Status of the Pacific Hake Resource and Recommendations for Management in 1985

by

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The modified Getz-Swartzman model provides an option to predict the performance of future fishing seasons based on selected management scenarios. As discussed by Francis et.al. (1984), in order to examine policy for a particular year (1985 in this case), the best current information on the status of the resource must be used.

Current Status of the Resource

Figure 1 gives the relative age-frequencies of 1983 catches in U.S. and Canadian waters. We feel the most important point to observe is the increasing reliance of the fishery on two year classes, 1977 and 1980. In 1982 and 1983, 62% and 77%, respectively, of the hake catches in numbers were comprised of these two year classes. Indications are that the 1981-83 year classes were total failures, and it is presently too early to tell much about the magnitude of the 1984 year class. Therefor for the next several years, the fortunes of the hake fishery will rely almost totally on the magnitude and productive capacity of these two year classes.

The estimate of stock biomass from the 1983 NWAFC trawl/hydroacoustic survey is 1.330 million t as compared with 1.537 million t and 1.197 million t in 1980 and 1977 respectively (Figure 2), indicating that the absolute magnitude of the resource, as reflected by the NWAFC surveys, has remained fairly constant over the past 6 years. What did change in 1983, however, was the distribution of biomass over the summer feeding area. Whereas in 1977 and 1980, 29% and 22%, respectively, of the biomass was estimated to be in the INPFC Vancouver area, in 1983 38% of the biomass was estimated to be in that area.

Examination of the 1983 catch and NWAFC trawl/hydroacoustic survey age-structured data revealed a strong possibility that growth in both weight and length of Pacific hake was severely retarded during late 1982 and 1983. Figure 3 shows average weight at age from the 1981-83 U.S. fishery and compares it with the weight-age relationship derived by Francis (1983) based on 1976-80 U.S. fishery data. There is no question that, on the average, hake weighed significantly less at age in 1983 than in previous years. Figure 4 shows average lengths at age from the 1977, 1980, and 1983 NWAFC west coast bottom trawl surveys, and compares them with the length-age relationship derived by Francis (1983), also based on 1976-80 U.S. fishery data. For ages 2 through 8, it is clear that length at age in 1983 was lower than in previous survey years. Figures 5-9 show mean length at age (from the U.S. fishery except where marked "Canada") by sex, bimonthly time interval, and INPFC area, for each individual year class from 1976-80. This can be compared with the length-age relationship of Francis (1983). It is apparent that, within the U.S. fishery zone, the average length at age for most, if not all, of the Pacific hake year classes normally expected to exhibit significant growth, was substantially reduced in 1983 and, perhaps, as early as late in 1982. There are two possible reasons for this decrease in average length at age, both related to the 1982-83 El Nino event off the west coast of North America. They are as follows:

1) Pacific hake exhibited a drastically reduced growth rate between the 1982 and 1983 fishing seasons. This would not be the only west coast stock of fish for which growth appeared to be significantly reduced between 1982 and 1983. K. Mais (Calif. Dept. Fish and Game) reported that, based on his September-October 1983 midwater trawl survey (CDF&G Cruise Report 83-X-7) in the southern California region, the size composition of adult anchovy was "very abnormal by the dominance of small fish". He attributed this to either the influx of large numbers of the slow growing southern anchovy subpopulation or drastically reduced growth rates in the northern anchovy subpopulation. Mais further reported that, based on his February-March 1984 midwater trawl survey (CDF&G Cruise Report 84-X-1) of the same region, the 1982 anchovy year class was the smallest for its age of any other sampled by their surveys (aproximately 20 years). Again, Mais attributed this to a combination of reduced growth and a protracted spawning period due to the warm water conditions of 1982-83. McLain (1983) reported that many fish species in the California Current system had poor growth in 1983 because of low biological productivity. He cited Parish (NMFS, Monterey) as saying that anchovy available to the California fishery in 1983 showed little or no growth. Furthermore, McGie (1983) reported that the 1982-83 El Nino severely reduced the average size of adult coho salmon taken off Oregon, and reduced the actual abundance of coho adults in the Oregon Production Index region to less than 50% of the pre-season estimate.

2) Pacific hake stratify on a north-south gradient by size, with larger fish, even within a year class, tending to occur farther north. The 1982-83 El Nino could have shifted the entire hake population to the north resulting in the observed decrease in average size at age by area along the coast. McLain (1983) reported that many species of fish exhibited a northward shift in abundance in 1983 as a result of the warm water anomoly. Figure 2 shows the estimated distribution of Pacific hake biomass by INPFC area from the 1977, 1980, and 1983 NWAFC

trawl/hydroacoustic surveys. It is obvious that a greater proportion of the population was found in the northern areas in 1983 than in previous survey years. Figure 10 presents estimates of the fraction of the Pacific hake stock occuring in the INPFC Vancouver area by age from the 1980 and 1983 surveys. It shows that, not only was the total biomass of hake distributed farther to the north in 1983 than in previous survey years, but that younger aged fish were found much farther north in 1983 than in 1980, or for that matter in 1977.

1985 Projections

Based on the above results, our opinion is that growth of Pacific hake has been seriously affected by the 1982-83 El Nino. As a result, projections of the 1985 fishing season were made using two sets of average-weights-at age: 1) the weights given by Francis et. al. (1984) used in previous projections, and 2) the average weights at age observed in the 1983 fishery. These values are given in Table 1. Using the latter (lower) weights at age will result not only in a reduction in estimated stock production from a yield per recruit point of view, but of higher removals in numbers of fish from both the 1983 and 1984 simulated fisheries.

As was the case for 1984 (Francis et. al. 1984), projections of the 1985 fishing season were made based on our best estimate of the status of the hake stock prior to the 1983 fishing season. This was obtained from the most recent cohort analysis (Francis et. al. 1984). The modified Getz-Swartzman model was then run to simulate 1983 and 1984 (projected) catches as follows:

	U.S.	Canada	Total
1983	73,100	40,800	113,900
1984	85,000	45,000	130,000

The 1984 U.S. catch was projected from current PacFIN statistics, and the 1984 Canadian catch was projected by S. McFarlane (PBS, Nanaimo).

