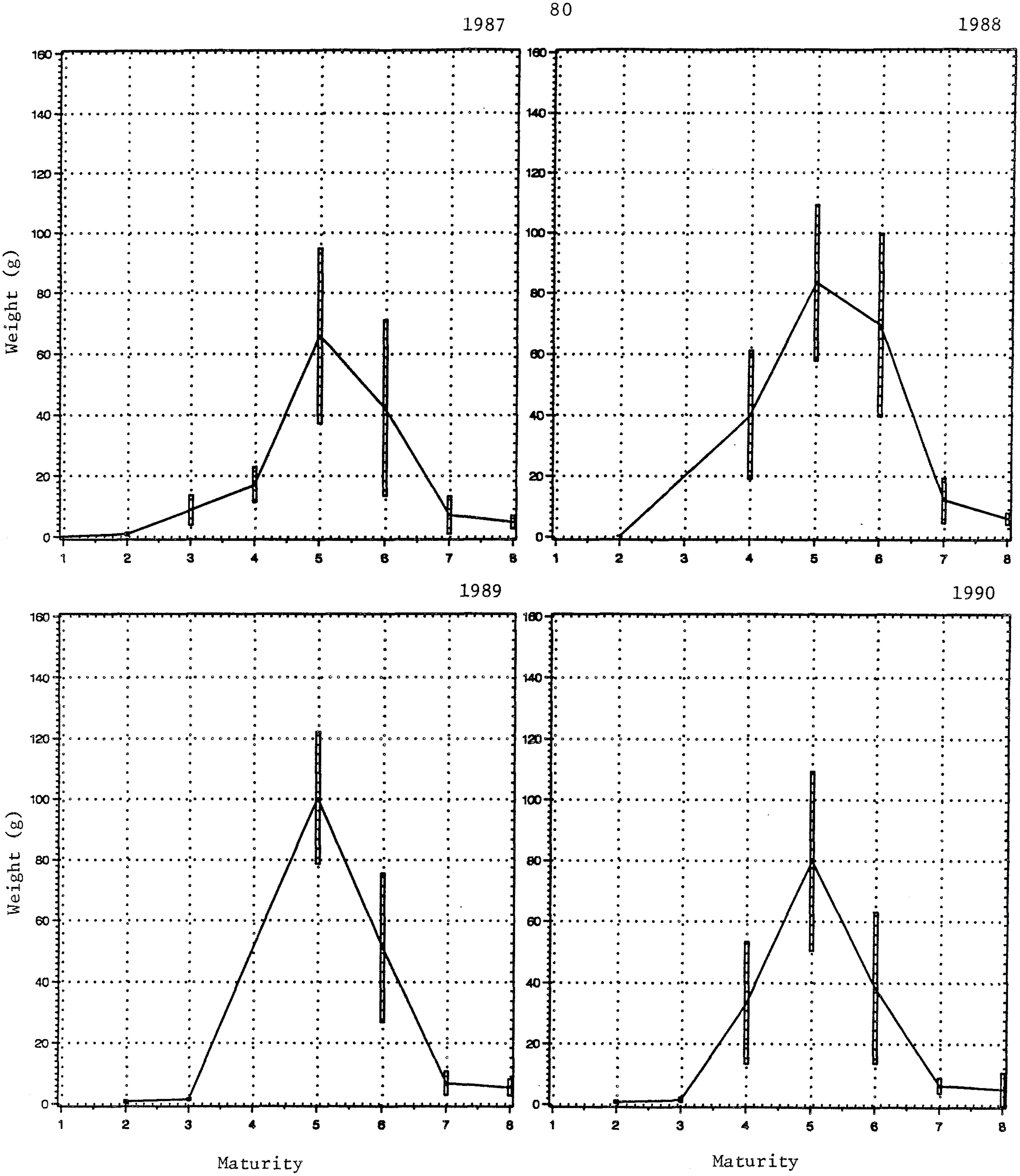


Figure 17. Mean weight of gonads by stage of maturity in female mackerel sampled, 1983-1991.



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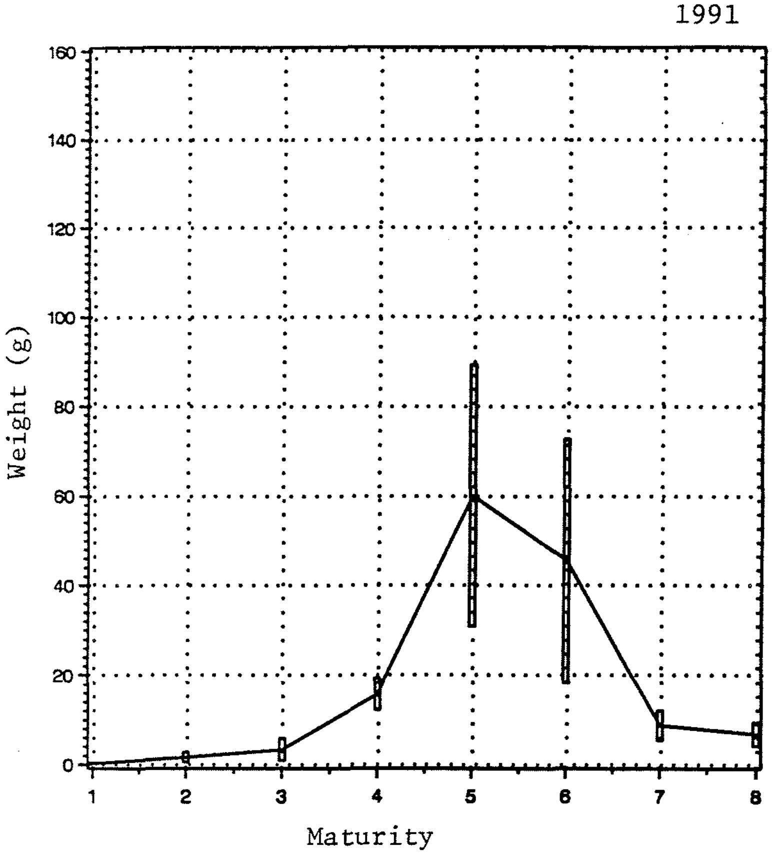

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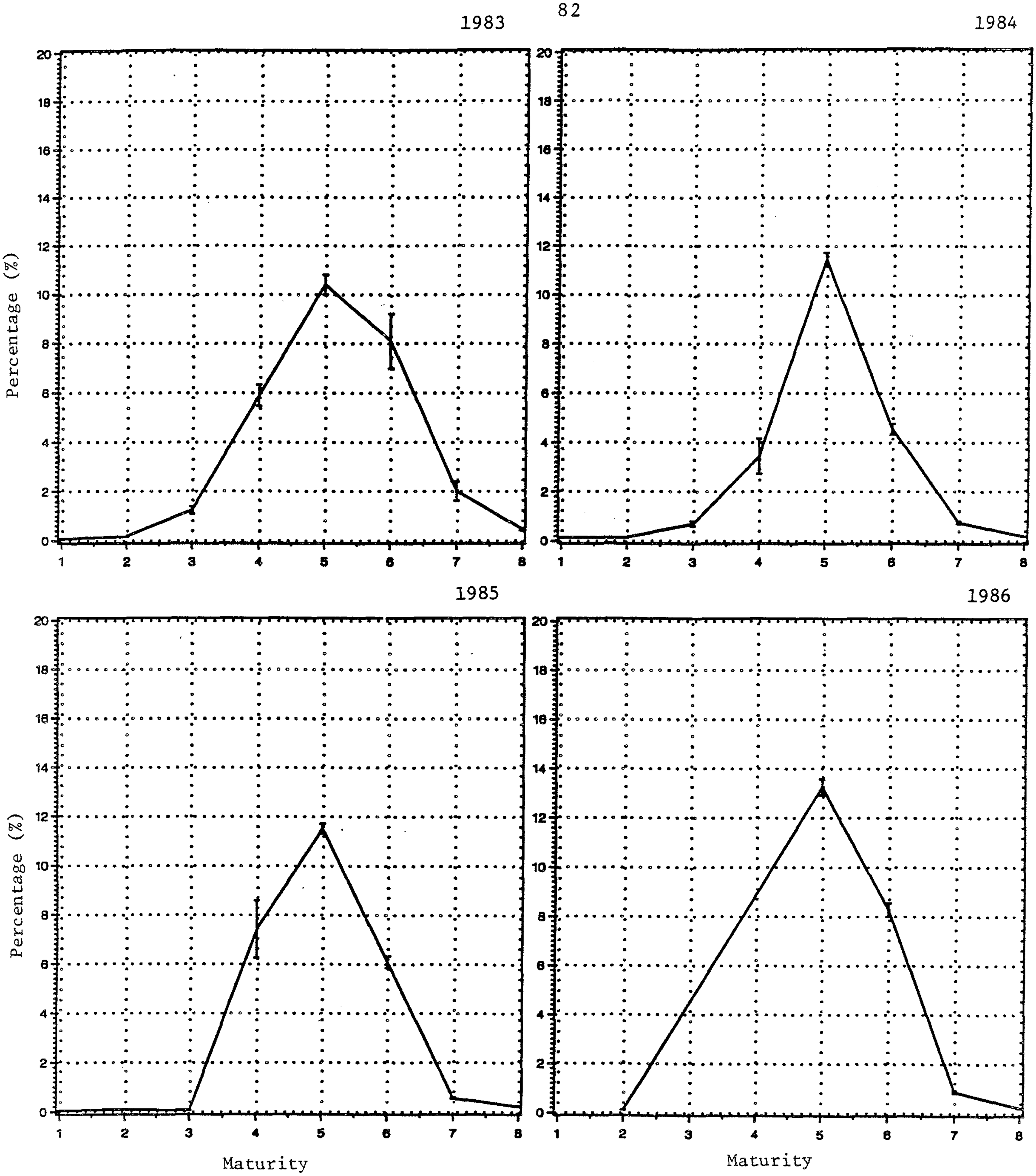
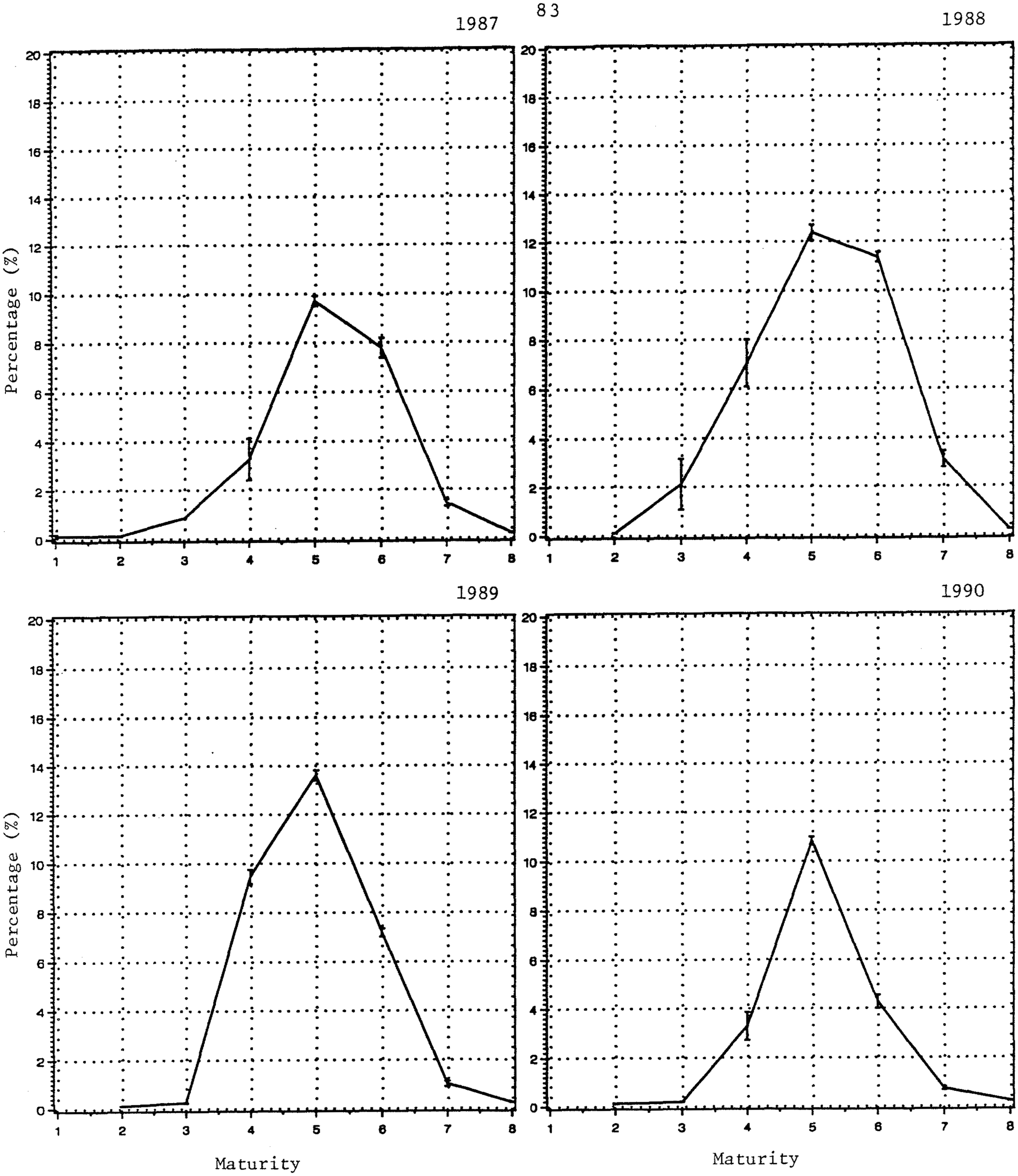


Figure 18. Mean values of the gonado-somatic index by stage of maturity in male mackerel sampled, 1983-1991.



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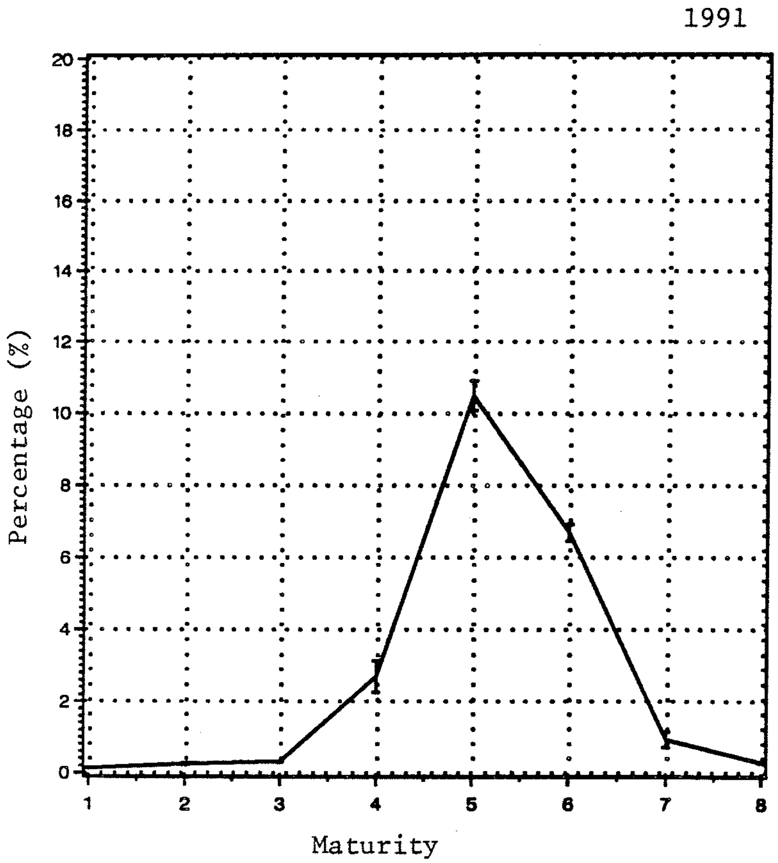

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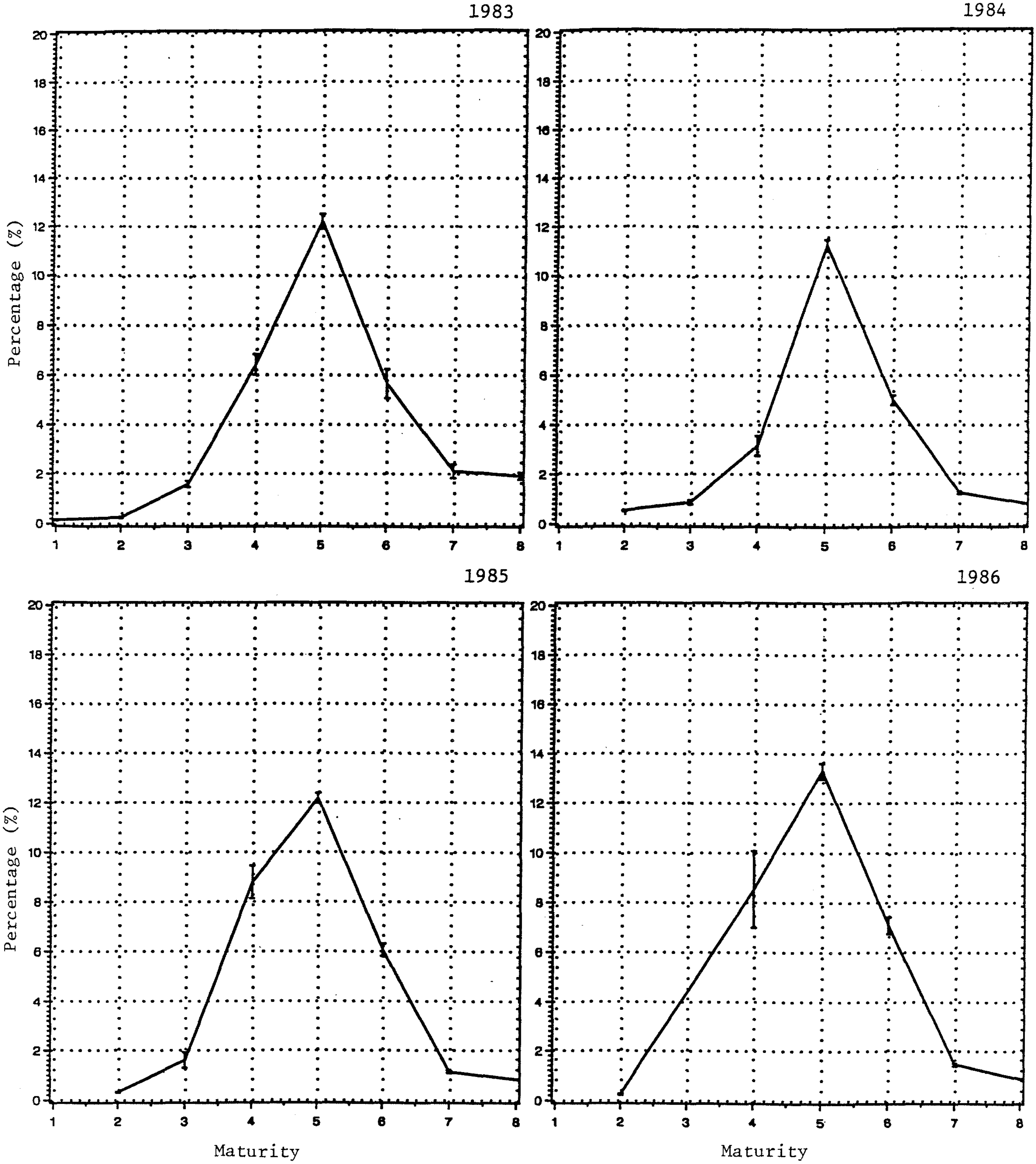
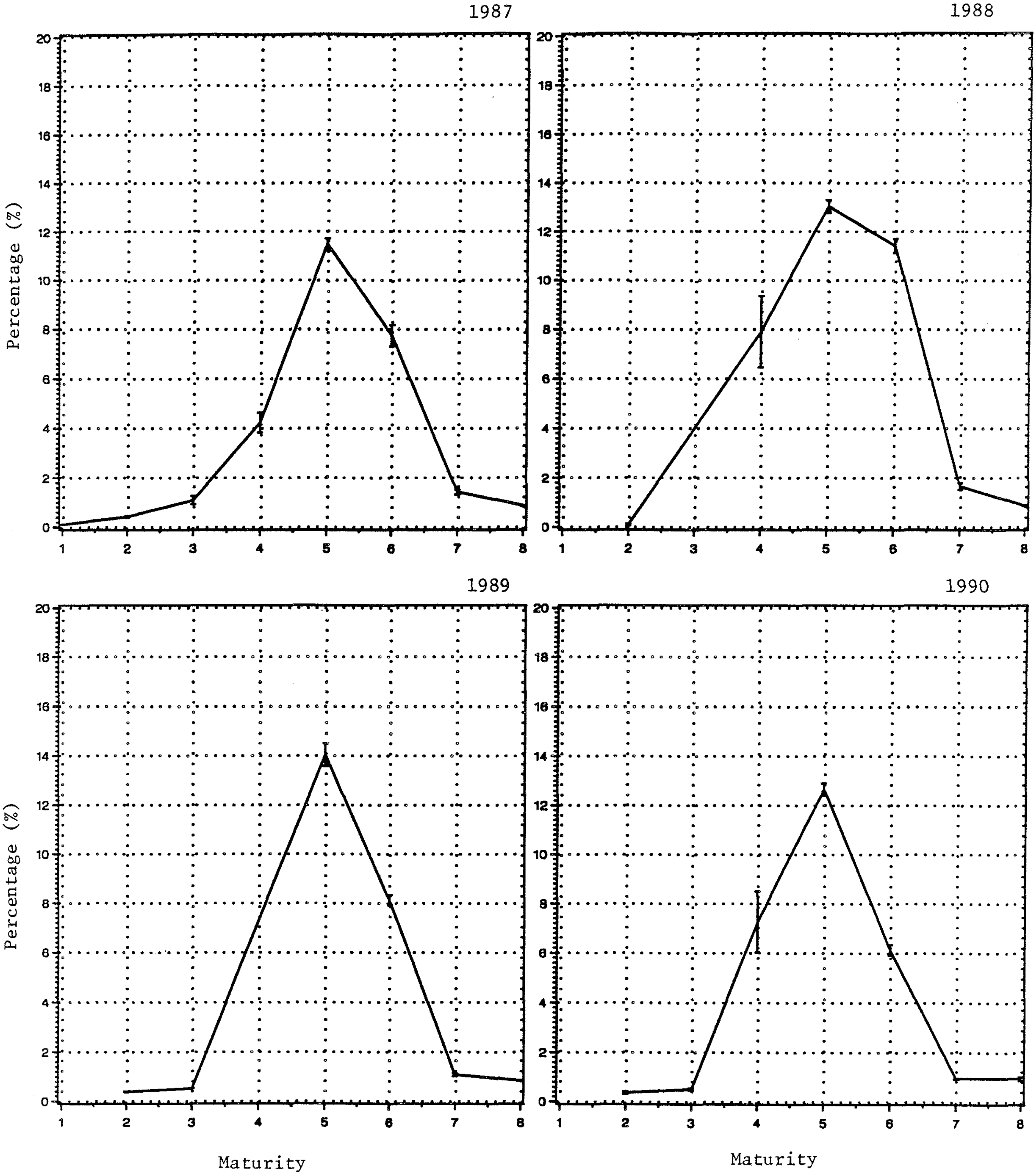


Figure 19. Mean values of the gonado-somatic index by stage of maturity in female mackerel sampled, 1983-1991.



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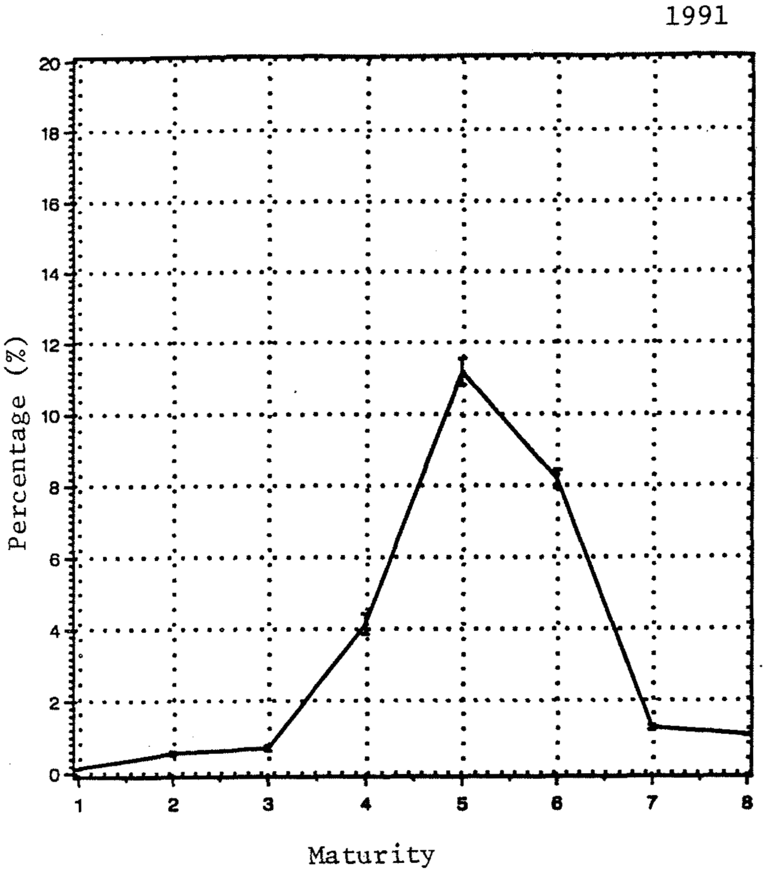

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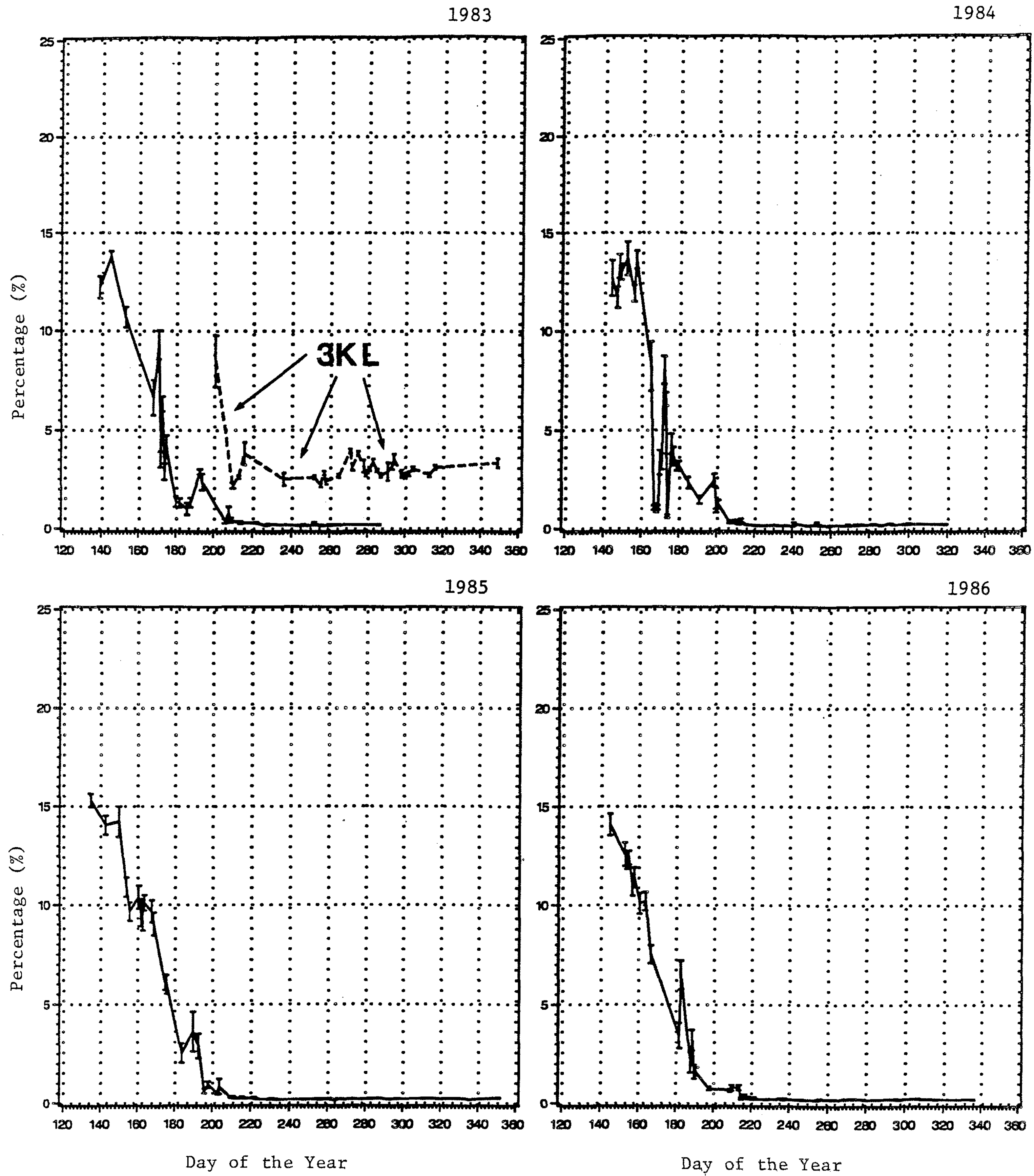
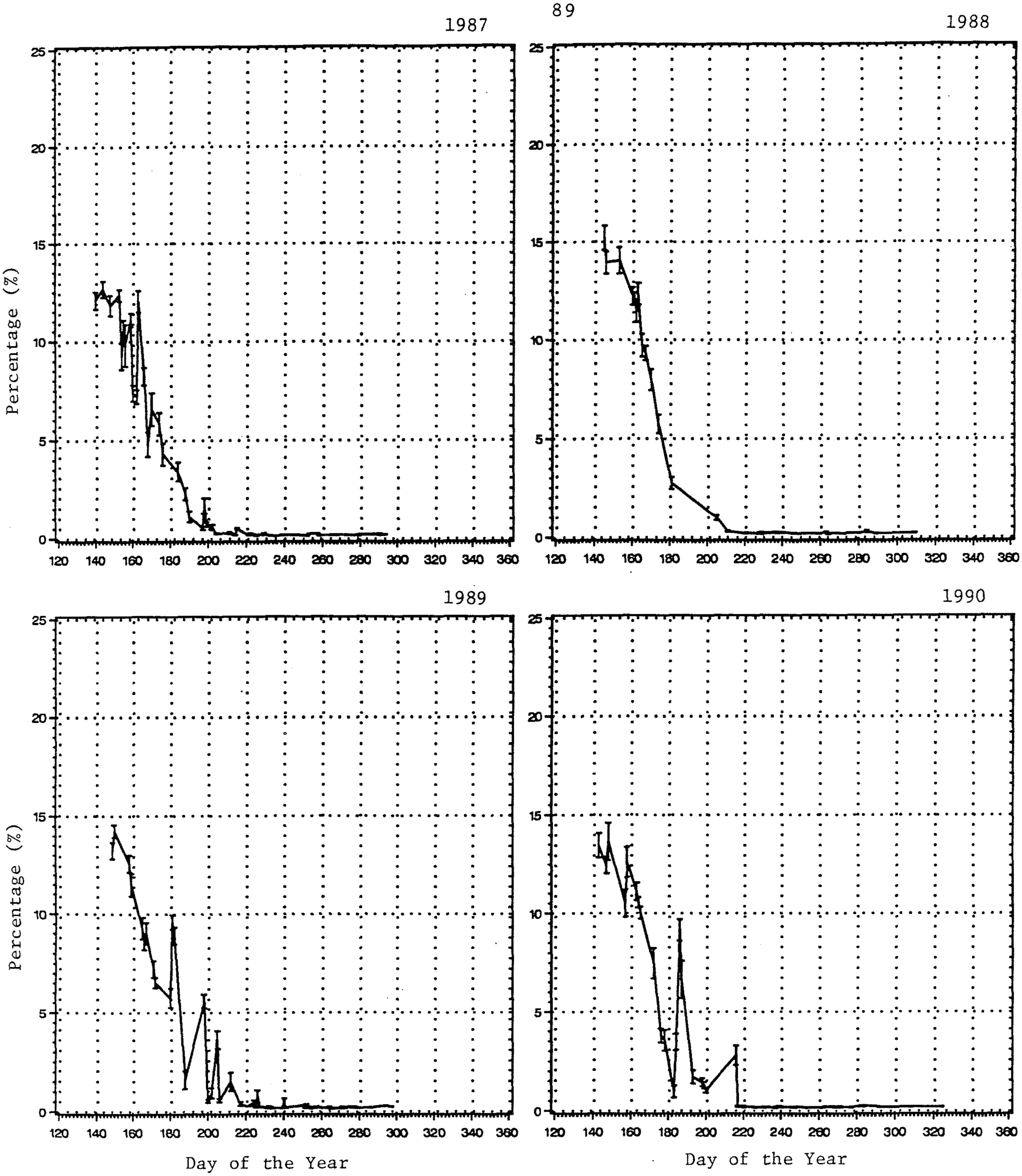


Figure 20. Daily variations in mean gonado-somatic index for male mackerel sampled, 1983-1991.



