Age and Size in Market Samples of Geoduc Clams *(Panope generosa)*

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AGE AND SIZE IN MARKET SAMPLES OF GEODUC CLAMS (Panope generosa)

by

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ABSTRACT

Harbo, R. M., B. E. Adkins, P. A. Breen, and K. L. Hobbs. 1983. Age and size in market samples of geoduc clams (Panope generosa). Can. MS Rep. Fish. Aquat. Sci. No. 1714: iii + 78 p.

Eight lots of geoducs harvested by the commercial fishery were sampled at processing plants. Each individual was measured in shell length, shell weight, and total wet weight. The heaviest individual measured was 2198 g. Shells were collected and later aged with the acetate peel technique. Geoducs recruited to the fishery beginning at age 4, and appeared to be fully recruited by age 12. The mean ages in these samples varied from 28 at Tofino to 61 at Spider Anchorage. The oldest individual was 146 years old. Mortality rates calculated from age frequencies were found to range from M=0.003-0.021. Growth rates determined from age, length and weight data, were similar to those found in other studies.

Key words: Geoduc, geoduck, ageing, growth, mortality, British Columbia.

RÉSUMÉ

Harbo, R. M., B. E. Adkins, P. A. Breen, and K. L. Hobbs. 1983. Age and size in market samples of geoduc clams (Panope generosa). Can. MS Rep. Fish. Aquat. Sci. No. 1714: iii + 78 p.

Huit débarquements de geoducks capturés par des pêcheurs commerciaux ont été échantillonnés aux usines de transformation. La longueur et le poids de l'oreillette ainsi que le poids humide total ont été notés pour chaque individu; le plus pesant totalisait 2 198 g. Les oreillettes ont été conservées et ont servi à la détermination de l'âge à l'aide de la méthode de l'impression sur acétate. Les geoducks faisaient partie des prises à partir de l'âge de 4 ans et ceux âgés d'au moins 12 ans semblaient tous faire partie de la population vulnérable. Les âges moyens des échantillons variaient de 28 ans, à Tofino, à 61 ans, à Spider Anchorage, et le plus vieil individu était âgé de 146 ans. La variation des taux de mortalité (M) calculés à partir des fréquences d'âge allait de 0,003 à 0,021. Les taux de croissance selon les données sur l'âge, la longueur et le poids étaient semblables à ceux mentionnés dans d'autres études.

Mots-clés: geoduck, détermination de l'âge, crossance, mortalité, Colombie-Britannique

INTRODUCTION

The geoduc, Panope generosa (Gould 1850), is a large subtidal clam widely distributed from Washington State through Alaska. Geoducs became the object of a commercial fishery in Washington State in 1970 and in British Columbia in 1976. The fishery is described by Harbo & Peacock (1983). In 1983, the landings for this species are expected to be 2950 tonnes.

The fishery is managed for sustainable yield with an annual quota (Harbo & Peacock 1983). This is currently derived from estimates of the standing stock and estimates of biological turnover rate. Stocks have been estimated by Cox & Charman (1980 and pers. comm.), and these estimates are being refined from logsheet information provided by fishermen. Estimates of biological production (Breen unpub. data) are based on growth, mortality and recruitment rates. These have been obtained from studies on Washington State populations (Anderson 1971; Goodwin 1976, Shaul & Goodwin 1982; Goodwin pers. comm.) and from limited studies on British Columbia populations (Breen & Shields 1983; Breen unpub. data; Cox & Charman pers. comm.)

Yield models now used for determining sustainable yield (Breen in prep.) are highly sensitive to estimates of natural mortality rate. Present estimates range from M=0.01-0.02 (Breen & Shields 1983) which correspond to finite annual survival rates of 95-99%. Two problems arise when these rates are used in managing the fishery. First, the range of estimates, while small in an ecological sense, is a large one in terms of resulting sustainable yield estimates. Second, mortality has been measured in only five British Columbia geoduc populations. Considering the size of the fishery and the importance of these estimates, it is essential to have rates based on a wider sample of populations.

Growth has similarly been studied in only a small sample of populations. Although the form of the growth curve is not as critical as mortality rate in estimating sustainable yields, one must understand growth differences among populations on different parts of the coast.

Growth and mortality rates can both be determined easily from samples of geoducs which have been aged and from which length and weight information have also been taken. The technique for ageing is described by Shaul & Goodwin (1982). Although the works cited above were based on research samples, the present study is based on samples of geoducs collected by the commercial fishery.

METHODS

Eight sets of samples and measurements from commercially harvested geoducs were taken from processing plants on Vancouver Island. Locations of origin are shown in Fig. 1. Geoducs are delivered to processing plants in

plastic cages, approx 0.5 x 0.5 x 0.5 m. Loads of geoducs delivered to the plant are separated according to the vessel of origin; hence the location and date of harvesting can be identified.

Sampling was carried out so as not to interfere with processing. We simply selected the first 15 cages encountered from each load. Whole wet weight was measured to the nearest gram. As geoducs are delivered to the plant one to three days after harvest, whole wet weight is highly variable because of varying sand and water losses. The water and sand content of geoducs is approximately 28% (Anderson 1970). Shell length, measured to the nearest mm, was taken as the longest possible measurement across the right valve (Fig. 2). Each valve was then dried and serially numbered with a waterproof felt pen. After these operations, geoducs were returned to the processing stream. The marked valves were recovered after shucking.

Two additional samples were provided to us directly by fishermen. These were from Cortes Island in Georgia Strait and Lemmens Inlet near Tofino. As the results below will show, they comprised juveniles which the fishermen collected during the course of commercial harvesting.

The right valves were cleaned and dried for ageing. (If the right valve was missing or seriously damaged the left valve was used instead. Many thin-shelled individuals, presumably juveniles, were broken in handling and transit.) Ageing was carried out as described by Shaul & Goodwin (1982). This involves counting internal growth lines on acetate peels made from polished sections of the hinge plates. Validation of the method is described in detail by Shaul & Goodwin (1982) and further validation was not attempted in this study.

Total mortality rate was estimated from the catch curve in the usual way (Ricker 1975), by assuming constant recruitment and determining the relation between log frequency and age. Because the fishery has operated for only 7 years, which is a short time relative to the mean length of life of geoducs, and because there is no reason to suspect the fishery of age-selectivity among individuals fully recruited to the fishery, the total mortality rate determined in this way should reflect natural mortality rate. Observations of individuals less than 11 years old were removed from the age frequencies to ensure that age-selective bias in the fishery was removed.

RESULTS

AGES ESTIMATED FROM ACETATE PEELS

The frequencies of ages are shown for each site in Figs. 3 to 12, and are combined in Fig. 13. The oldest individual age estimated was 146, at Kyuquot. Mean age varied from 28 at Elbow Bank to 61 at Spider Anchorage (Table 1). The samples of small geoducs provided by fishermen had mean ages of 6.5 and 7.6, and the lowest age in each was 3 (Table 1). The youngest ages

harvested by the fishery at each site (Table 1) ranged from 4 to 12. However, few individuals less than 12 were seen in market samples (Fig. 13).

In several of the age frequencies there appeared to be groups of ages which were more abundant than others. For instance, in the Blunden Island data (Fig. 8) ages from 68-78 form a mode. It is of interest to see whether such modes are synchronous in samples from different places - synchrony would suggest a widespread common cause of good recruitment. In five age frequencies reported by Breen & Shields (1983), there was a hint that such synchrony might have been present. However, when the age frequencies are combined (Fig. 13), there are no modes. If the modes seen in individual population samples are real, and not sampling artefacts, their causes must be localized.

GROWTH IN SHELL LENGTH

The relation between shell length and age is seen in Figs. 14 to 23 for each site, and is combined for all sites in Fig. 24. These curves are generally flat after age 10 to 15; in other words growth in length appears to be rapid for the first 10 years, and then it practically ceases. After this, the shell appears to become thicker rather than larger, as shown below. The rapid increase in shell length in juveniles can be seen in Figs. 15 and 17.

Mean lengths are compared among sites in Table 1. Mean lengths ranged from 137-162 mm in market samples, with standard deviations from 10 to 15. Variation in mean length among sites was not related to variation in mean age (Table 1), which indicates real differences in the sizes to which geoducs grow in different habitats.

GROWTH IN WHOLE WET WEIGHT

Age and whole wet weight are compared in Figs. 25 to 34 for each site, and in Fig. 35 for all sites combined. For a given age, weight was considerably more variable than length. As already seen in growth in length, growth in weight appeared to be rapid over the first 10 to 15 years, and then slowed dramatically. The rapid increase in juvenile weight can be seen in Figs. 26 and 28. Unlike growth in shell length, growth in weight appears to continue at a slow rate for many years.

Mean weights are compared among sites in Table 1. In market samples these varied from 755-1242 g. Standard deviations ranged from 218-325. The mean weight of all market samples was 1065 g. The heaviest individual measured was 2198 g at Kyuquot. Again, there was no relation between mean weight and mean age among sites, and in general those sites with greater mean lengths had higher mean weights.

ESTIMATED MORTALITY RATES

Mortality rate estimates are shown in Table 2. The highest estimate was M=0.021 at Elbow Bank; the lowest was M=0.003 at Blunden Island. Most sites were in the range M=0.01-0.02.

DISCUSSION

The results above are consistent with what is already known about geoduc populations. In particular, they support the conclusion that geoducs have low turnover rates. Estimated mortality rates and mean ages, lengths, and weights observed in this study fell within the same range as those found in five populations by Breen & Shields (1983), who also observed similar patterns of growth.

The pattern of age frequencies is generally consistent with low, constant recruitment.

Geoducs appear to grow quickly in both length and weight for the first 10 years. Growth in length then practically stops, weight continues to increase slowly for many years, and the shell becomes steadily thicker and heavier.

Mortality rates, estimated from age frequencies as described above, depend on several assumptions. First, the method assumes that mean recruitment has been roughly constant over the ages examined. Since some age groups appear to be stronger than others, this assumption appears not to hold perfectly within individual sites. The effect on estimated mortality rates might be to slightly over-estimate mortality if recent strong recruitment had occurred; conversely to under-estimate mortality if recent recruitment had been weak. There is no way to evaluate such possible errors, except to point out that all the mortality estimates reported here and in Breen & Shields (1983) fell within the same range. If mortality rate estimates are very sensitive to variations in recruitment, and if such variations were timed differently among sampled populations (as suggested above), then one would expect to see more variability in mortality rate estimates. The similarity of these estimates indicates that the assumption of constant recruitment is satisfactory.

The second assumption is that the fishery takes all recruited individuals without bias as to age. This assumption might fail in several ways. The fishery may be biased against younger (smaller) individuals. Harvesters may discard older individuals, which tend to have darker meat color (L. Yamanaka, pers. comm.). In these harvester biases, individual divers may have very different harvesting patterns with respect to geoduc age. The sampling procedure may introduce sampling error by non-randomly selecting geoducs from a harvested site. Sampling may be biased against younger individuals, since these have the thinnest and most fragile shells.

There is no way to evaluate these possible sources of bias in evaluating market sampling as a source of population information about geoducs. However, it appears from this first examination of market sampling that results are similar to those obtained from direct population sampling (e.g. Breen and Shields 1983). Thus market sampling may be a valid way to study geoduc population parameters.

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Table 1.

Site #	Shell #	Date Sampled	Location	n	Mean age (Range)	n^1	Mean Length (mm) (Range)	S.D.	n^1	Mean wt (g) (Range)	S.D.
1.	FF	June 19, 1981	Spider Anchorage	193	60.9 (12-118)	300	144.6 (90-175)	11.89	300	972.8 (150-1643)	216.1
	no shells	April 16, 1982	Spider Anchorage			147	149.7 (105-184)	16.39	147	1085.0 (410-1894)	325.0
*2.	GG	July 27, 1981	Cortes Island	19	6.5 (3- 8)	27	100.0 (49-130)	21.37	27	244.4 (22- 435)	130.0
3.	EE	June 5, 1981	Crofton	145	36.2 (8- 73)	212	137.1 (99-173)	13.15	250	754.9 (94-1607)	237.9
*4.	JJ	Feb. 23, 1982	Clayoquot-Lemmens Inlet	29	7.6 (3- 40)	48	114.4 (76-144)	18.69	48	435.9 (137- 915)	208.3
5.	KK	Aug. 12, 1982	Clayoquot-Shot Island	120	29.5 (10- 60)	127	162.4 (141-187)	10.62	131	1187.4 (756-1876)	218.2
6.	DD	May 21, 1981	Clayoquot-Blunden Island	153	57.4 (11-117)	210	148.9 (118-173)	11.02	250	1126.1 (260-1830)	236.5
7.	CC	May 21, 1981	Clayoquot-Elbow Bank	171	28.3 (4- 69)	175	159.9 (95-192)	14.73	223	1076.4 (182-1902)	322.1
8.	AA	Mar. 19, 1981	Rolling Roadstead	251	35.2 (7- 99)	281	153.7 (102-194)	14.58	295	1165.2 (247-2054)	303.6
9.	BB	April 4, 1981	Kyuquot	208	39.3 (5-146)	254	154.5 (119-195)	14.43	261	1242.3 (225-2198)	314.8
10.	MM	Aug. 5, 1982	Kyuquot-Aktis Island	157	41.4 (8-126)	215	146.1 (104-190)	14.32	222	1044.4 (361-2116)	309.3
			All true market samples	1398	41.2 (4-146)	1774	150.0 (90-195)	15.12	1932	1064.9 (94-2198)	310.4

*not market samples; samples of juveniles were provided by fishermen.

n = number of shells aged.

N^1 = number of geoducks measured in this variable.

Table 2. Mortality rates estimated from age frequencies.

Site #	Location	Mortality Rate
1.	Spider Anchorage	0.004
3.	Crofton	0.010
5.	Clayoquot-Shot Island	0.014
6.	Clayoquot-Blunden Island	0.003
7.	Clayoquot-Elbow Bank	0.021
8.	Rolling Roastead	0.014
9.	Kyuquot	0.012
10.	Kyuquot-Aktis Island	0.014

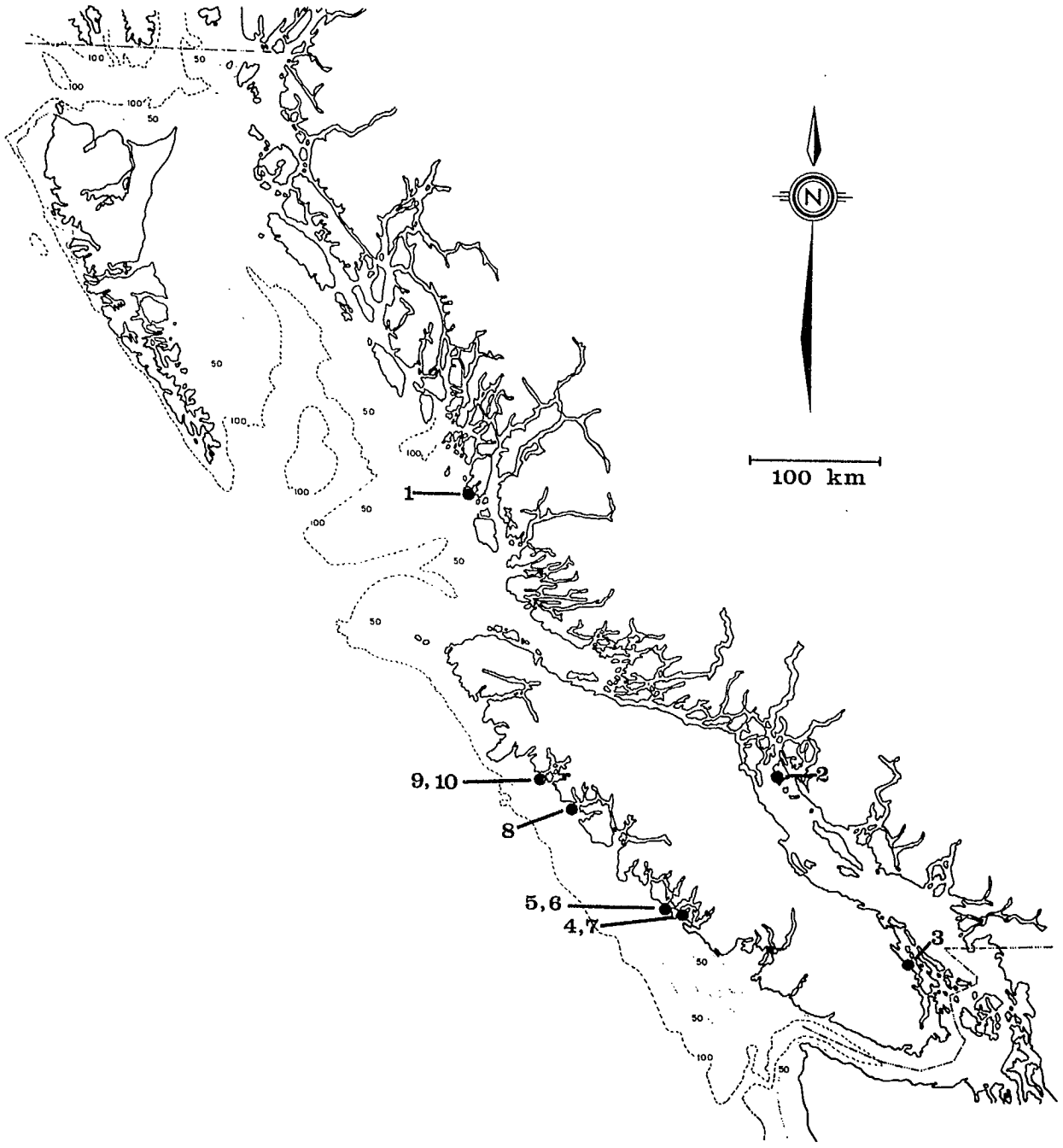

Fig. 1. Market sample sites. See Table 1 for names.