The most recent cohort analysis provided no estimates of year class strength after the 1979 year class. All signs have indicated that the 1980 year class was extremely strong, certainly through 1982 prior to its recruitment to the fishery. One wonders, however, what the effect of the 1982-83 El Nino was on the absolute abundance of this year class. Figure 5 shows how growth of this year class appears to have been affected. We hope that with more complete catch-effort and age-structure information from the 1983-84 fisheries, we will be able to assess whether this crucial year class suffered any abnormal mortalities. As was the case in Francis et. al. (1984), our 1985 projections were therefor evaluated assuming both optimistic (XWR = 3.030 billion fish) and average (AWR = 1.074 billion fish) warm 1980 year class recruitment at age 3. As was mentioned earlier, indications are that the 1981, 1982, and 1983 year classes were extremely small. For example, K. Mais (CDF&G Cruise Report 83-X-

3) reported that juvenile hake of the 1983 year class were "extremely scarce" in his November 1983 midwater trawl survey in the southern California region. At present, we have no information on the size of the 1984 year class (first indications should be available before the end of 1984 from the Fall 1984 CDF&G midwater trawl survey of the southern California region). Therefor, 1985 projections were examined assuming cold years (poor recruitment) for 1981-84. The management algorithm of Francis et. al. (1984) was then run for 1985 assuming both warm and cold year recruitment for the 1985 year class.

Mean values of single and split stock projections are given in Table 2. Each line of the table is the mean of four model runs: 1) optimistic 1980 recruitment (XWR), warm (good) year recruitment in 1985 (W85), 2) XWR, cold (poor) year recruitment in 1985 (C85), 3) average warm year recruitment in 1980 (AWR), W85, and 4) AWR, C85. These four runs present a range of options for the 1980 and 1985 year classes which we feel are a realistic reflection of what we know about them. Unfortunately, sensible split stock runs could not be made for the 1983 weight-at-age option due to the manner in which the model wanted to split the stock (due to the reduced weight at age, the model, with its existing parameters, distributed stock biomass heavily into the U.S. zone, whereas, the 1983 NWAFC survey showed just the opposite - Figures 2 and 10). We therefor decided to estimate we feel this run would have produced based on an analysis of variance approach (Total catch = (131)(311)/(215) = 190). Further investigations of the U.S./Canada stock distribution mechanisms are ongoing and should enable us to more accurately re-estimate model parameters and make these important runs early in 1985.

At the end of Table 2 we present our best estimate of what the 1985 ABCs should be for Pacific hake. These turn out to be the mean values between the single and split stock runs pro-rated to the U.S. and Canadian fishing zones according to the mean pro-rations from the split stock runs. One must keep in mind that the pro-rations based on the management algorithm are only an example of how the catch might be partitioned between the two fisheries. We certainly feel more confident with the estimates of total stock production than we do with the pro-rations.

In summary, we feel that the most important point to come out of this analysis is that there is evidence that the Pacific hake stock could have suffered a significant reduction in production as a result of the 1982-83 El Nino. At the same time, there is increasing evidence that environmental conditions cause considerable dislocations of the stock on the summer fishing grounds along the west coast of the U.S. and Canada, dislocations which could have a significant impact on the availability of the resource to the two fisheries. Until these effects are fully investigated, management of the resource should lean on the side of conservatism.

References

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Table 1. Average weight at age (kg.) of Pacific hake in the U.S. and Canadian fishery zones.

Age	Francis et. al. (1984) U.S.	Canada	Combined	1983 Data U.S. 1)	Canada 2)	Combined
3	0.443	-	0.443	0.351	0.434	0.366
4	0.545	-	0.545	0.422	0.482	0.452
5	0.644	0.791	0.663	0.506	0.551	0.541
6	0.729	0.904	0.769	0.590	0.618	0.612
7	0.798	0.977	0.855	0.670	0.700	0.691
8	0.853	1.095	0.947	0.726	0.751	0.745
9	0.898	1.183	1.023	0.750	0.767	0.761
10	0.933	1.228	1.078	0.780	0.794	0.790
11	0.962	1.286	1.134	0.812	0.820	0.817
12	0.985	1.377	1.205	0.849	0.876	0.867
13	1.000	1.377	1.219	0.920	0.937	0.931
14	1.007	1.377	1.233	1.011	1.026	1.022
15+	1.007	1.377	1.233	1.137	1.137	1.137

1) 83 fishery - 3 year running mean.

2) 83 U.S. Vancouver area fishery - 3 year running mean.

Table 2. Mean values of single and split stock allowable catch projections for 1985.

Stock Option	Growth Option		Yield (1000 t)	Effort (1000 d)	CPUE (t/d)
Single	Francis (1984)		215	4.8	44.8
	83 Data		131	3.7	35.4
Split	Francis (1984)	Tot	311	10.6	29.3
		US	213	4.3	49.5
		Can	98	6.3	15.6
	83 Data	Tot	190	Note: This is an estimate of what these model runs might produce.	
		US	130		
		Can	60		
1985 ABC		Tot	212		
		US	145		
		Can	67		

Figure 1. Relative age-frequency of Pacific hake catch in 1983, U.S. and Canadian waters.