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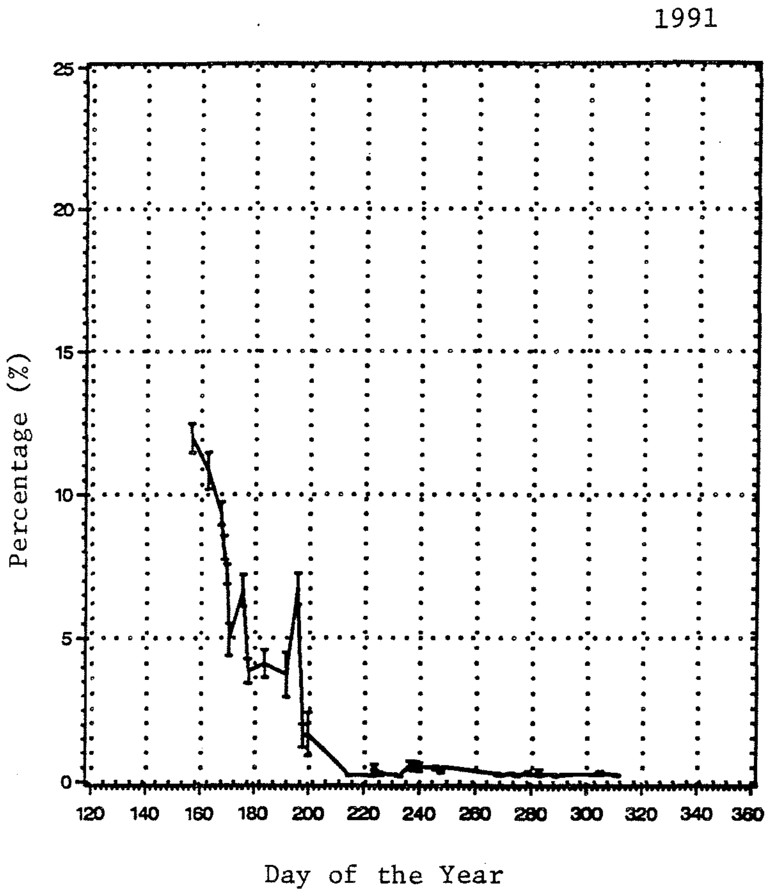

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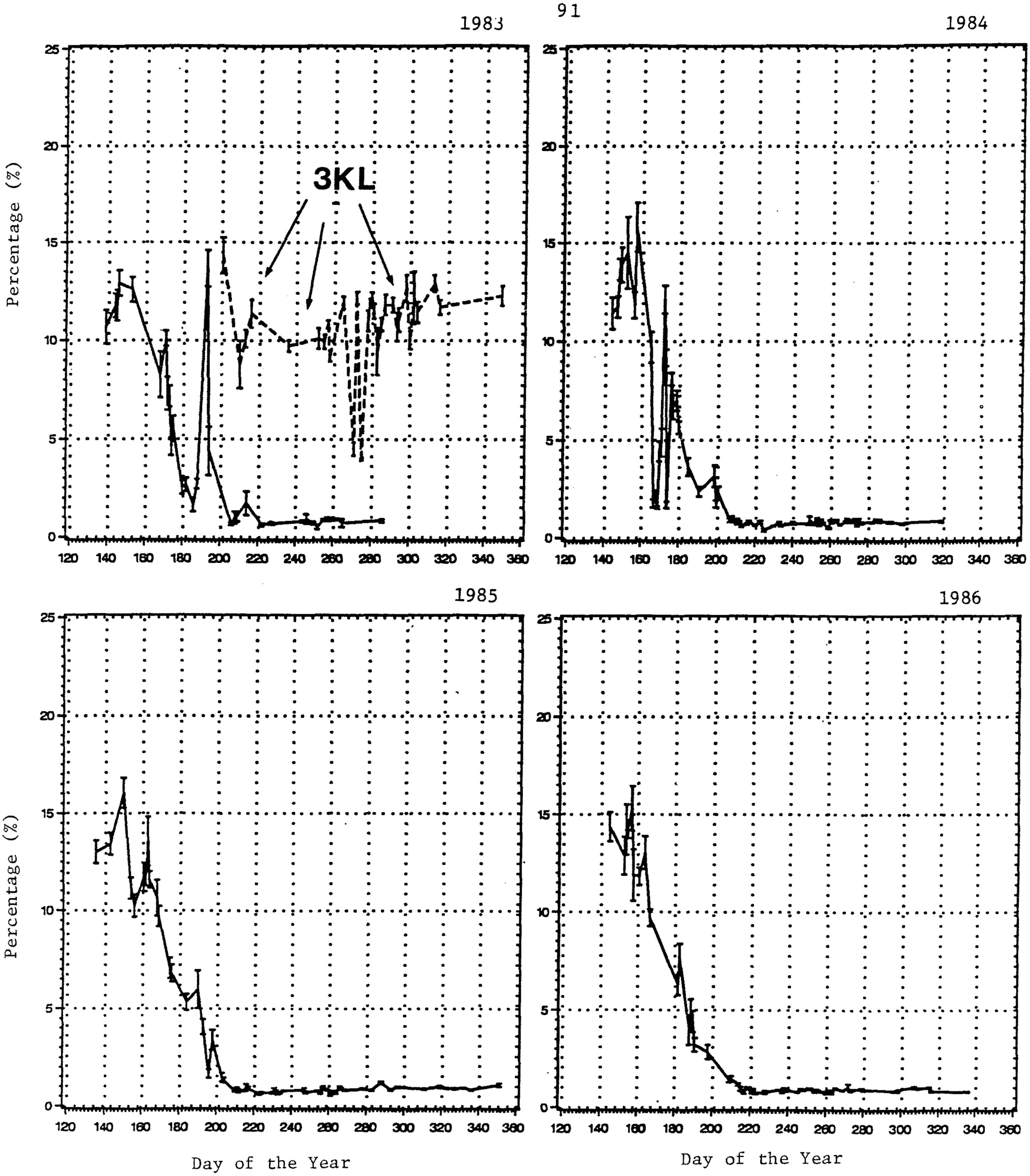
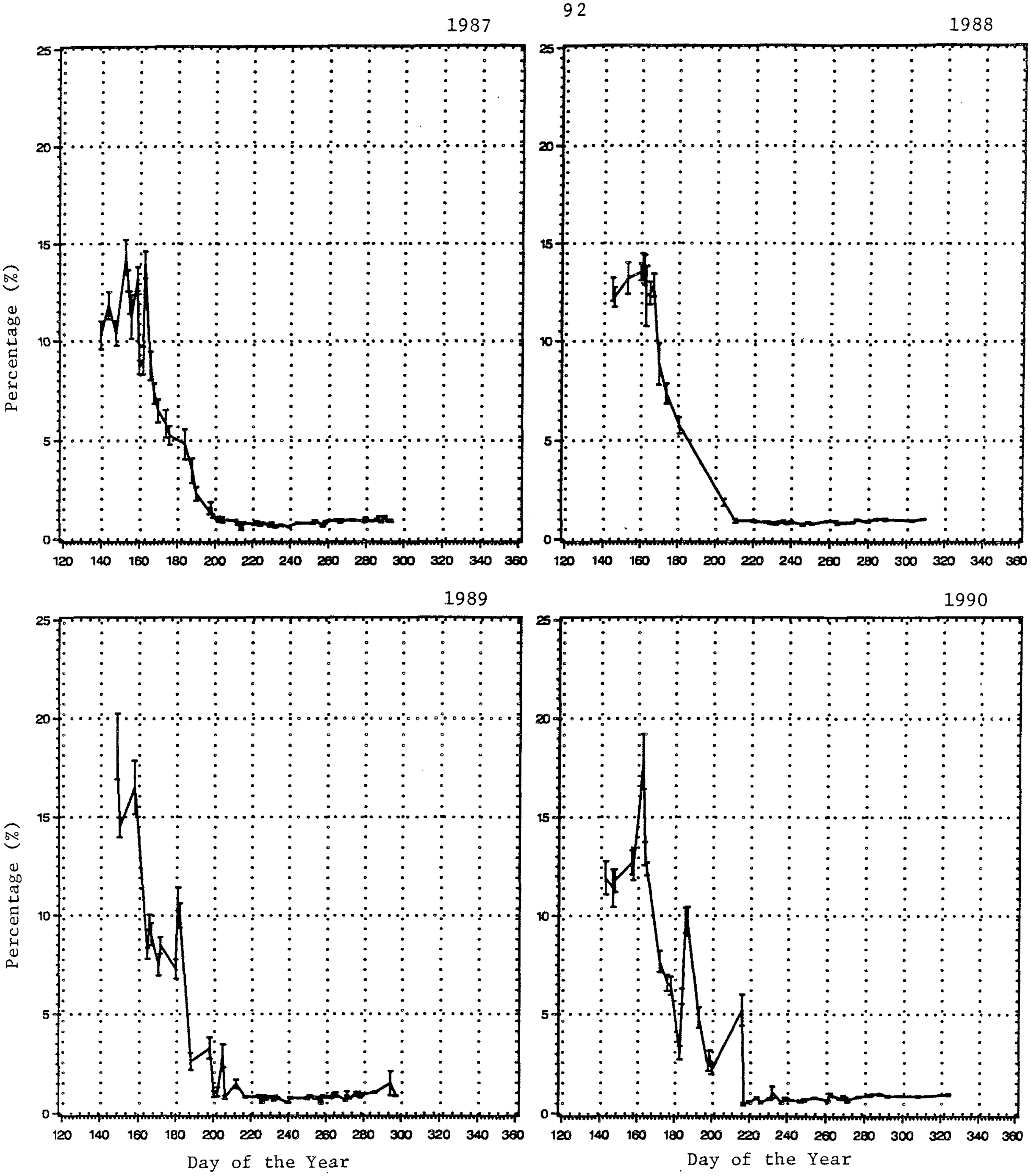


Figure 21. Daily variations in mean gonado-somatic index for female mackerel sampled, 1983-1991.



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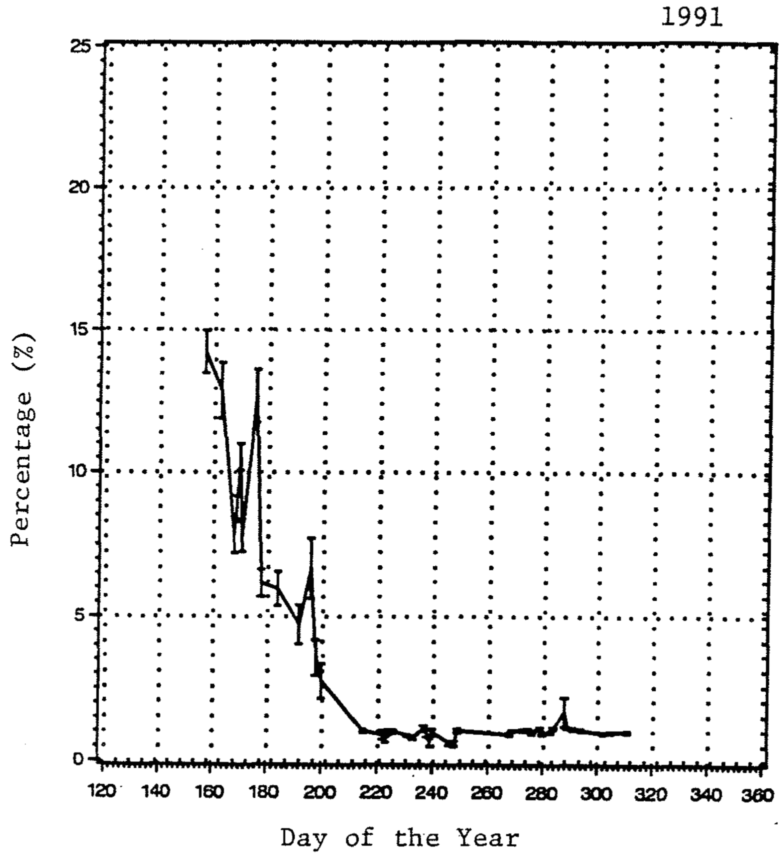

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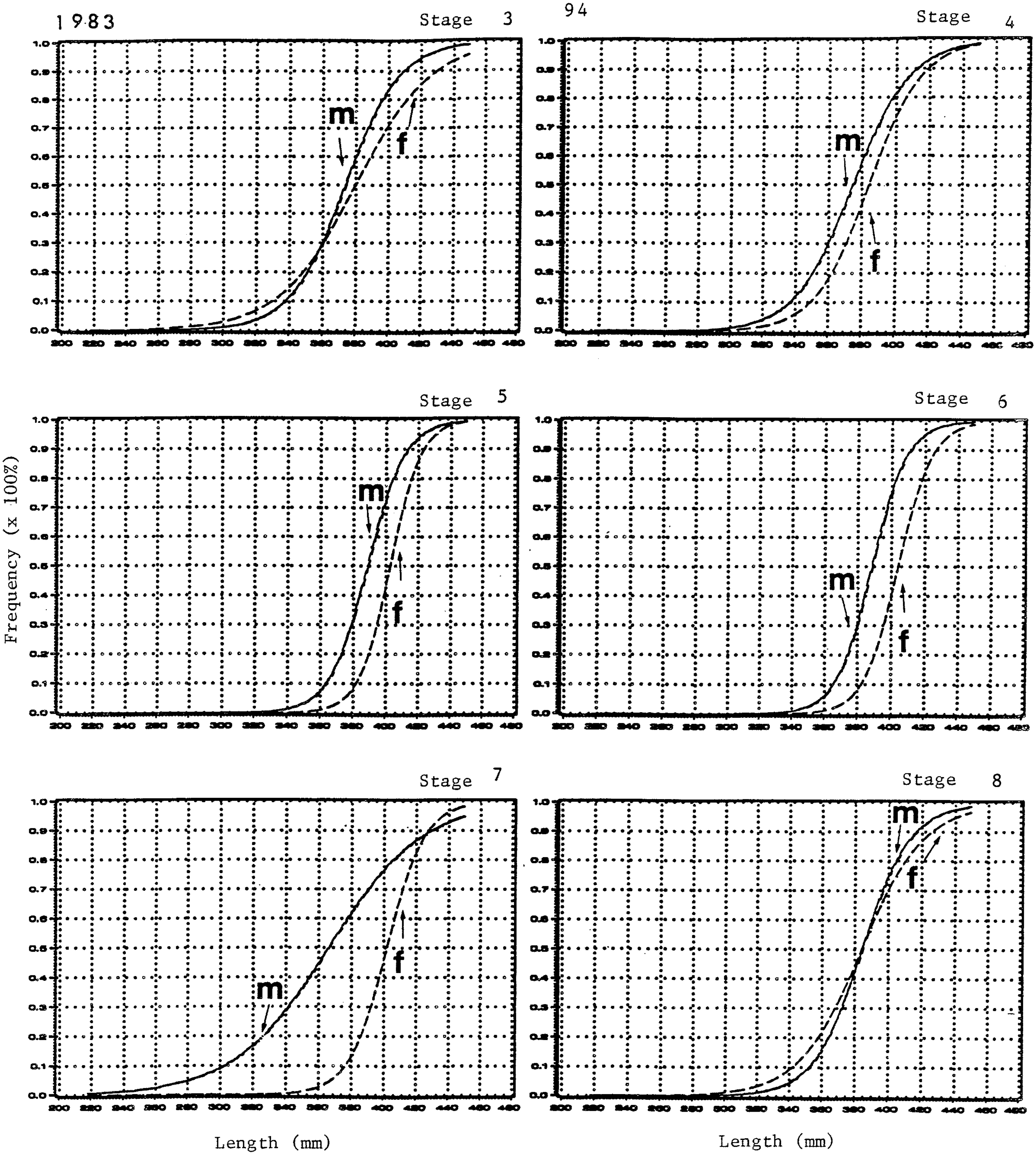
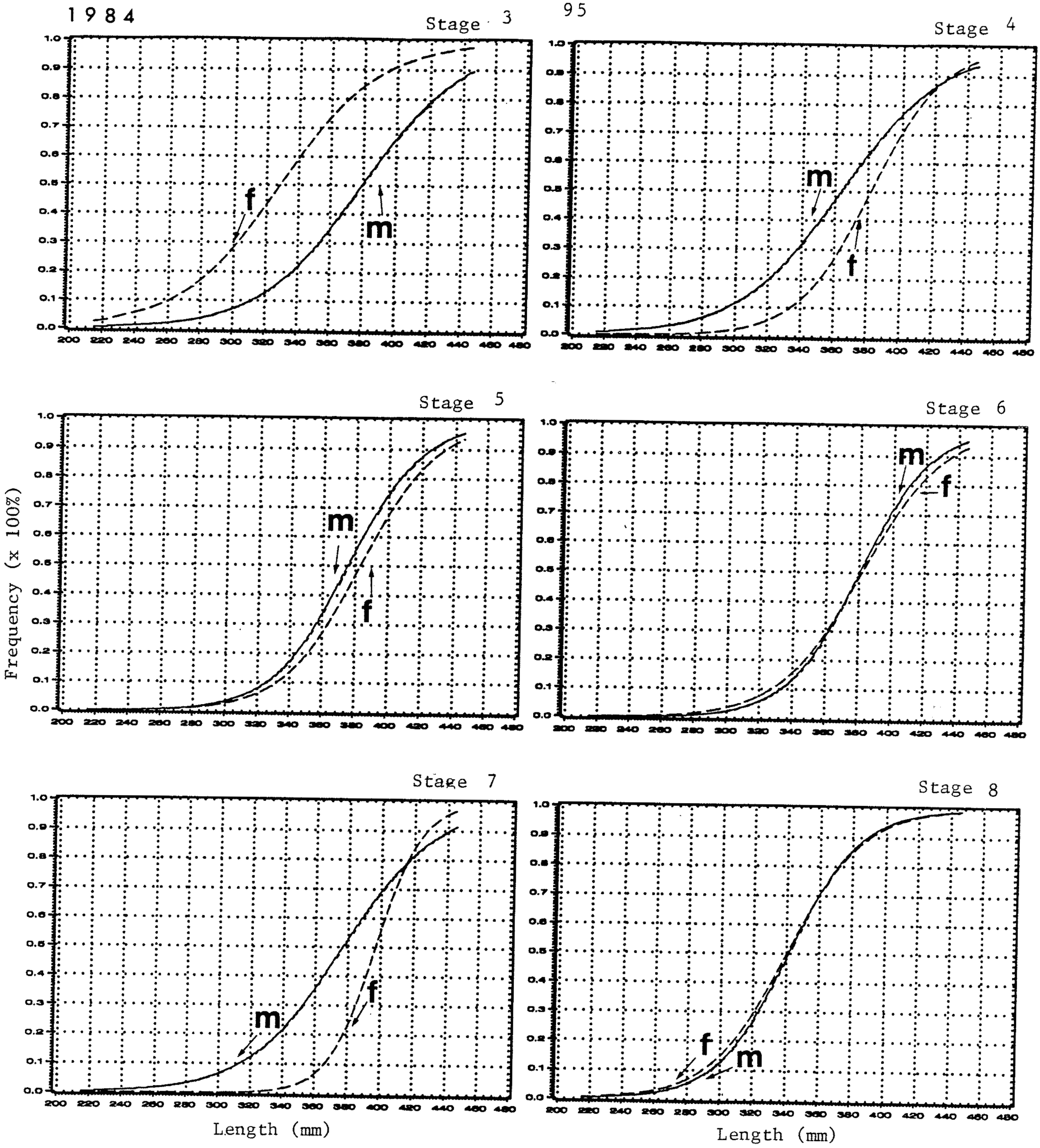


Figure 22. Cumulative annual frequencies by length and gonad maturity in male and female mackerel sampled, 1983-1991.



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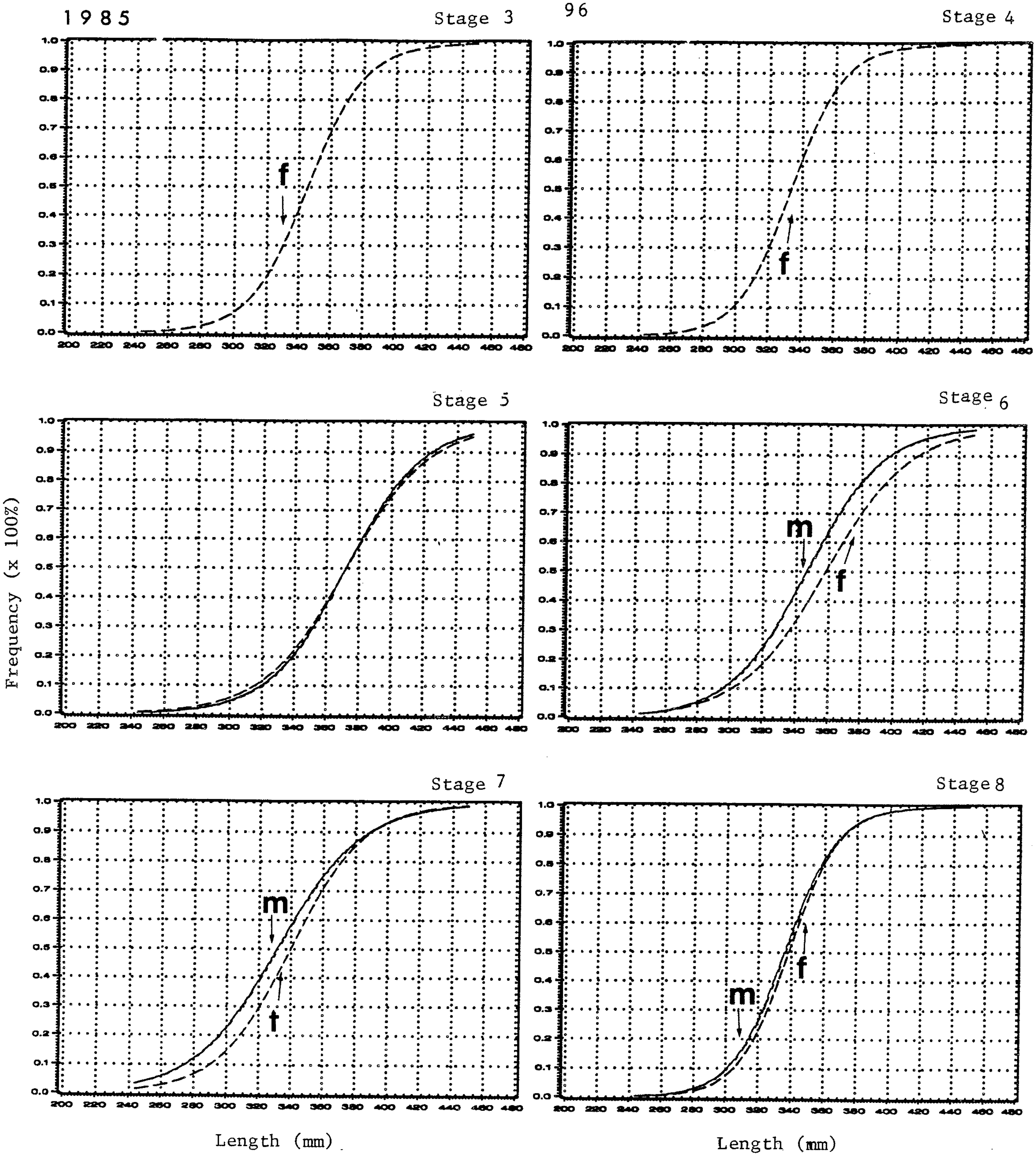

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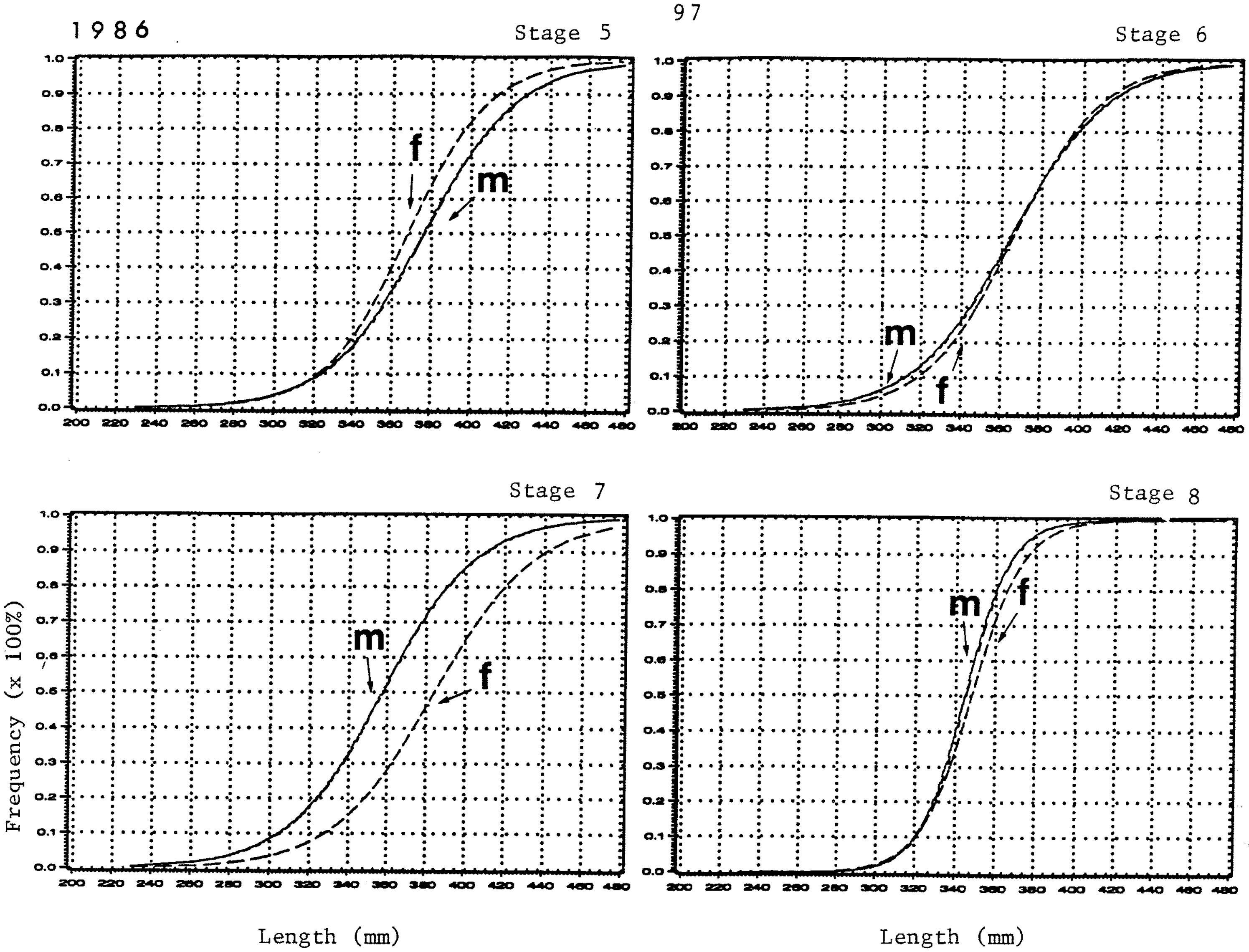