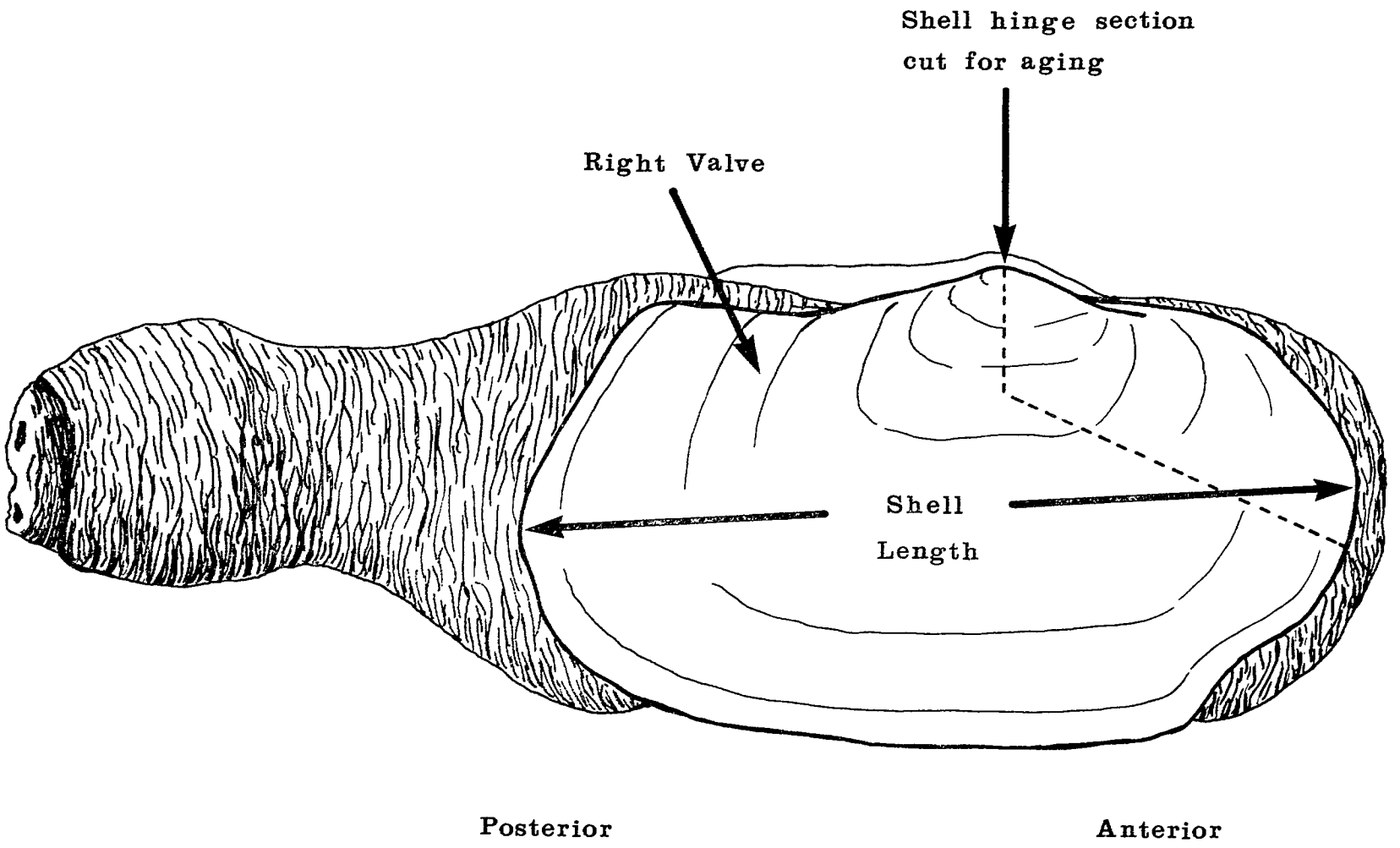

Fig. 2. Geoduc clam (Panope generosa).

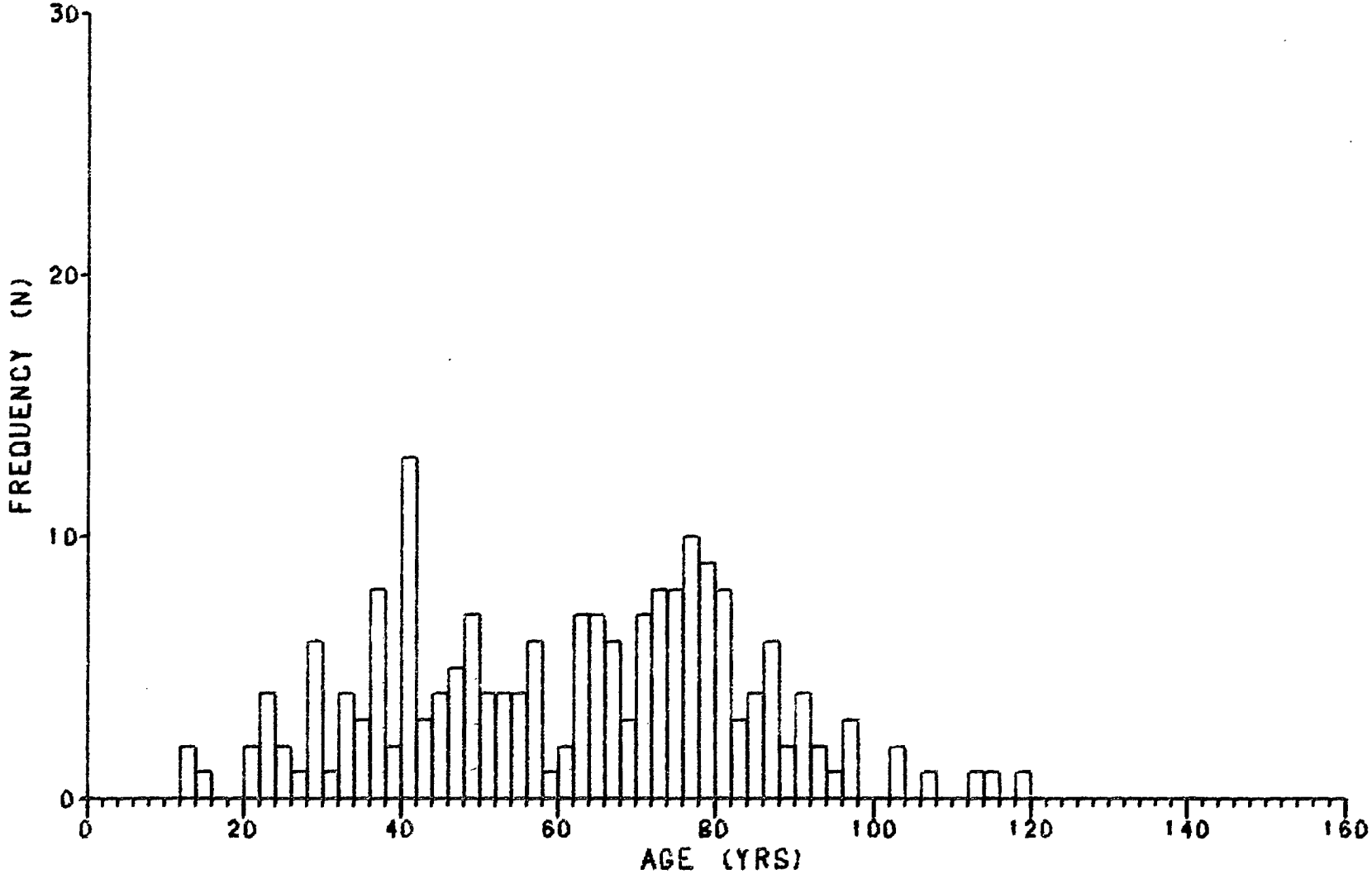

Fig. 3. Plot of age frequency, Spider Anchorage, June 29, 1981.

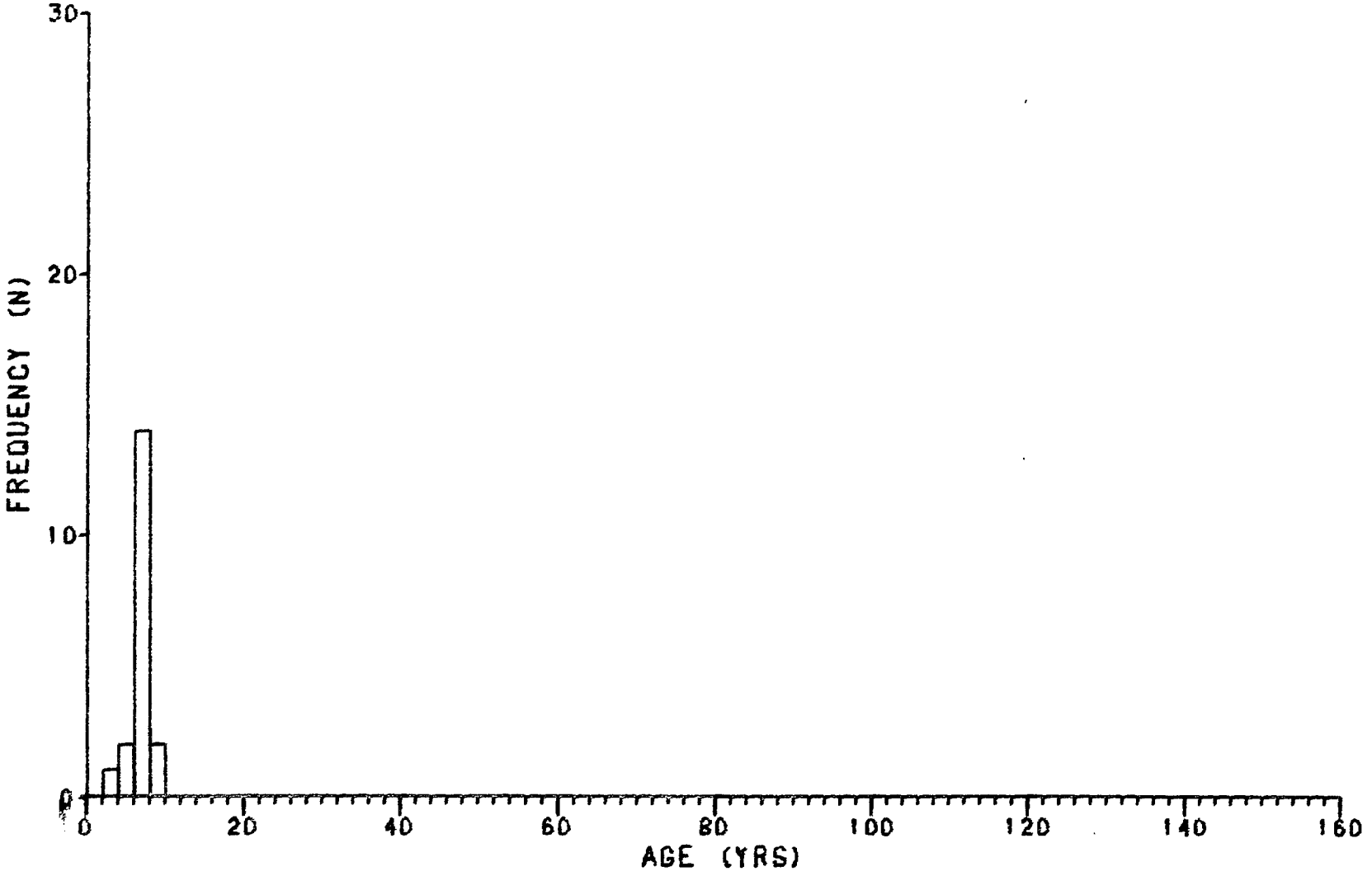

Fig. 4. Plot of age frequency, Cortes Island, July 27, 1981.

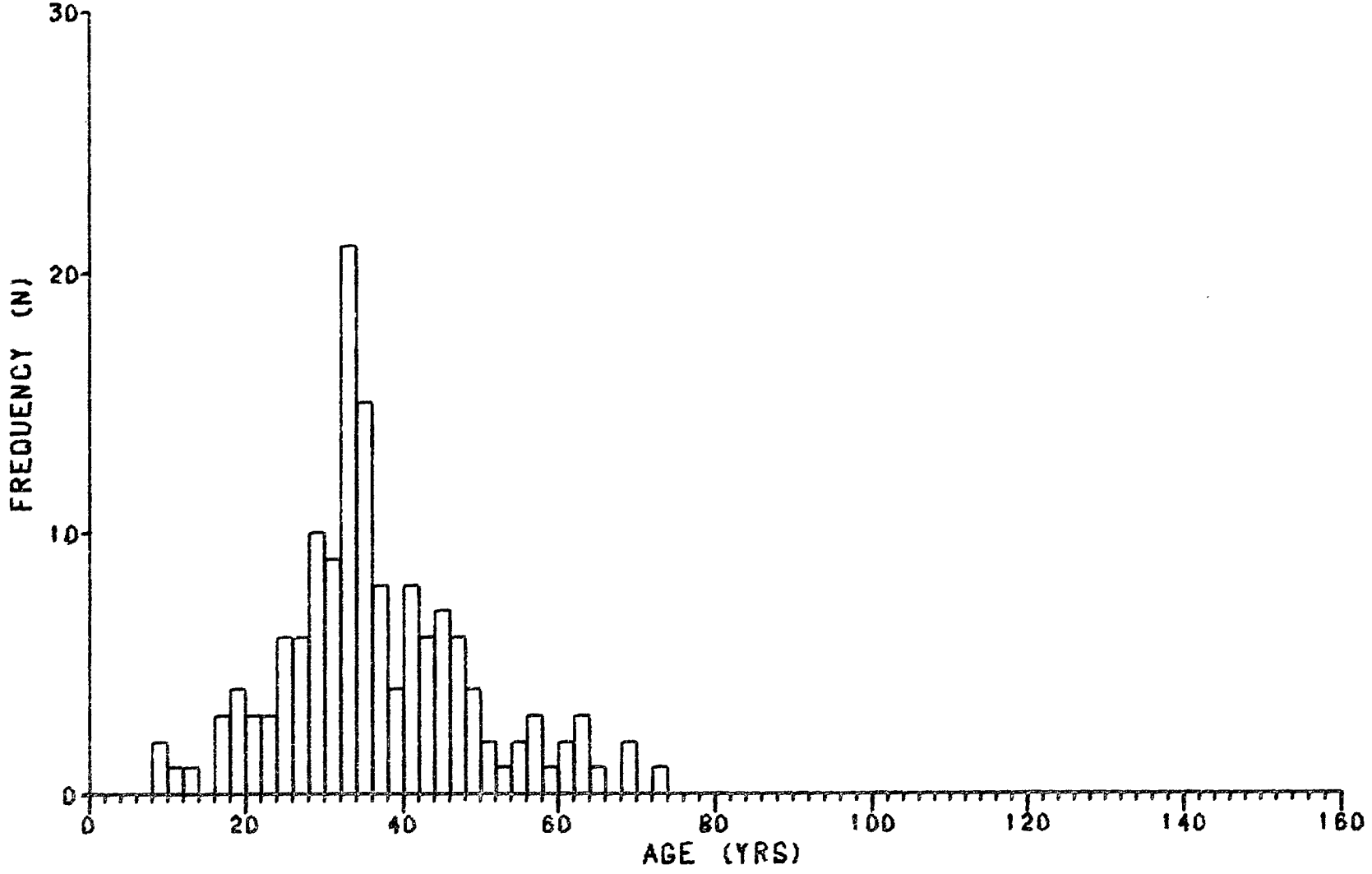

Fig. 5. Plot of age frequency, Crofton, June 5, 1981.

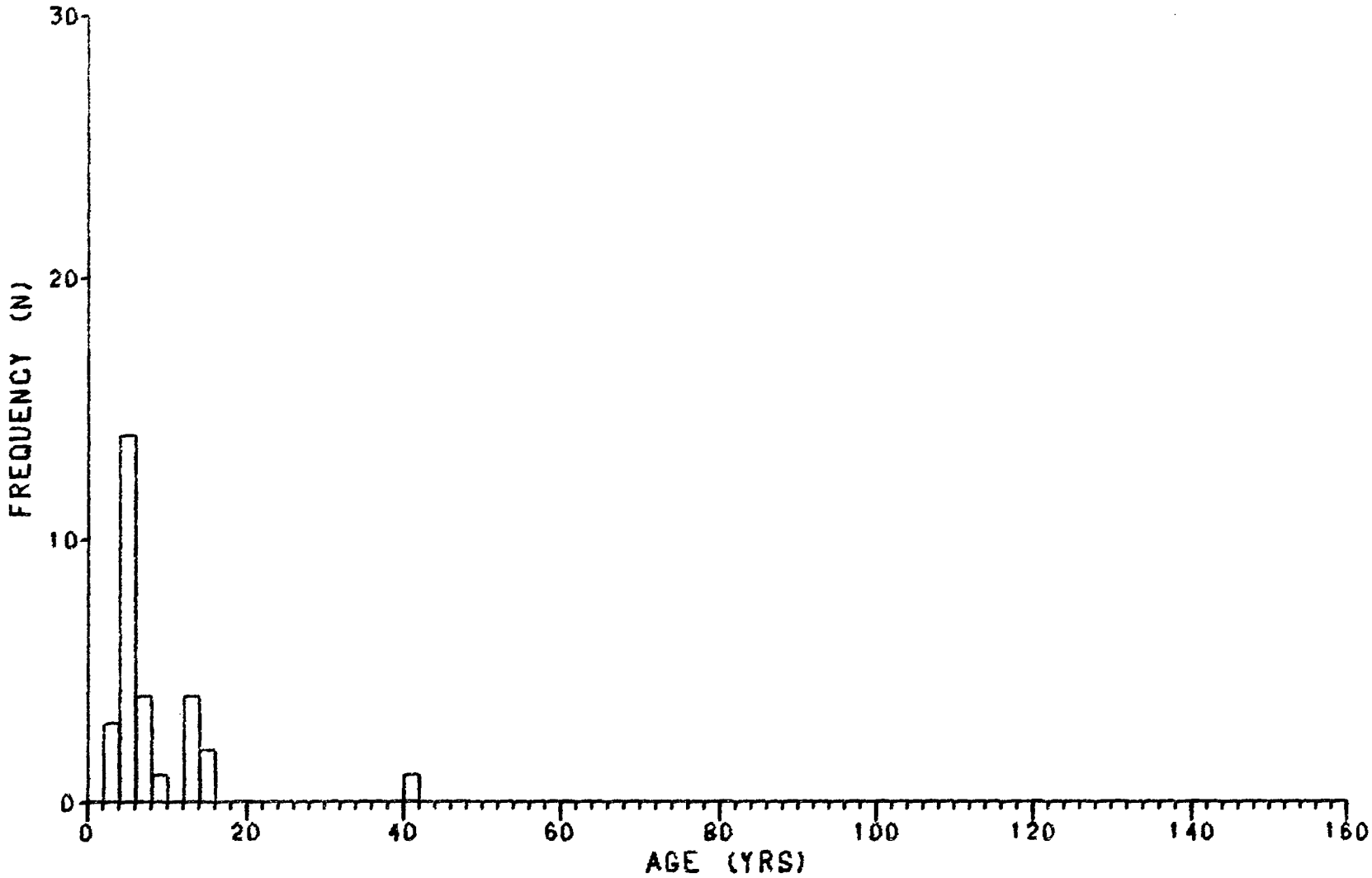

Fig. 6. Plot of age frequency, Clayoquot-Lemmens Inlet, February 23, 1982.