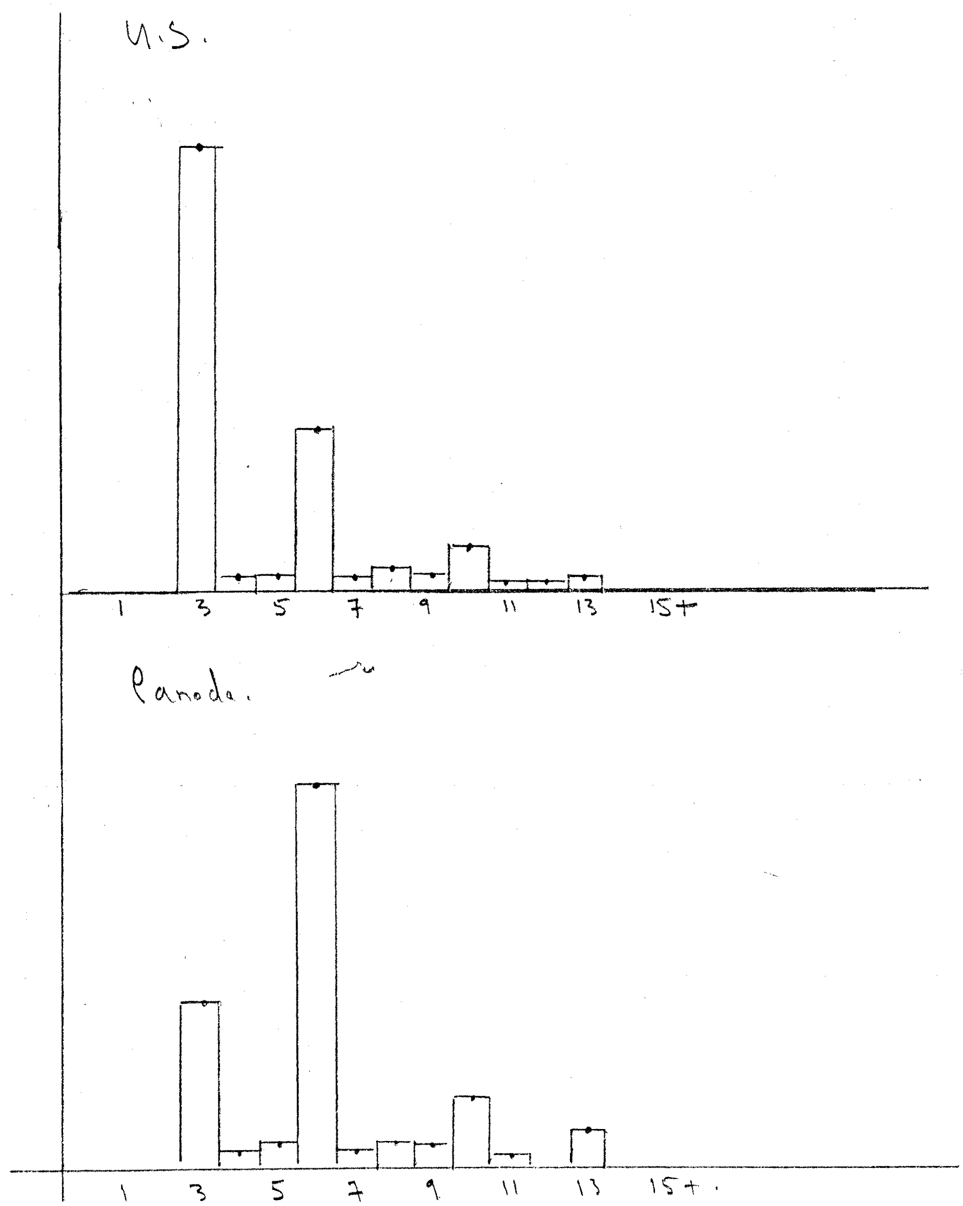

Figure 2. Distribution of Pacific hake biomass from 1977, 1980 and 1983 NWAFC trawl/hydroacoustic surveys.