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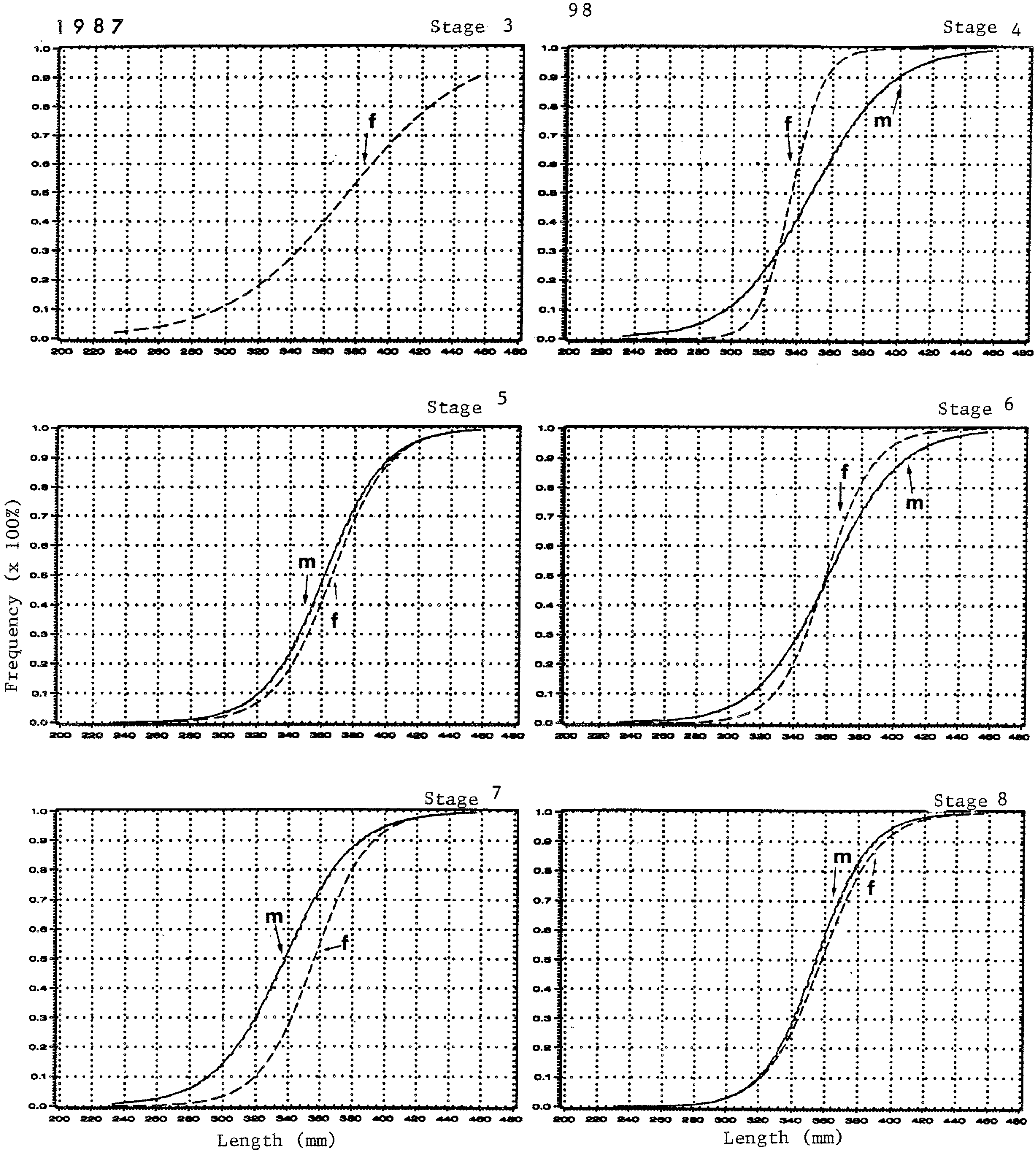

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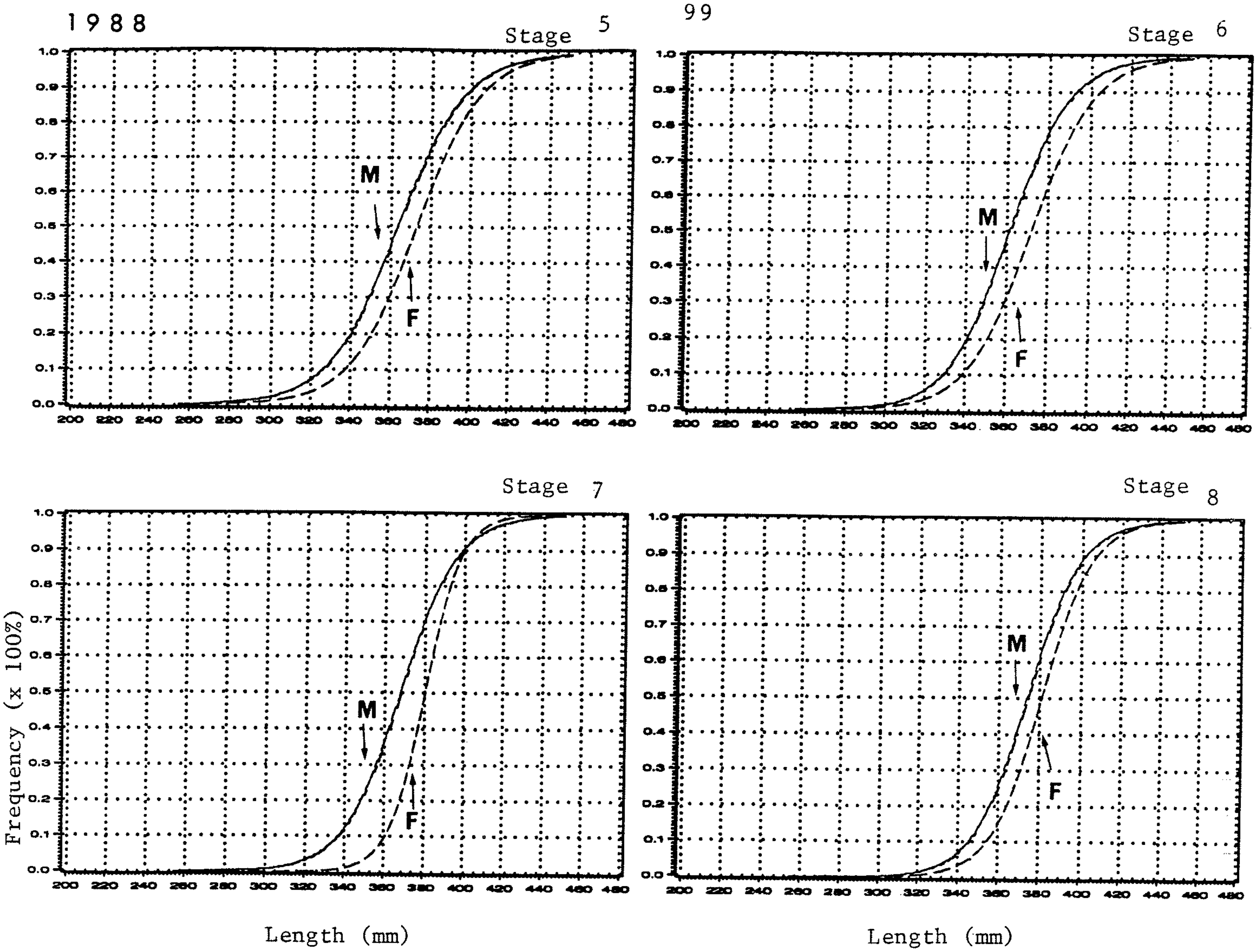

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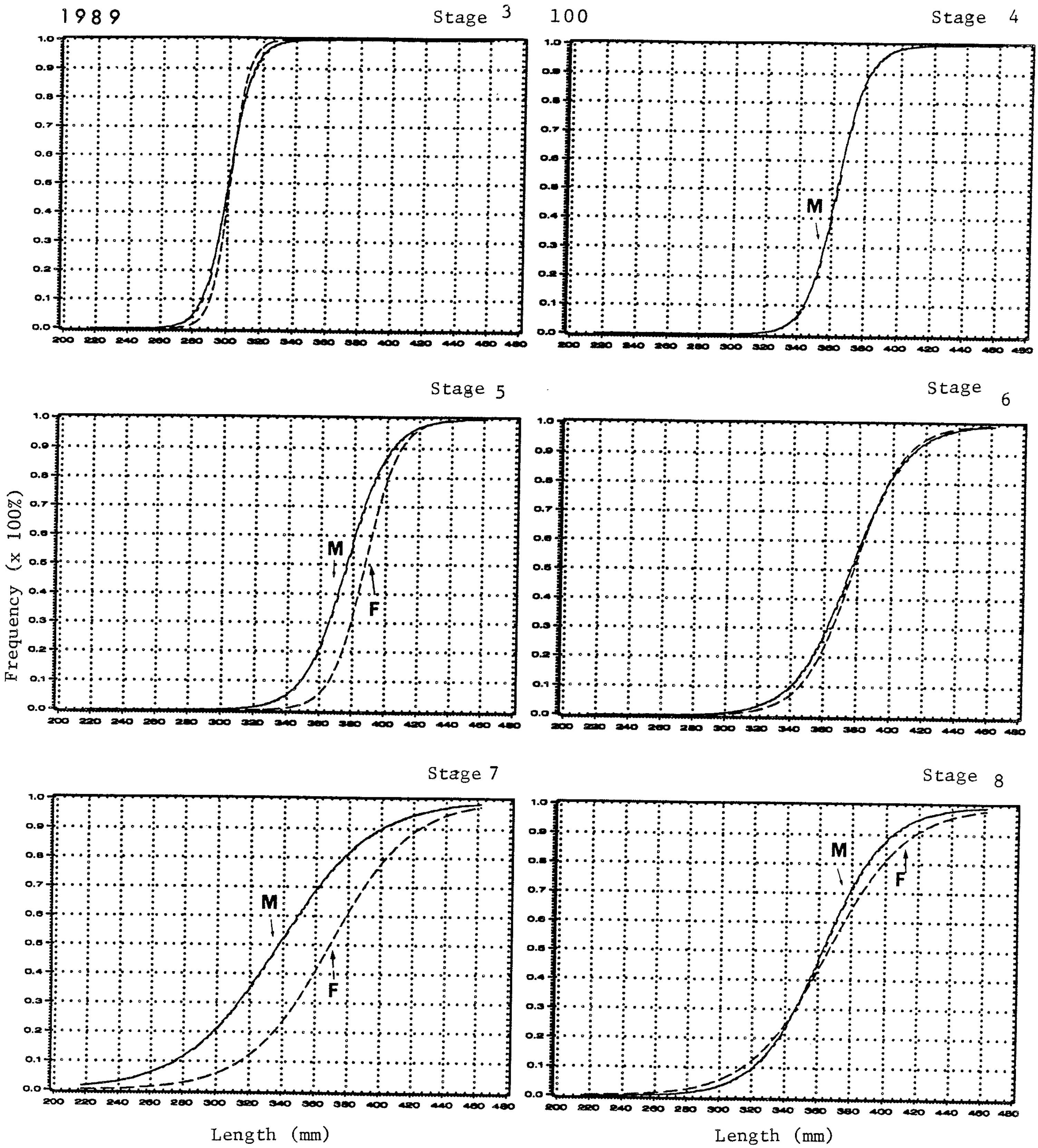

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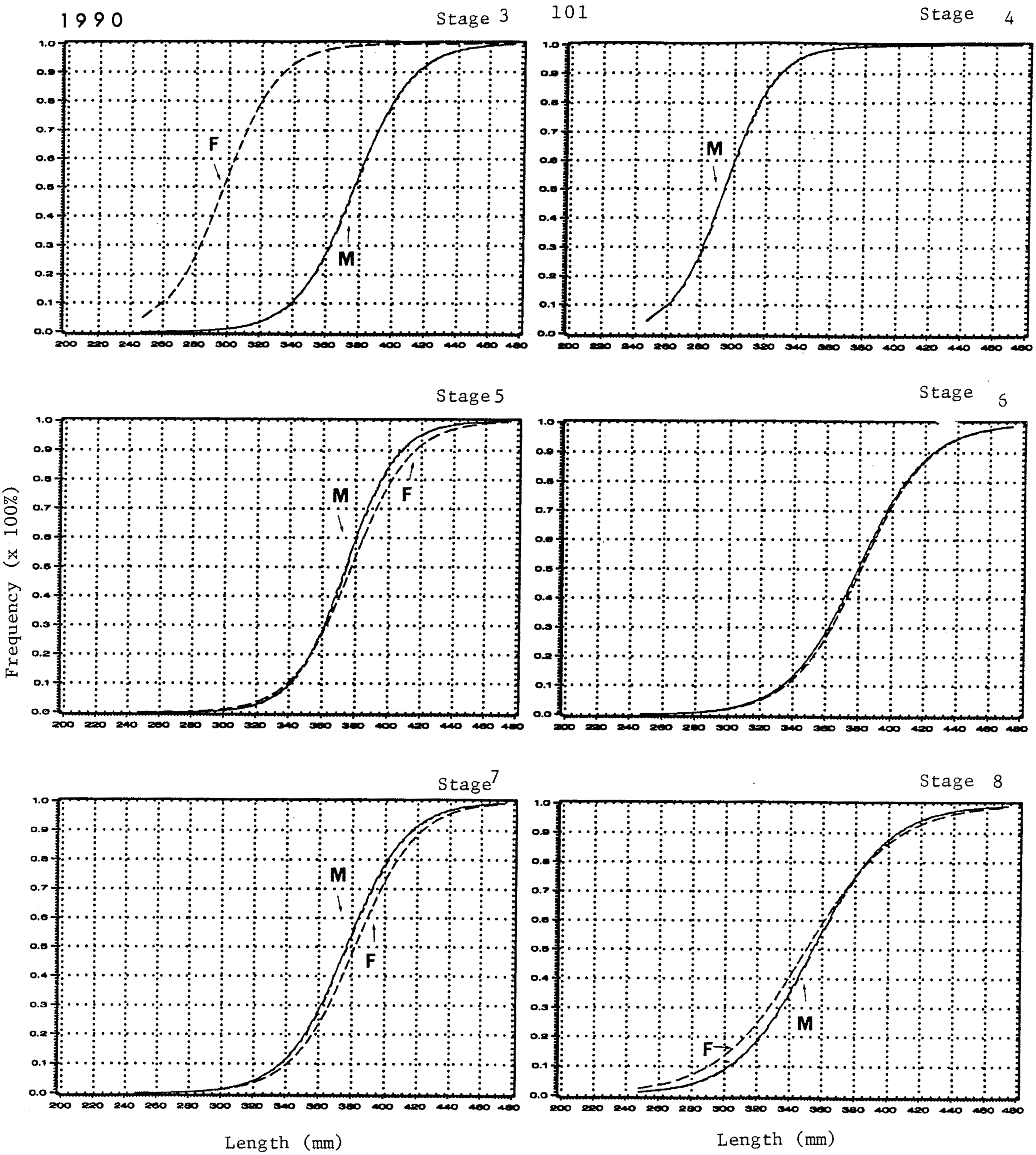

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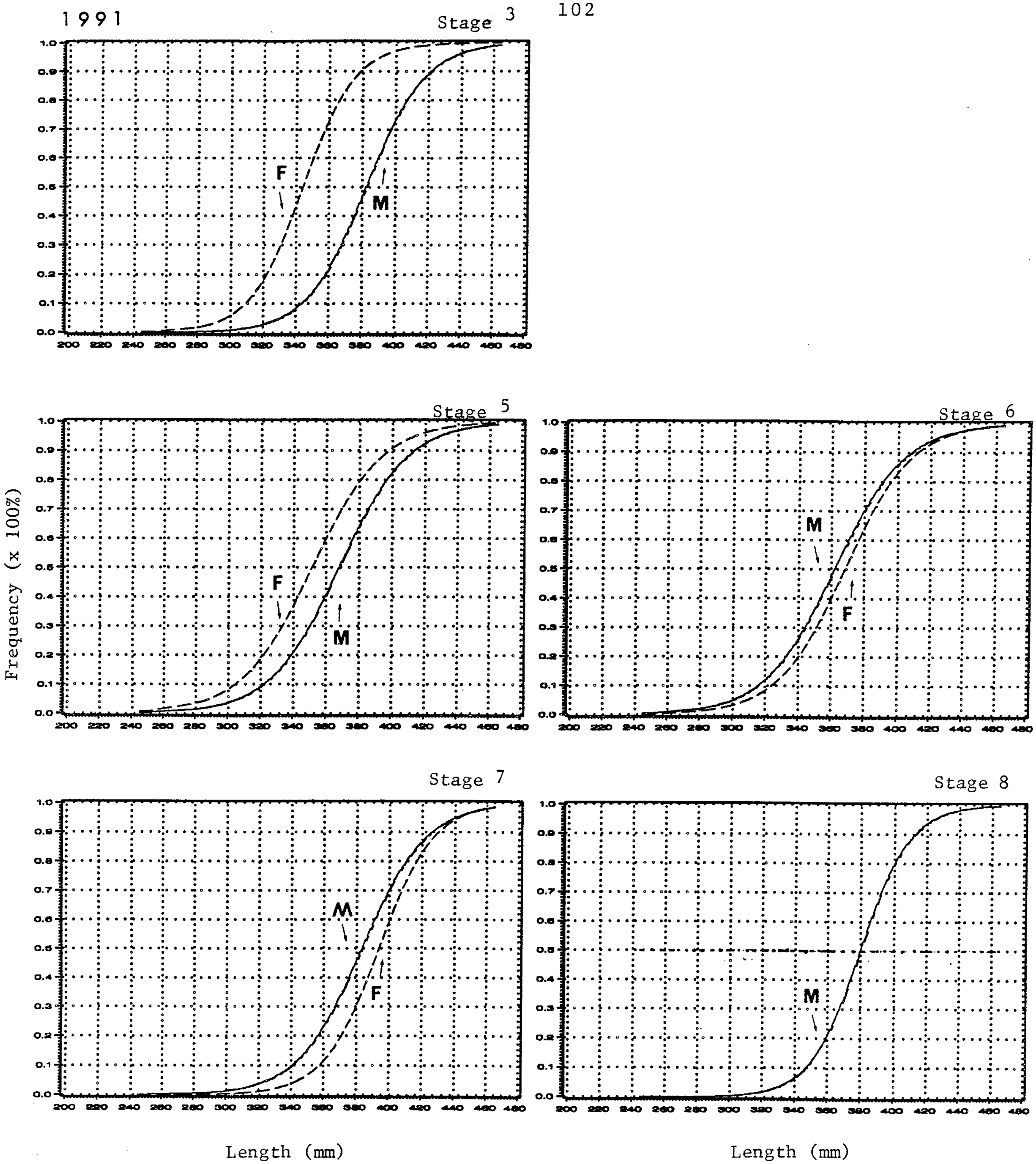

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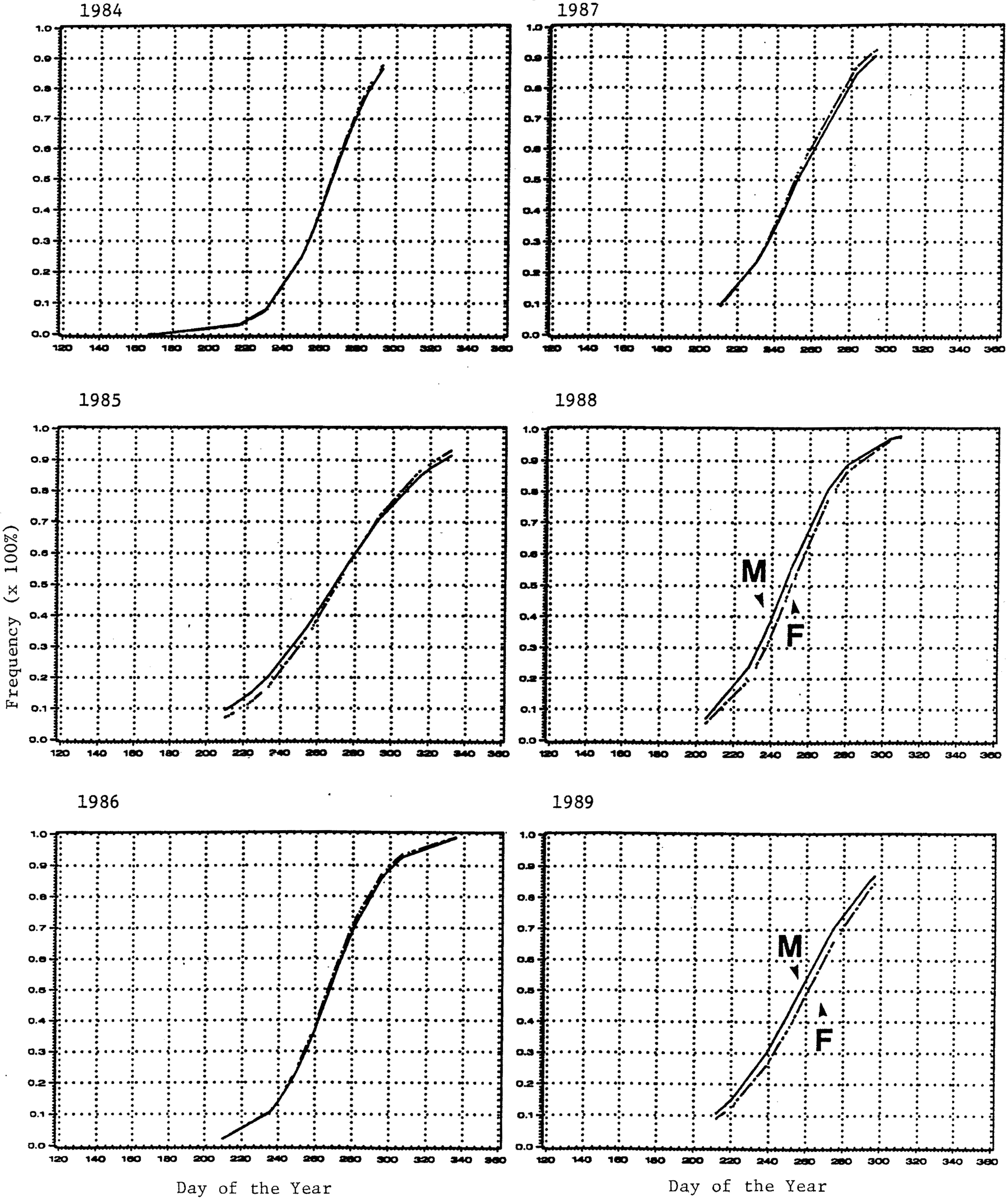

Figure 23. Cumulative daily frequencies predicted for male and female mackerel in gonad maturity stage 8 sampled, 1983-1991 in NAFO division 3K, East Coast of Newfoundland.

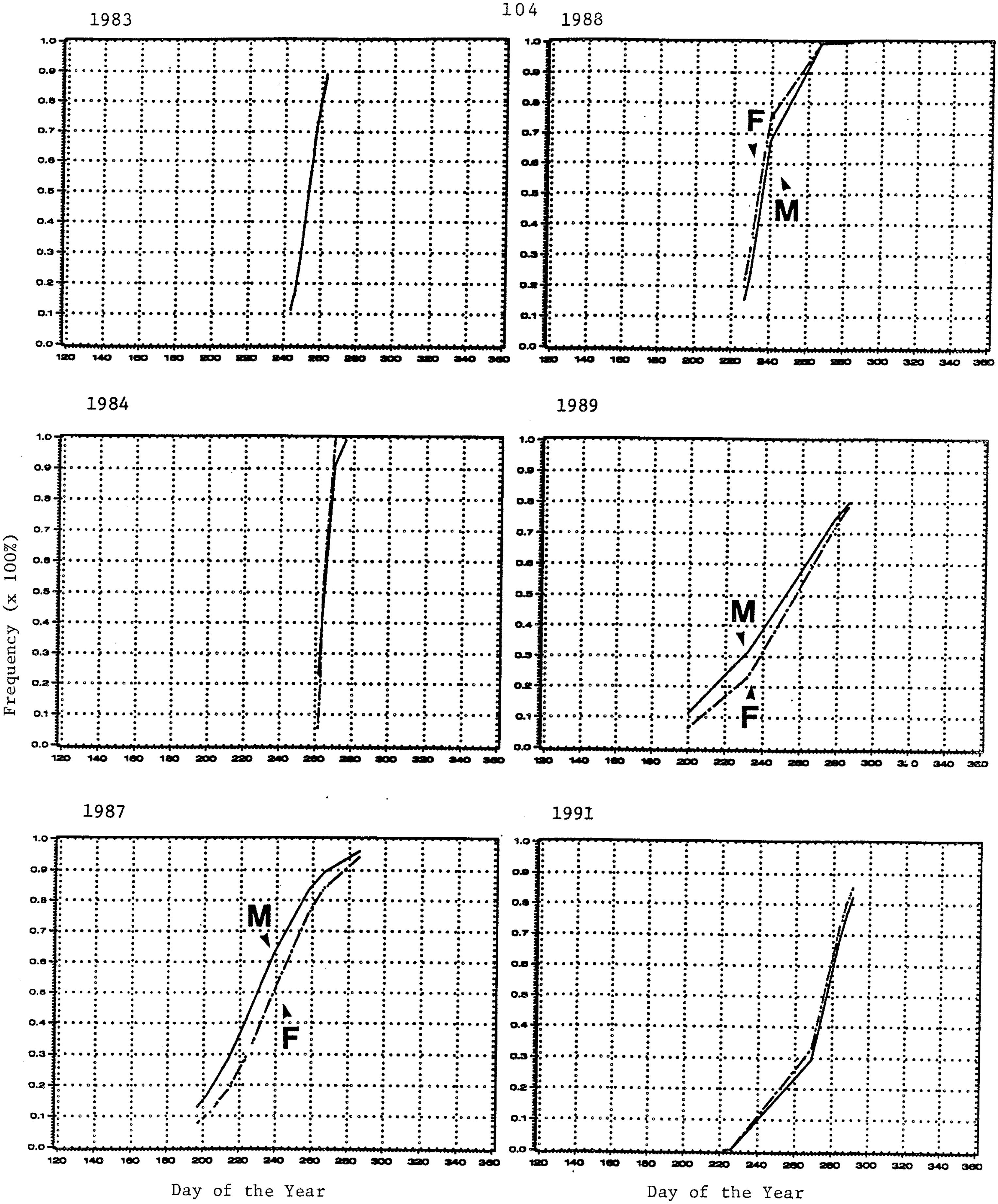

Figure 24. Cumulative daily frequencies predicted for male and female mackerel in gonad maturity stage 8 sampled, 1983-1991 in NAFO subdivision 4Rc, West Coast of Newfoundland.

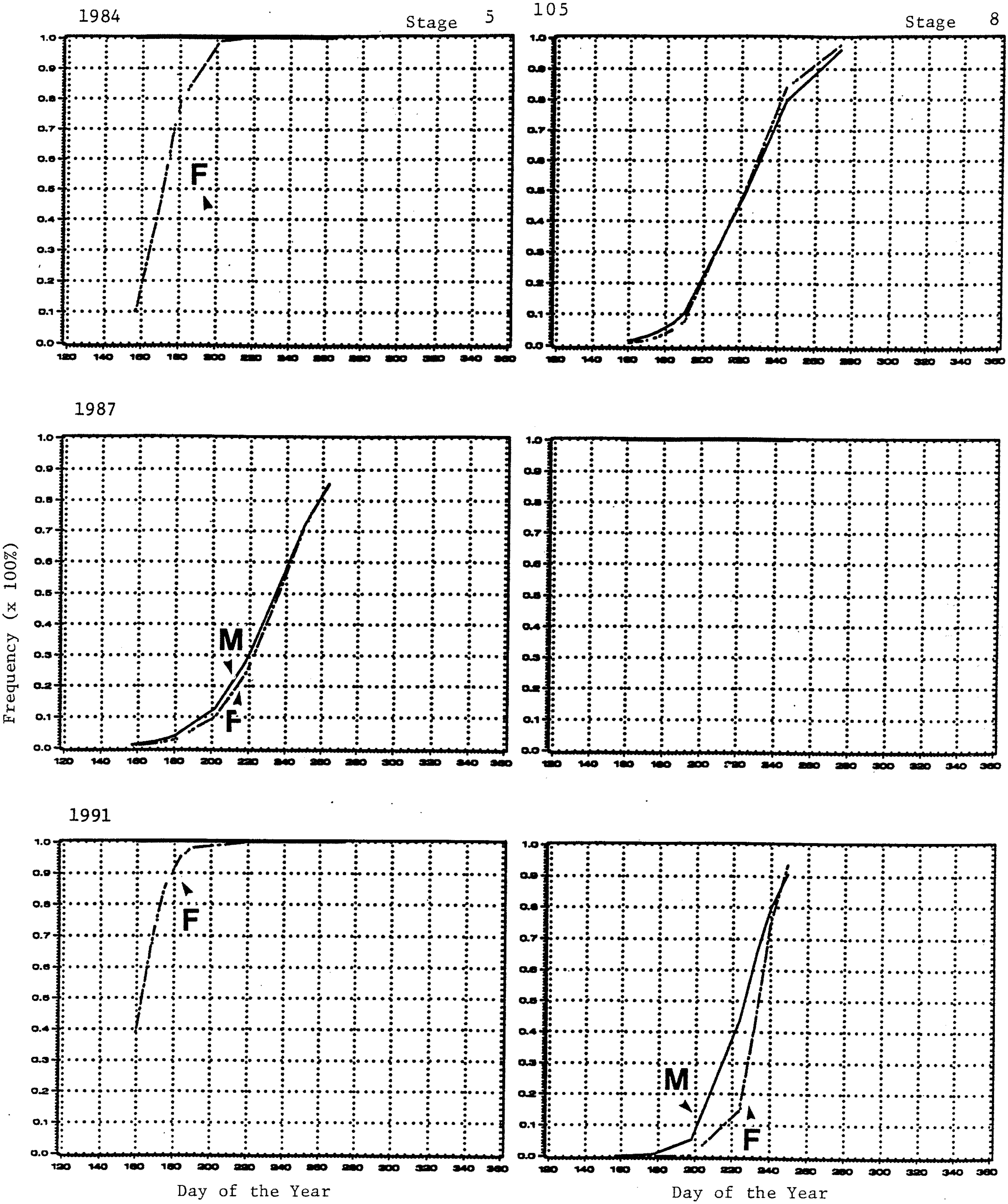

Figure 25. Cumulative daily frequencies predicted for male and female mackerel in gonad maturity stages 5 and 8 sampled, 1983-1991 in NAFO subdivisions 4Tm and 4Tn, Chaleur Bay.