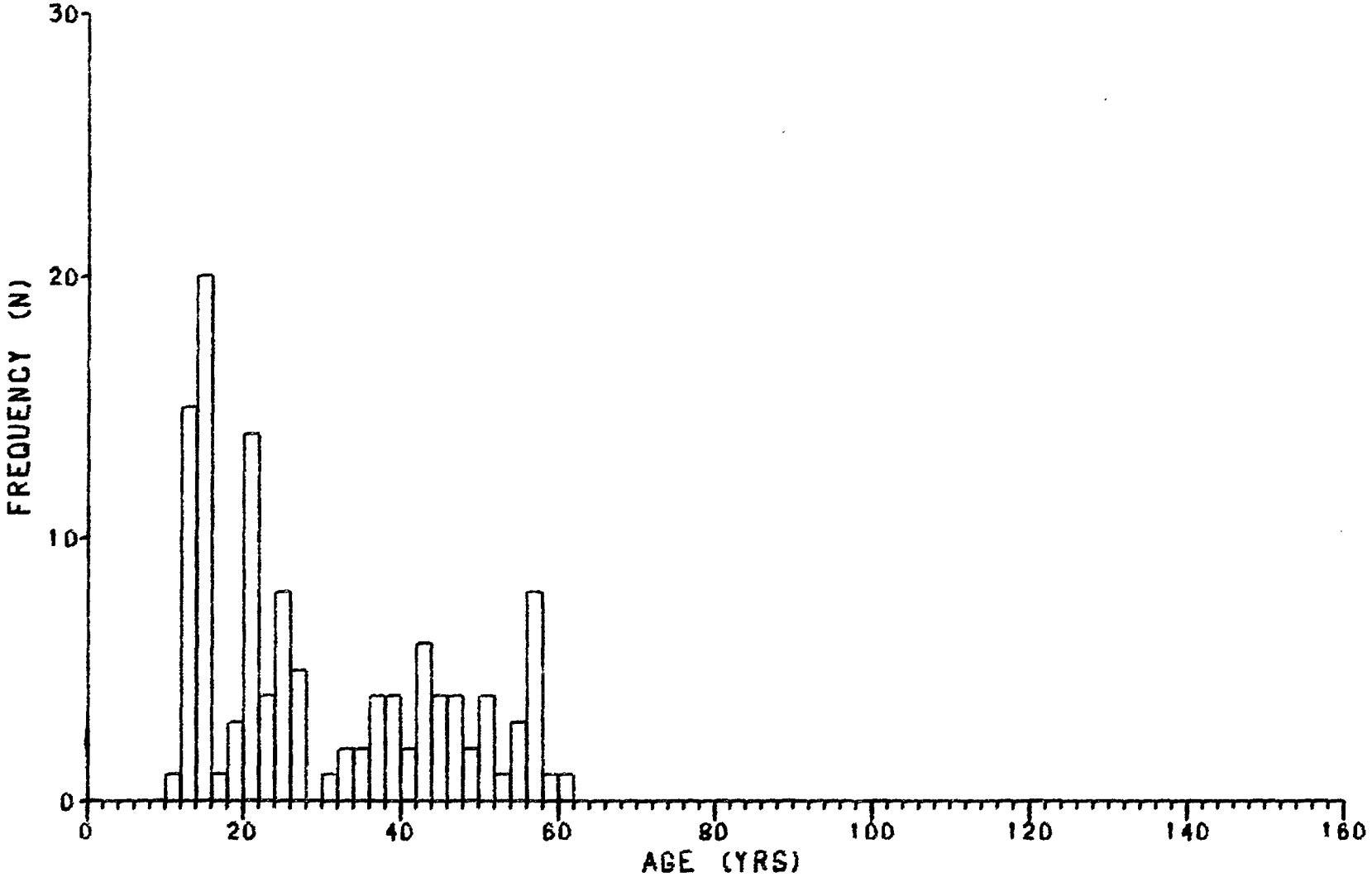

Fig. 7. Plot of age frequency, Clayoquot-Shot Island, August 12, 1982.

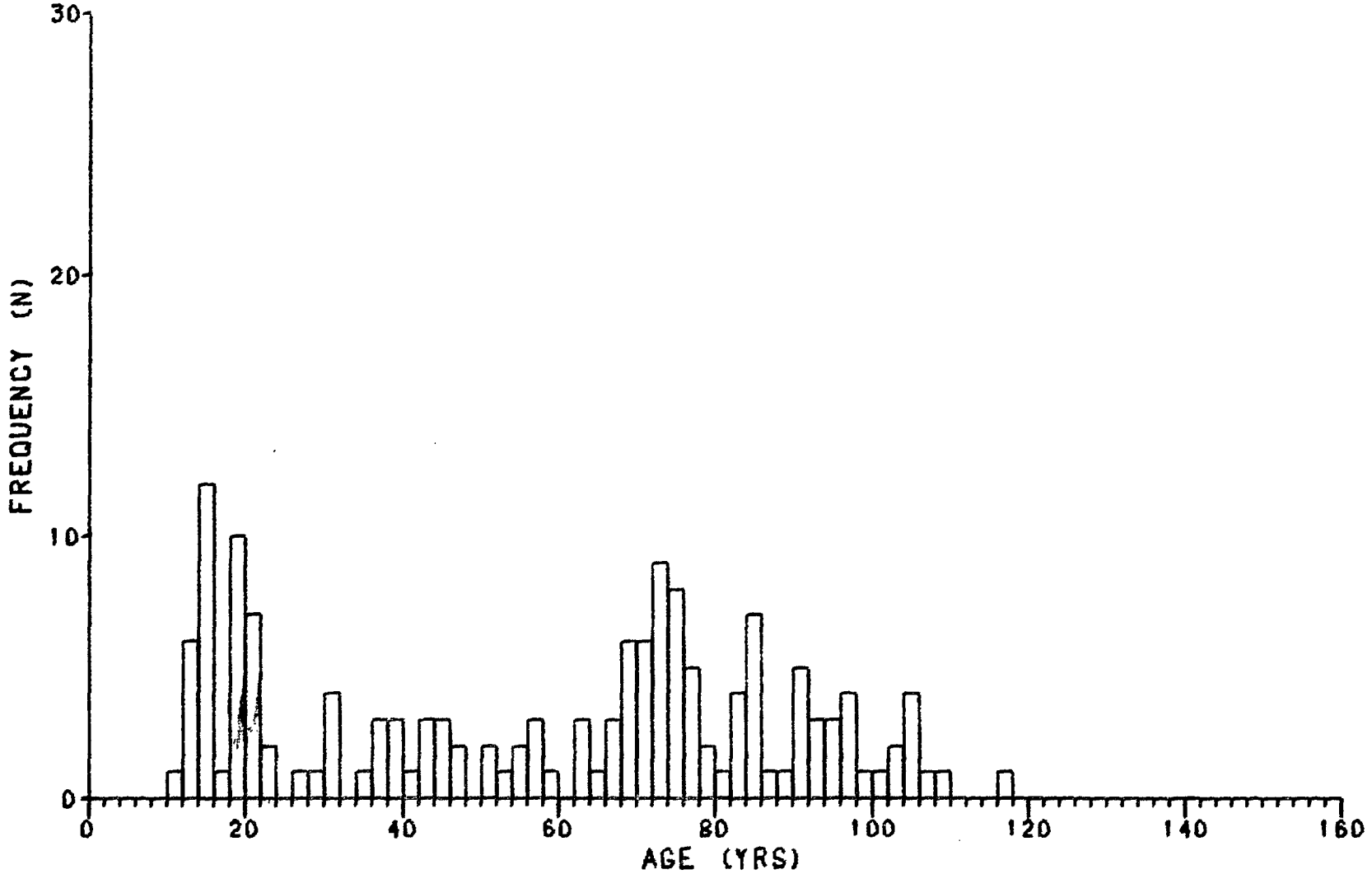

Fig. 8. Plot of age frequency, Clayoquot-Blunden Island, May 21, 1981.

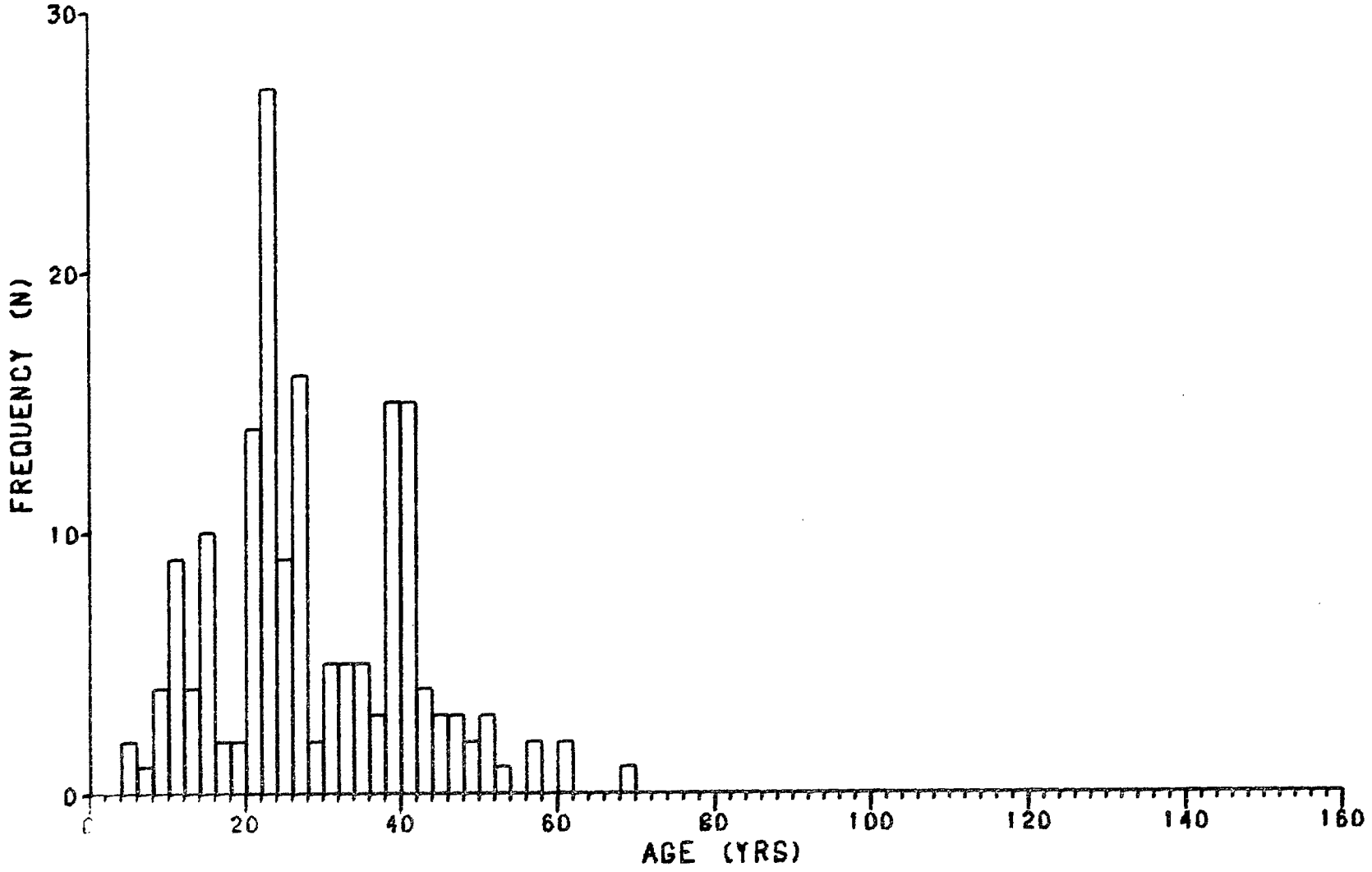

Fig. 9. Plot of age frequency, Clayoquot-Elbow Bank, May 21, 1981.

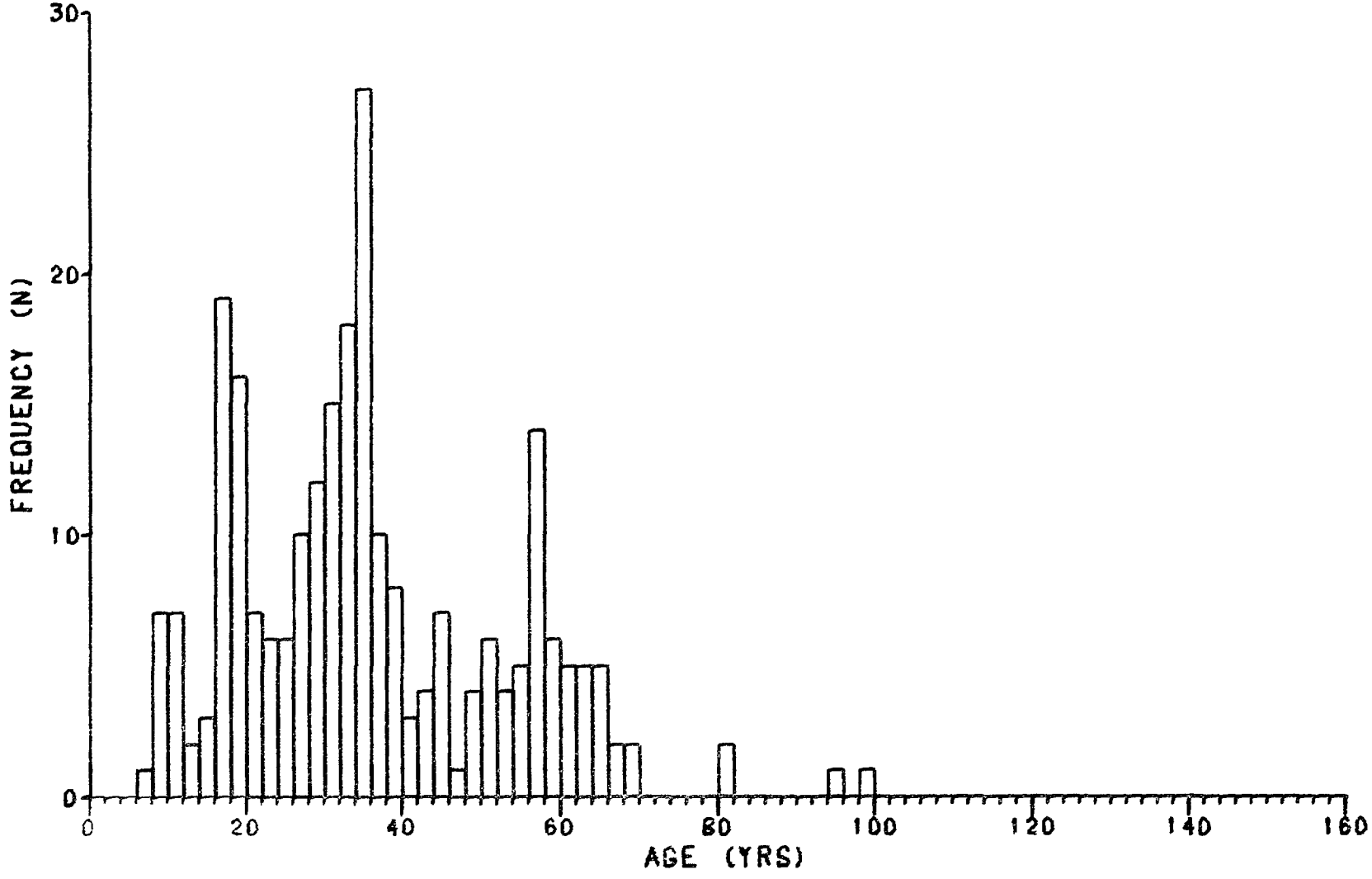

Fig. 10. Plot of age frequency, Rolling Roadstead, March 19, 1981.

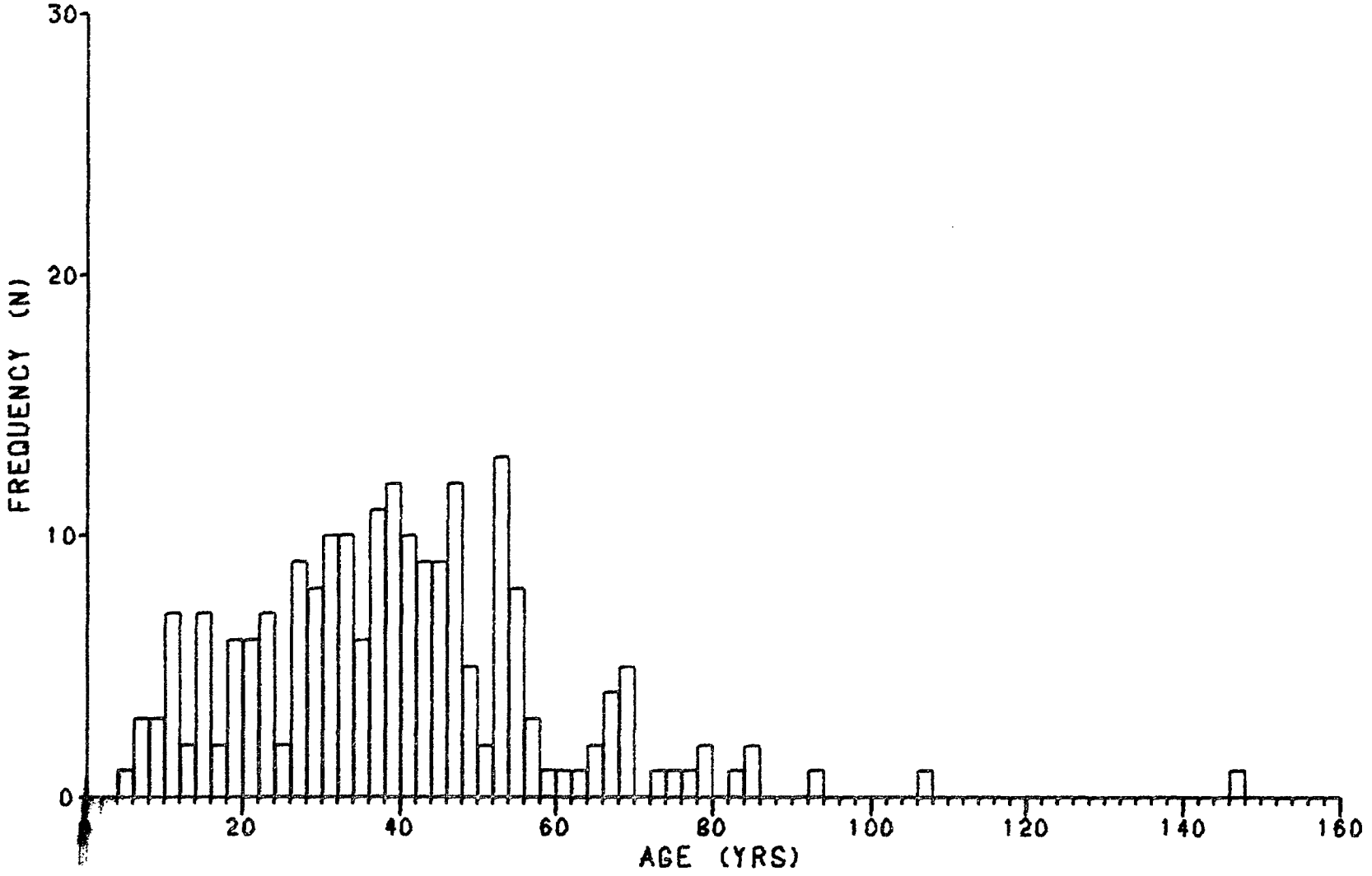

Fig. 11. Plot of age frequency , Kyuquot, April 4, 1981.