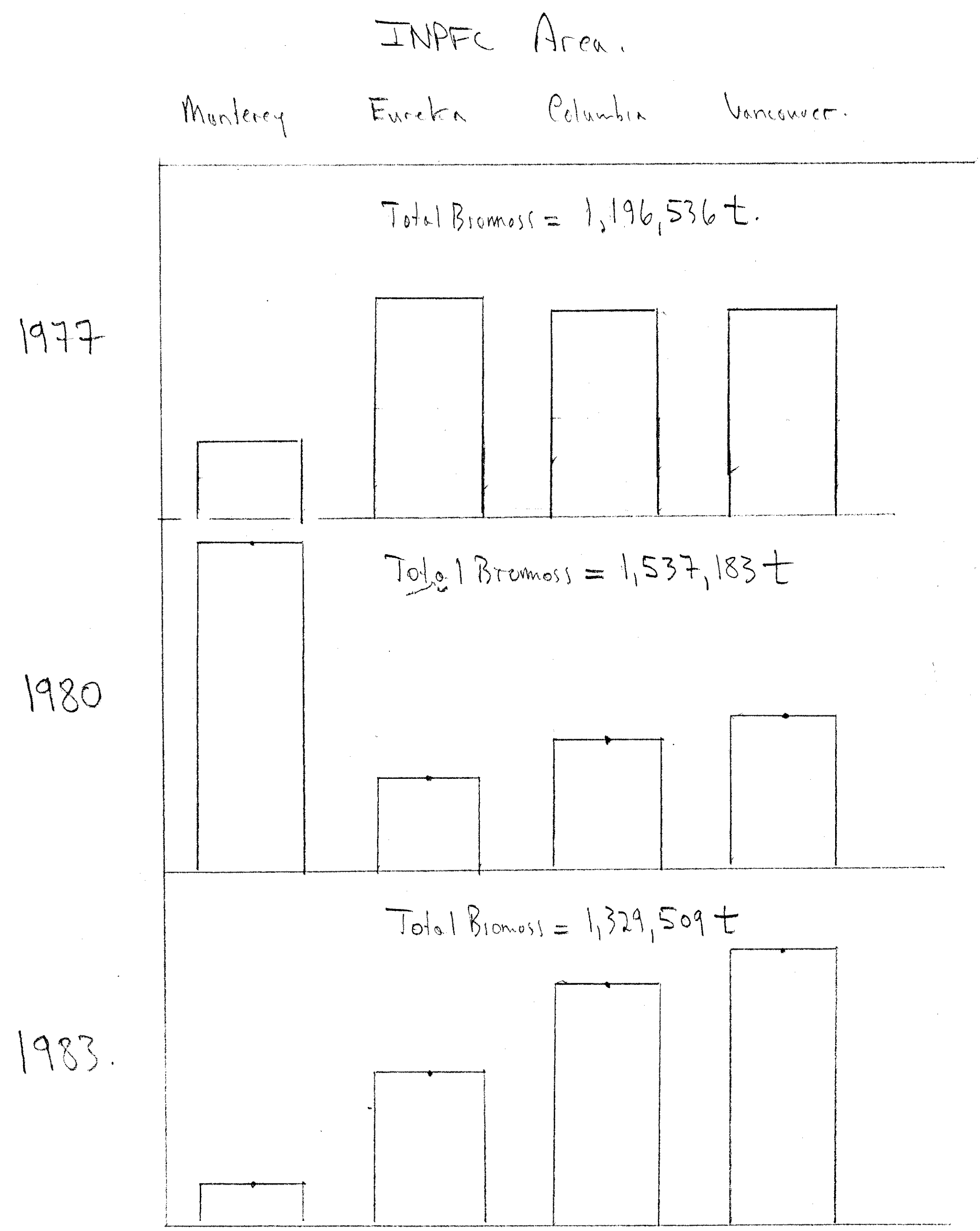

Figure 3. Pacific hake – average weight (kg) at age from 1981–83 U.S. fisheries.

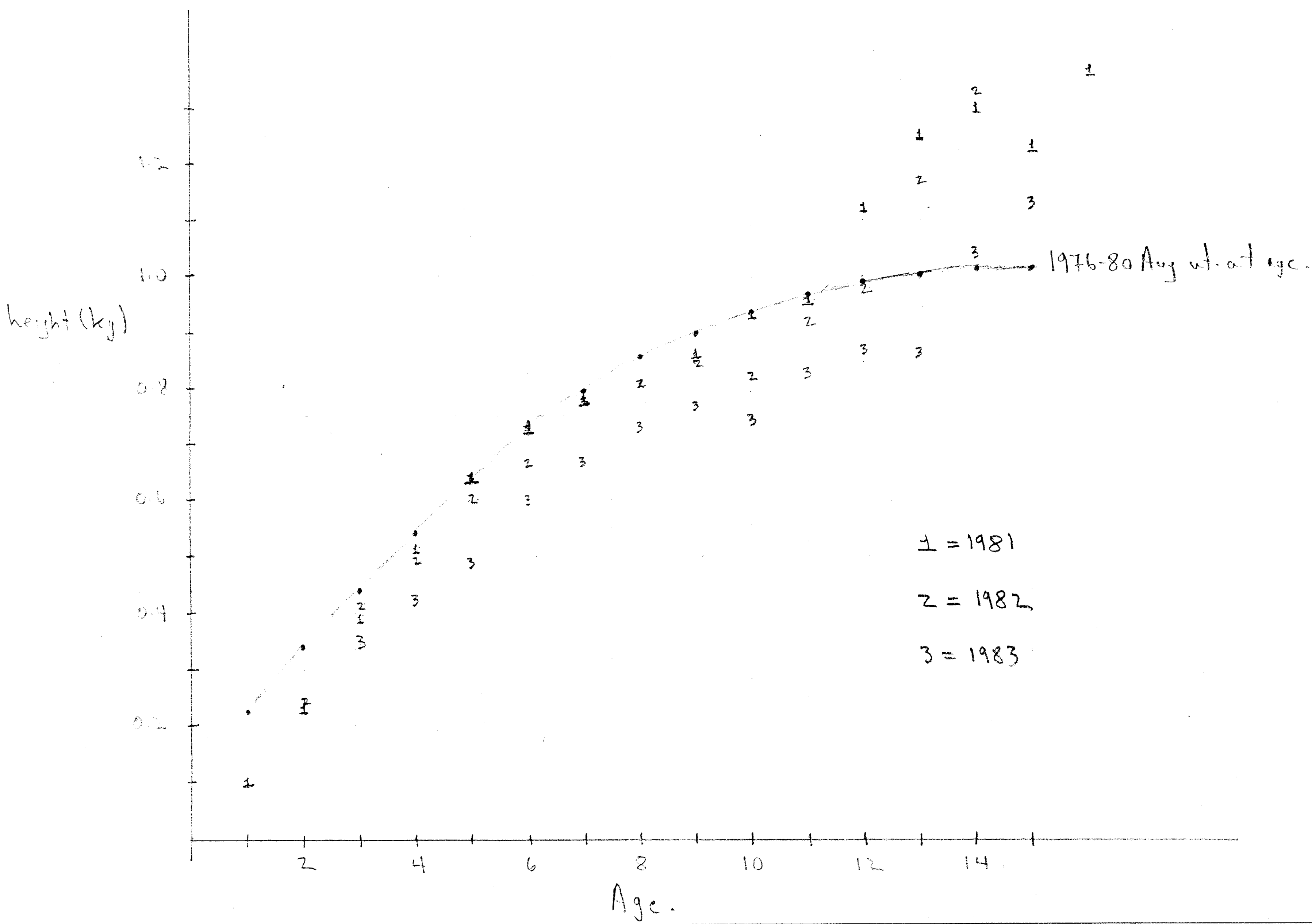

Figure 4. Pacific hake - average length at age from 1977, 80, 83 NWAFC bottom trawl surveys.