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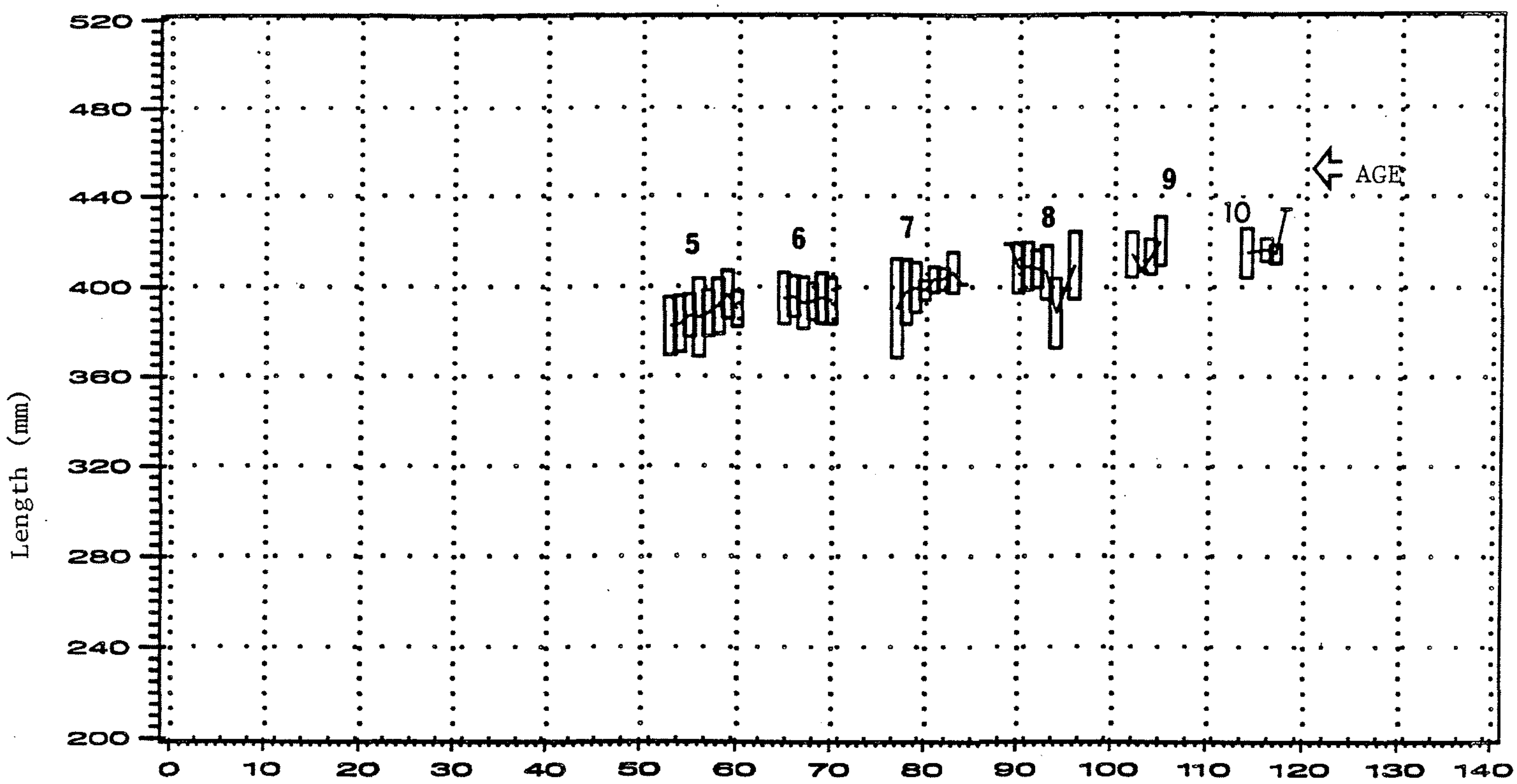

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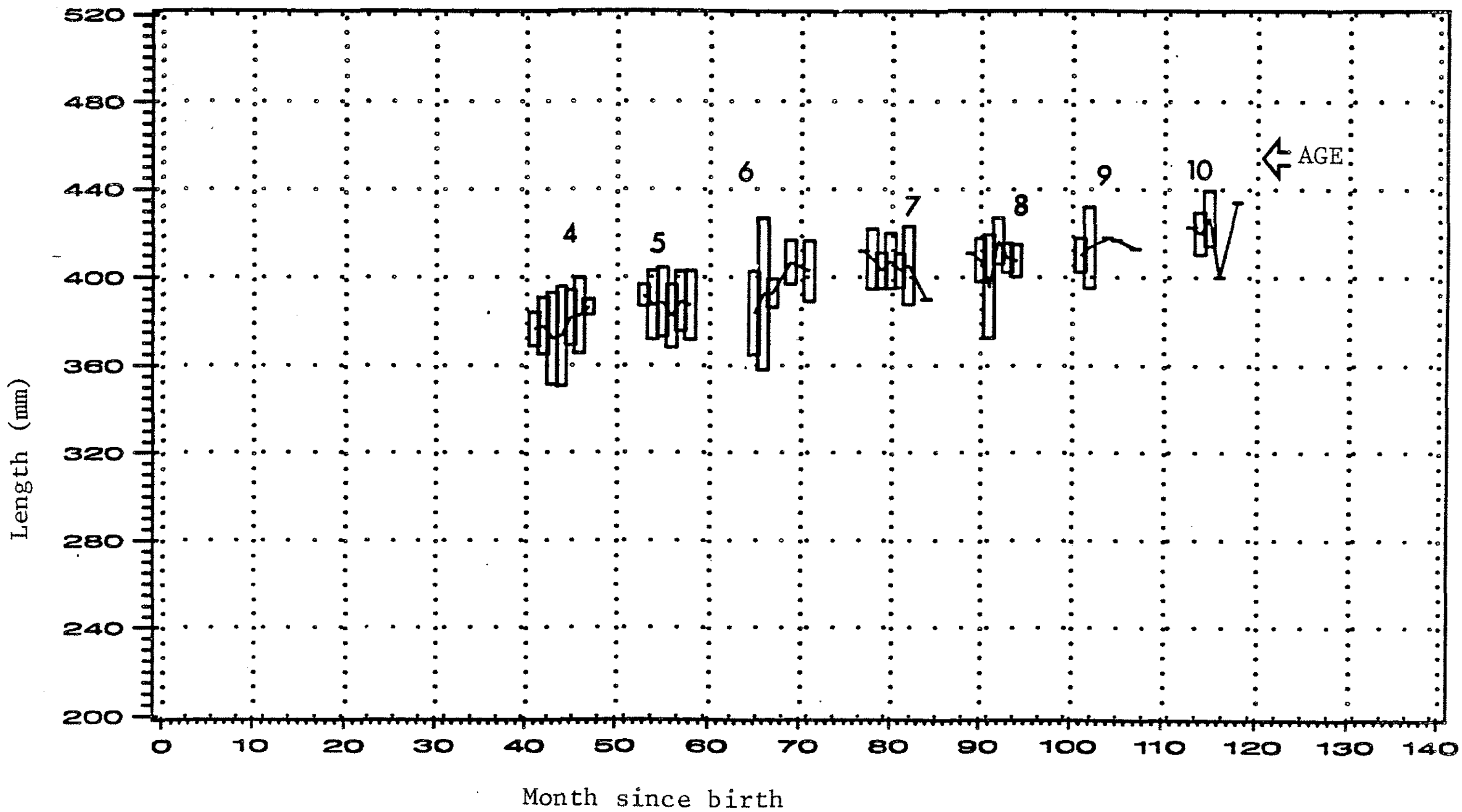
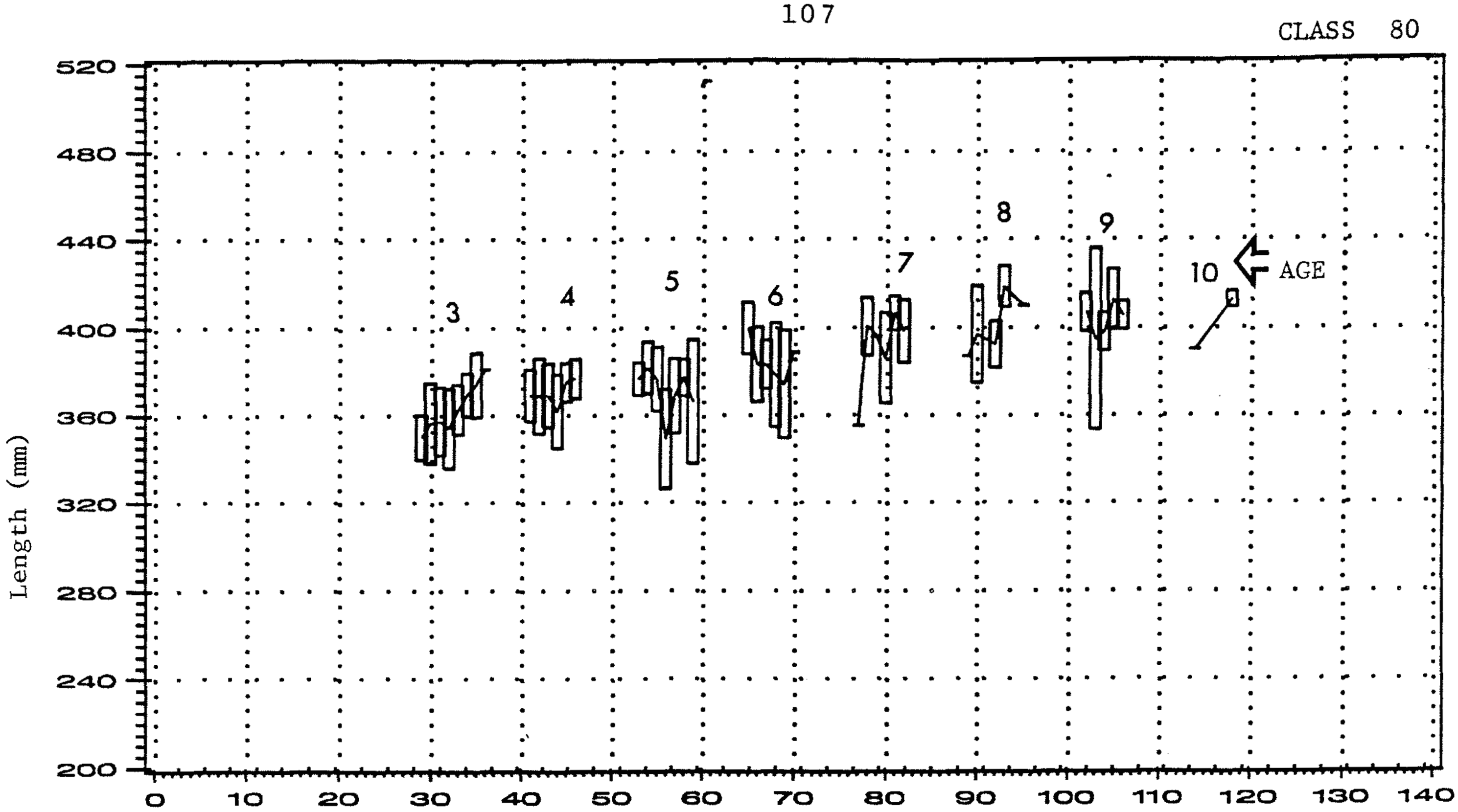


Figure 26. Monthly and annual variations in mean length for main year-classes present in mackerel sampled, 1983-1991.



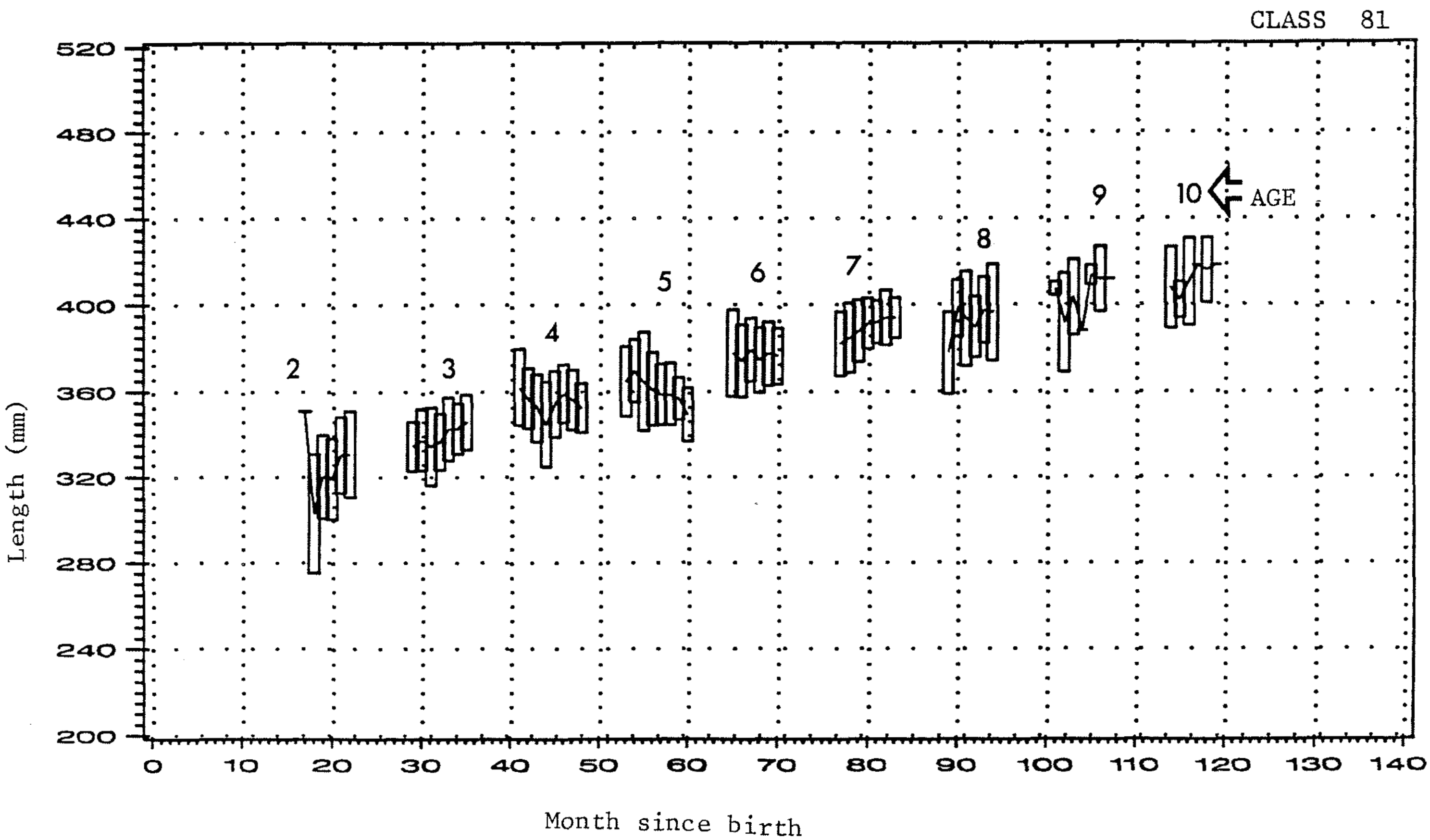


Figure 26. (cont'd).

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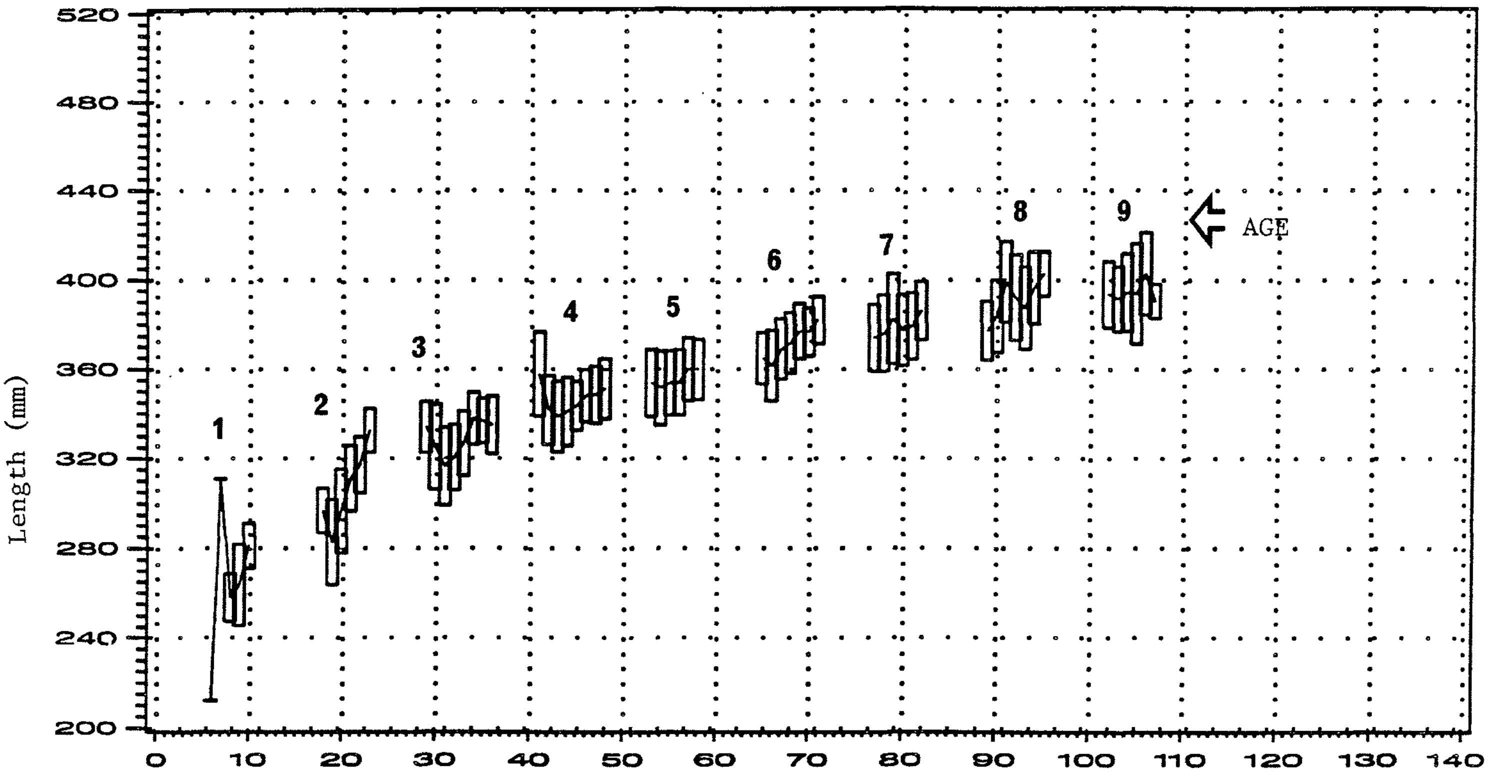

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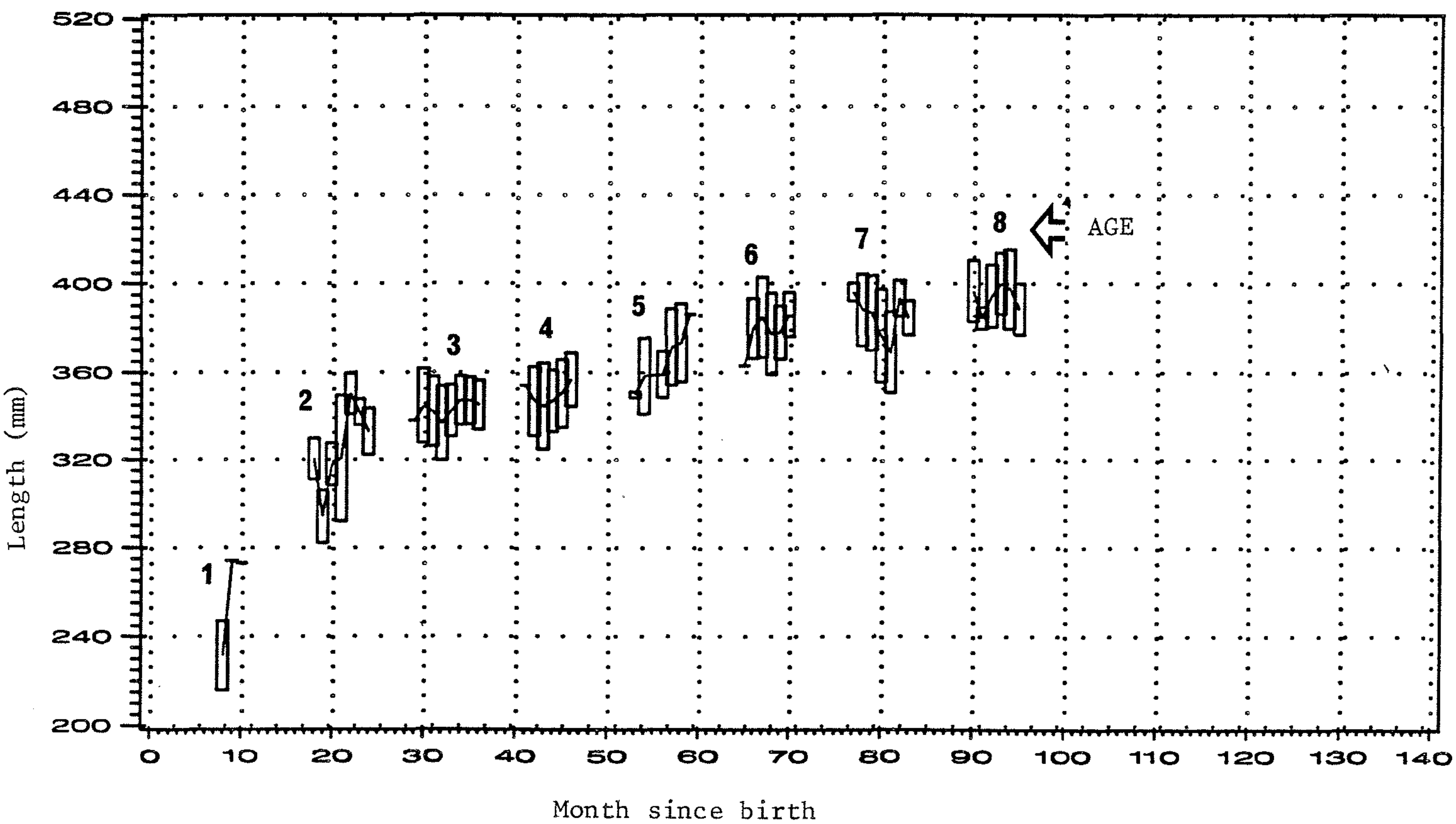

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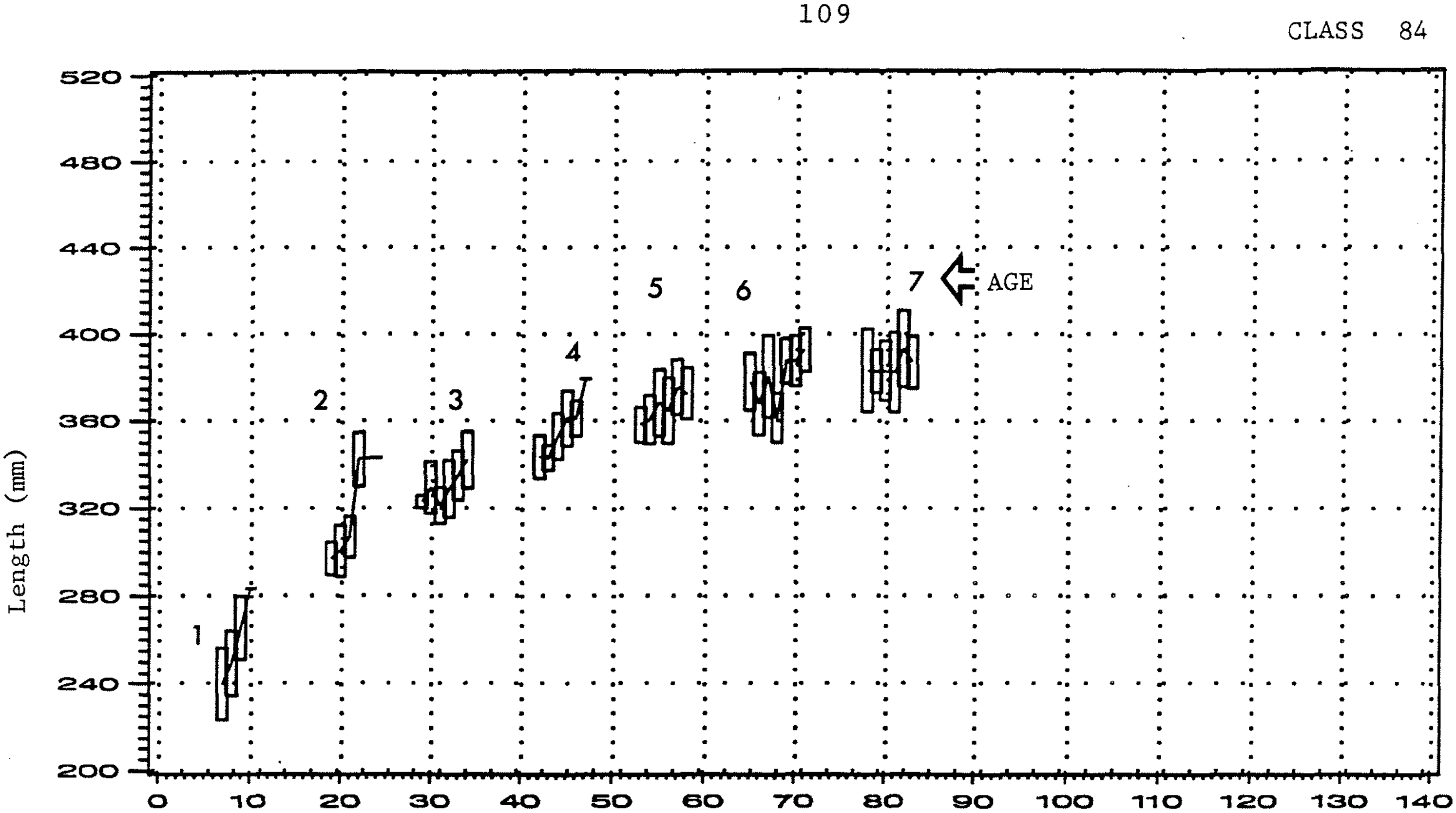