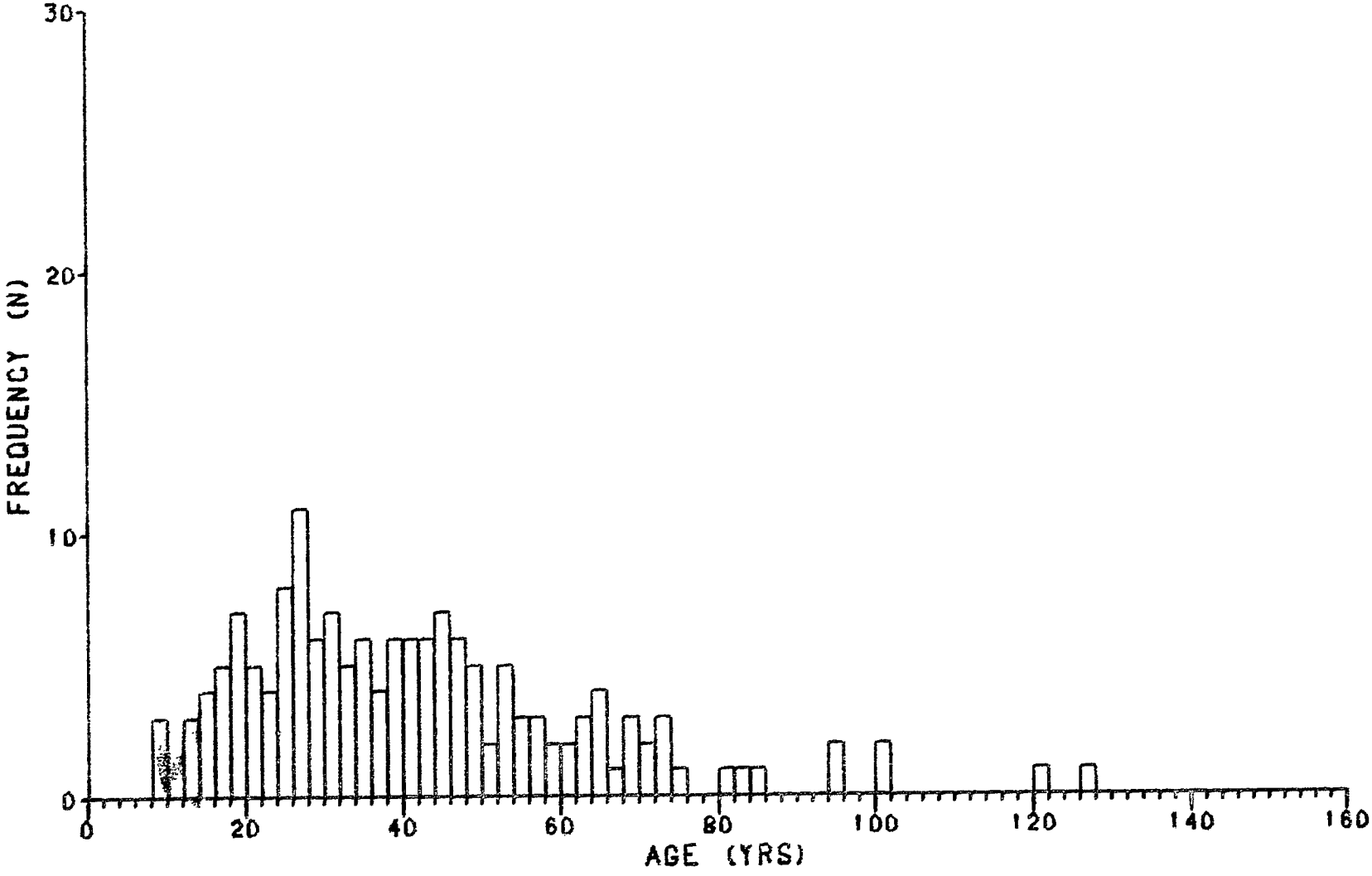

Fig. 12. Plot of age frequency, Kyoquot-Aktis Island, August 5, 1982.

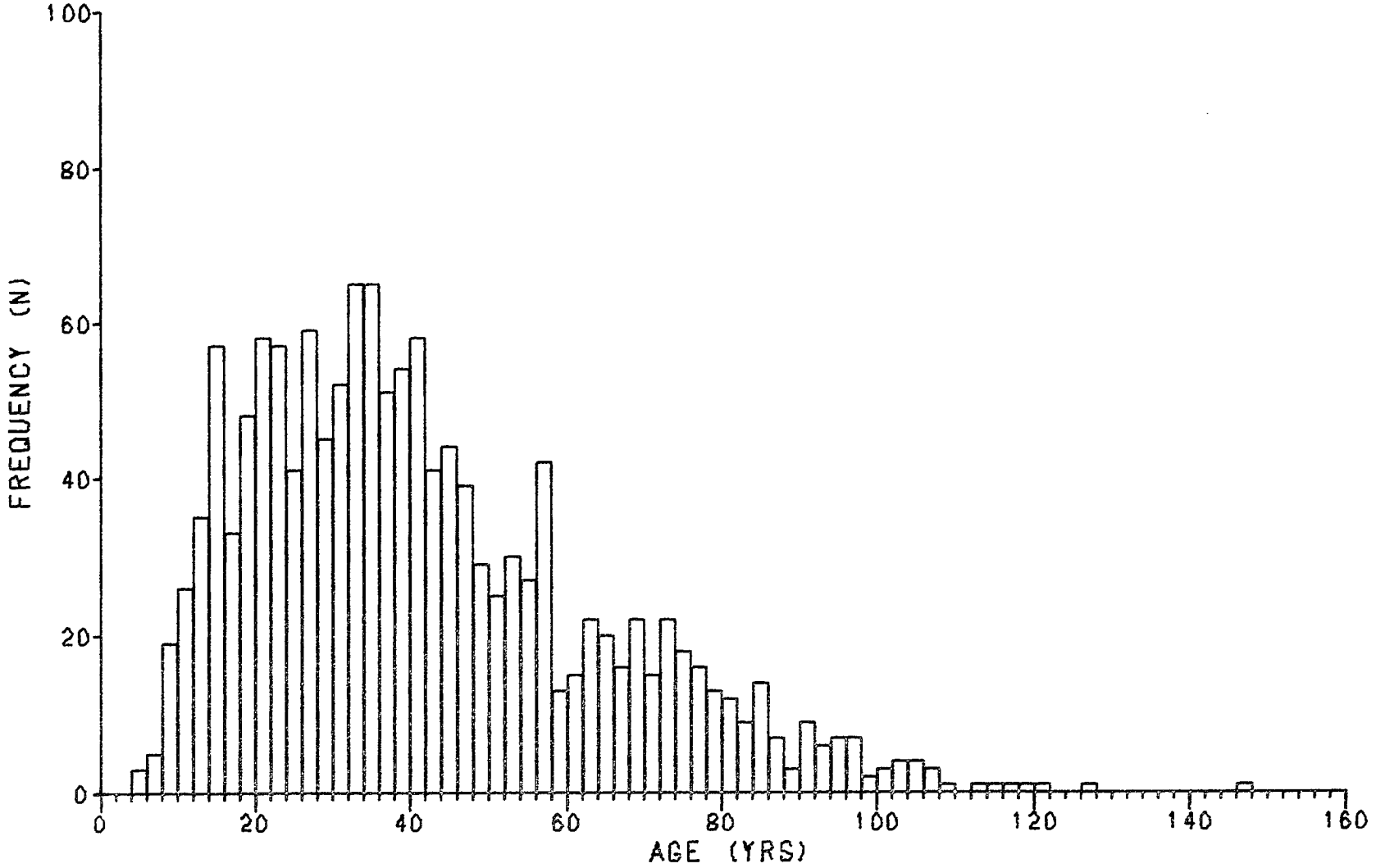

Fig. 13. Plot of age frequency, all areas combined.

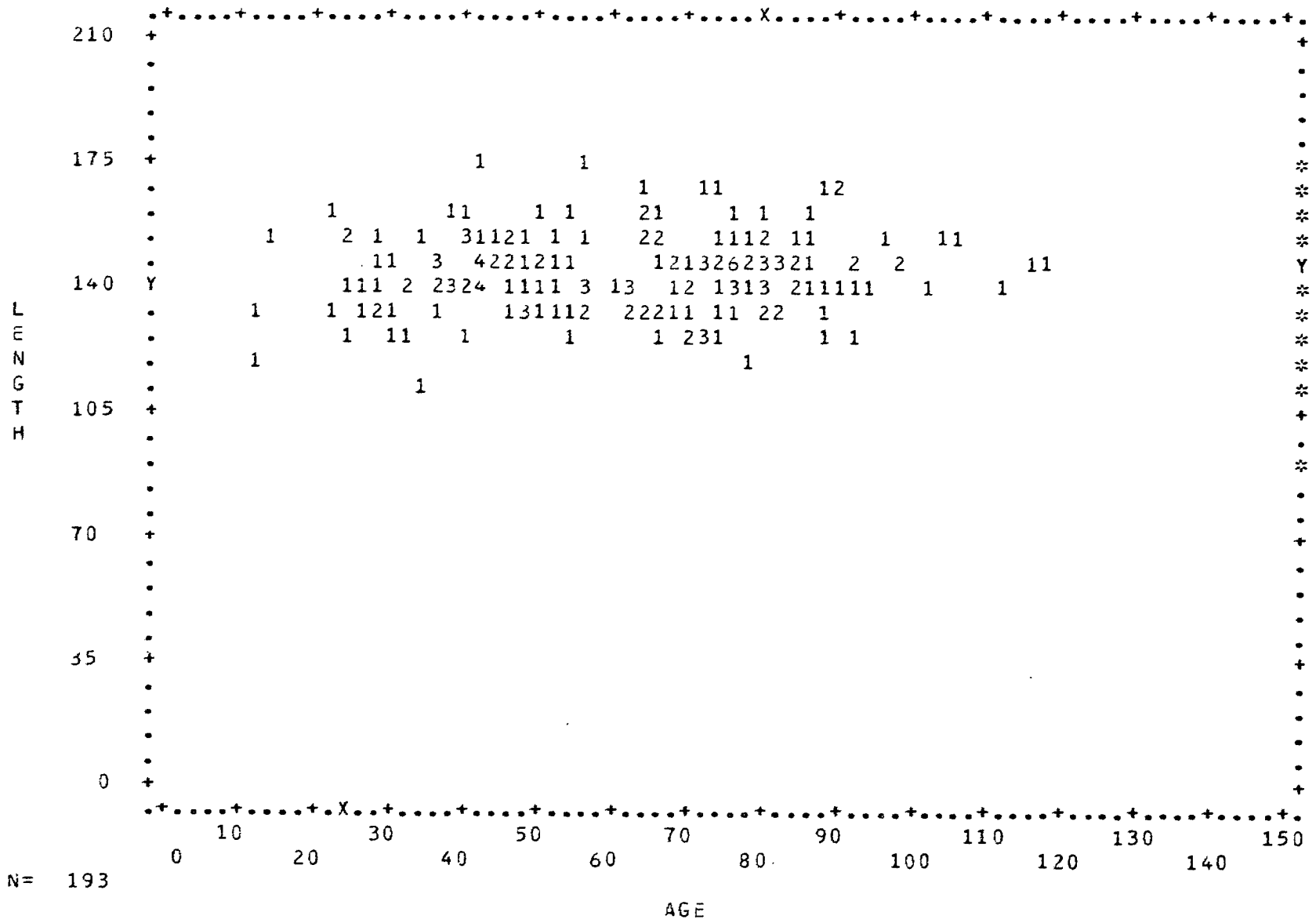

Fig. 14. Plot of length vs age, Spider Anchorage, June 29, 1981.

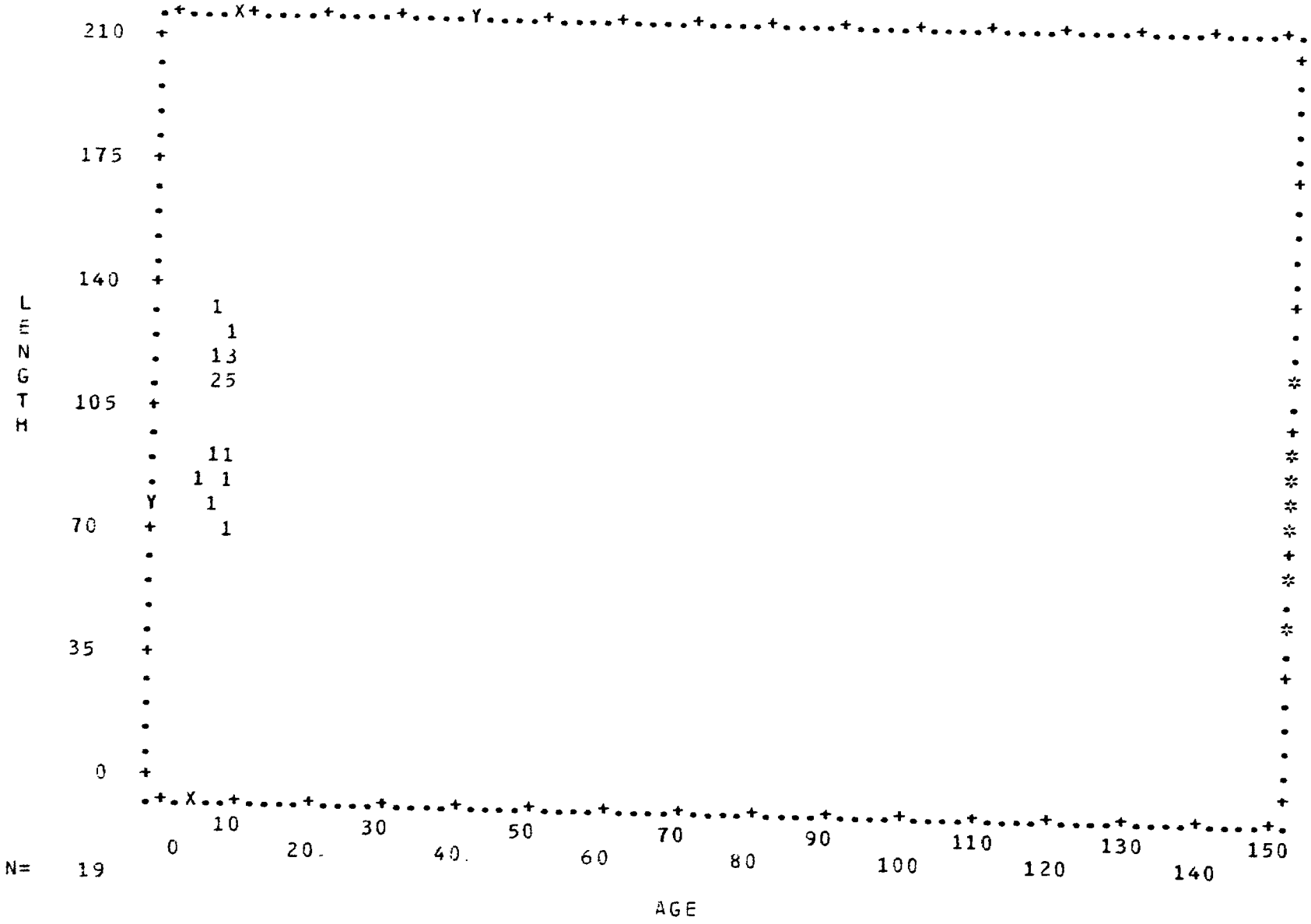

Fig.15. Plot of length vs age, Cortes Island, July 27, 1981.

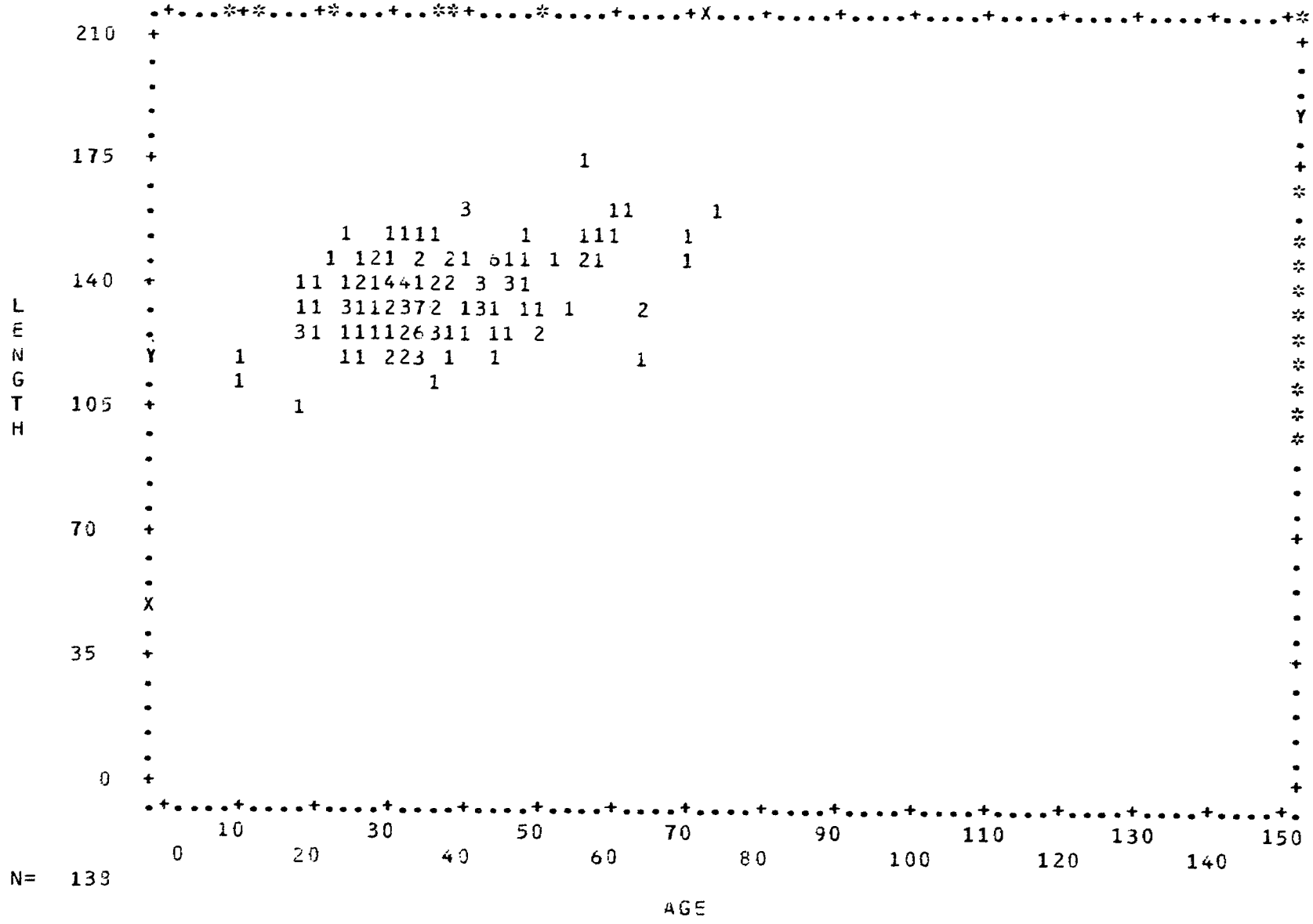

Fig. 16. Plot of length vs age, Crofton, June 5, 1981.