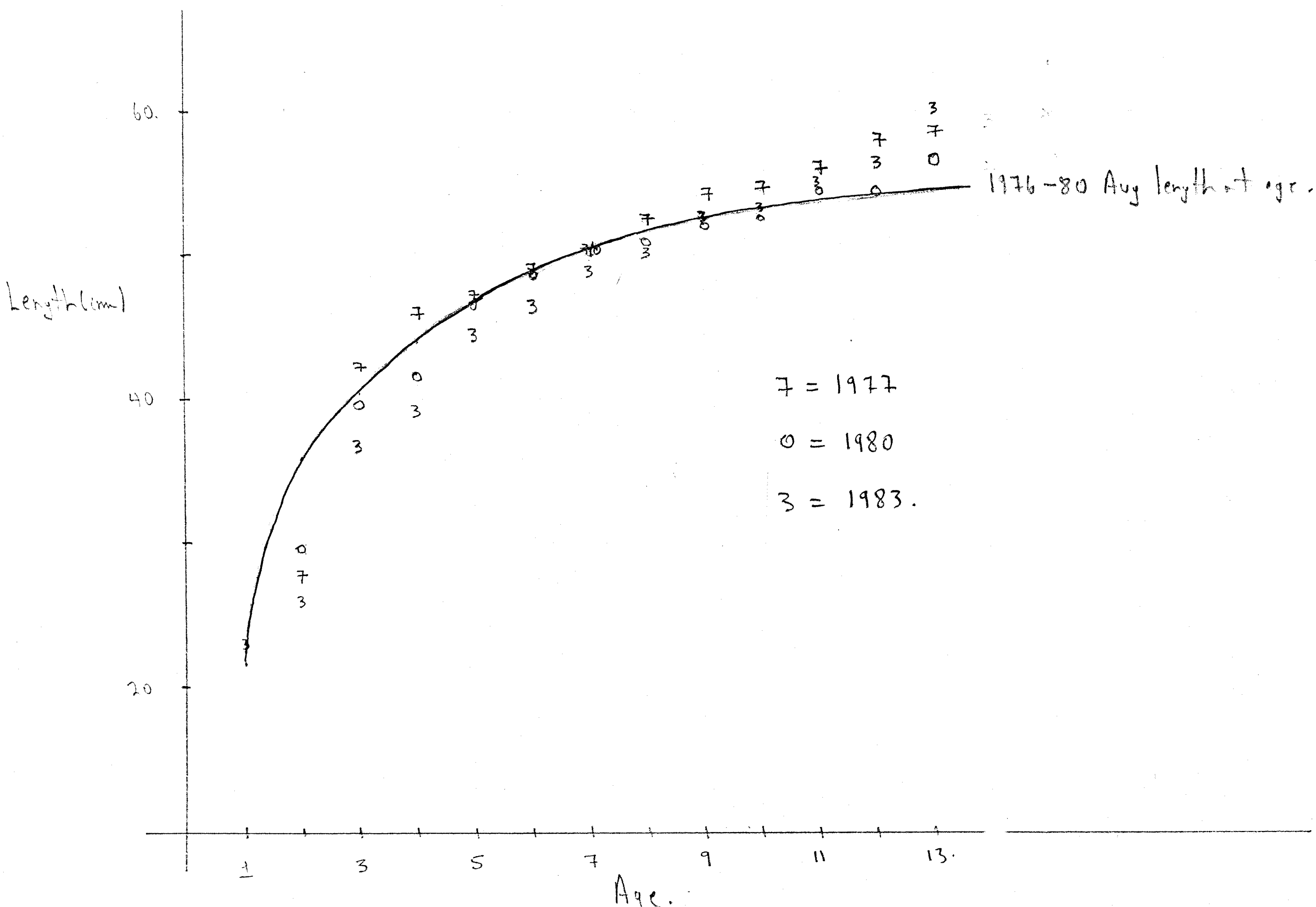

Figure 5. Pacific hake – average length at age for 1980 year-class.