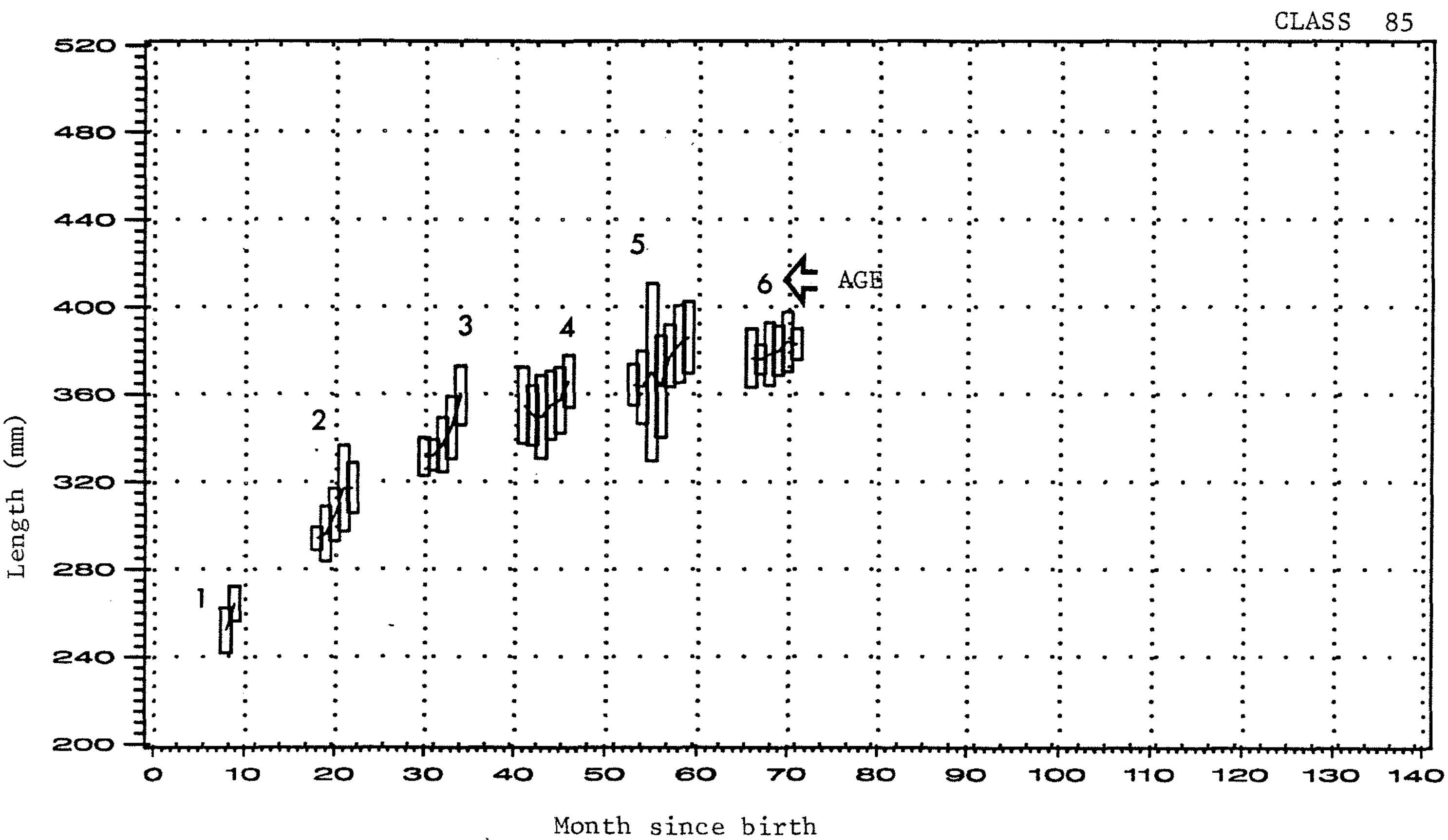

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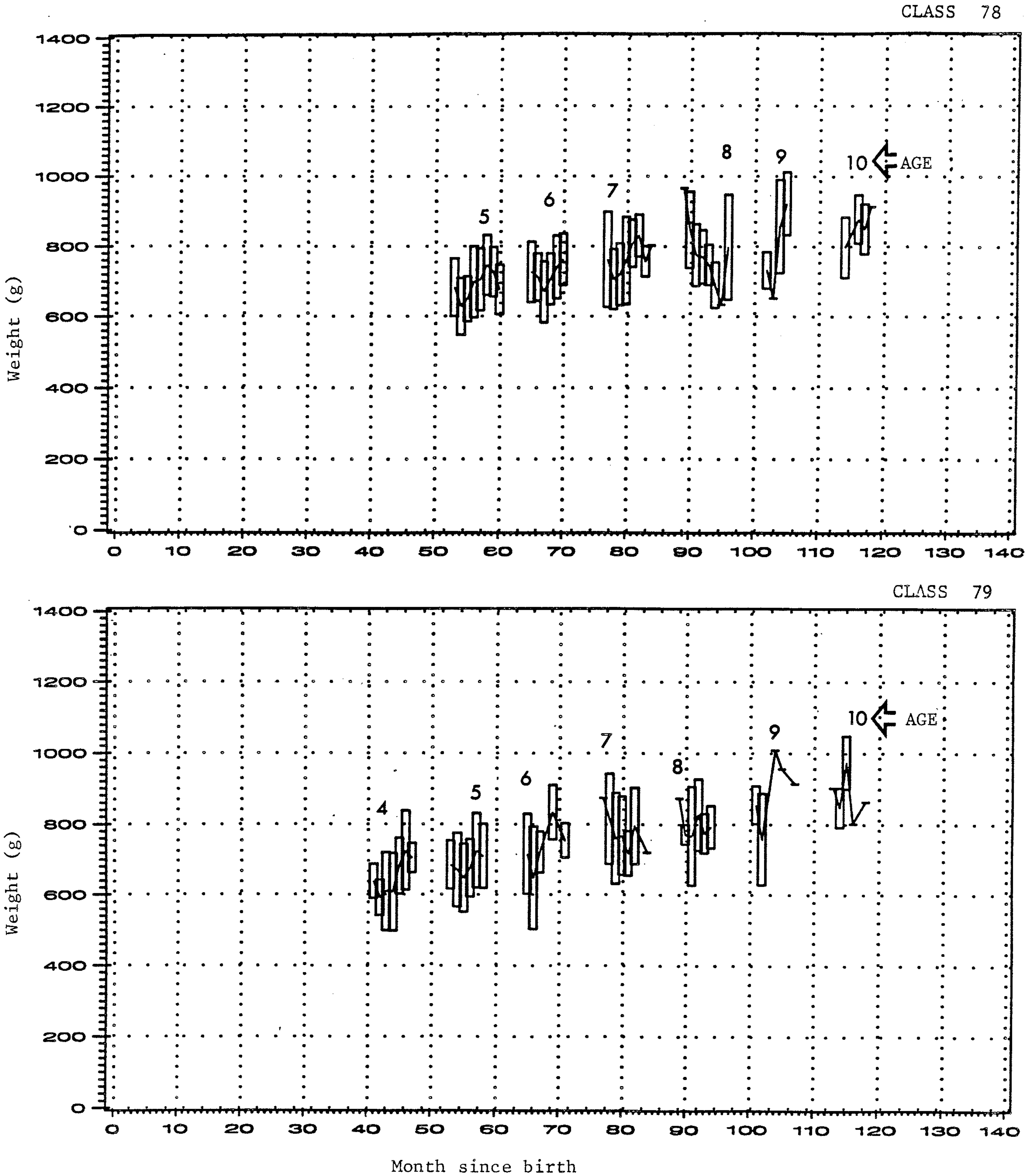
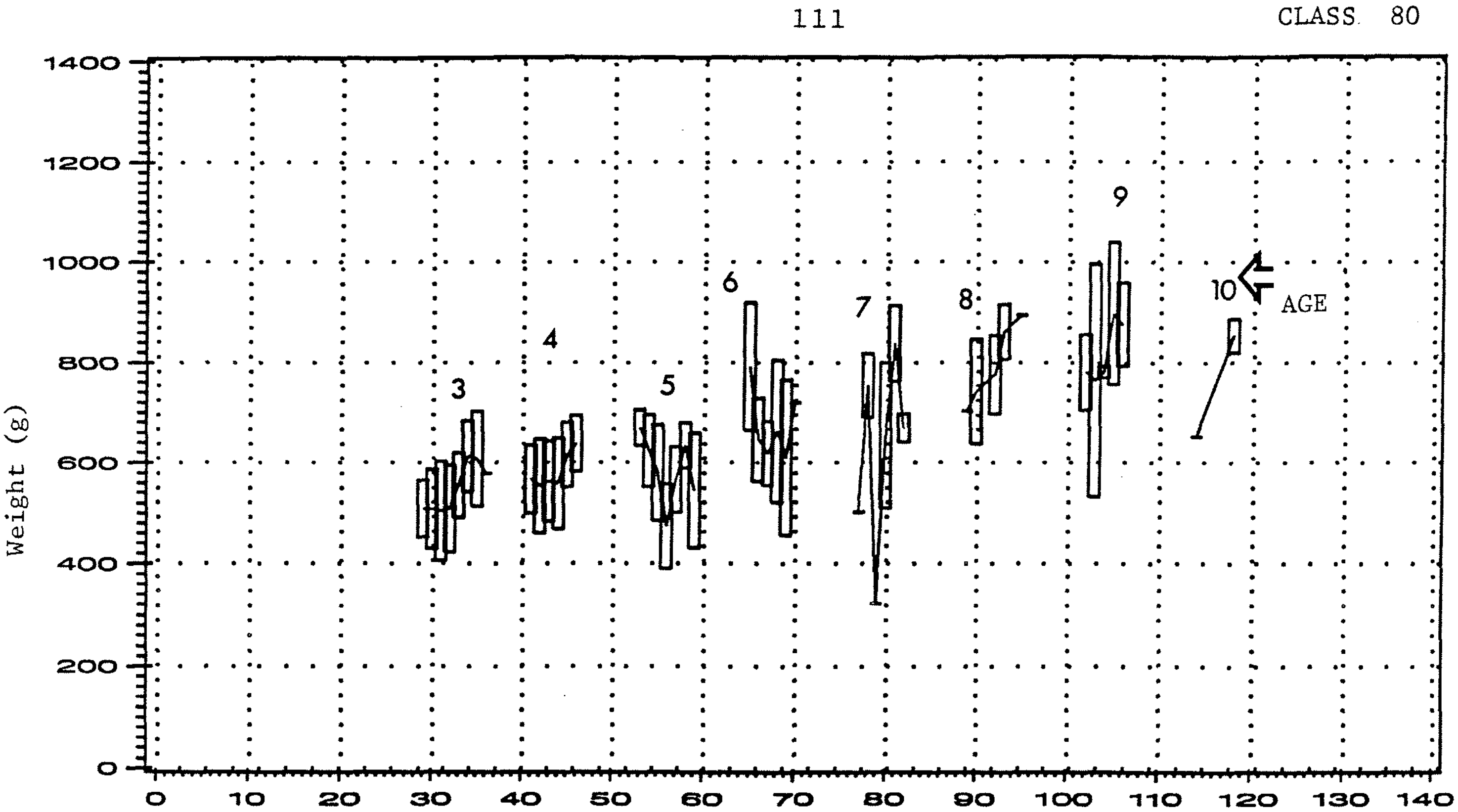


Figure 27. Monthly and annual variations in mean weight for main year-classes present in mackerel sampled, 1983-1991.



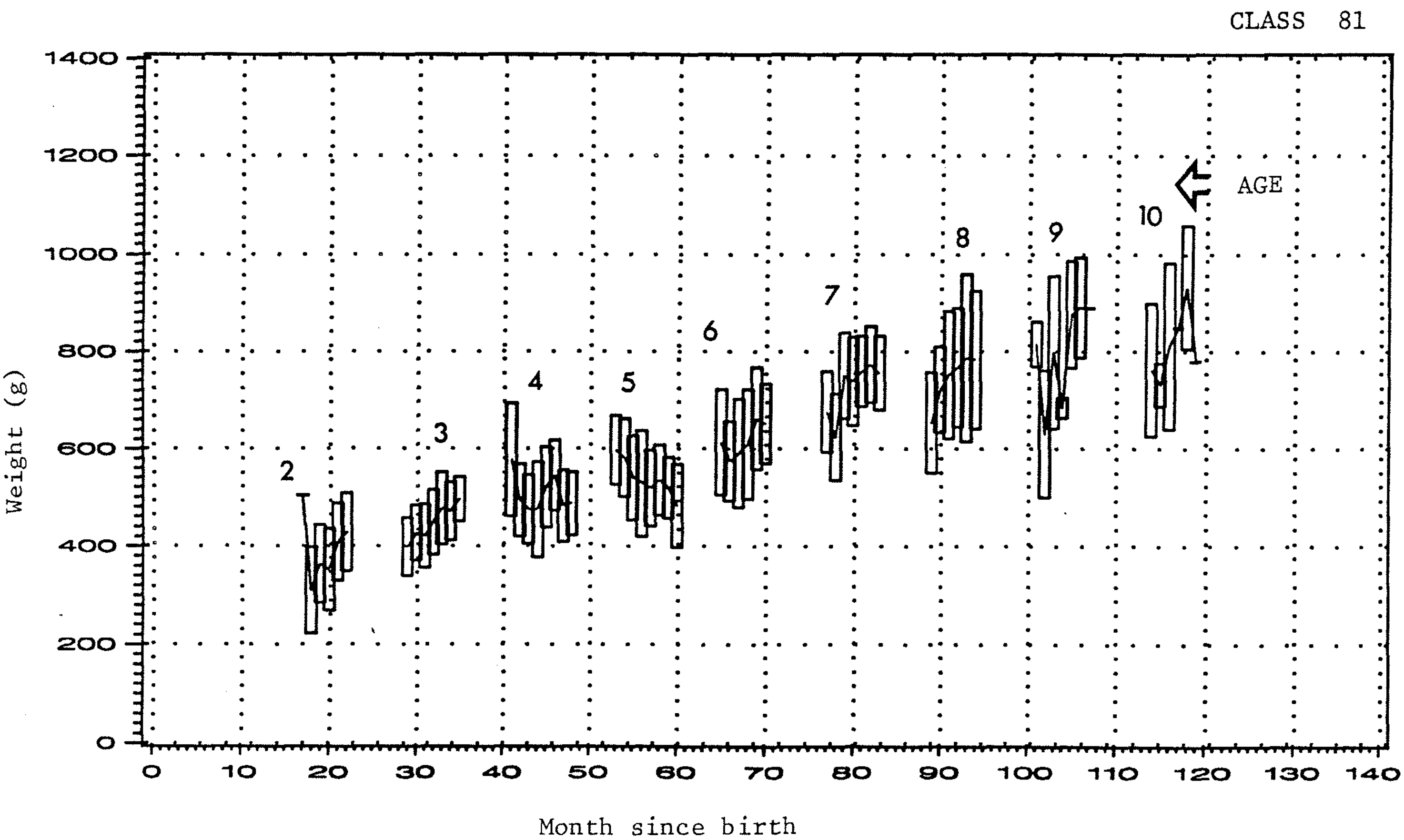
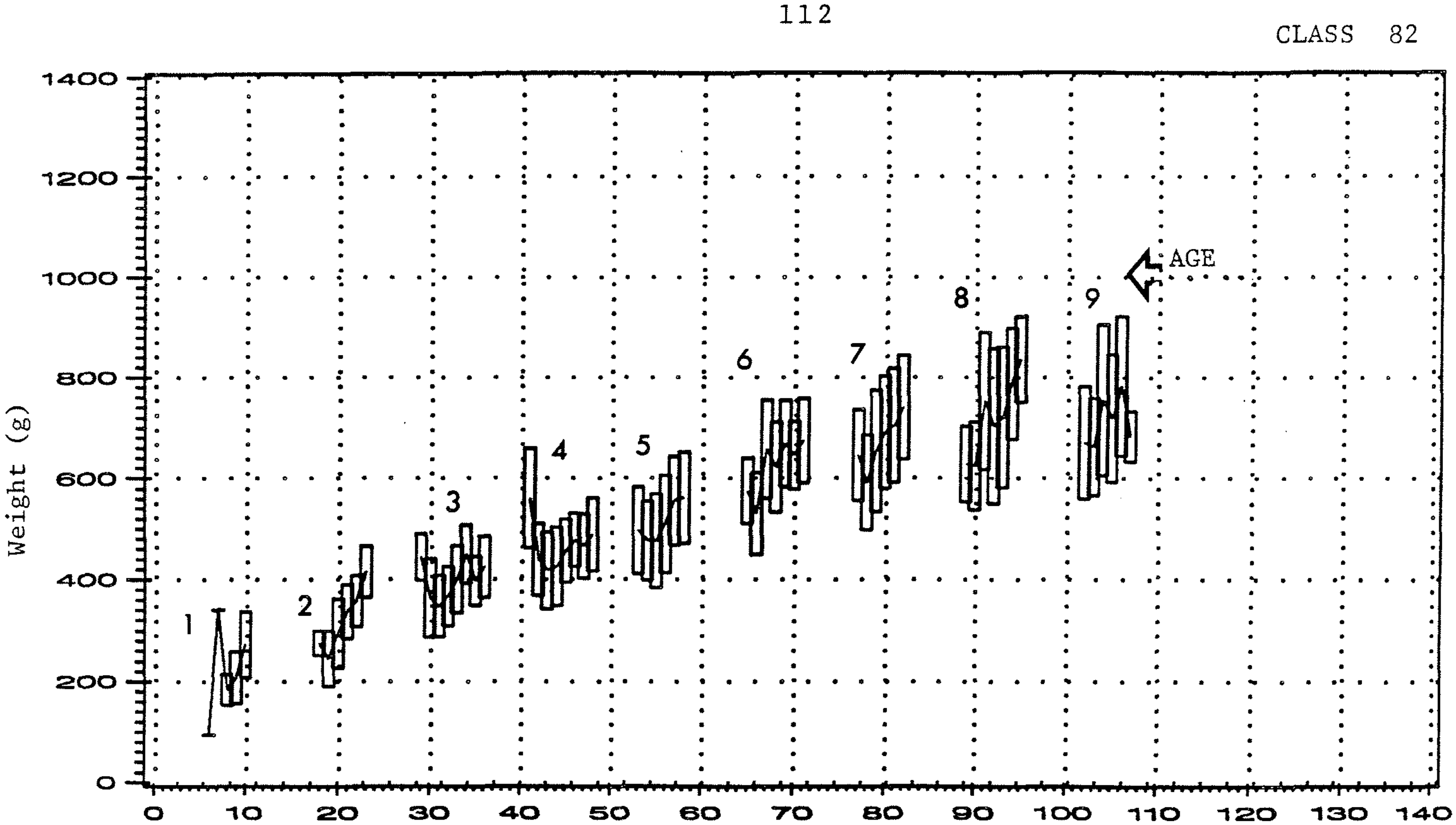


Figure 27. (cont'd).



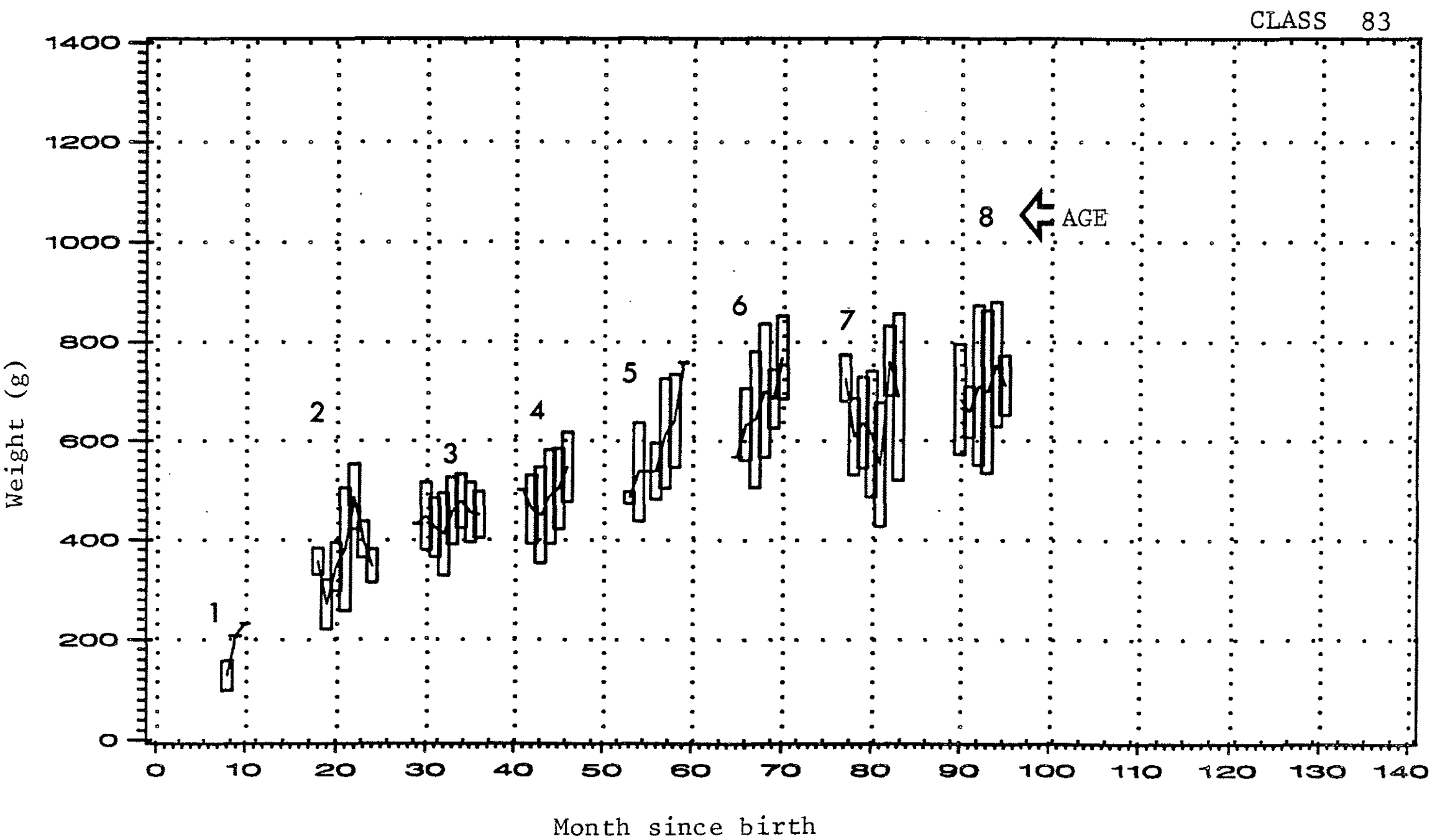


Figure 27. (cont'd).

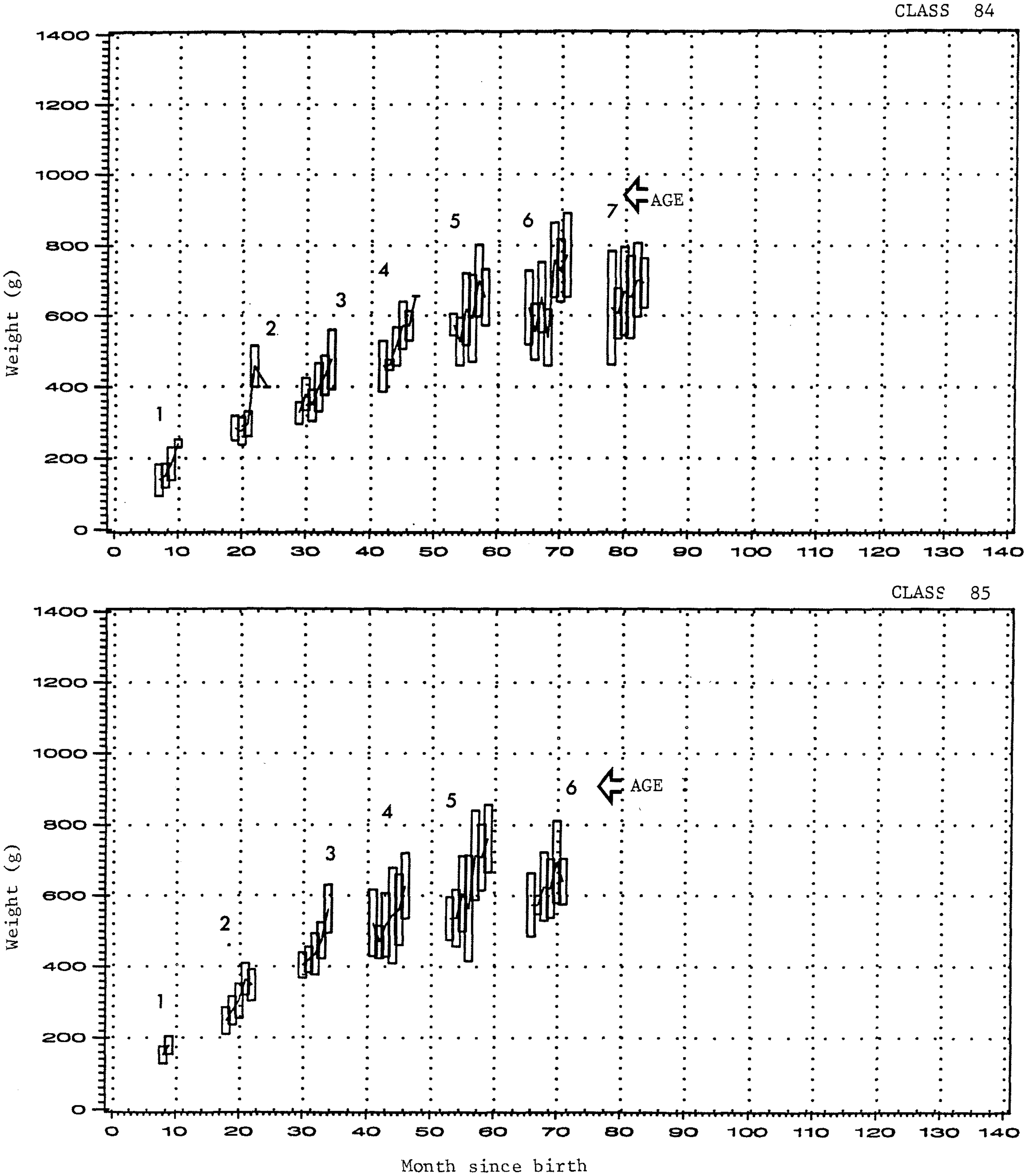


Figure 27. (cont'd).

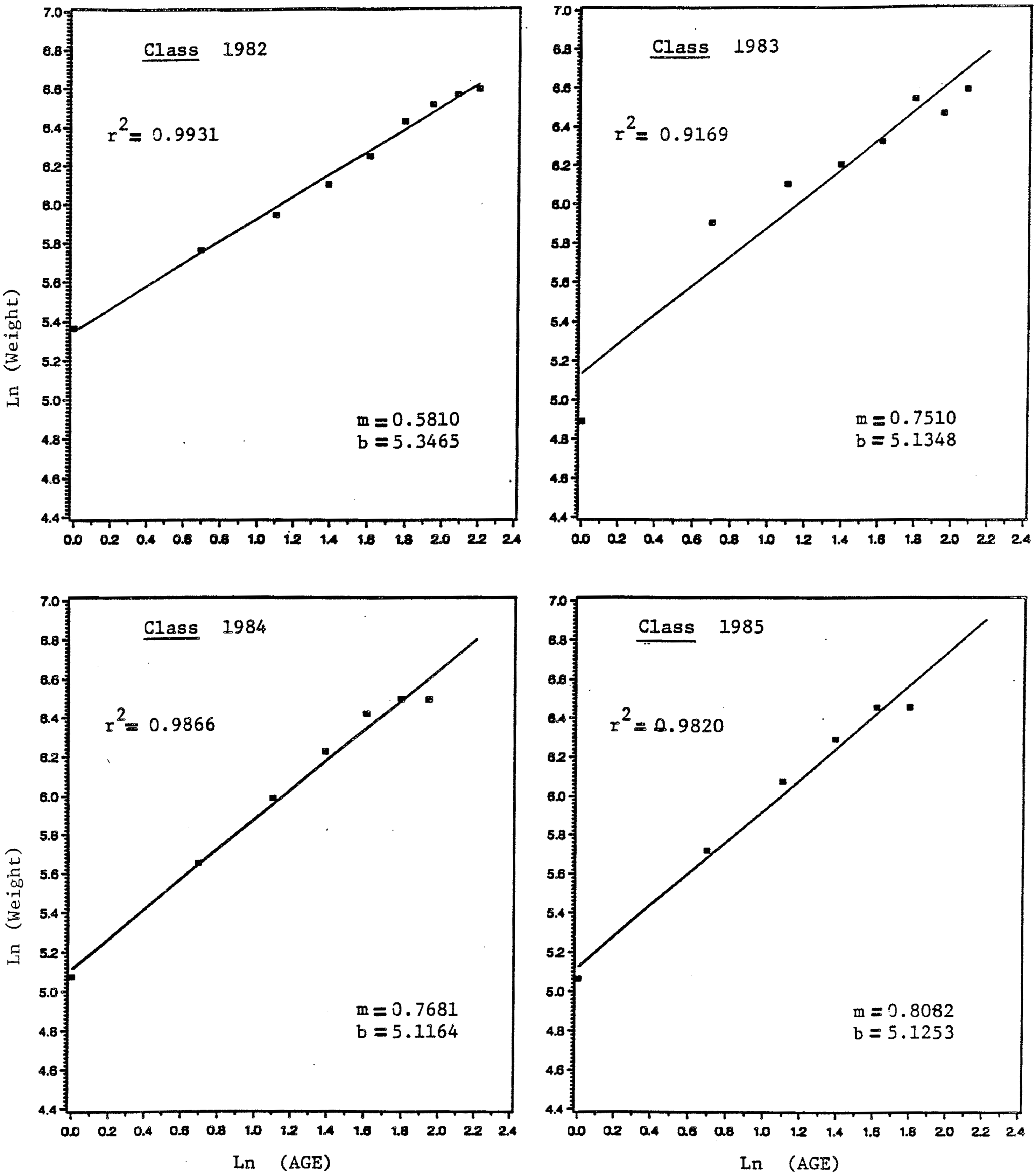


Figure 28. Instantaneous growth rate (slope of linear regressions) calculated on weight at age values for mackerel of 1982 to 1986 year-classes.

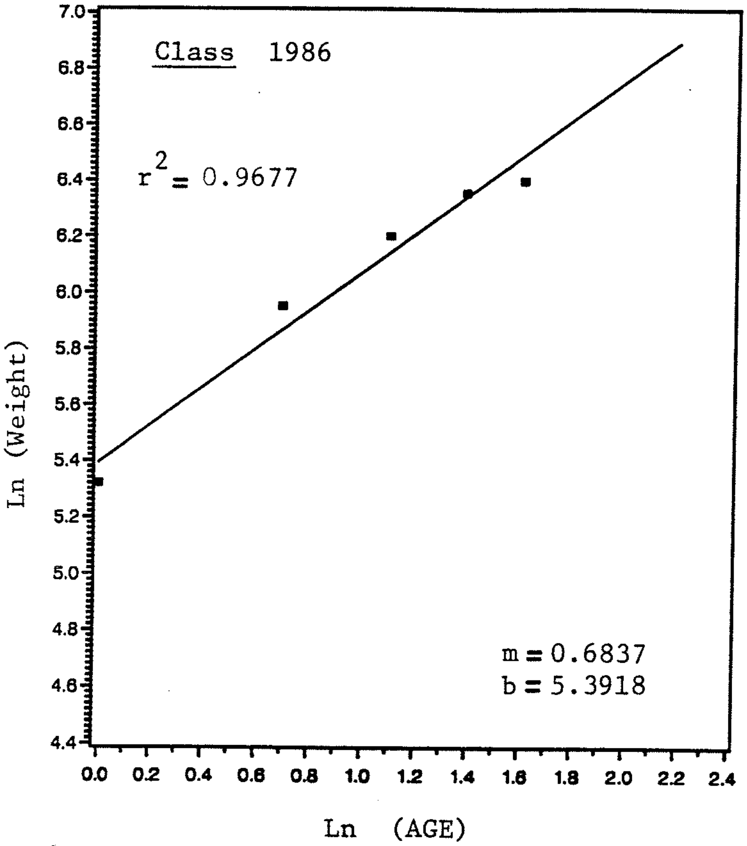


Figure 28. (cont'd).

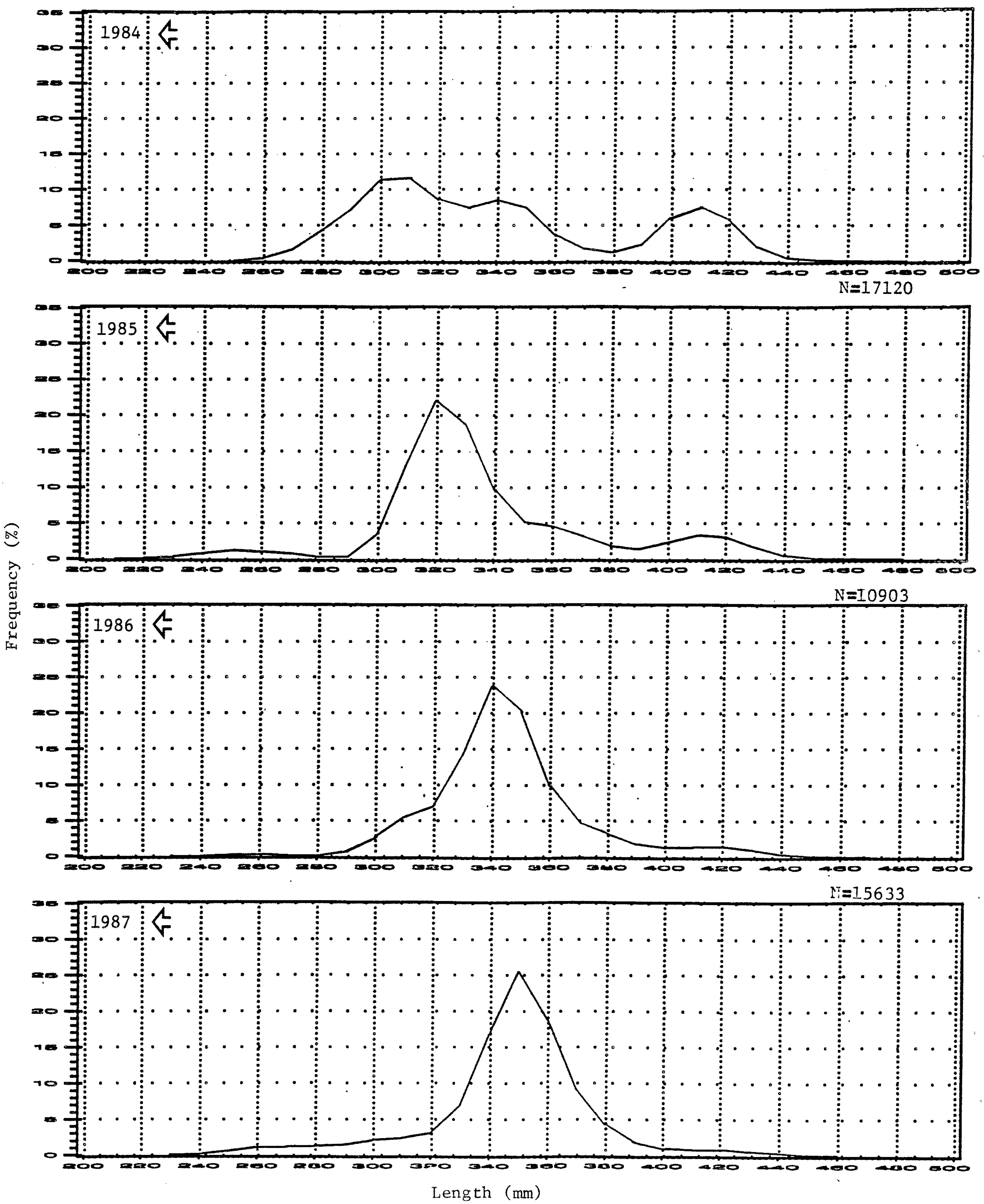


Figure 29. Annual frequency distributions of length for all mackerel measured in Subarea 4 between 1984 and 1991, (1983 data not available).