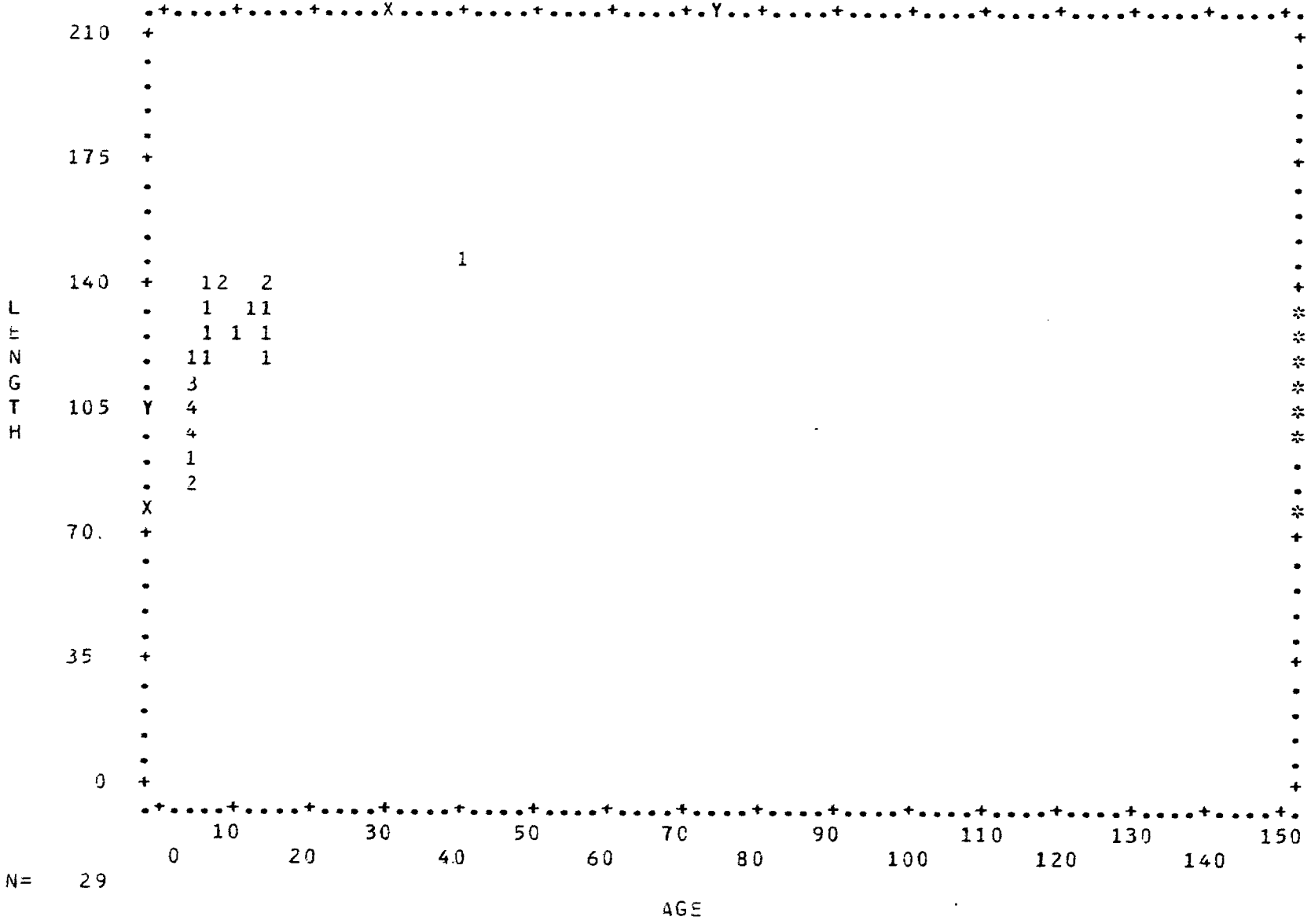

Fig. 17. Plot of length vs age, Clayoquot-Lemmens Inlet, February 23, 1982.

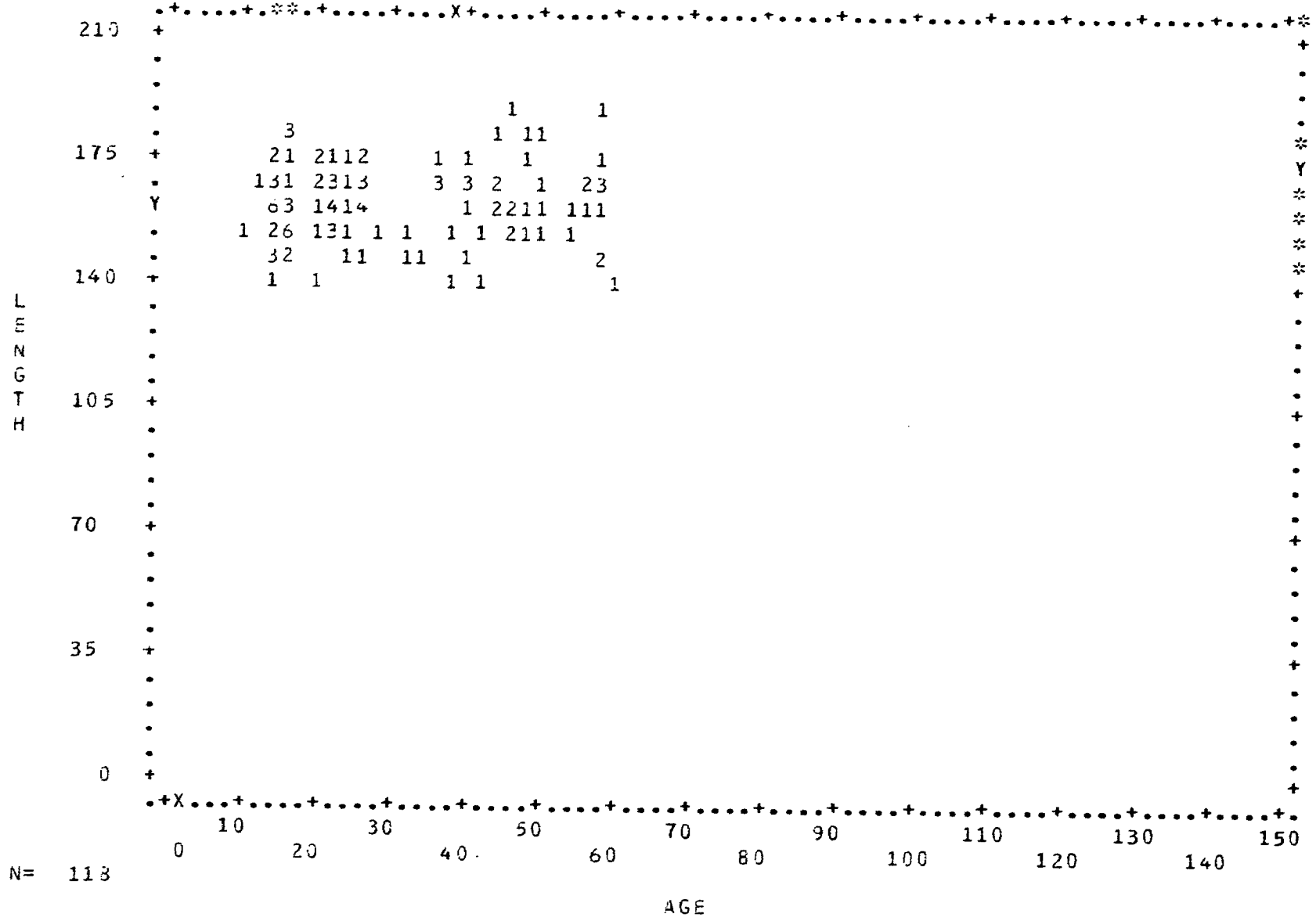

Fig. 18. Plot of length vs. age, Clayoquot-Shot Island, August 12, 1982.

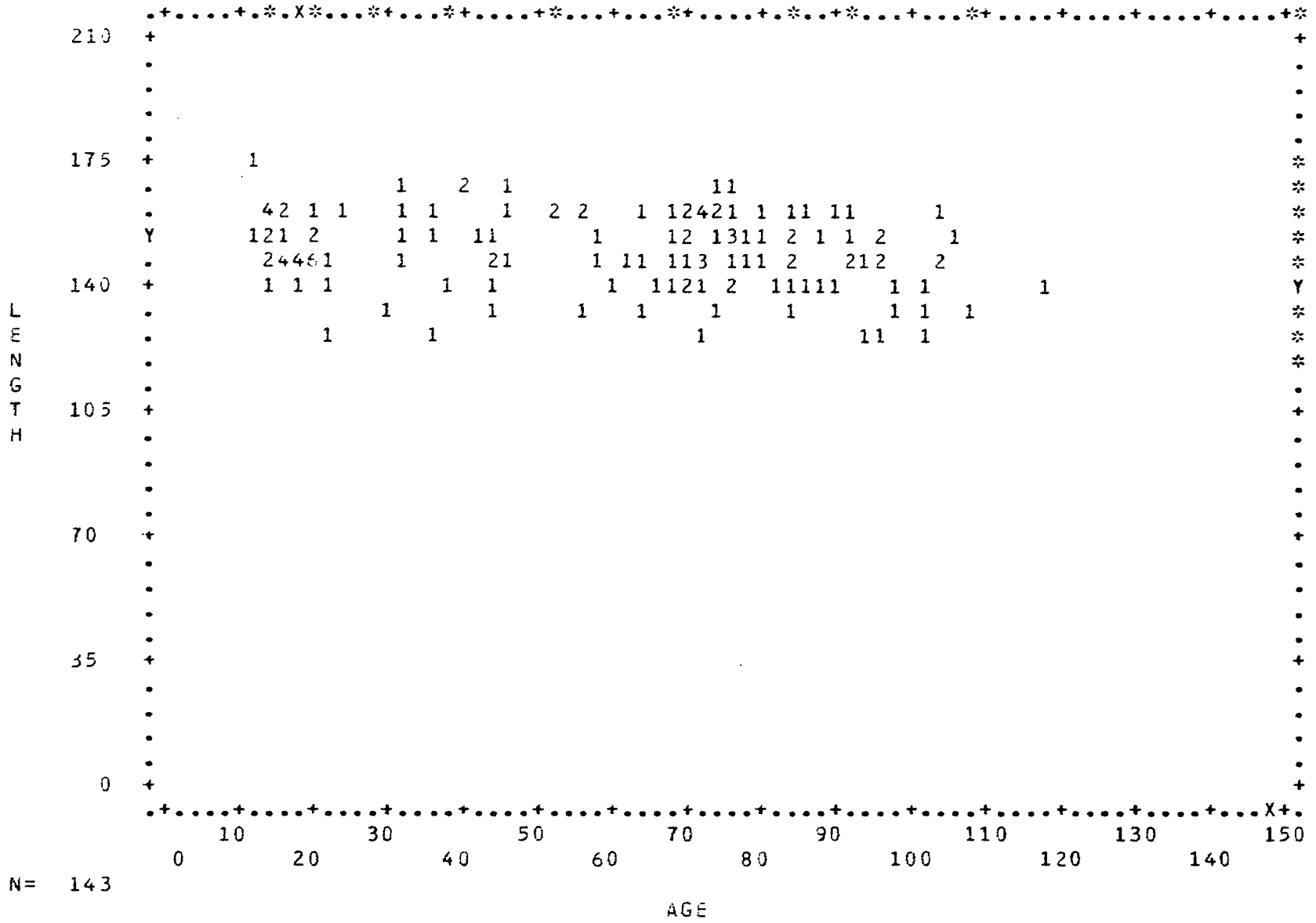

Fig. 19. Plot of length vs age, Clayoquot-Blunden Island, May 21, 1981.

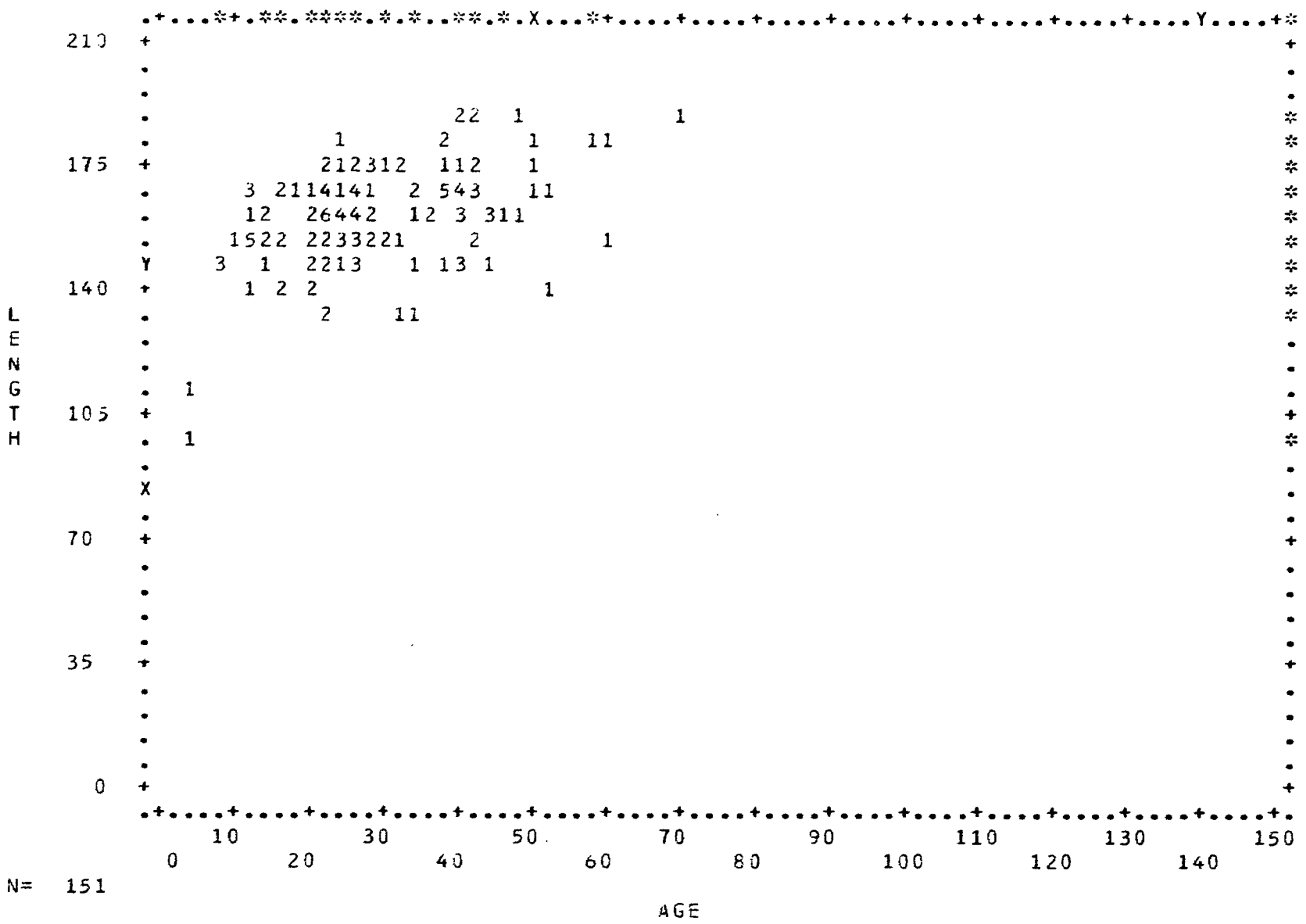

Fig. 20. Plot of length vs age, Clayoquot-Elbow Bank, May 21, 1981.