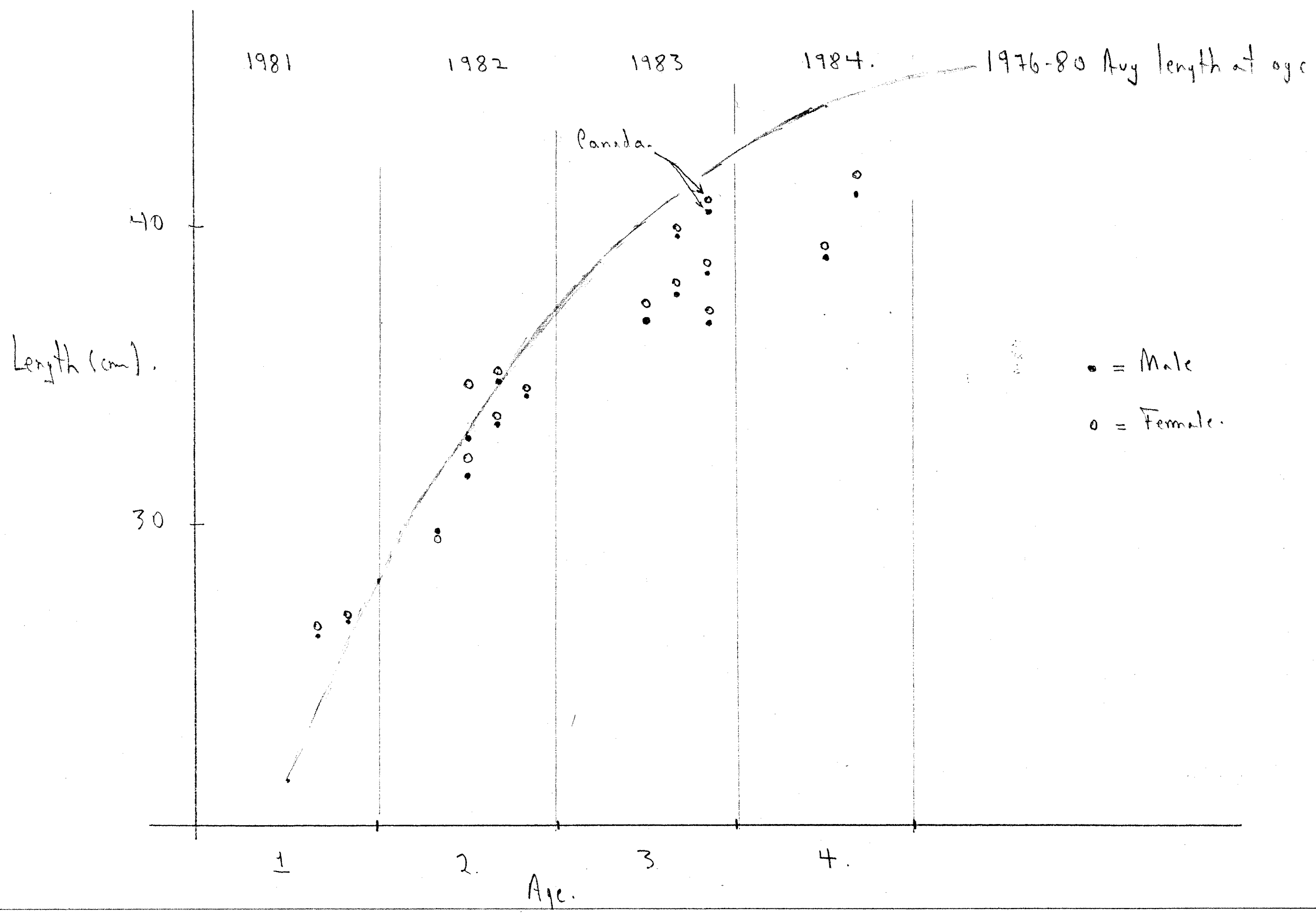

Figure 6. Pacific hake- average length at age for 1979 year-class.

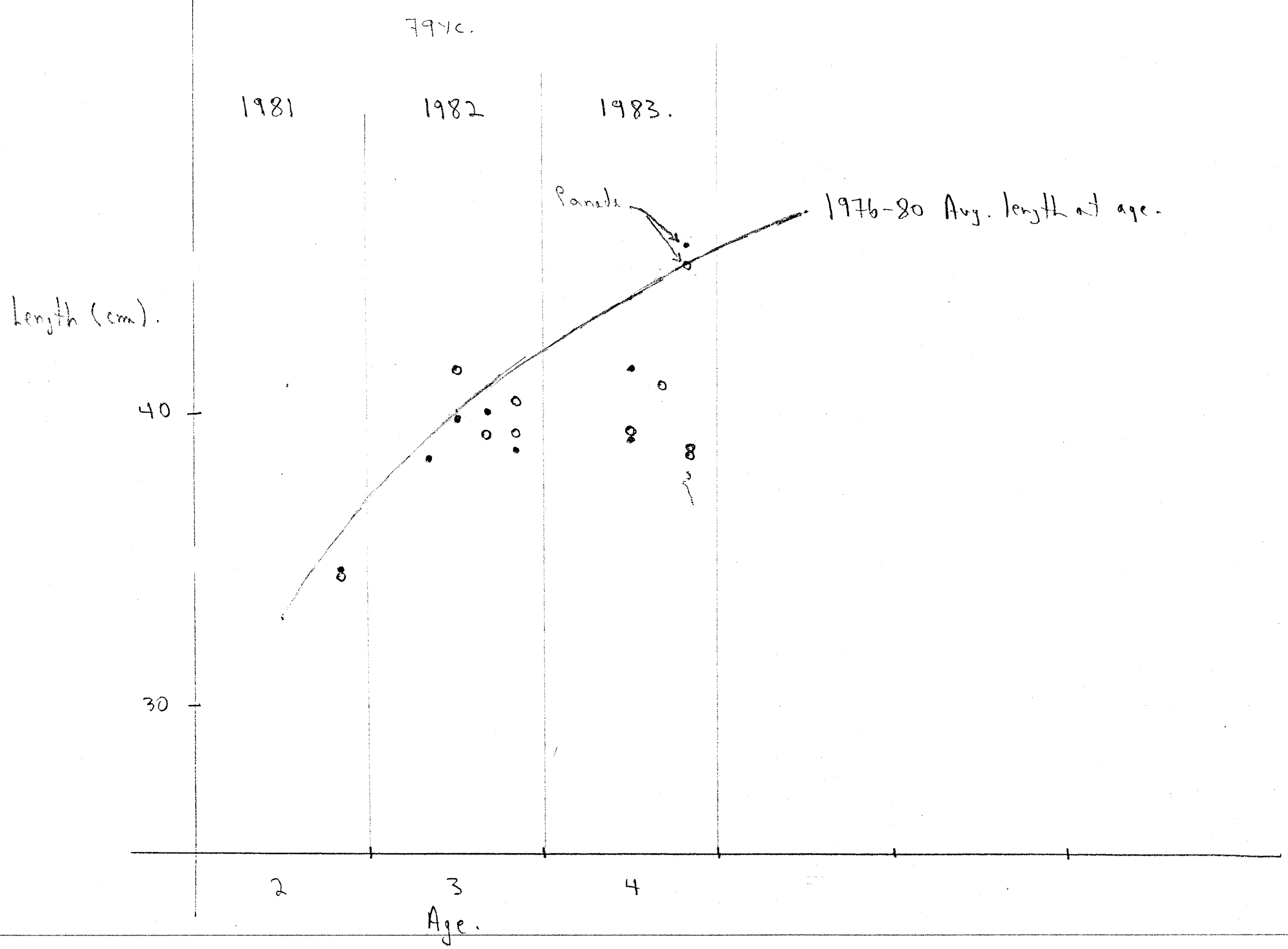

Figure 7. Pacific hake – average length at age for 1978 year class.