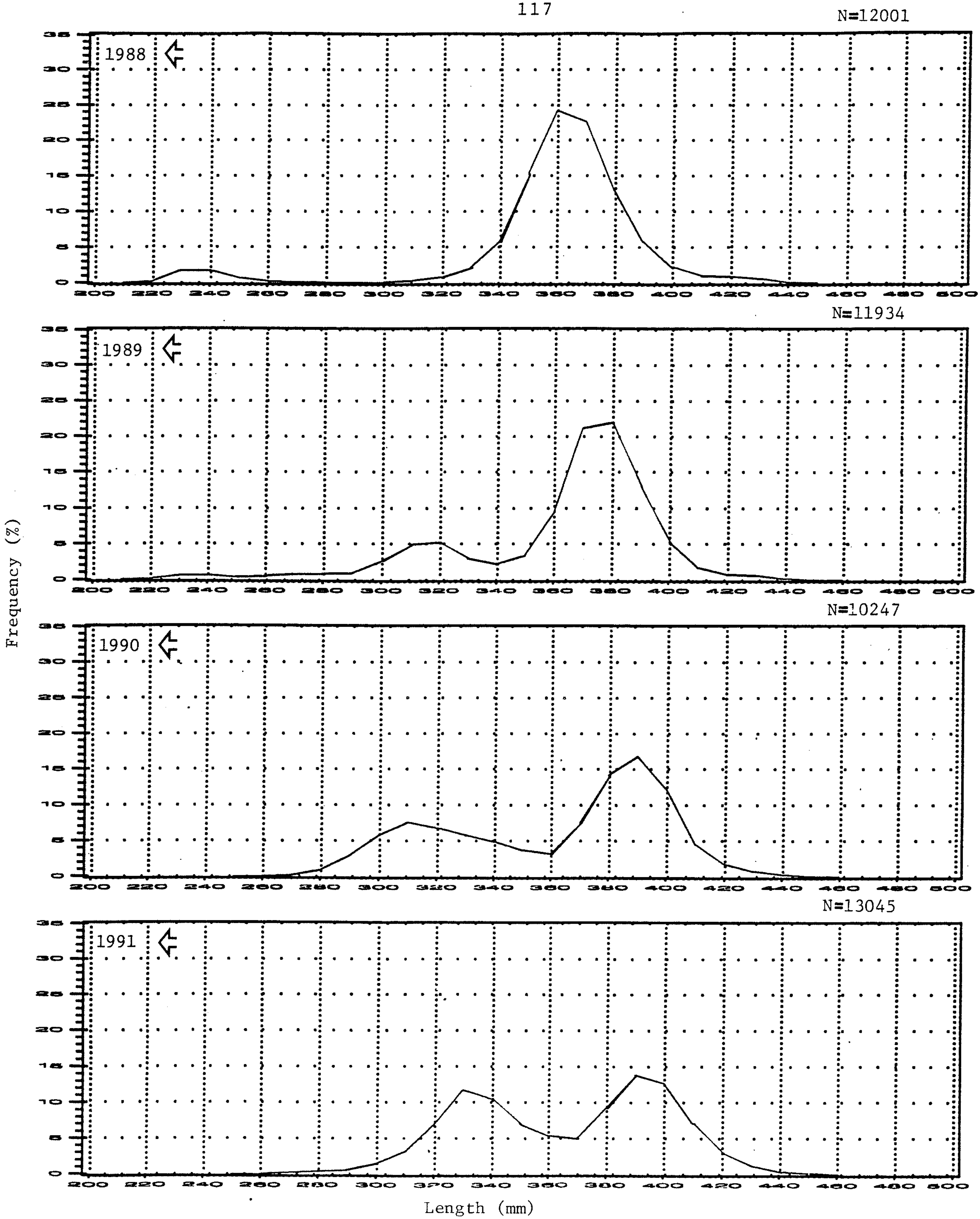


Figure 29. (cont'd).

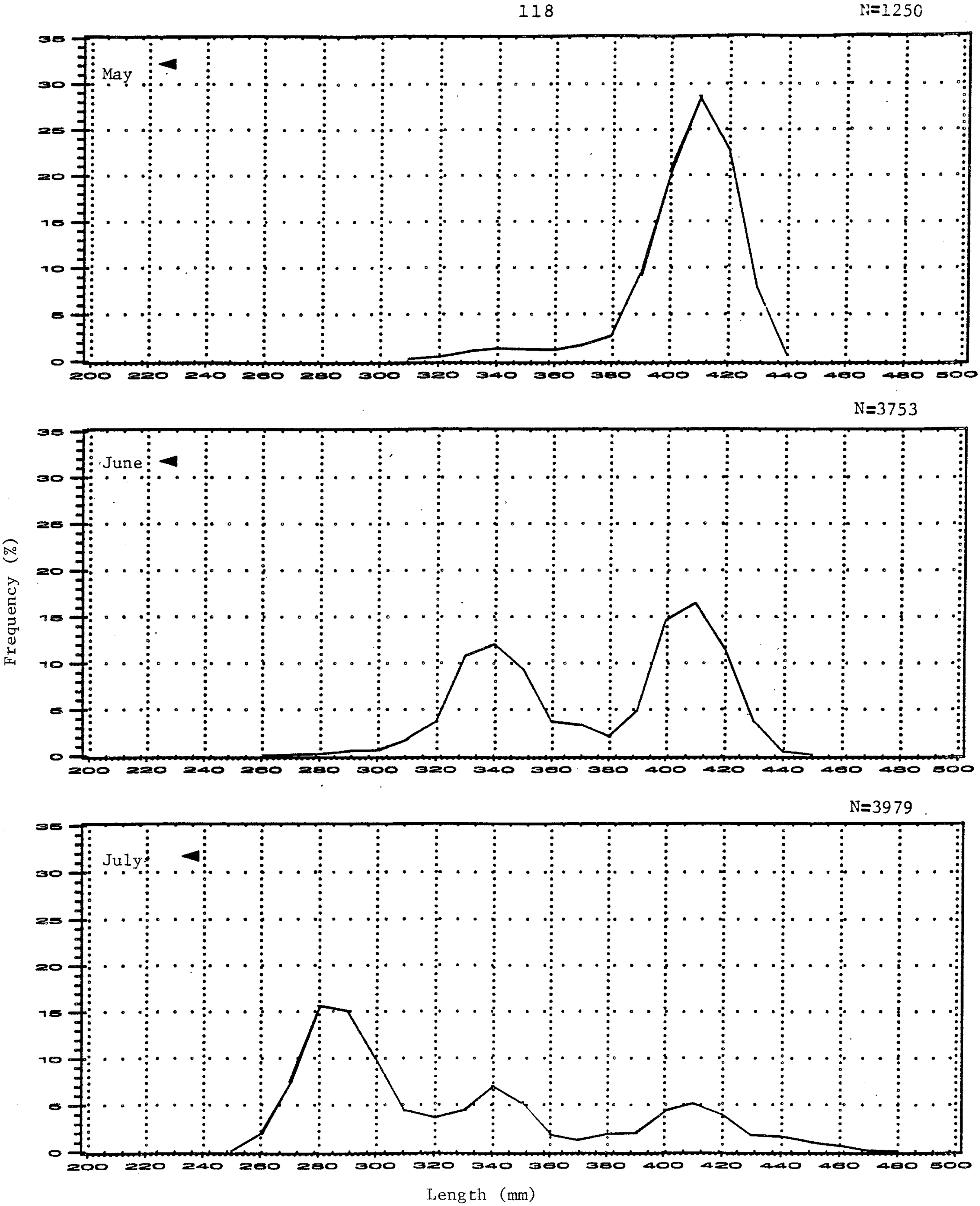


Figure 30. Monthly frequency distribution of length of mackerel measured in Subarea 4 in 1984.

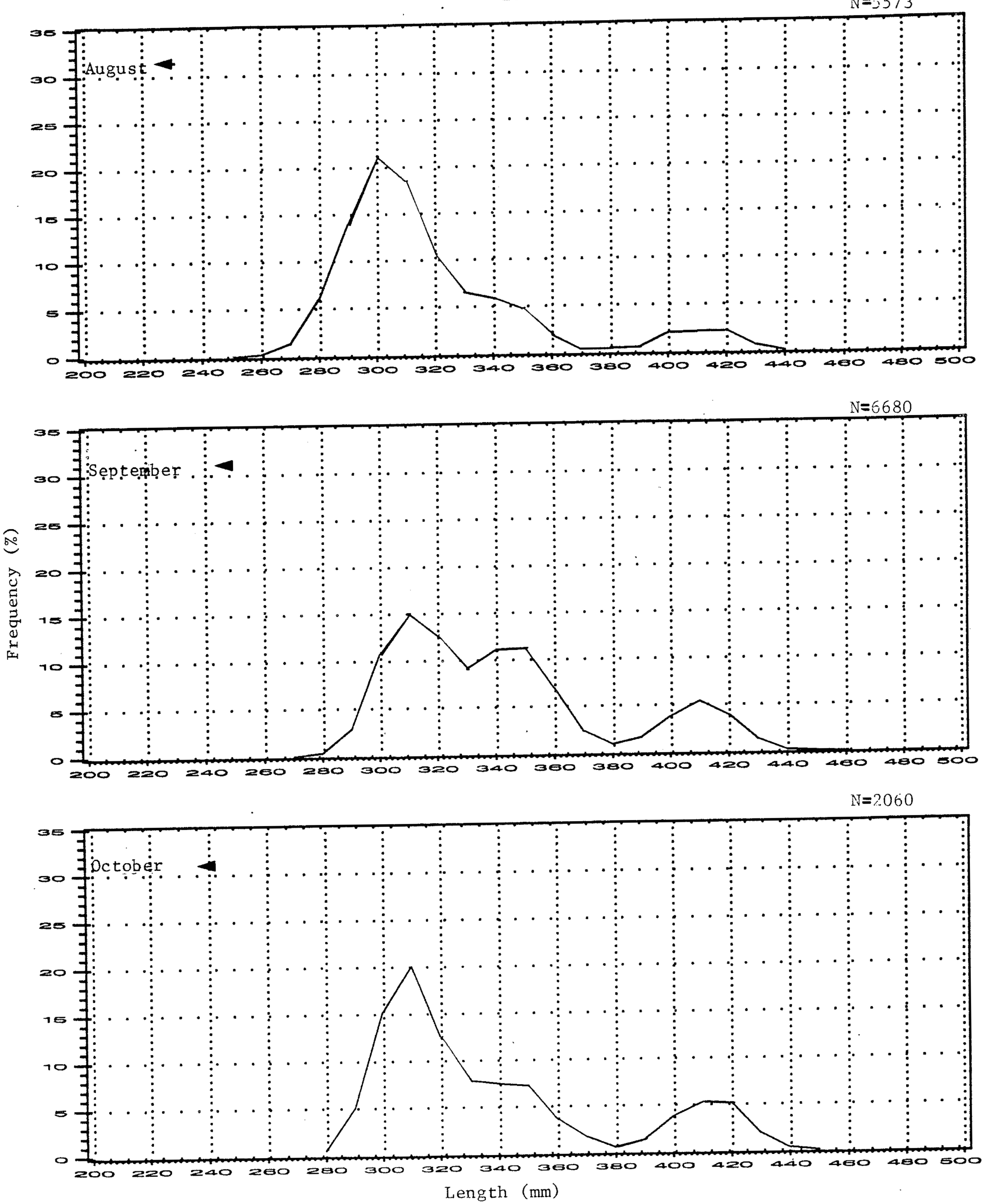


Figure 30. (cont'd).

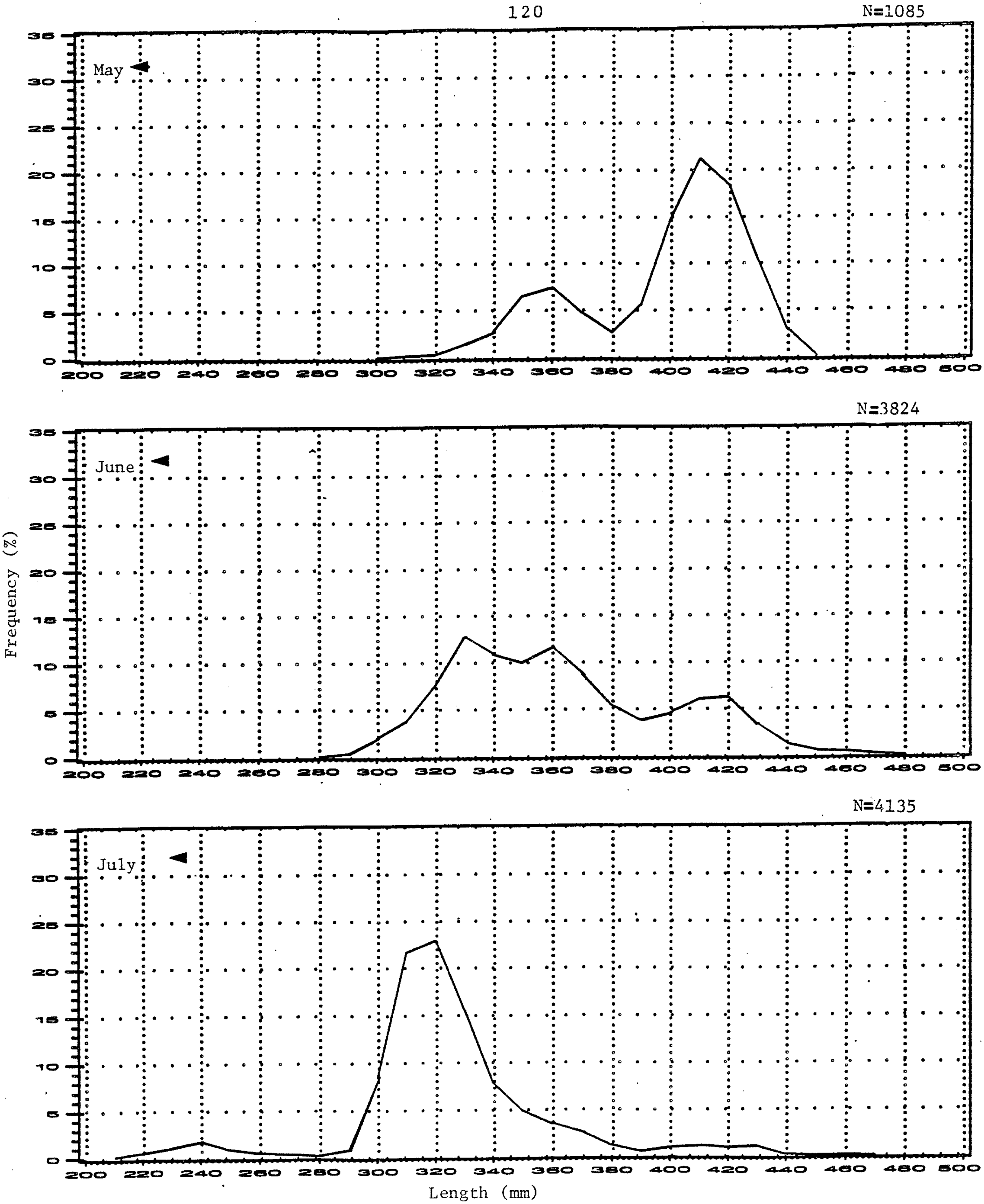


Figure 31. Monthly frequency distribution of length of mackerel measured in Subarea 4 in 1985.

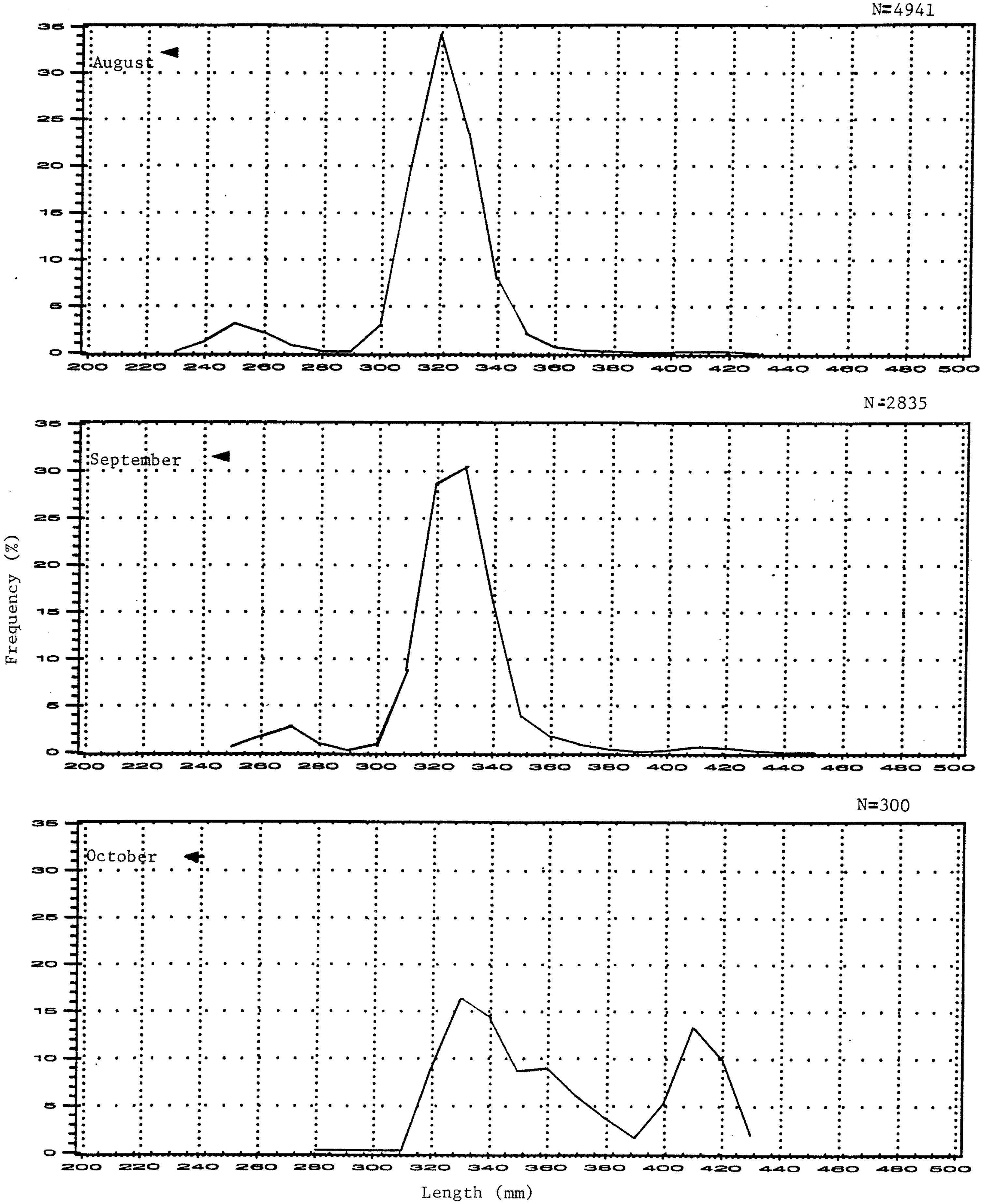


Figure 31. (cont'd).

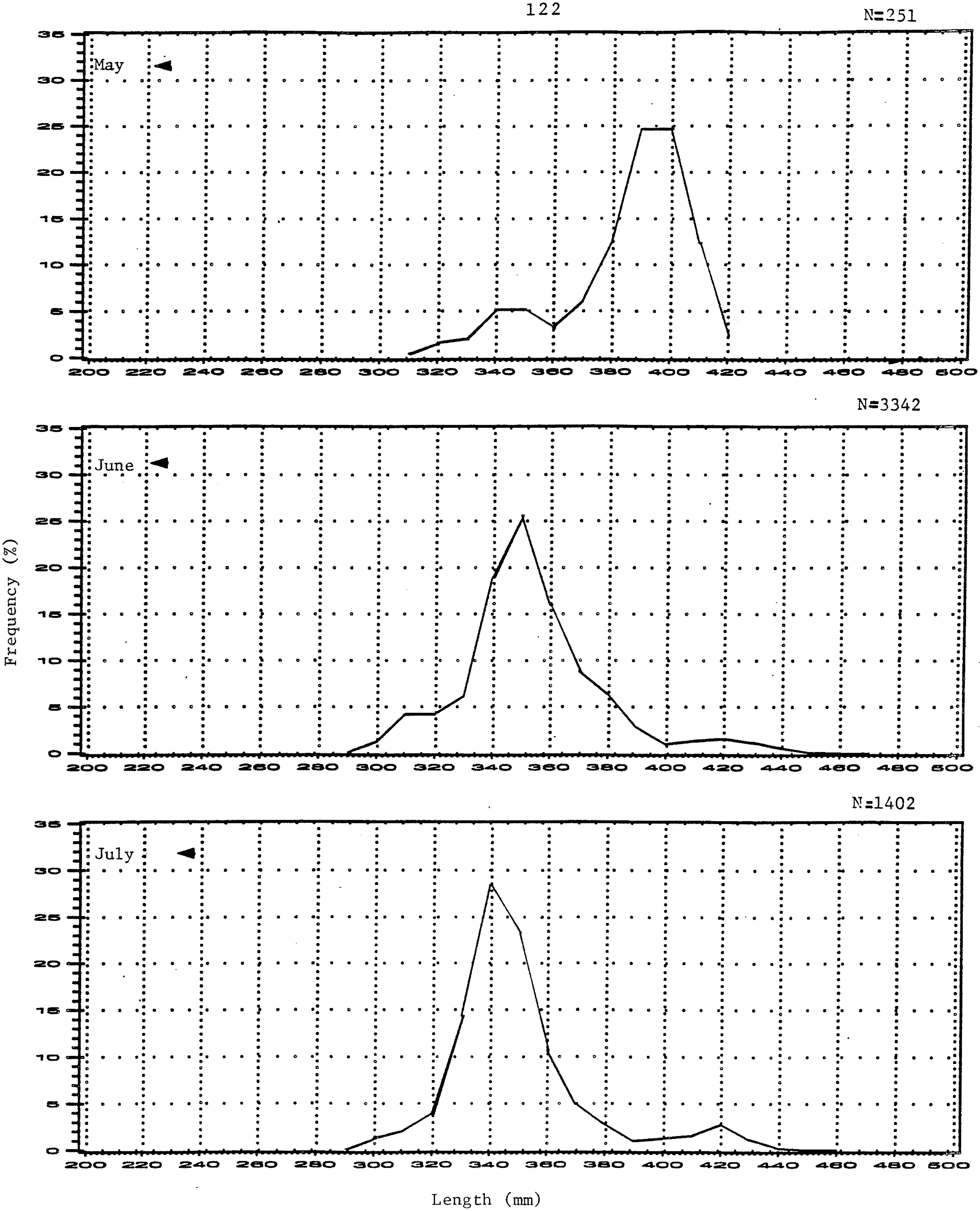


Figure 32. Monthly frequency distribution of length of mackerel measured in Subarea 4 in 1986.

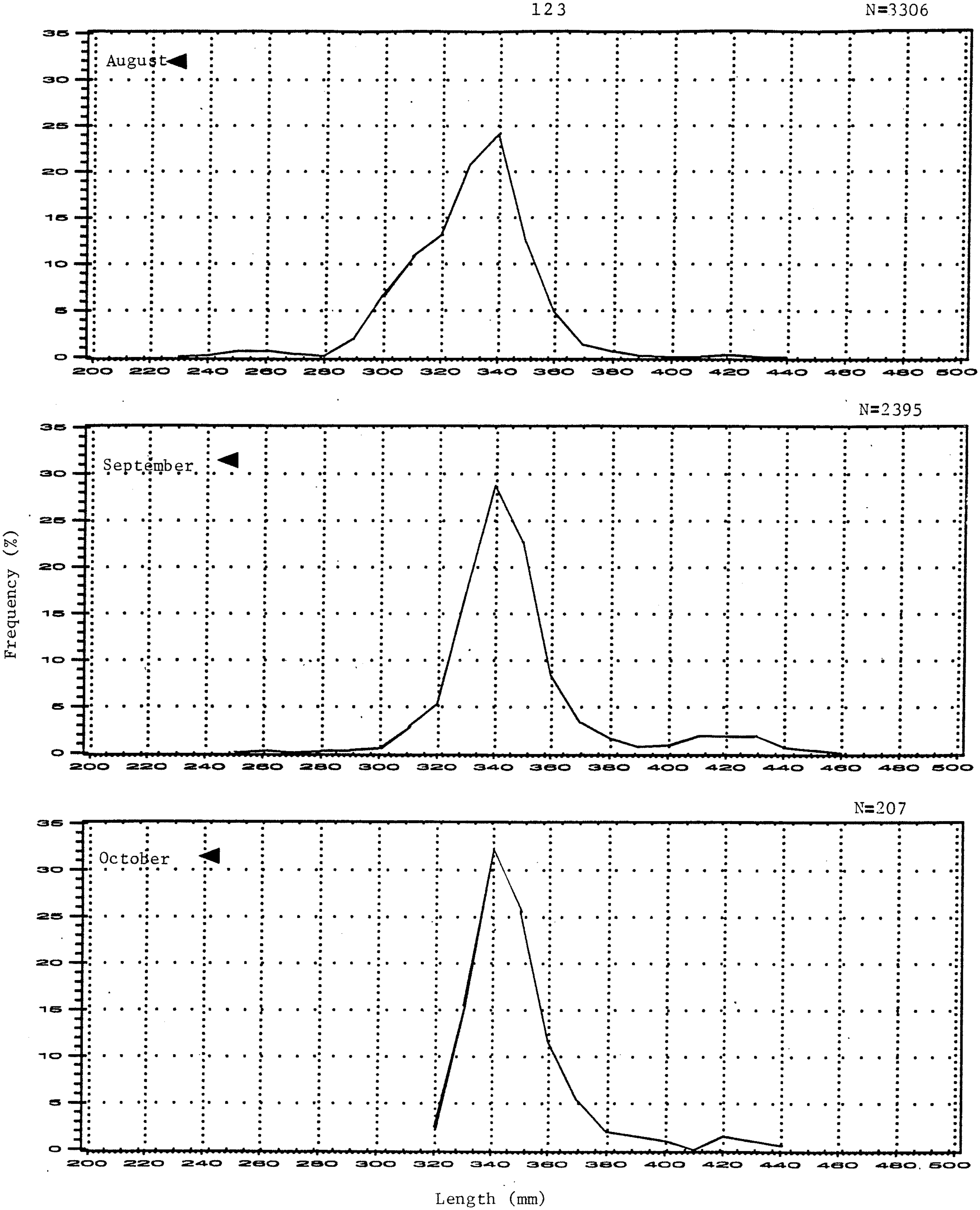


Figure 32. (cont'd).

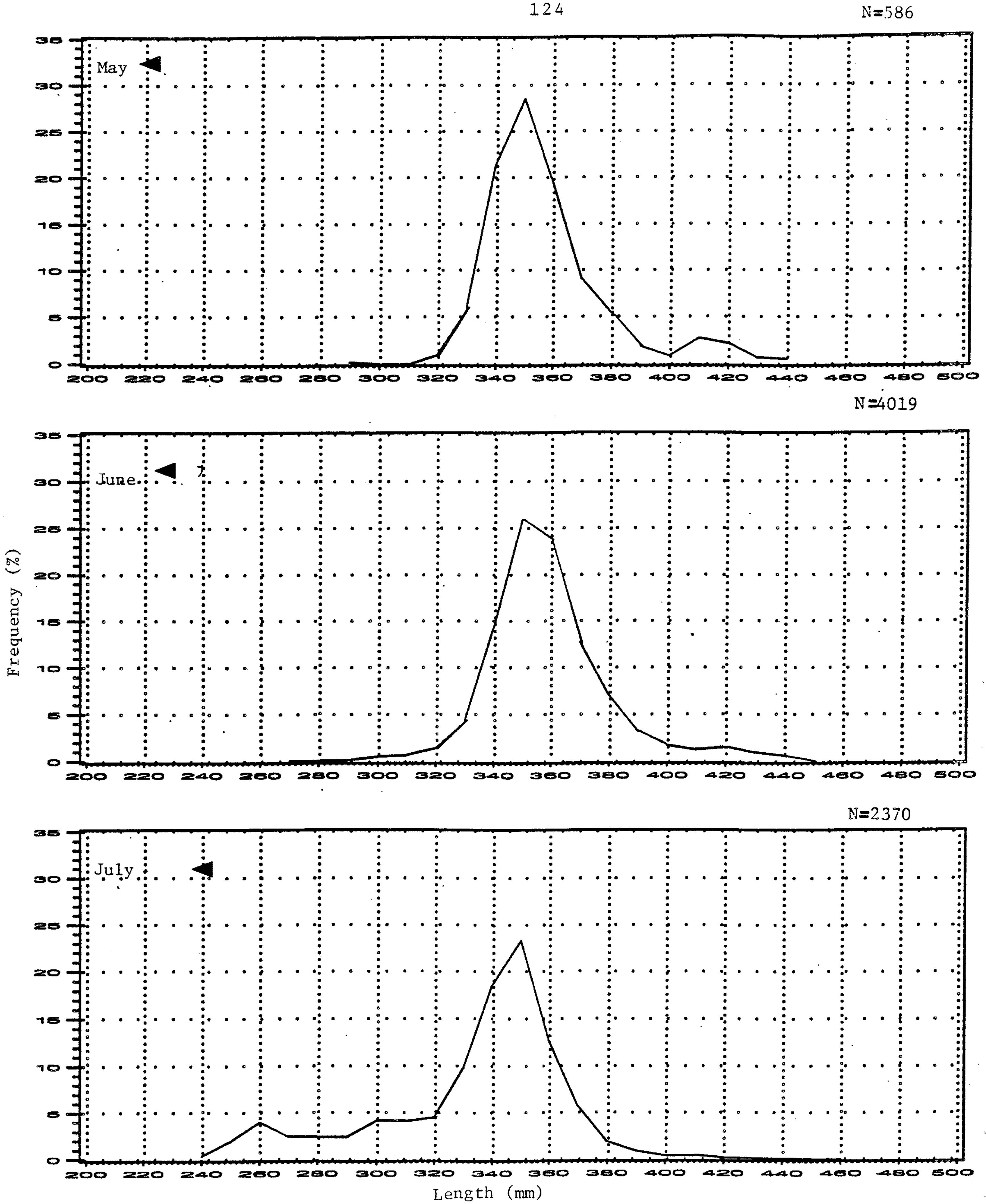


Figure 33. Monthly frequency distribution of length of mackerel measured in Subarea 4 in 1987.