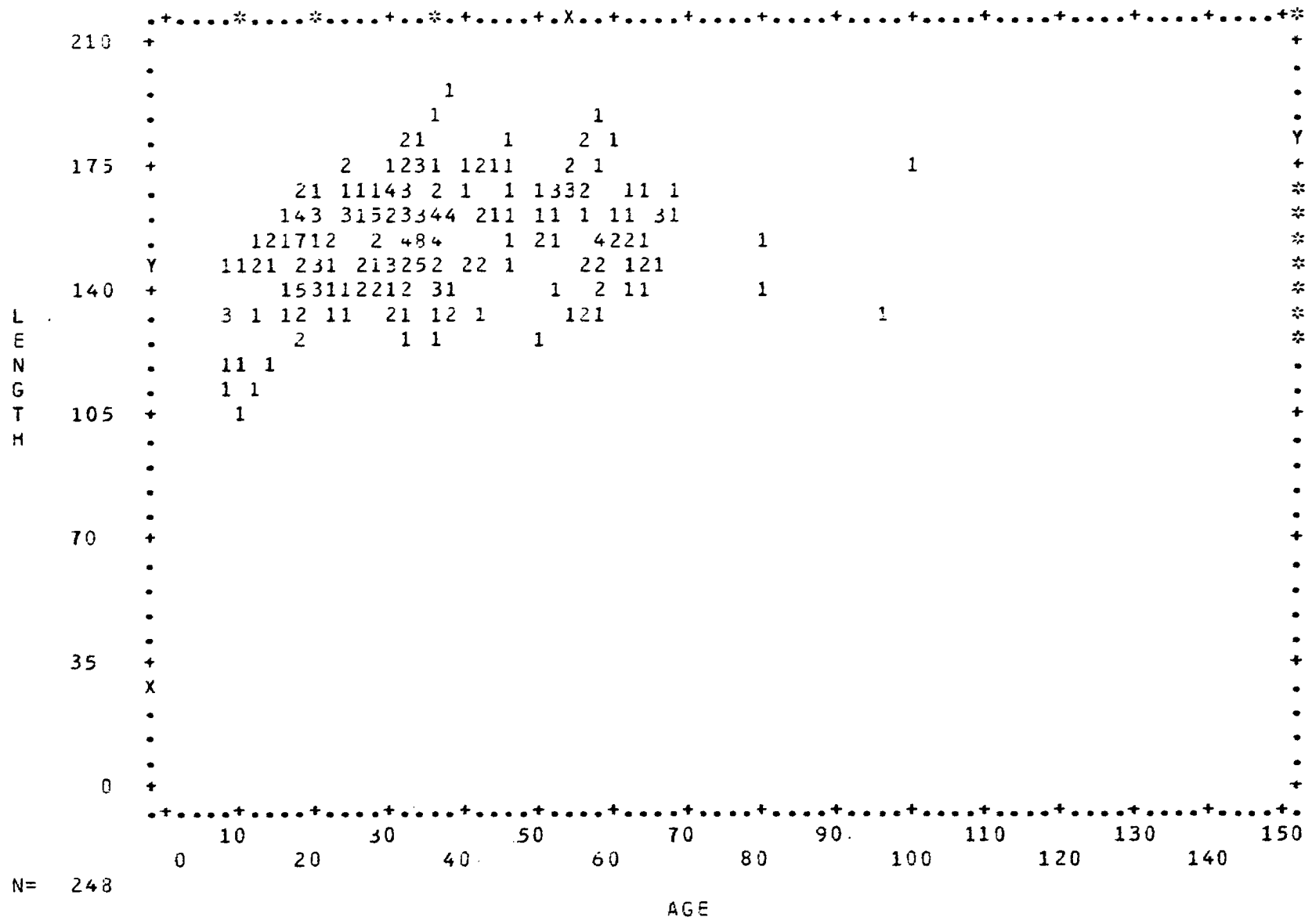

Fig. 21. Plot of length vs age, Rolling Roadstead, March 19, 1981.

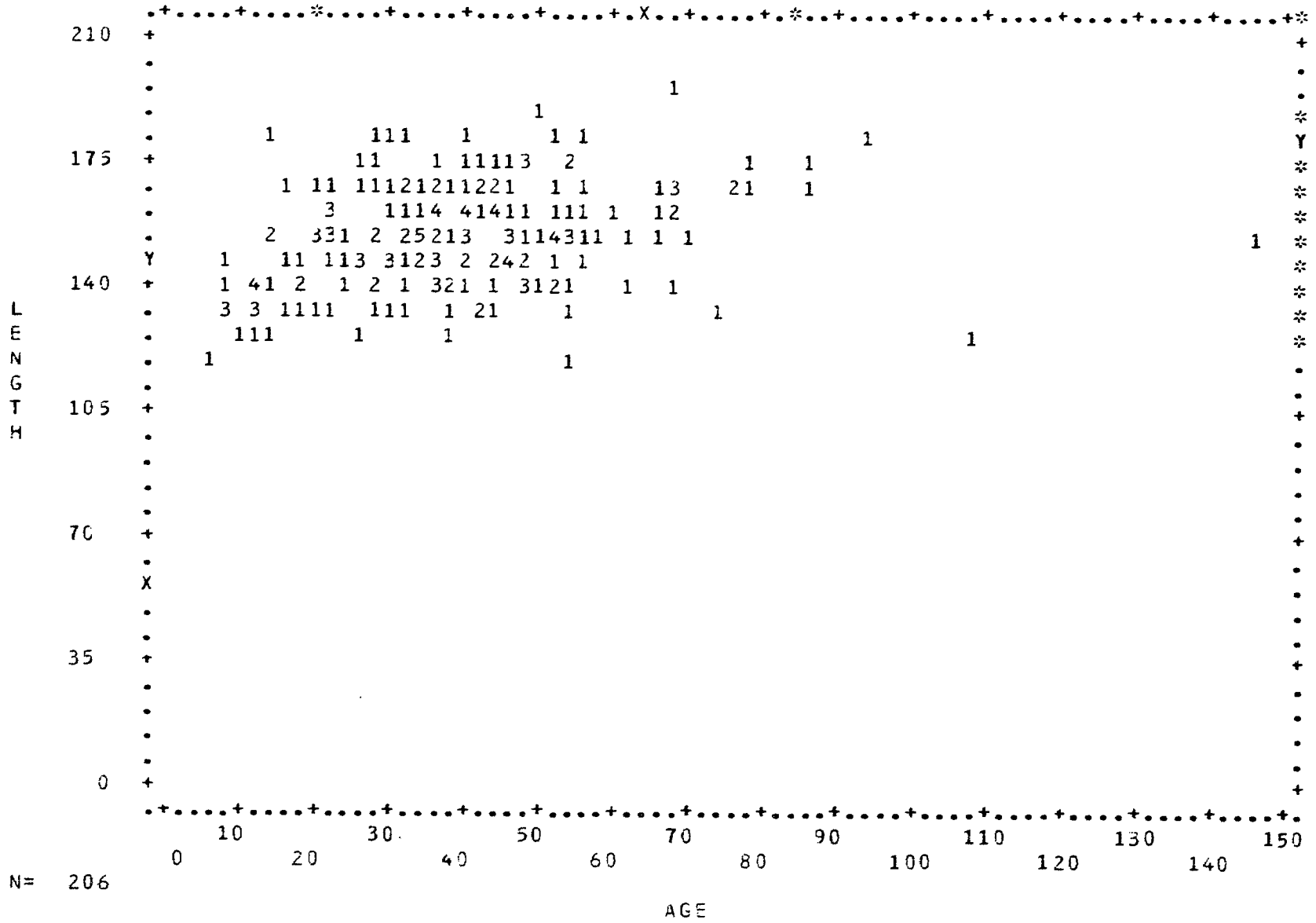

Fig. 22. Plot of length vs age, Kyuquot, April 4, 1981.

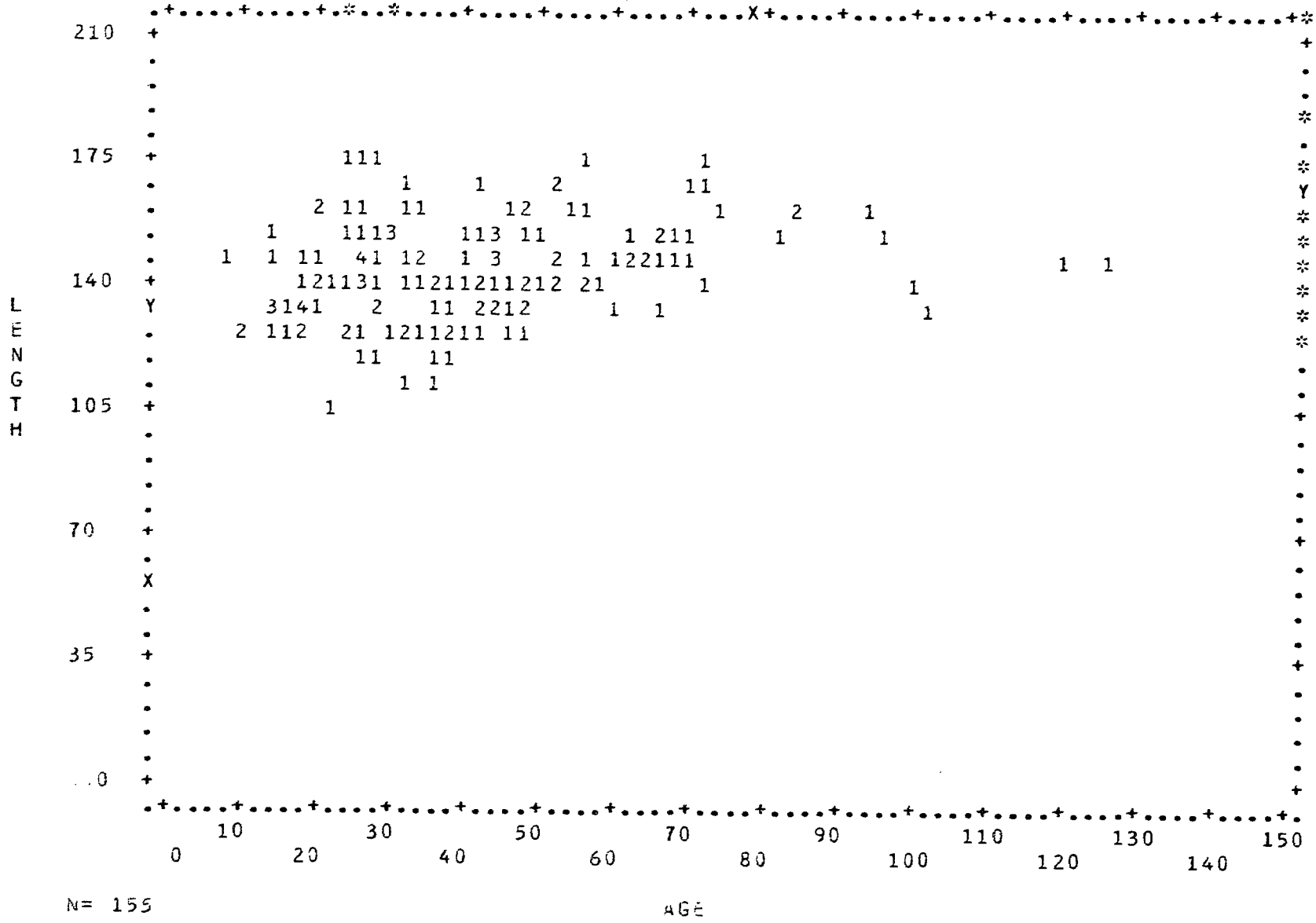

Fig. 23. Plot of length vs age, Kyuquot-Aktis Island, August 5, 1982.

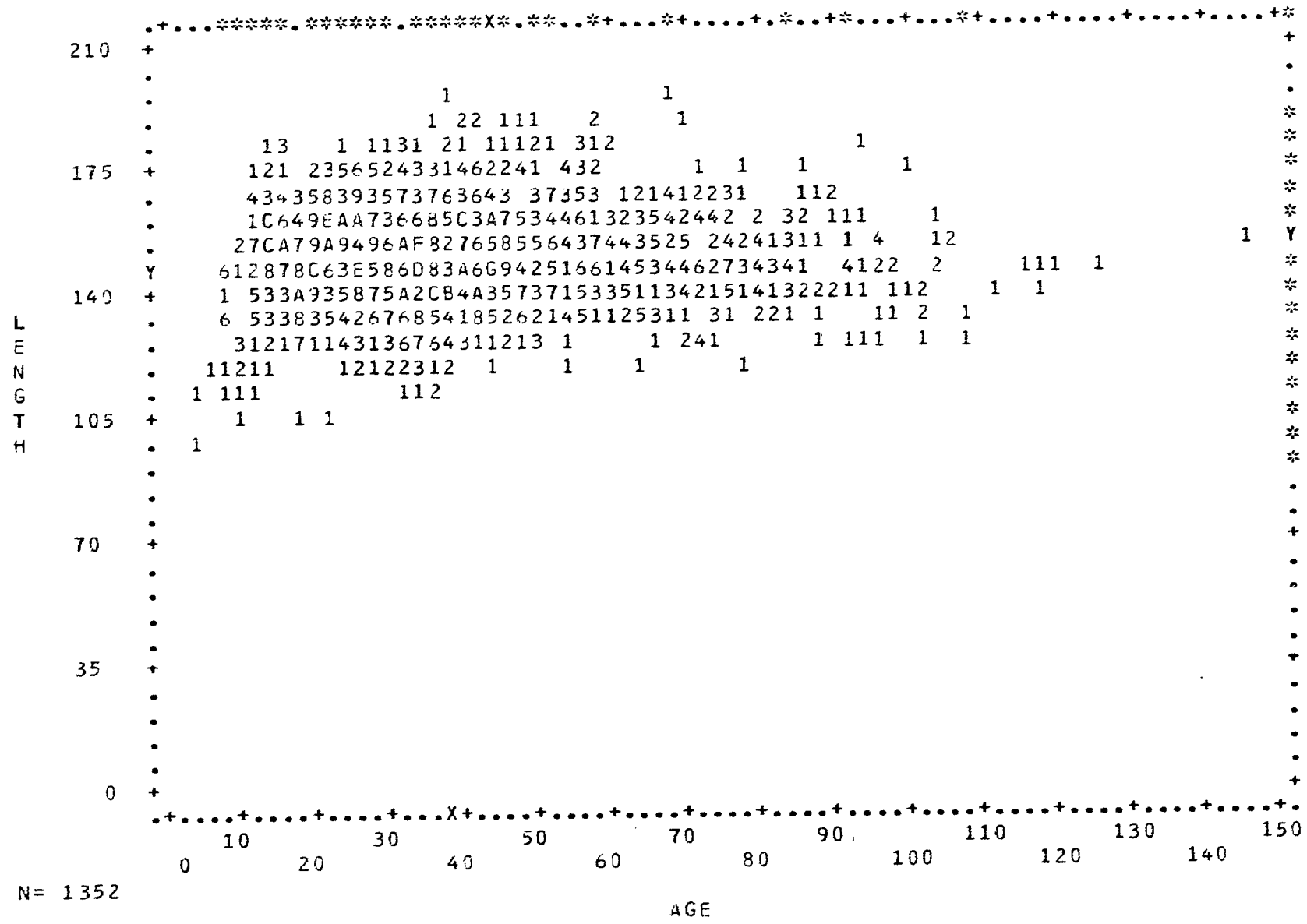

Fig. 24. Plot of length vs age, all areas combined.

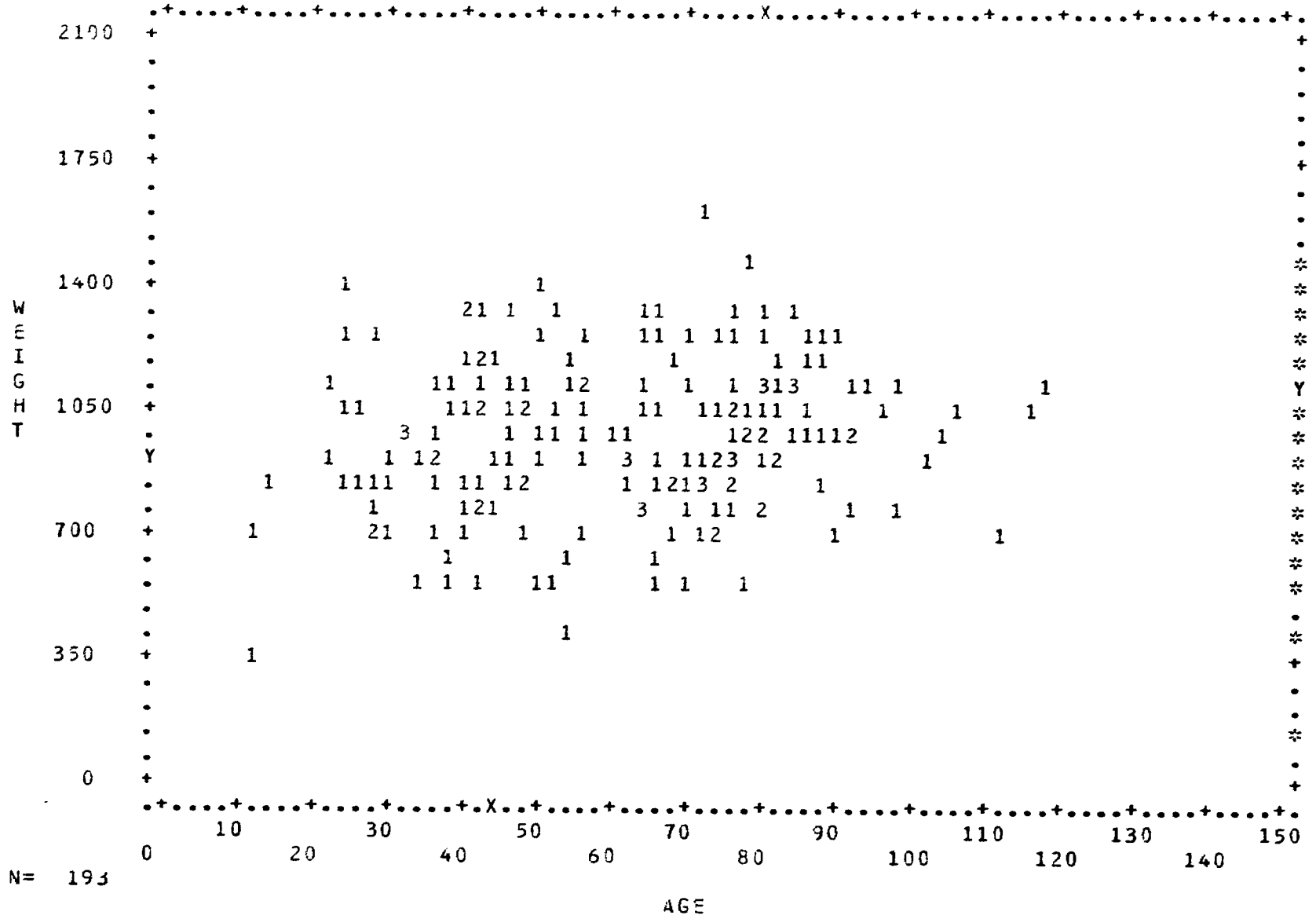

Fig. 25. Plot of weight vs age, Spider Anchorage, June 29, 1981.