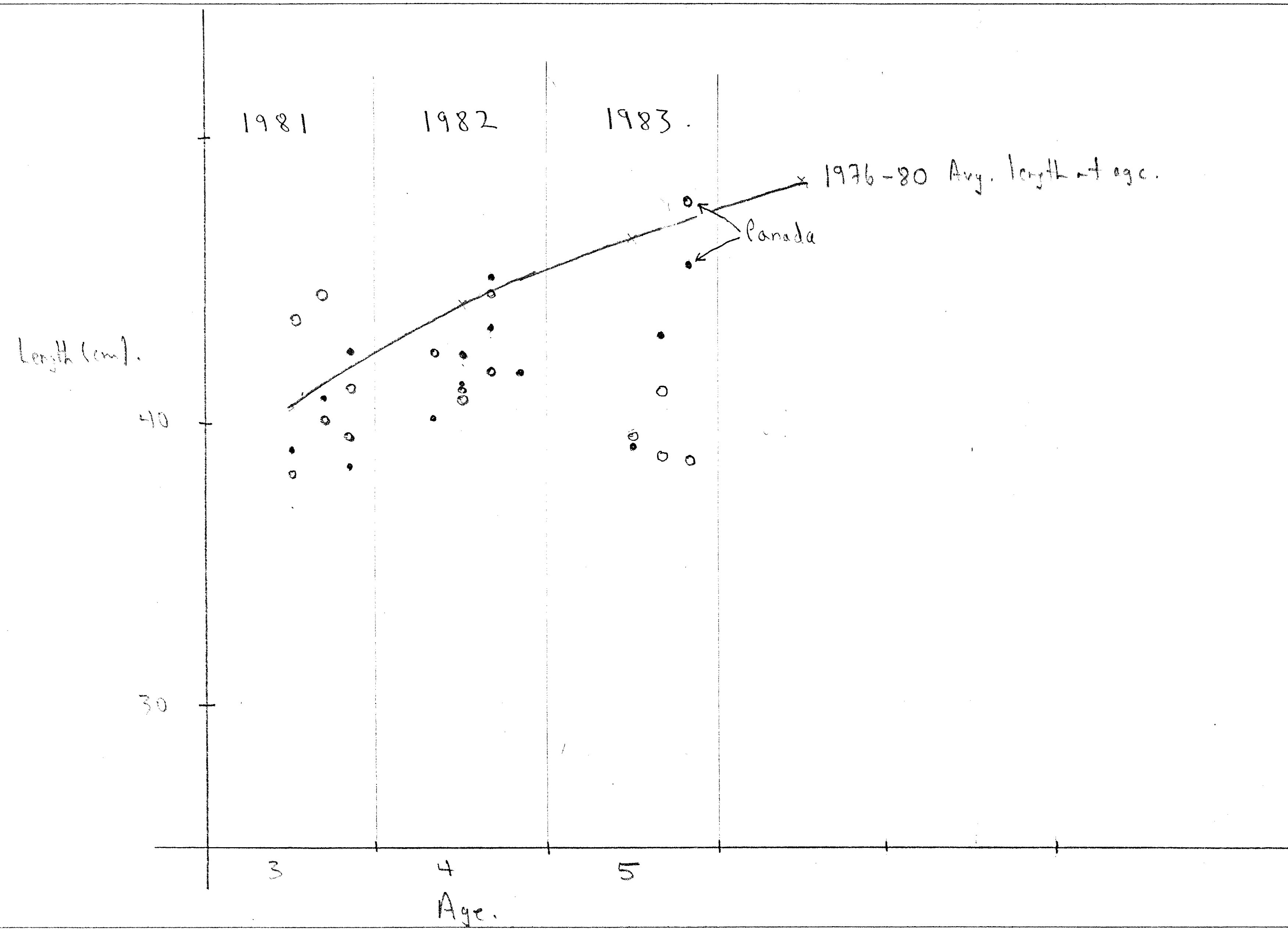

Figure 8. Pacific hake – average length at age for 1977 year class.