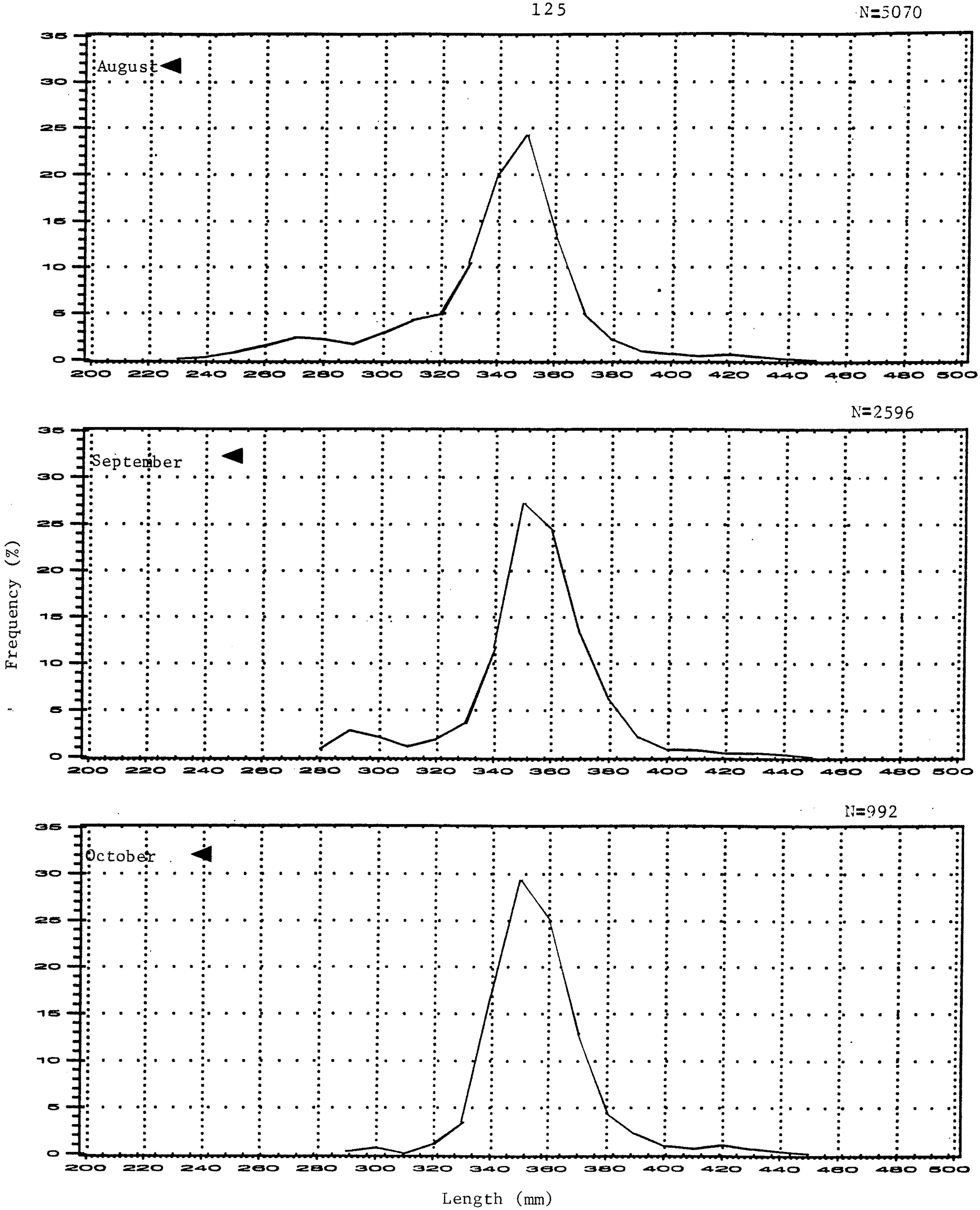


Figure 33. (cont'd).

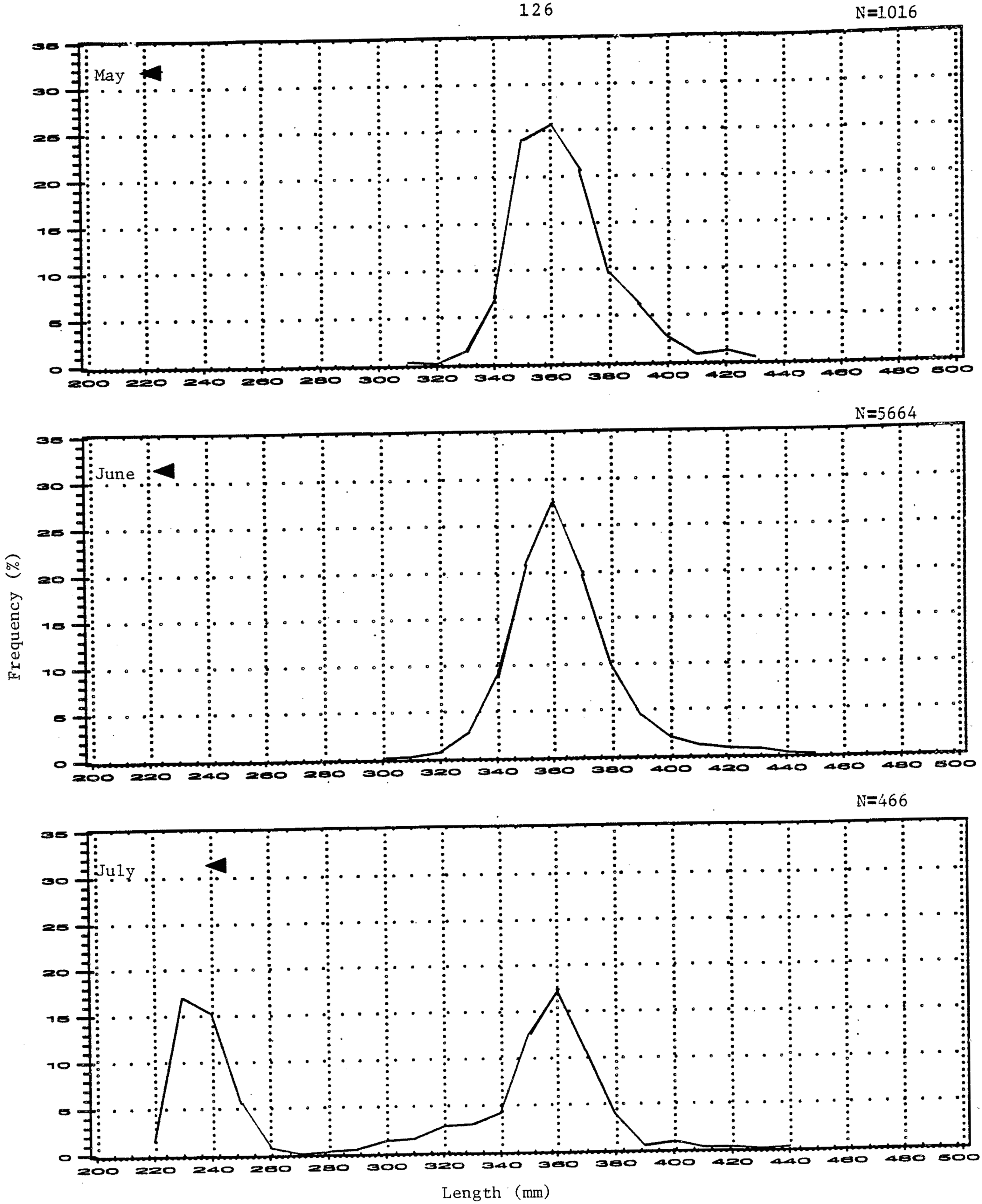


Figure 34. Monthly frequency distribution of length of mackerel measured in Subarea 4 in 1988.

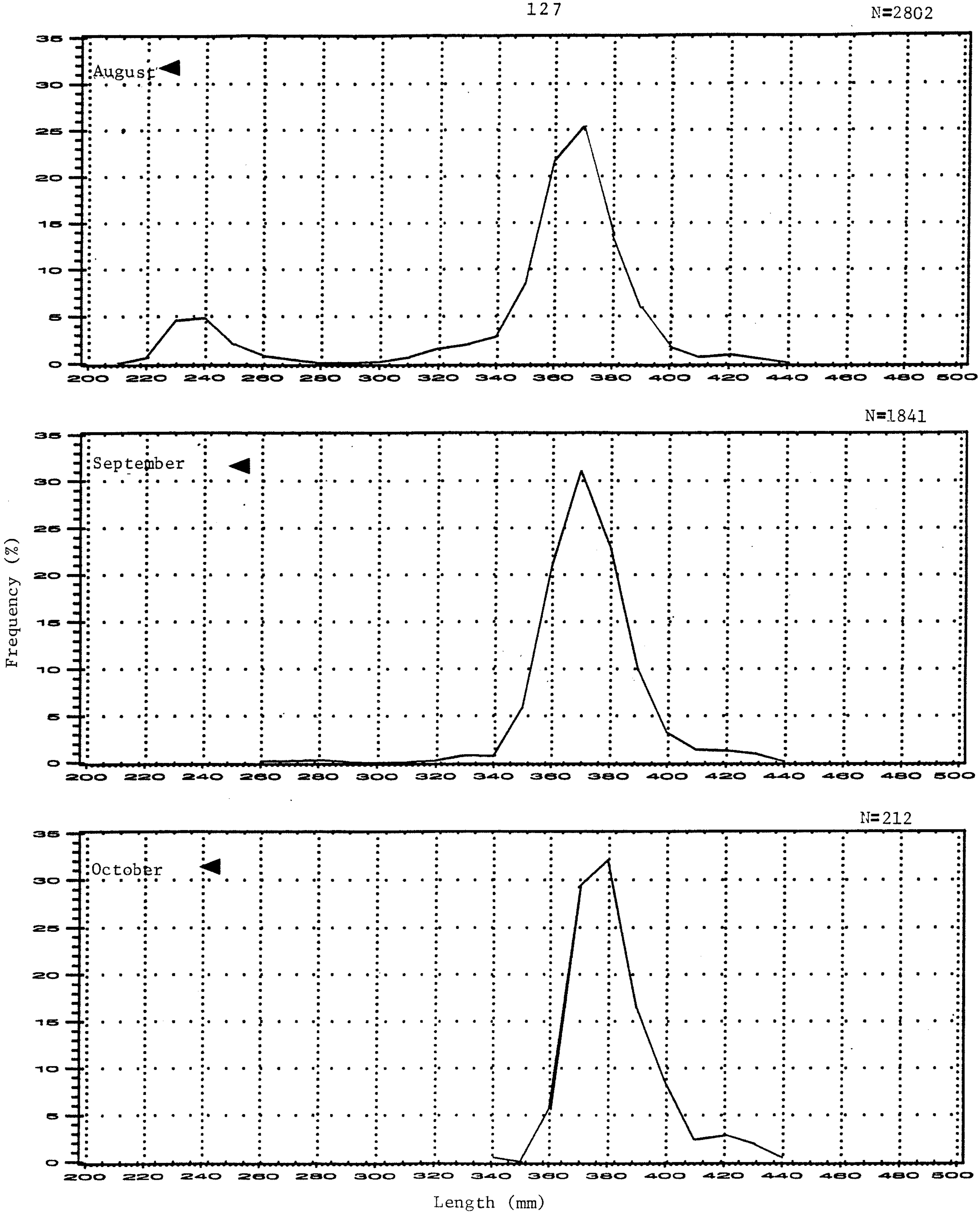


Figure 34. (cont'd).

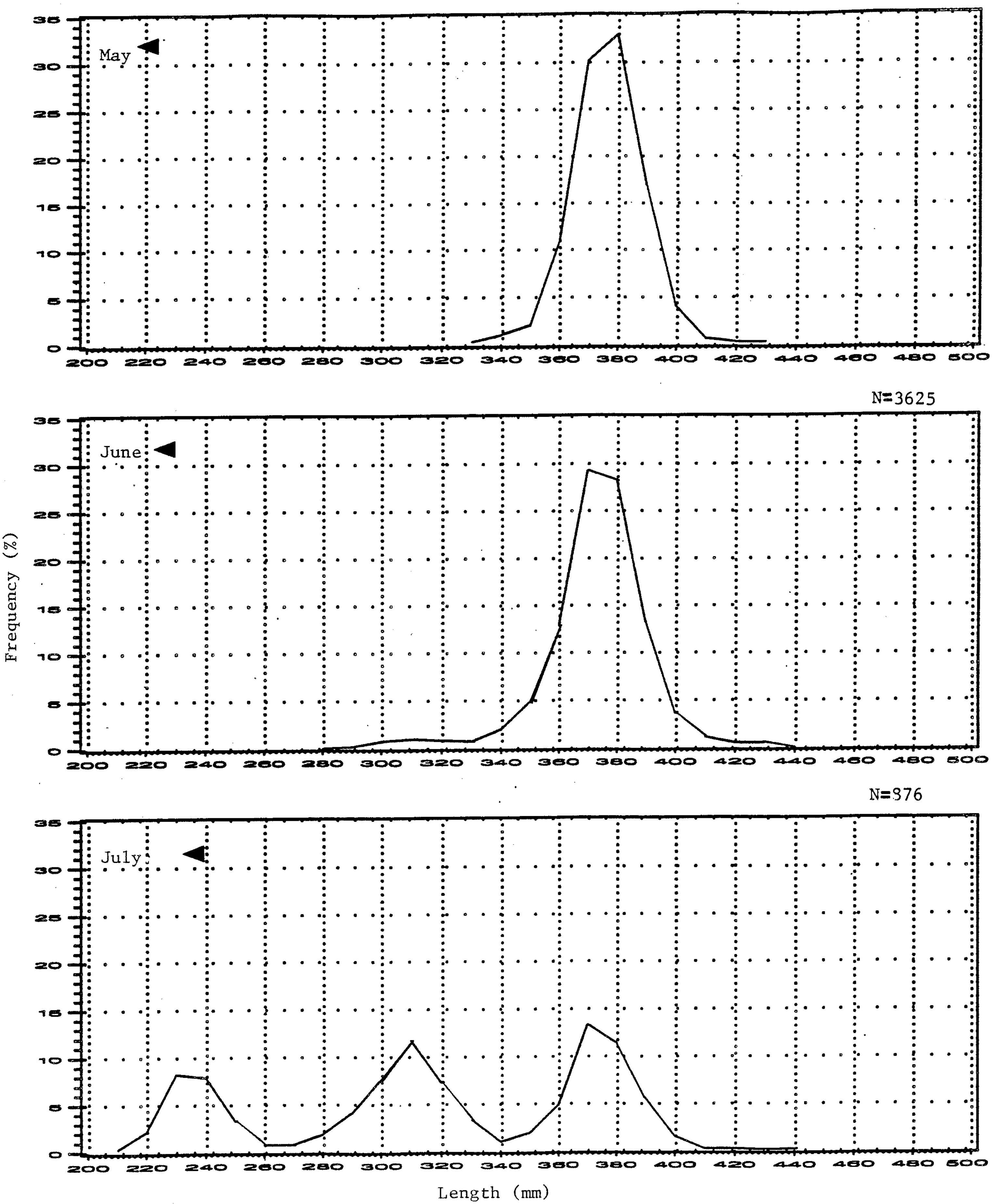


Figure 35. Monthly frequency distribution of length of mackerel measured in Subarea 4 in 1989.

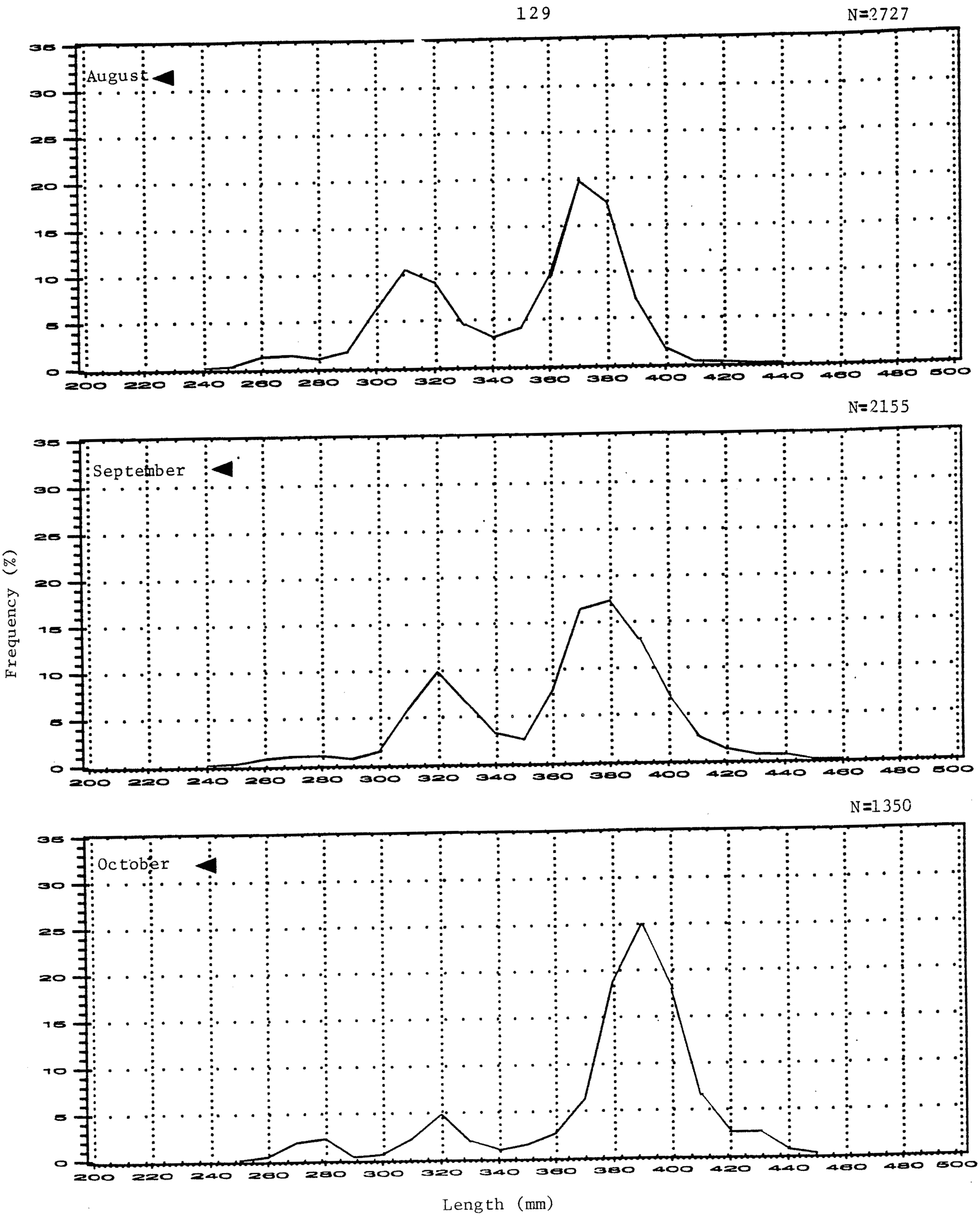


Figure 35. (cont'd).

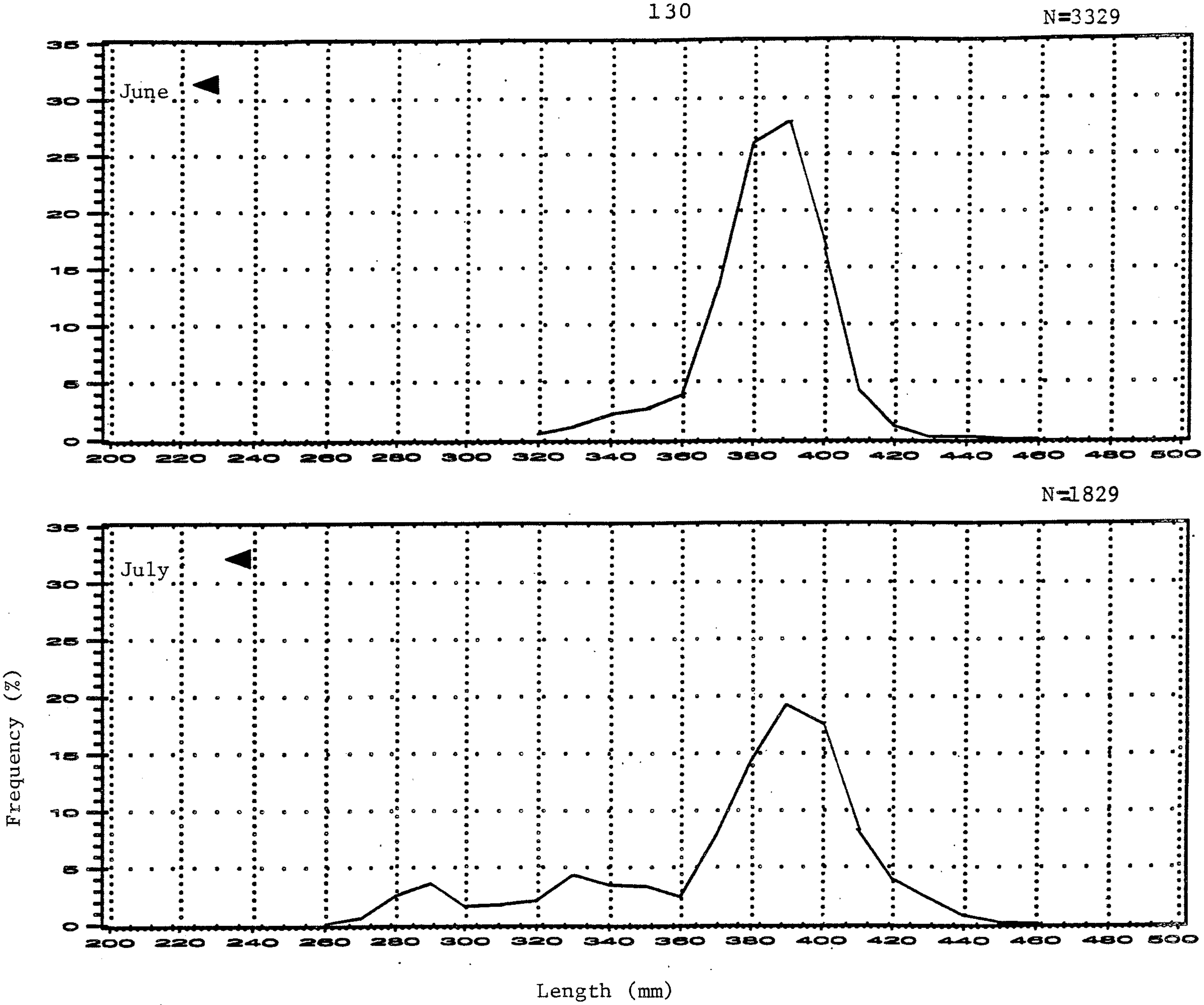


Figure 36. Monthly frequency distribution of length of mackerel measured in Subarea 4 in 1990.

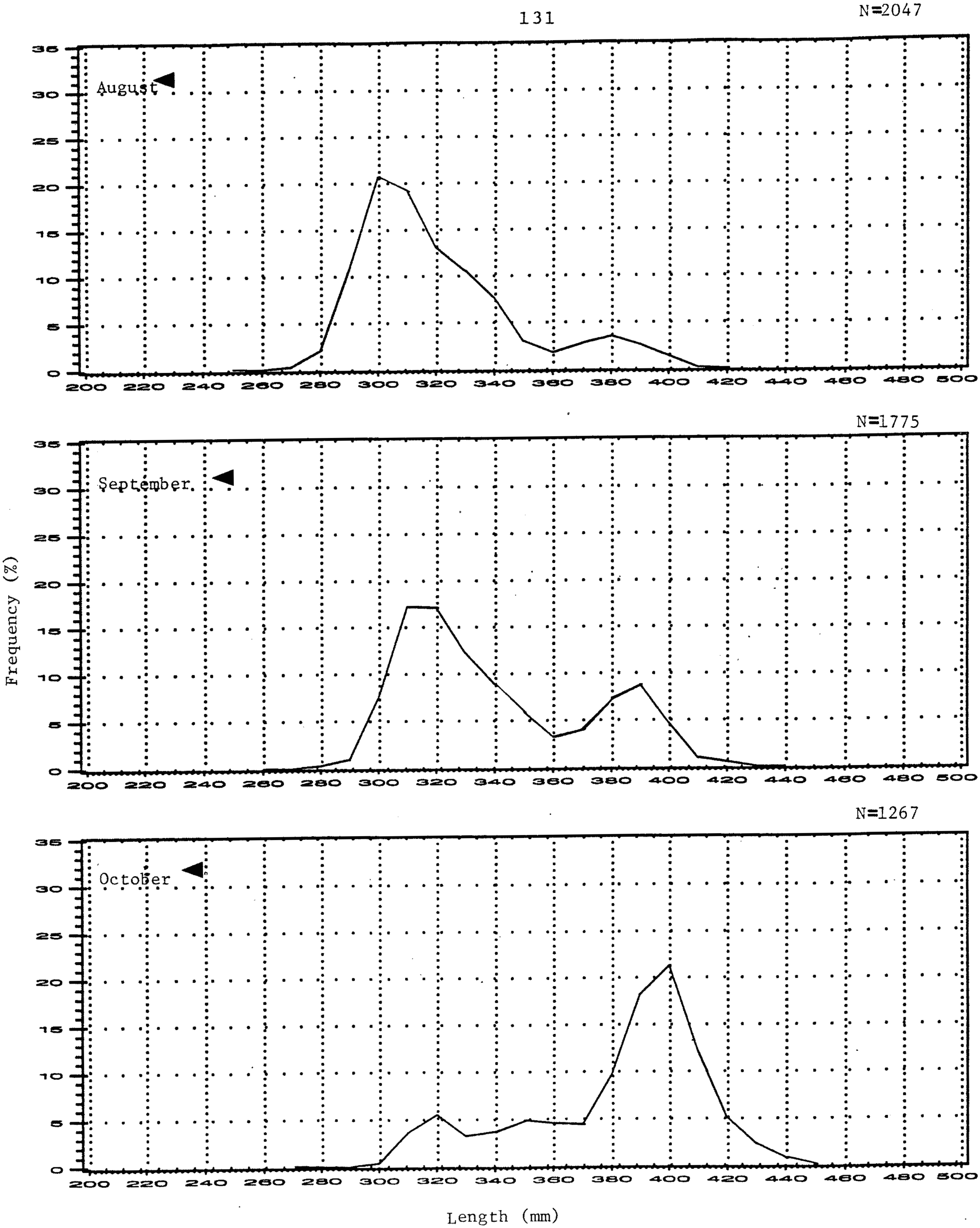


Figure 36. (cont'd).

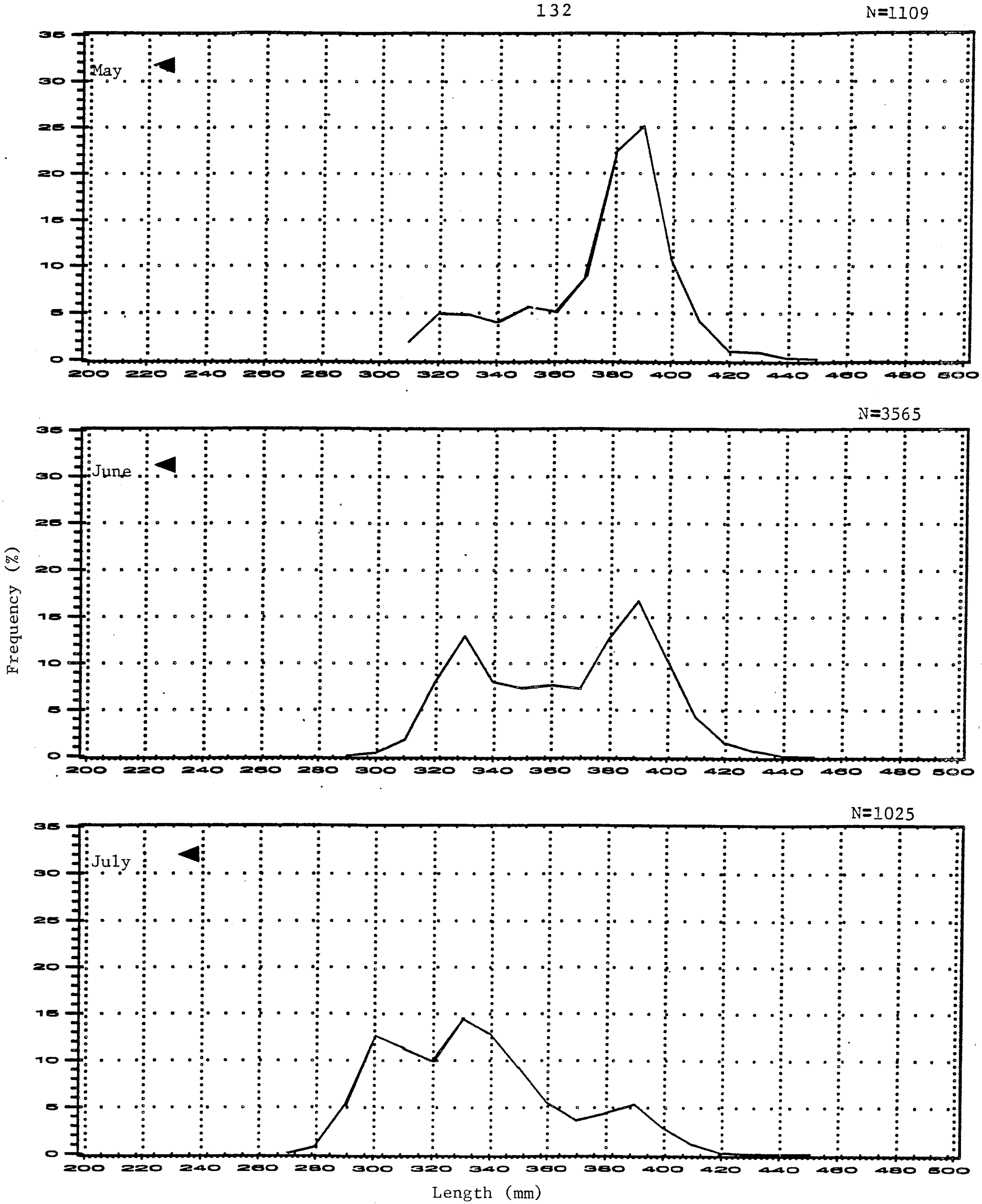


Figure 37. Monthly frequency distribution of length of mackerel measured in Subarea 4 in 1991.