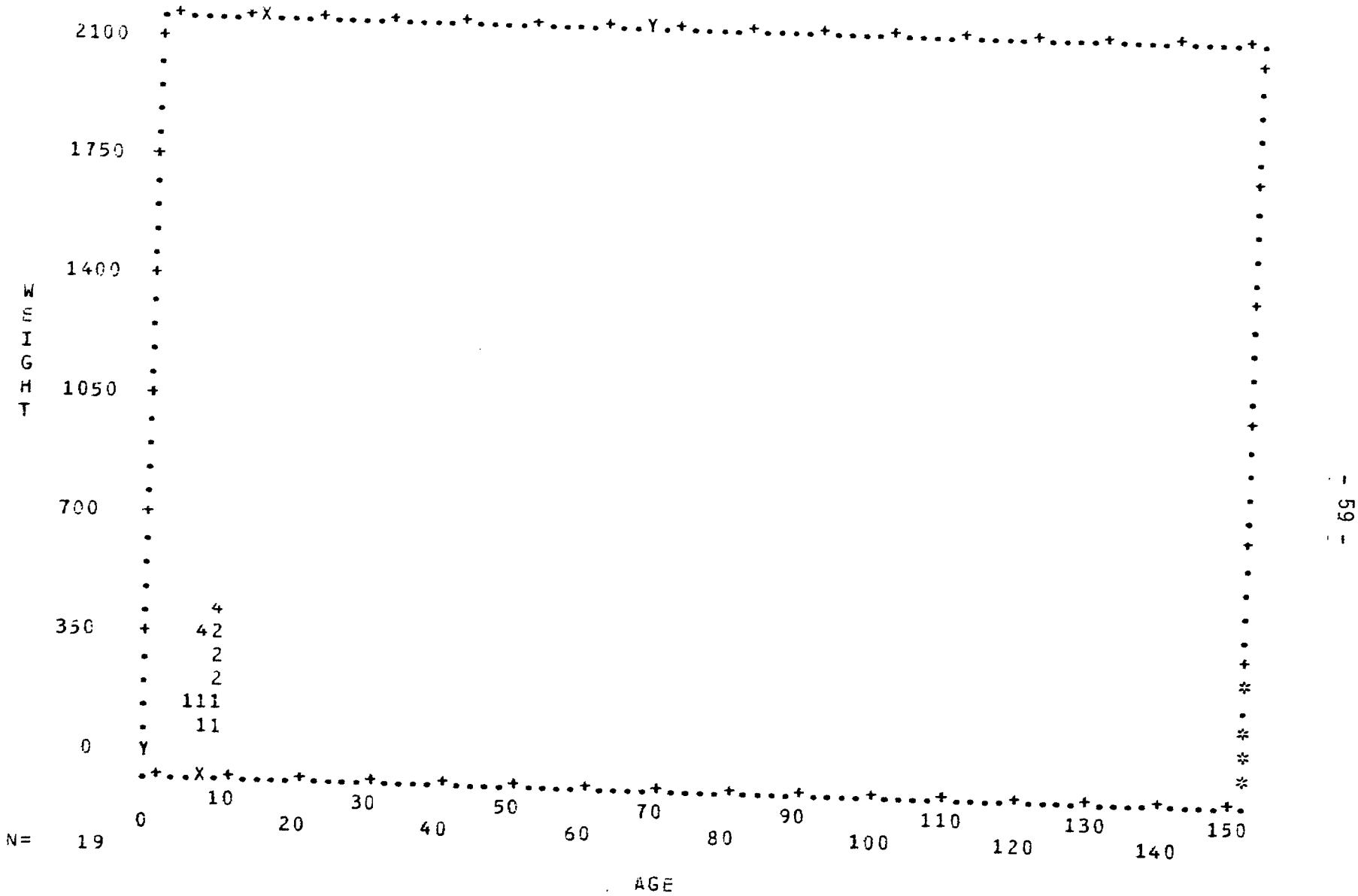

Fig. 26. Plot of weight vs age, Cortes Island, July 27, 1981.

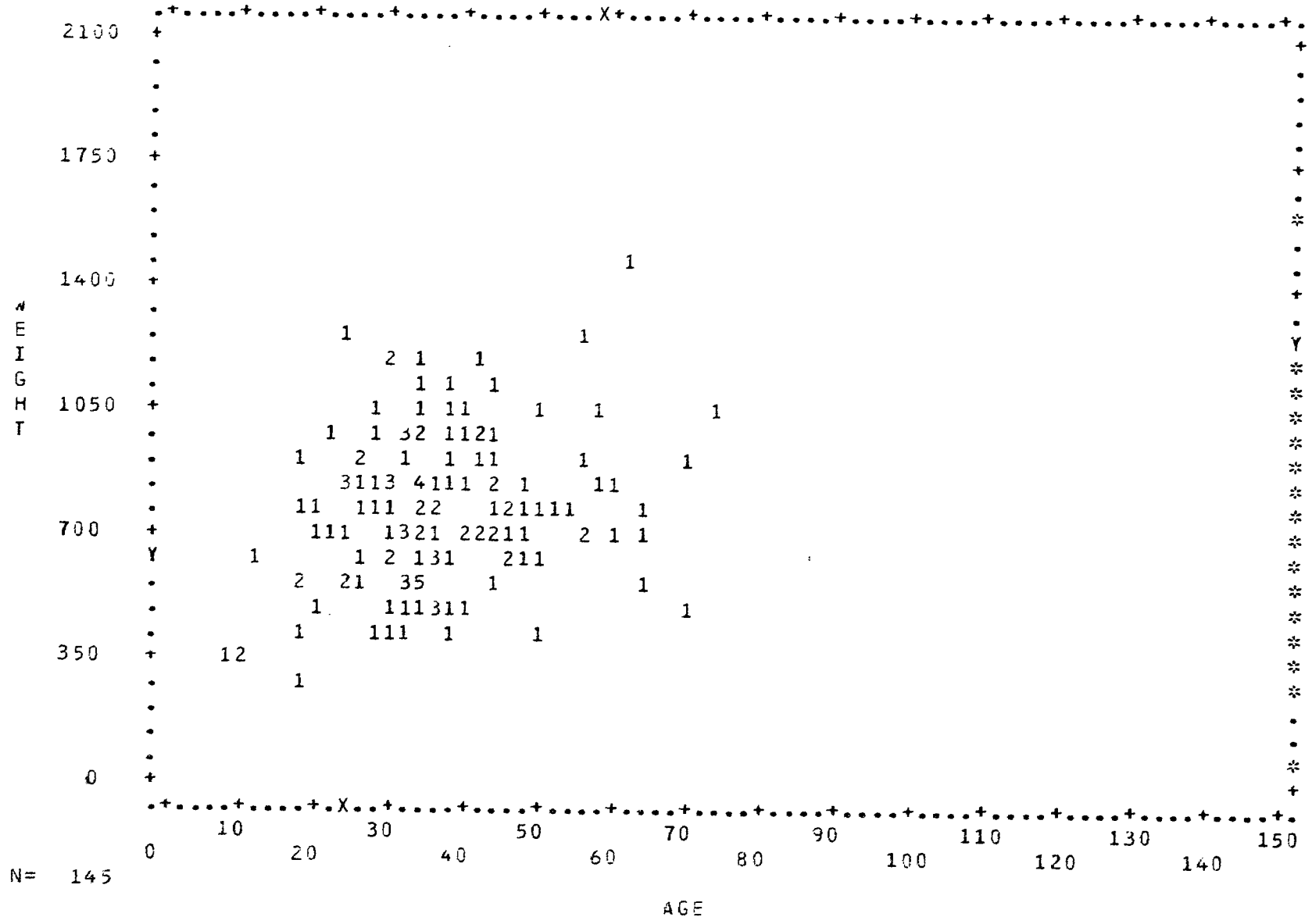

Fig. 27. Plot of weight vs age, Crofton, June 5, 1981.

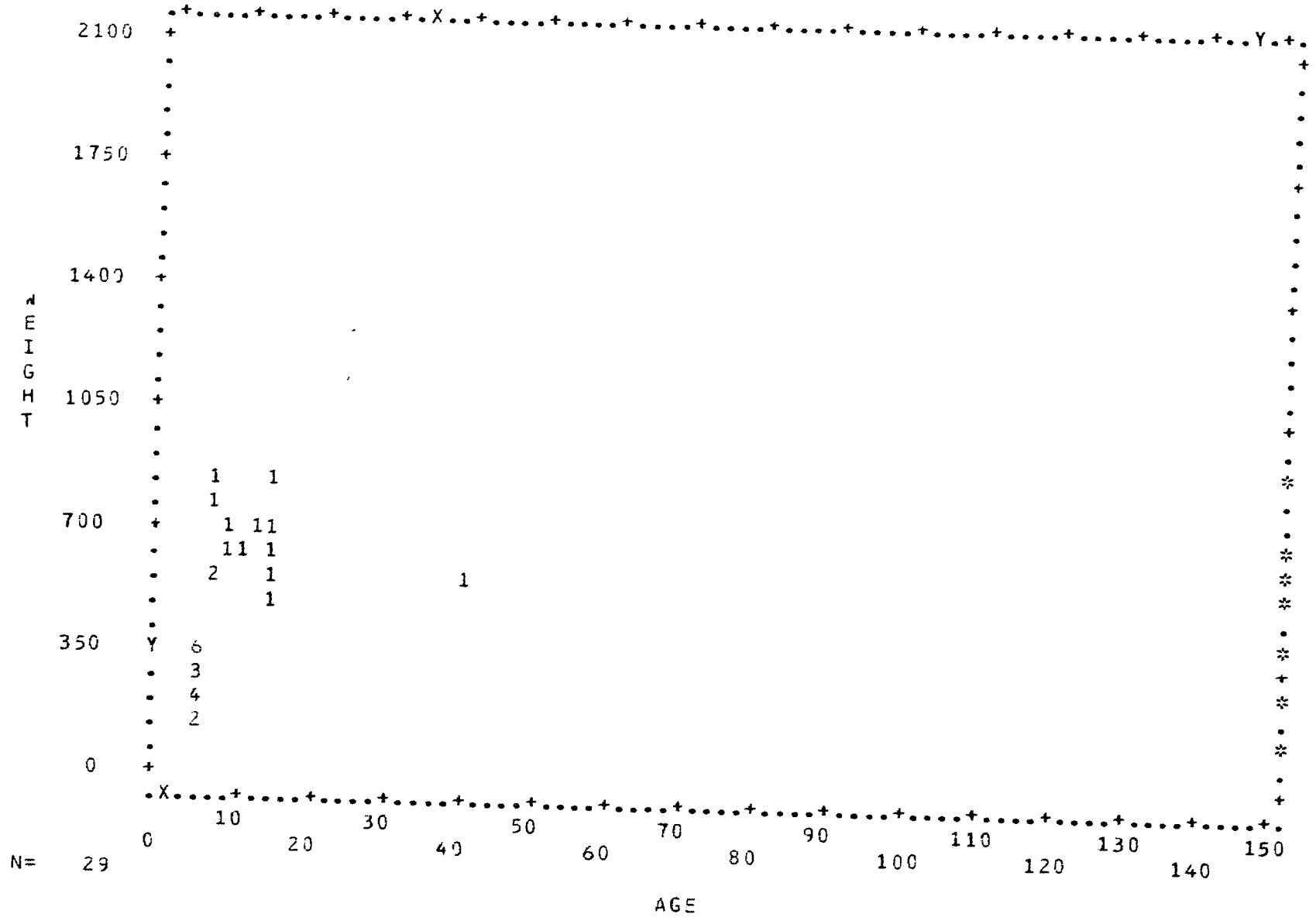

Fig. 28. Plot of weight vs age, Clayoquot-Lemmens Inlet, February 23, 1982.

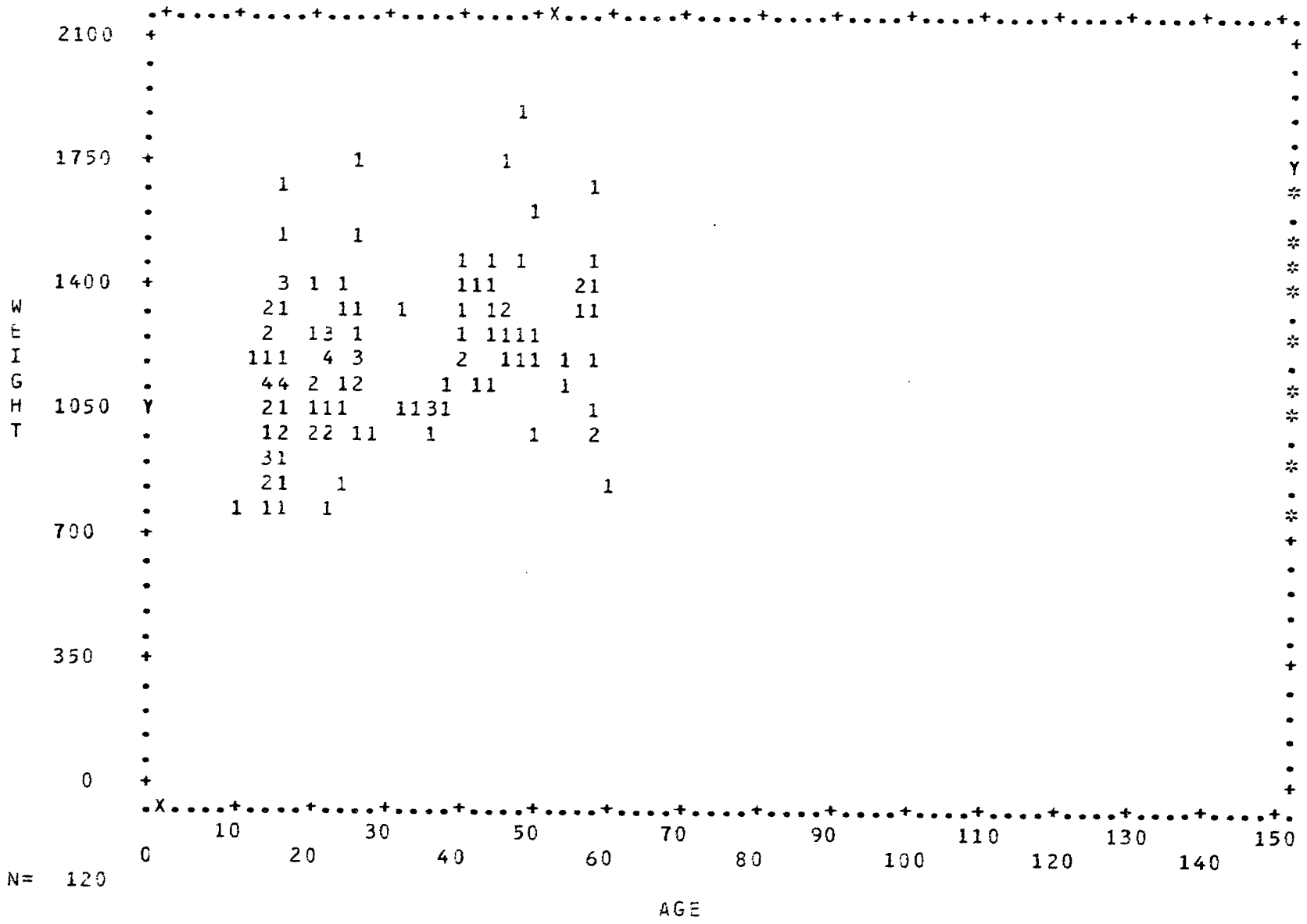

Fig. 29. Plot of weight vs age, Clayoquot-Shot Island, August 12, 1982.

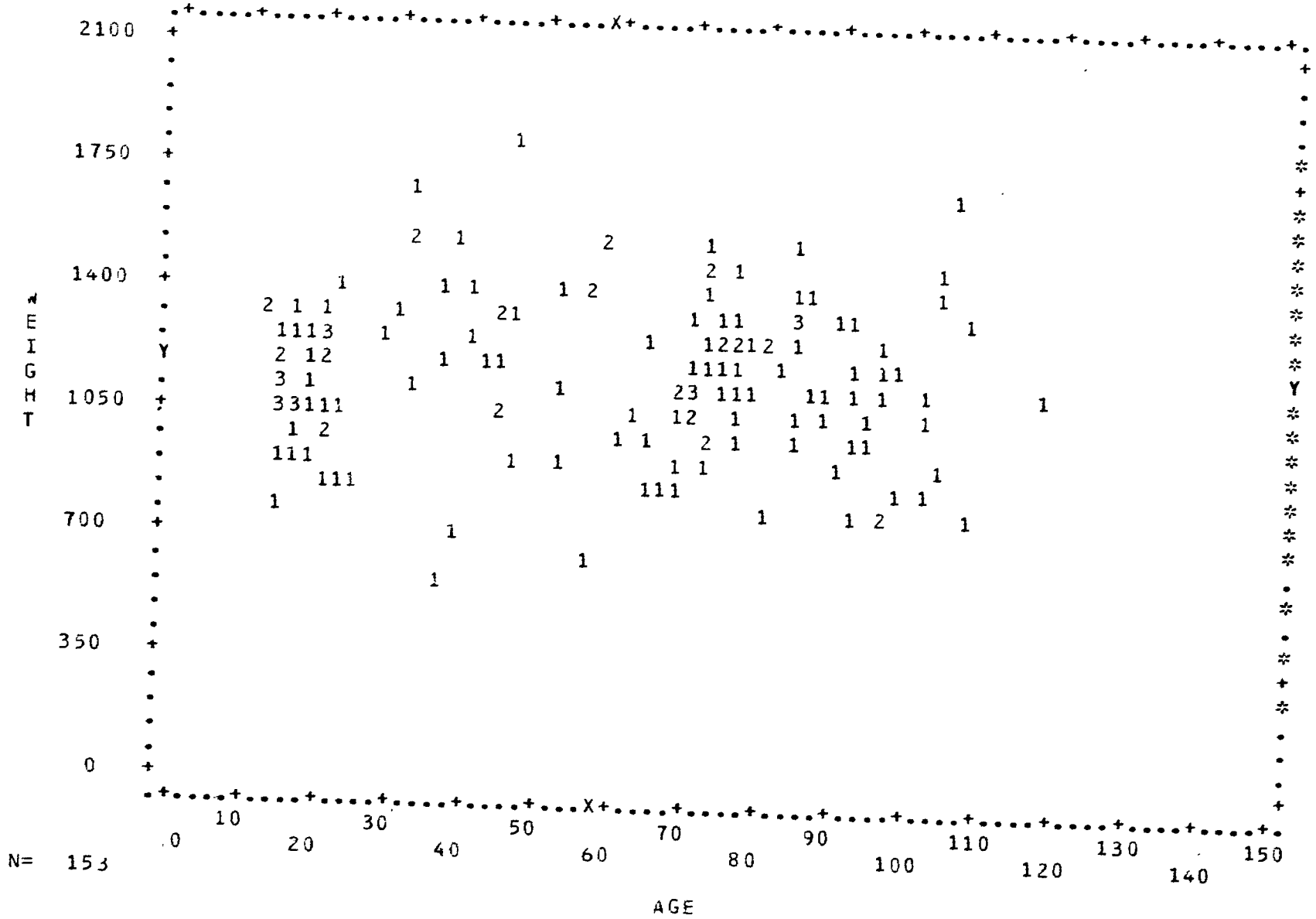

Fig. 30. Plot of weight vs age, Clayoquot-Blunden Island, May 21, 1981.