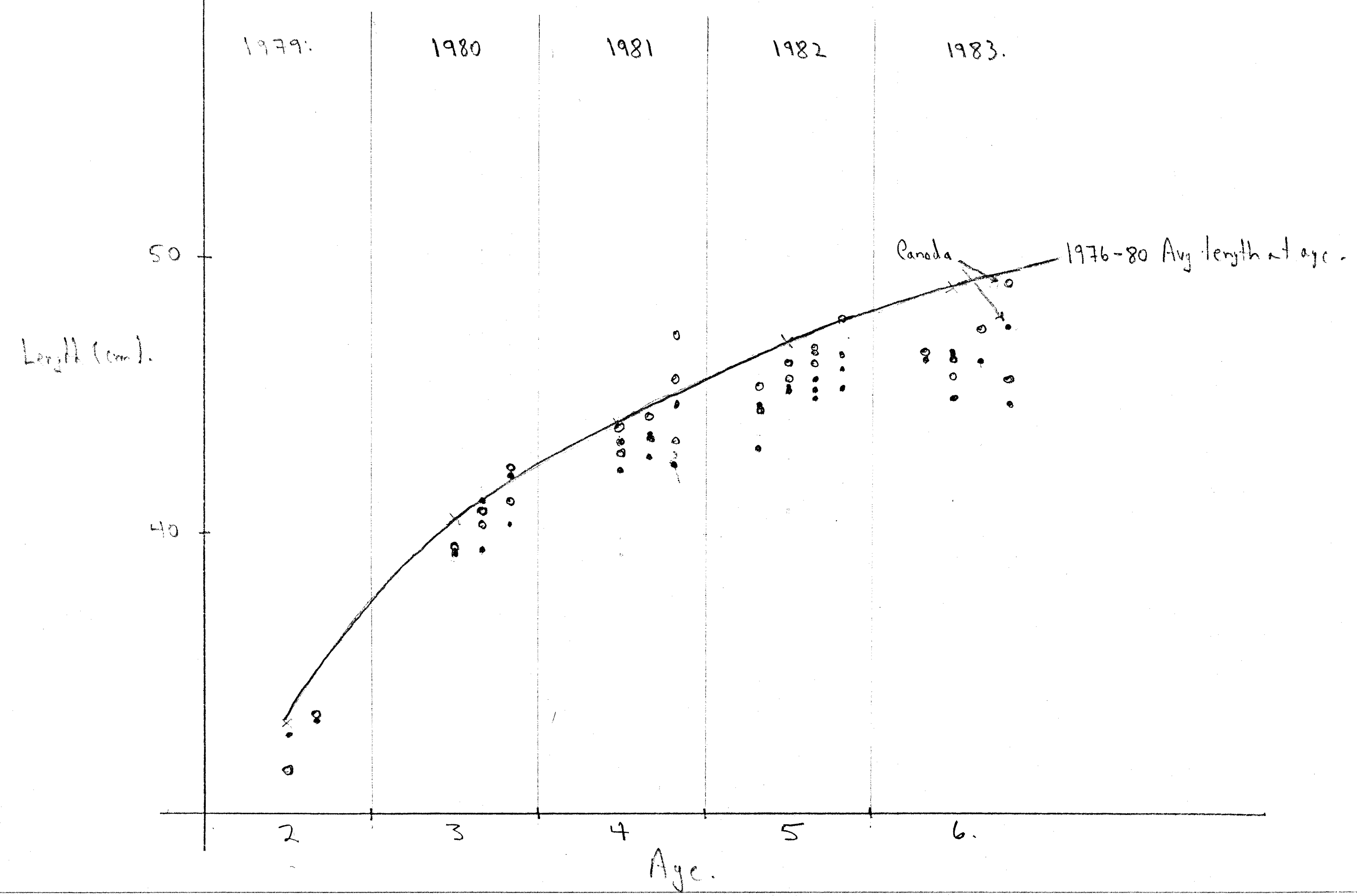

Figure 9. Pacific hake – average length at age for 1976 year class.

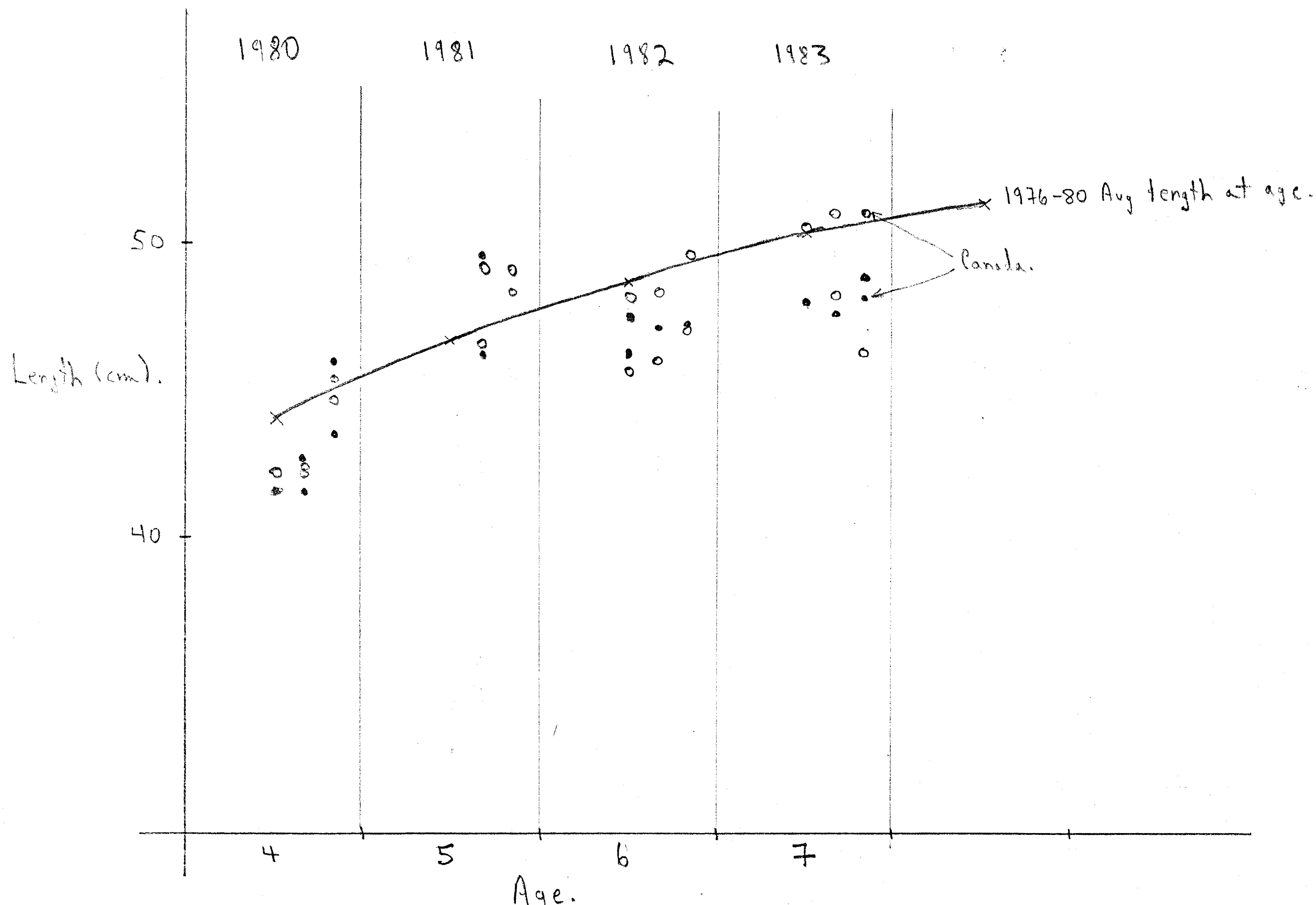

Figure 10. Fraction of Pacific hake stock in INPFC Vancouver area by age, 1980 and 1983 NWAFC trawl/hydroacoustic survey.