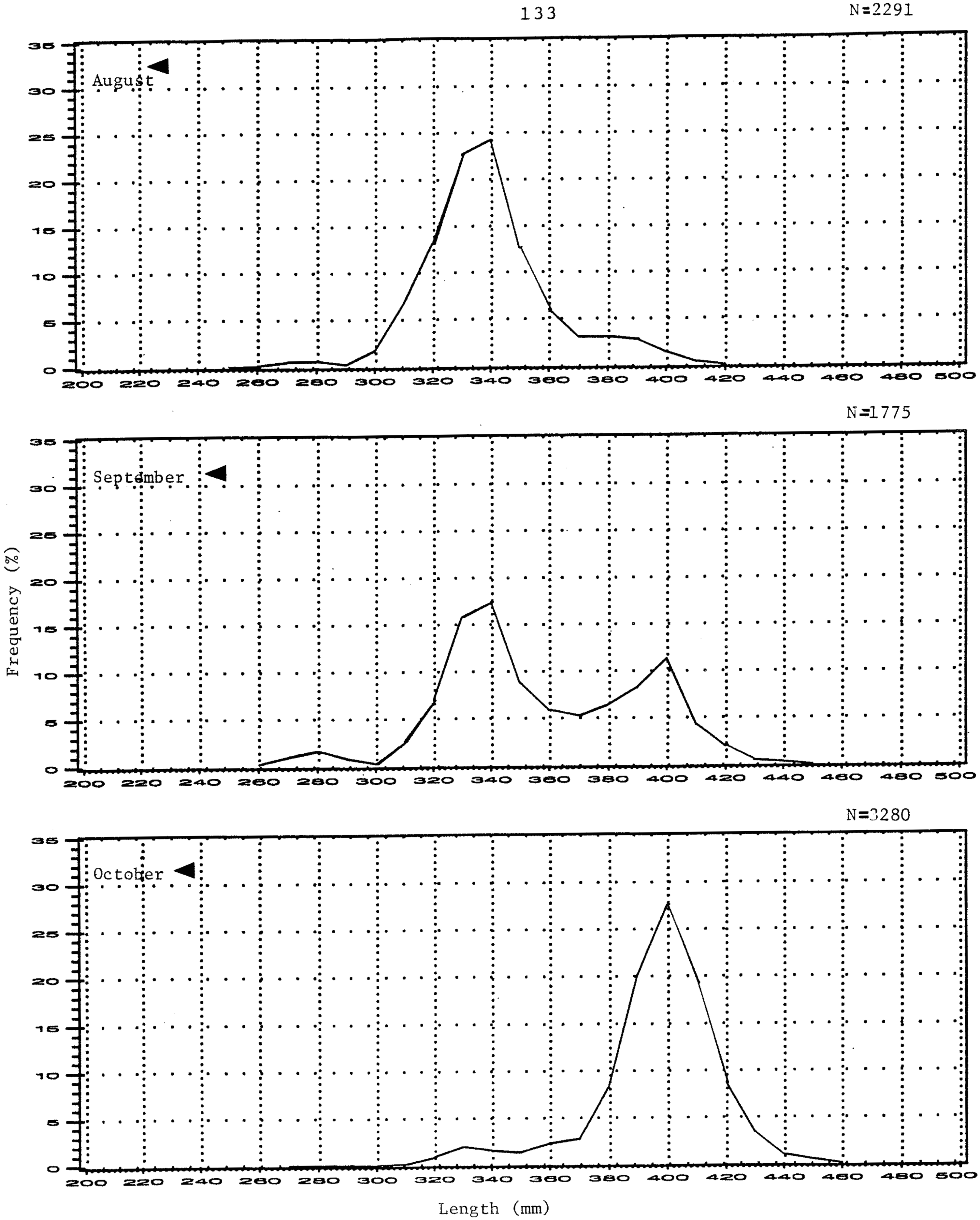


Figure 37. (cont'd).

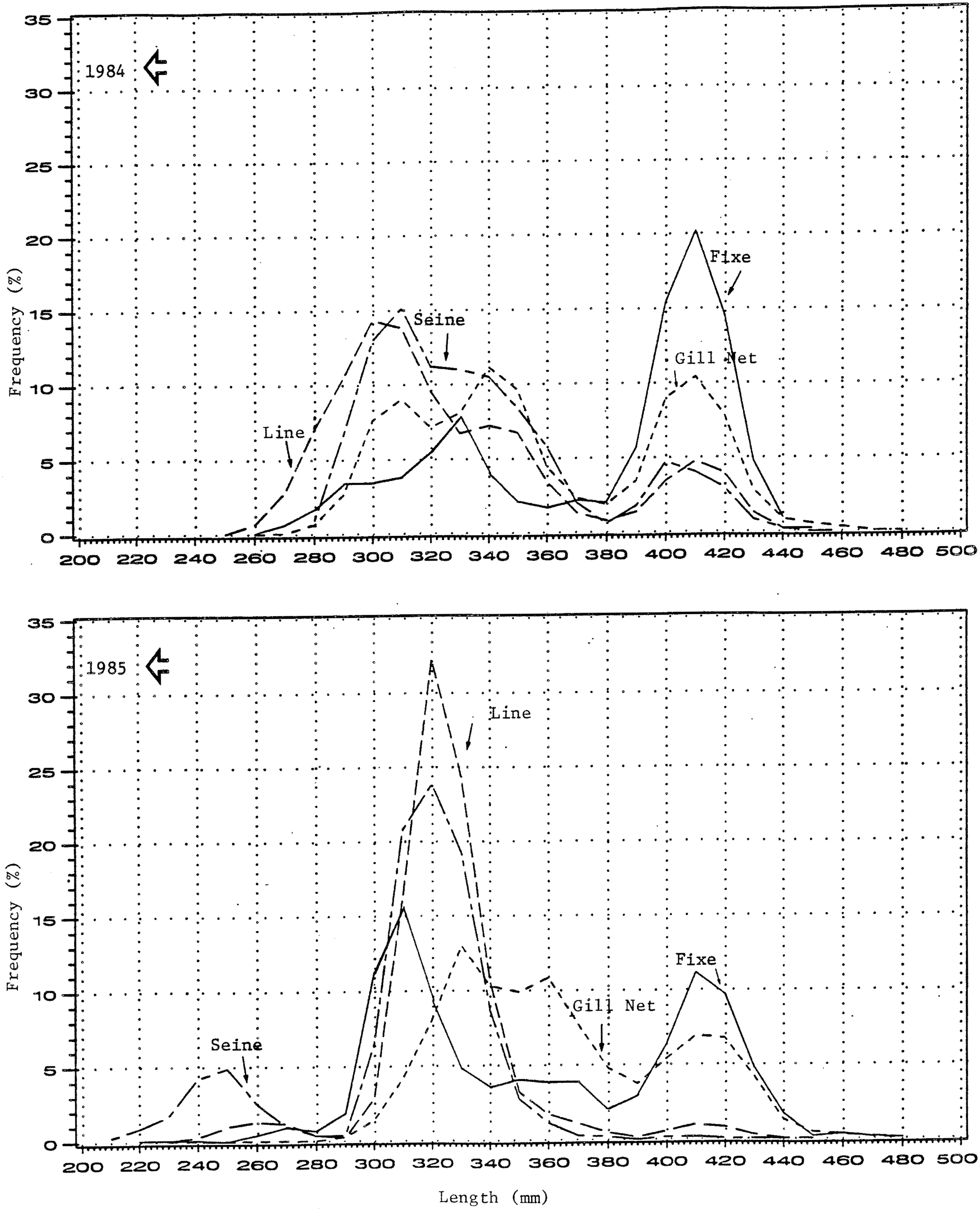
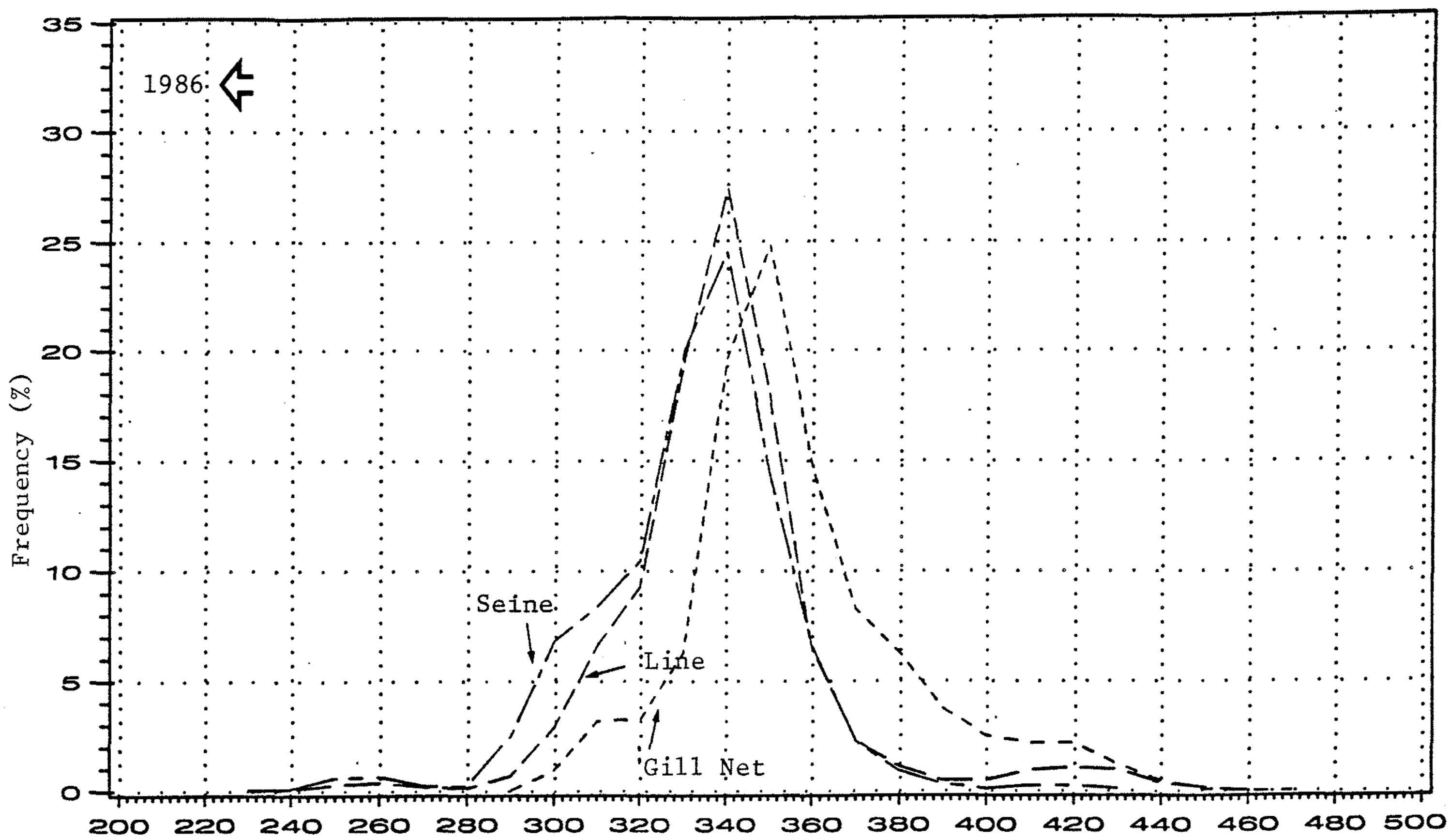


Figure 38. Annual frequency distributions of length for various categories of gear.



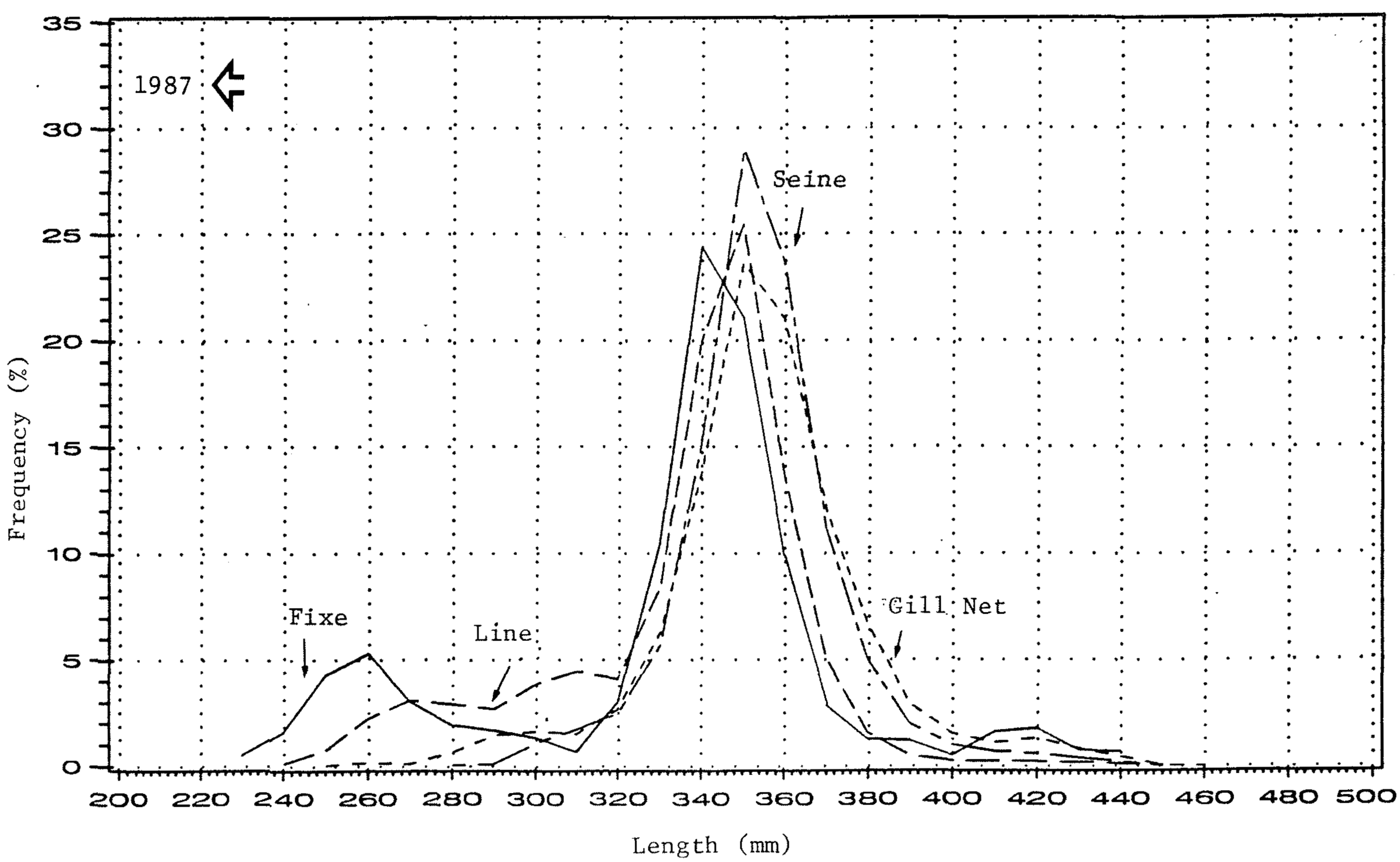
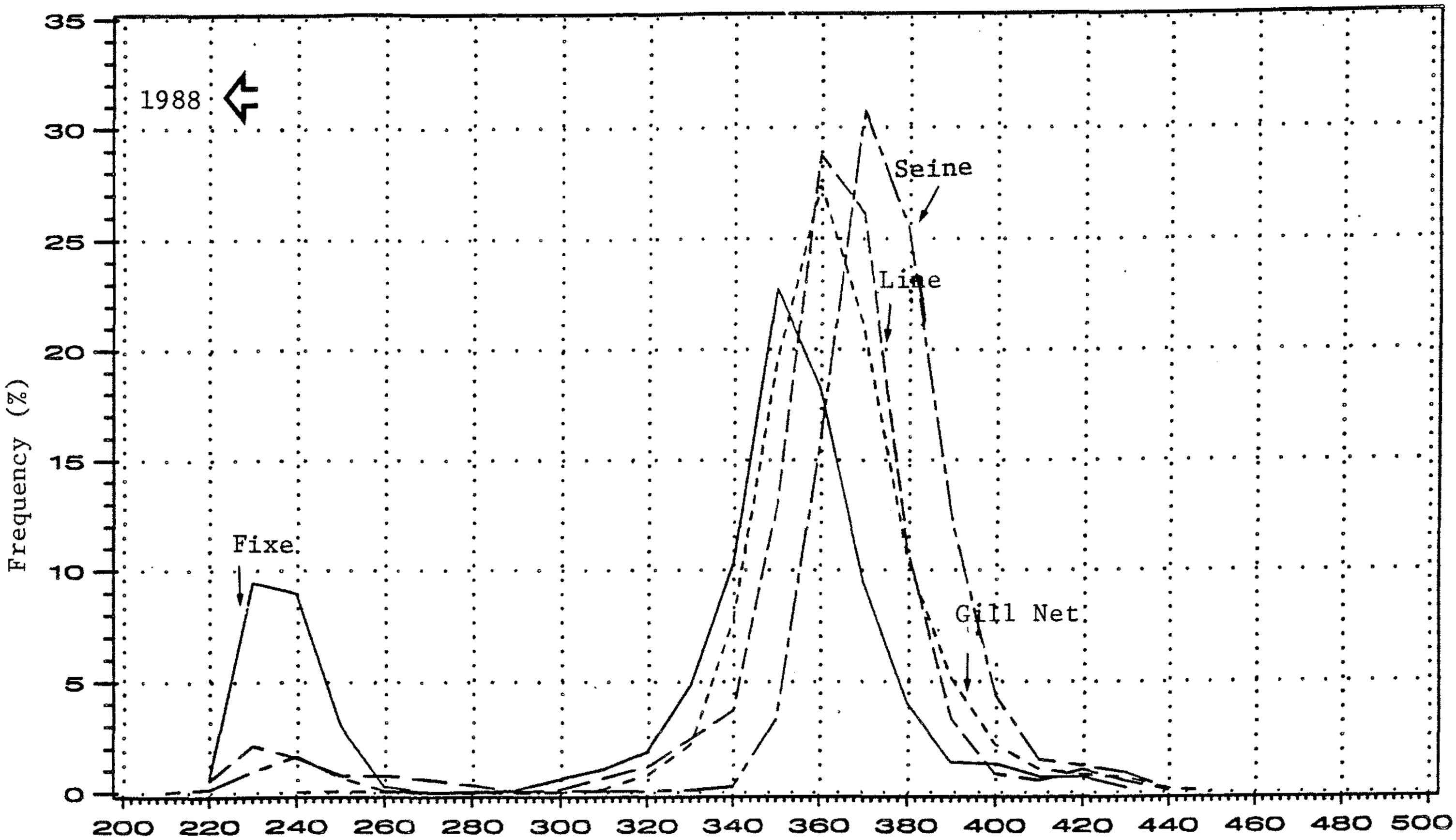


Figure 38. (cont'd).



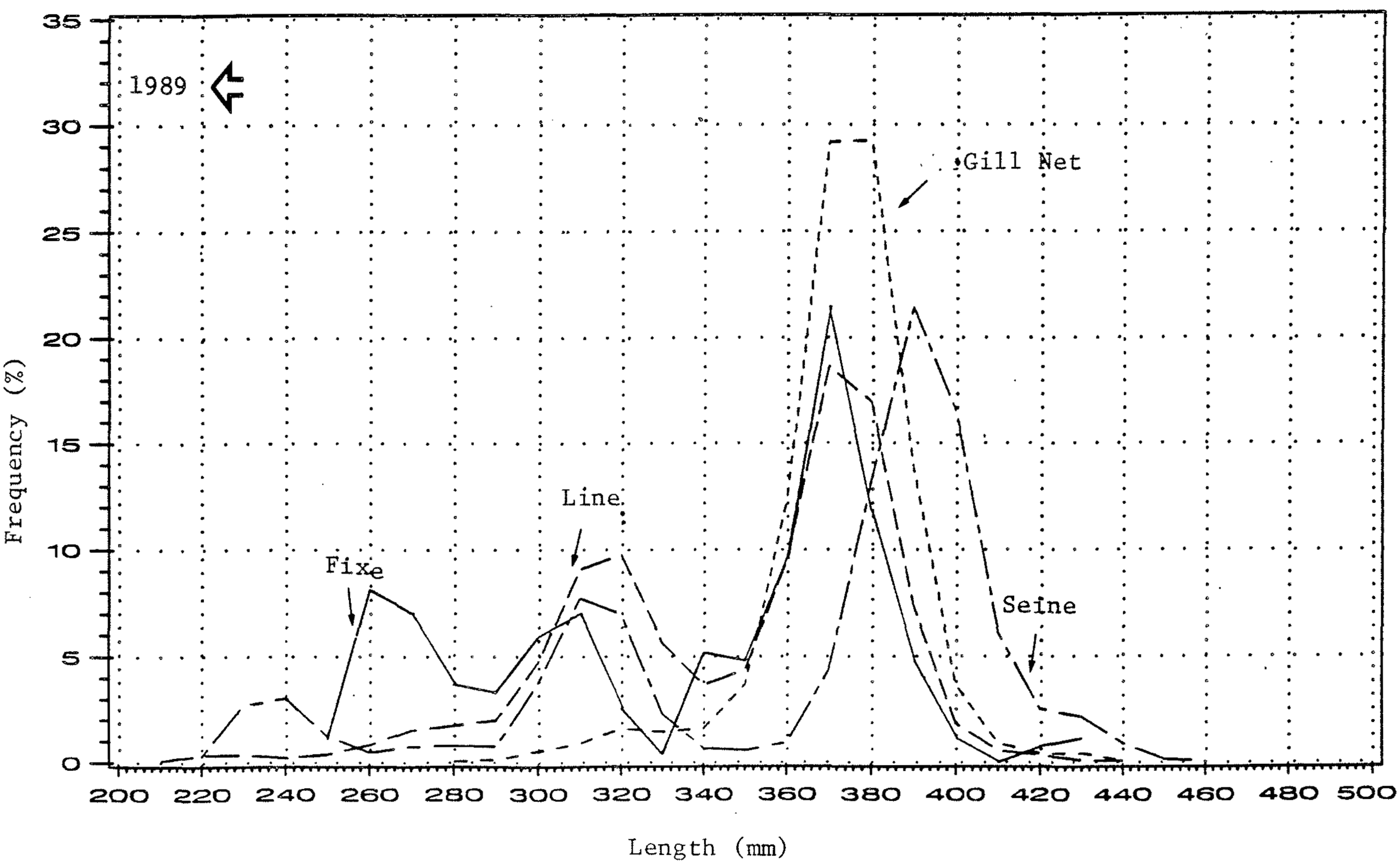
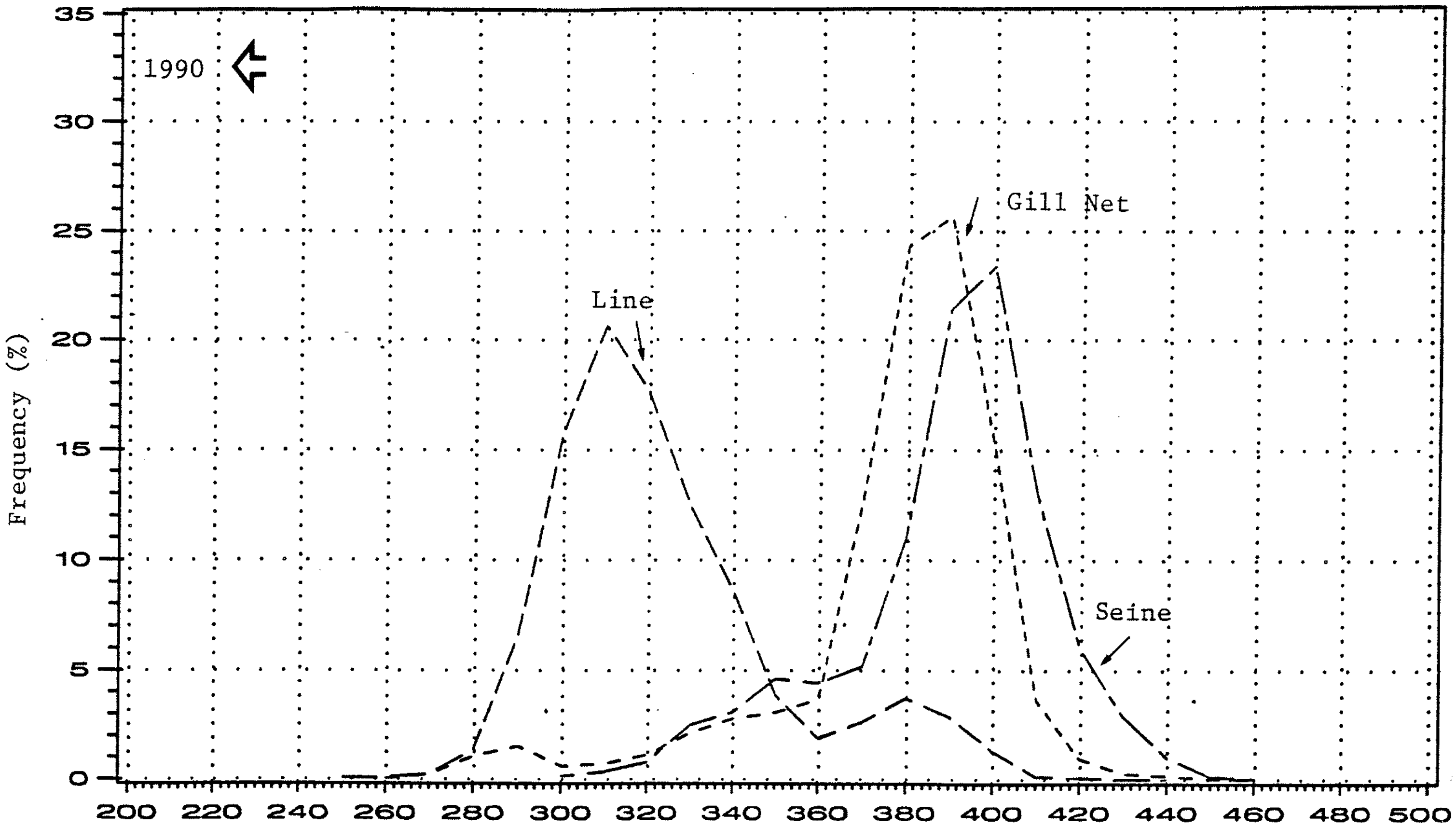


Figure 38. (cont'd).



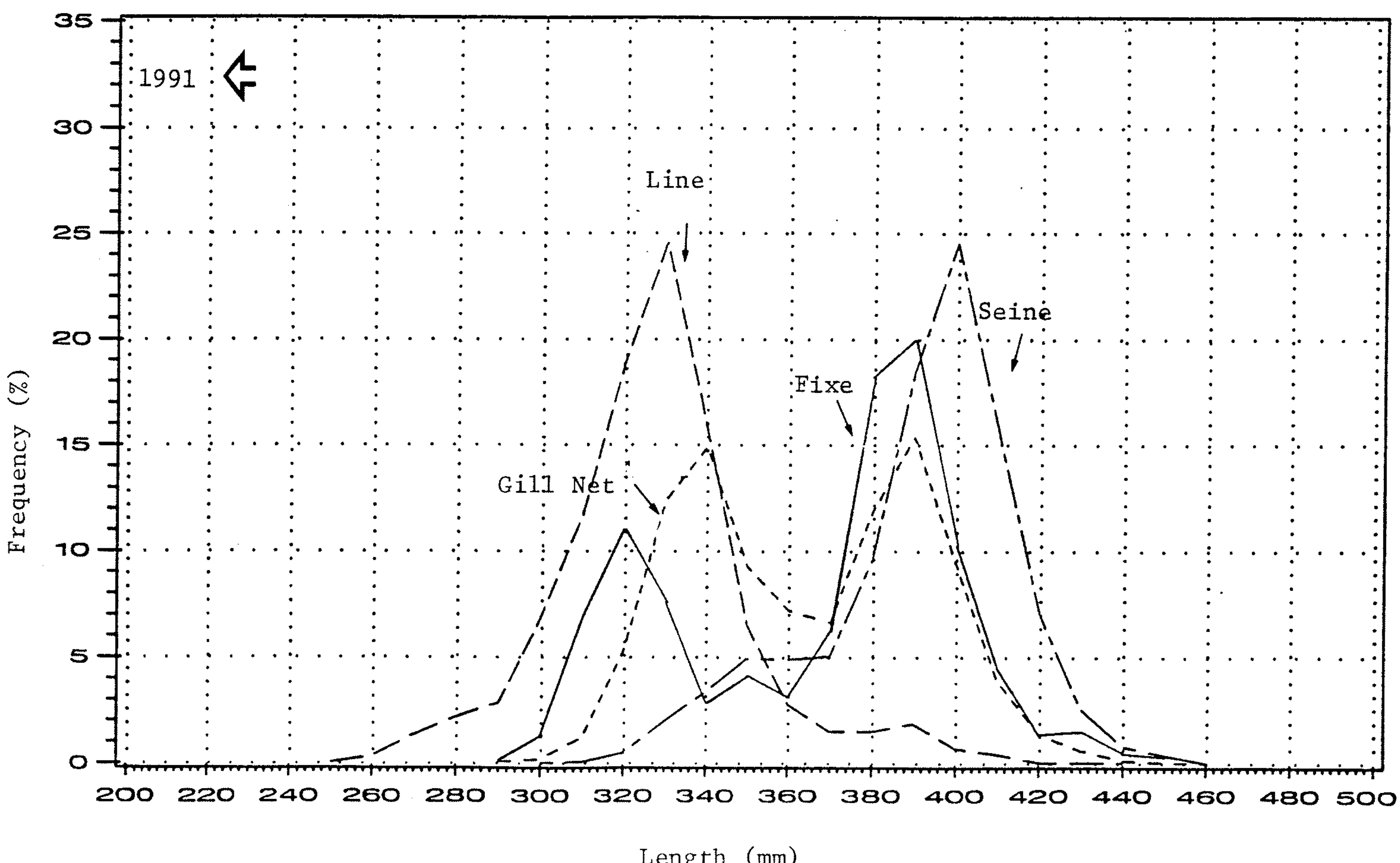


Figure 38. (cont'd).