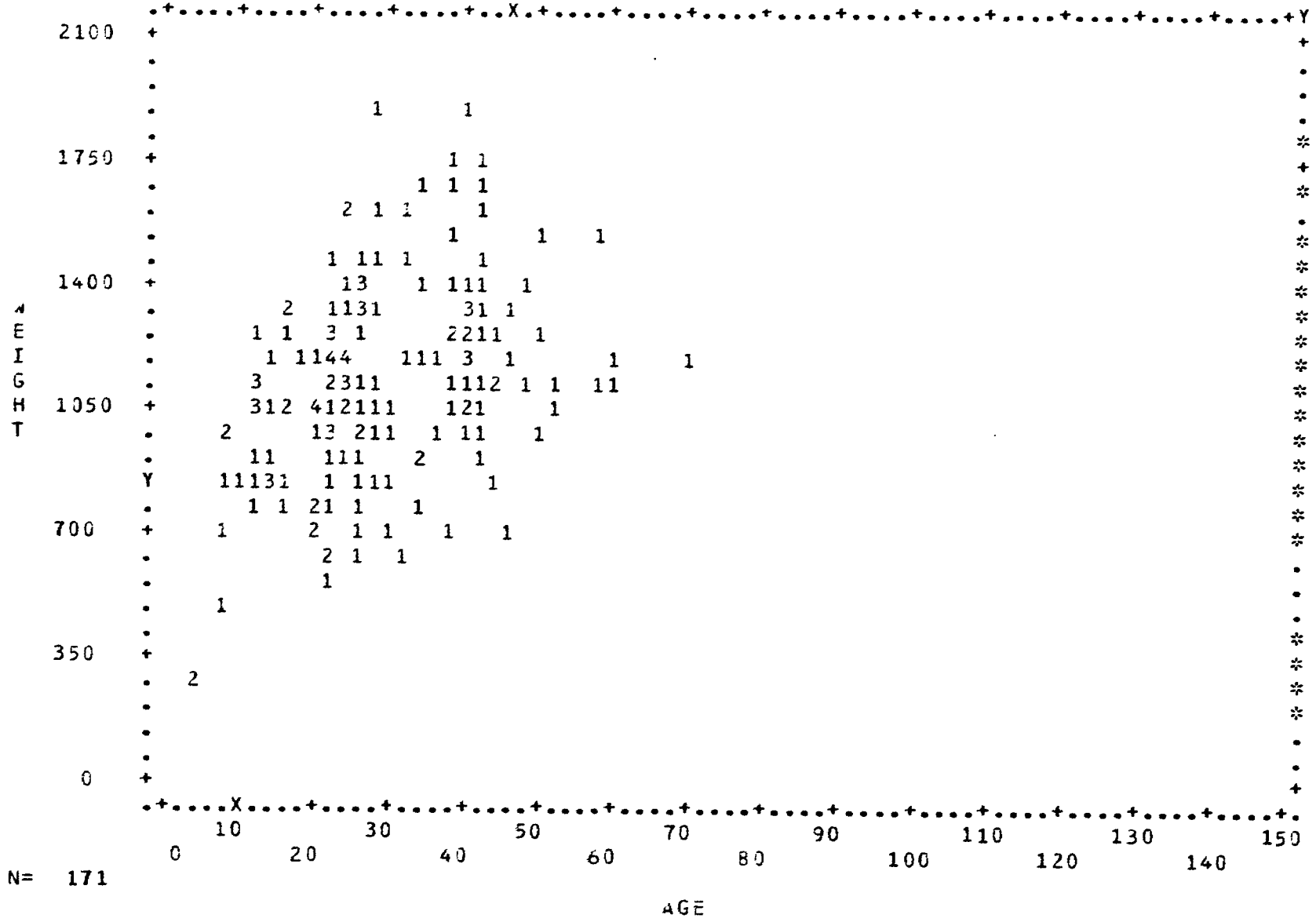

Fig. 31. Plot of weight vs age, Clayoquot-Elbow Bank, May 21, 1981.

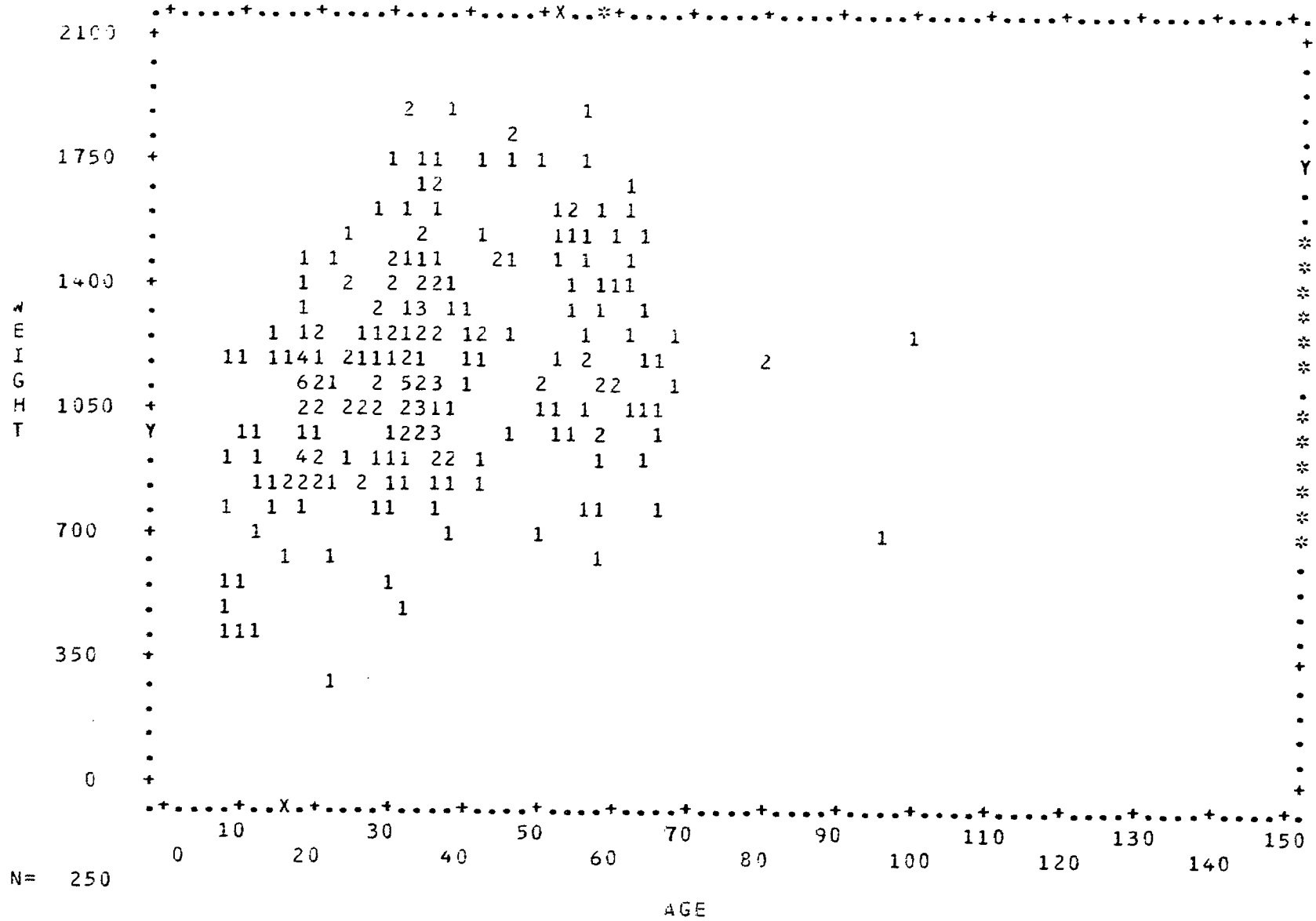

Fig. 32. Plot of weight vs age, Rolling Roadstead, March 19, 1981.

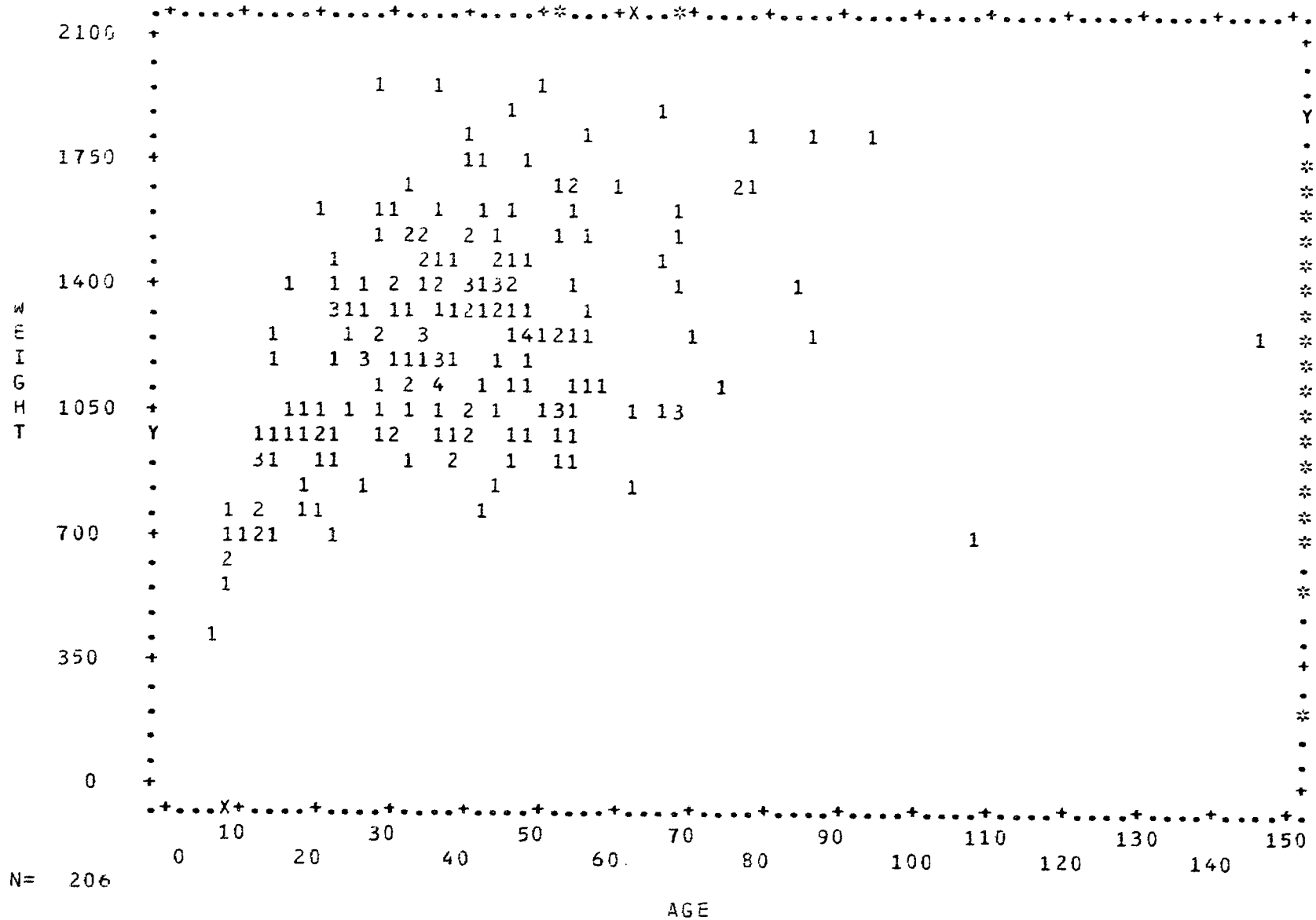

Fig. 33. Plot of weight vs age, Kyuquot, April 4, 1981.

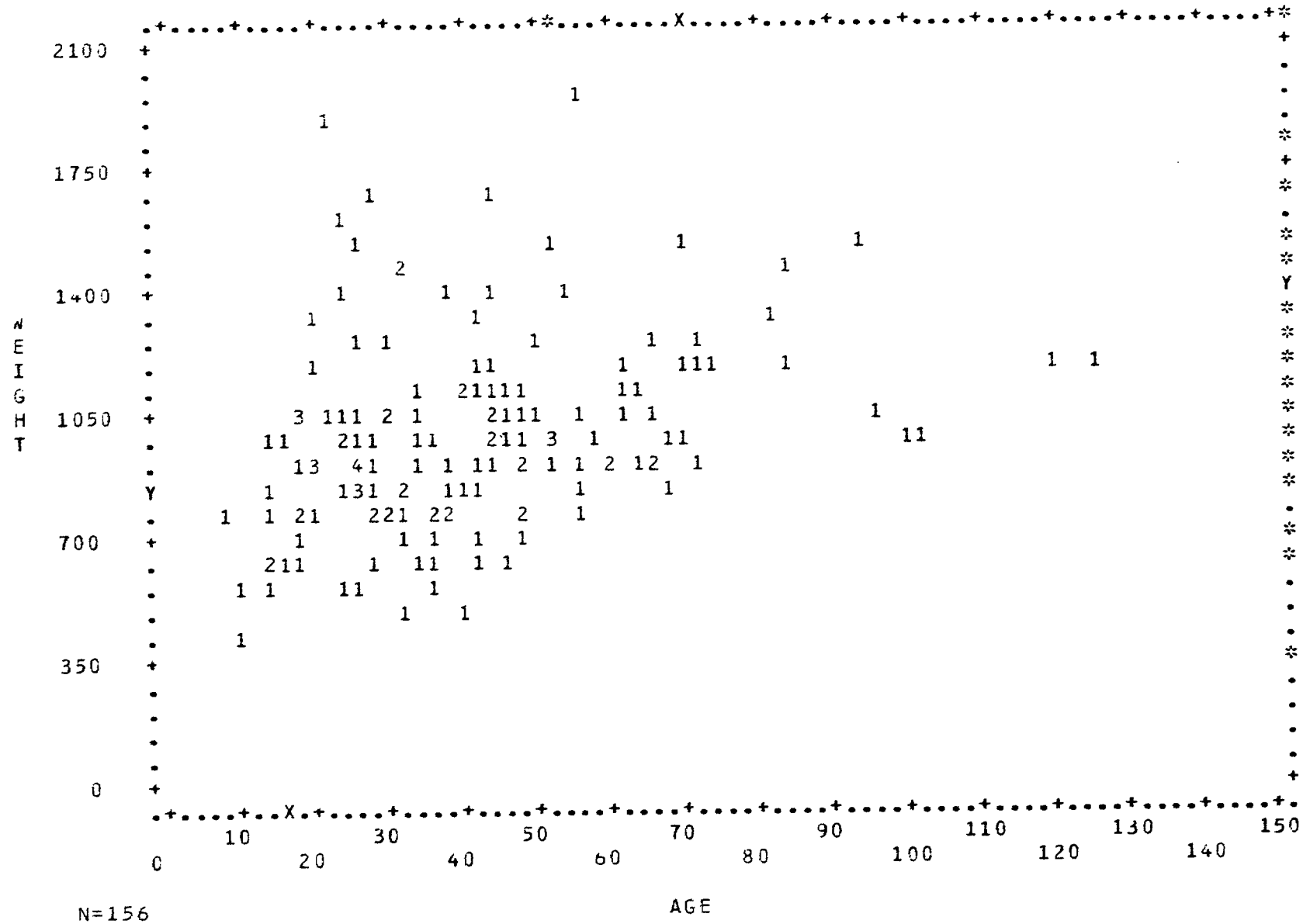

Fig. 34. Plot of weight vs age, Kyuquot-Aktis Island, August 5, 1982.

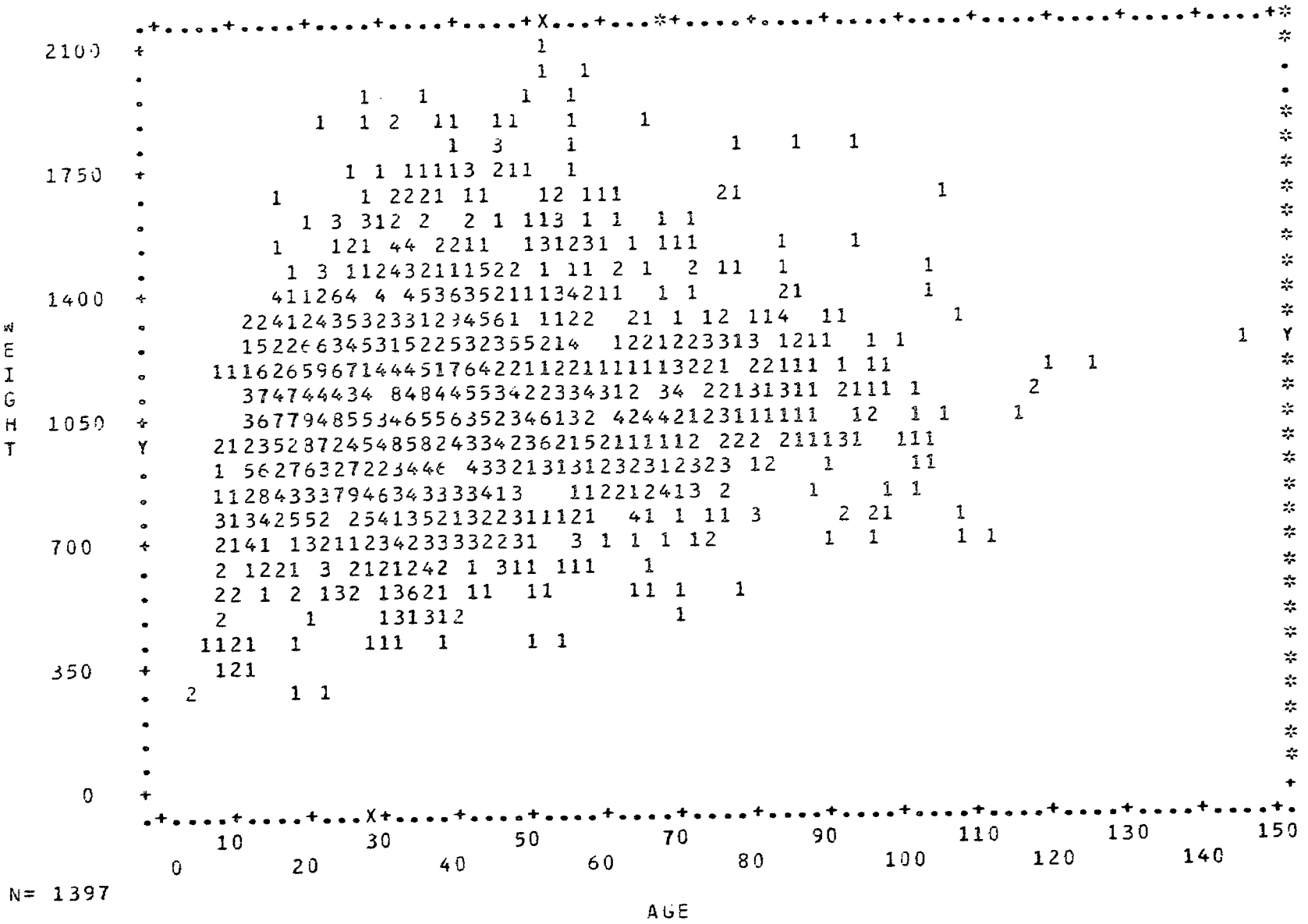

Fig. 35. Plot of weight vs age, all areas combined.