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INTRODUCTION

Population studies on the juvenile sockeye salmon populations in Lake Washington have been conducted for the past several years. Principal funding has been provided through the Sea Grant Program (NOAA) and the International Biological Program (NSF). The Washington Department of Fisheries (WDF) has demonstrated an active interest in the program, and has contributed both manpower and financial support. Results of acoustic studies on the 1967 year class were reported in Thorne and Woodey (1970). Studies on the 1968 year class were transmitted to WDF in an informal report. Other commitments have delayed written communication of the subsequent results. The purpose of this report is to rectify that deficiency and to report to WDF the results of both net haul and acoustic estimates of the 1969 and 1970 year classes. In addition, the initial studies on the 1971 year class are reported.

MATERIALS AND METHODS

Net hauls were made aboard the R.V. *Commando* using a 10-ft Issac-Kidd midwater trawl. Fish densities were determined from catches by assuming a strained volume of 1,000 m^3 per minute of trawling and a 100% catching efficiency. Population estimates were obtained by calculating a weighted mean density, with weighting proportional to the volume associated with the area and depth strata of the trawl location.

Acoustic techniques have evolved considerably. Initial surveys in February and November 1969 were conducted from the R.V. *Commando*, and subsequent surveys from the 18-ft *Thunderbird*. An analog voltage integrator was used to process data from the February and November 1969 and February 1970 surveys with calibration by regression against net hauls (Thorne and Woodey, 1970). A digital echo integration system was applied to subsequent surveys with calibration by echo counting (Thorne, 1972), and net hauls were used only for species ocmposition data. Acoustic surveys typically consisted of about 15 evenly distributed transects. Variances were determined by grouping observations in depth and area strata. Confidence intervals included variability from calibration relationships.

The population estimates are of sockeye available to net and acoustical gear in the limnetic area of the lake over depths greater than approximately 20 ft. Sockeye salmon inshore of these depths or close to the bottom would be excluded. A new year class entering the lake does not become fully available to the sampling gear until some time during summer because of their tendency to remain inshore. Occasionally during late winter the yearlings are concentrated toward the shallower south end of the lake, and under these conditions a portion may be undetected if near the bottom.

RESULTS AND DISCUSSION

Estimates of population size for various year classes of juvenile sockeye salmon obtained from net hauls and acoustic surveys from February 1969 to October 1972 are presented in Table 1.

Net haul and acoustic estimates are compared in Fig. 1. The two techniques yielded generally similar results. The slope of the regression of net haul results on acoustic surveys was 1.01 with standard deviation of 0.14. The regression did not include the February 1969 to February 1970 series which were not independent since the acoustic data were calibrated by net hauls. The results show that catching efficiency is not significantly different from 100% with the assumption of 1,000 m^3 strained per minute of trawling, and that gear selectivity is not a major factor. The assumption of 2.5-m by 2.5-m mouth opening may be conservative. If the maximum possible opening (3 m by 3 m) is assumed the net efficiency is 70%. It is also possible that the net hauls are biased toward higher densities. The net sampling power is much less than the echo sounders, and the net haul estimates are typically based on about 15 trawl stations. Some subjectivity is unavoidable in assigning density values to unsampled areas and depth strata. Nonetheless, the regression comparison demonstrates that, with the given assumptions, the net haul series yield similar results and are extremely informative in complement with acoustic surveys as well as providing estimates on many dates when acoustic surveys were not conducted.

The limnetic population levels as a function of time during lake residence are illustrated in Figs. 2, 3, and 4 for the 1969, 1970, and 1971 year classes, respectively. The 1969 year class reached a peak of 32 million in August, then decreased dramatically to a level of about 3.8 million in March-April before outmigration. The 1970 year class sockeye salmon also reached a peak in August, then steadily decreased to outmigration. However, the peak was much less, about 3.7 million, as was the apparent mortality, so that the level in March prior to outmigration was about 2.5 million. The drop in April 1972 was probably due to outmigration, since this series was conducted the 25th of the month. Data on the 1971 year class is incomplete. However, recruitment of the juveniles to the limnetic zone was unusually slow. The population size at the last data point (October) was less than the 1970 year class at the comparable sampling period.

The seasonal population estimates provide valuable data for evaluating magnitudes and possible causes of mortality during lake residence. However, the population levels prior to outmigration are of particular and immediate value for predicting the level of returns, assuming reasonably constant marine survival. Returns are now complete on the 1967 and 1968 year classes, so that examination of marine survival and inferences on future returns can be made. A plot of presmolt estimates and returns for the 1967 and 1968 year classes is given in Fig. 5. The mean 1967 year class presmolt estimate is the average of the net haul and acoustic survey estimates in February 1969. The mean 1968 year class estimate is an average of the February 1970 acoustic estimate and the February 1970 and March 1970 net haul estimates. The acoustic estimates with confidence intervals and the net haul estimates are also plotted. The mean estimates compared with subsequent returns suggest a marine survival of about 7%.

The average of the March and April 1971 net haul and acoustic estimates for the 1969 year class was 3.8 million. If the marine survival is 7%, this would suggest a return of 270,000 fish. Correspondingly, the average of the March 1972 acoustic and net haul series was 2.5 million, suggesting a return of 175,000 fish.

Prediction of future runs on the basis of two data points is obviously risky, particularly when the magnitudes of the confidence intervals on the acoustic estimates and the variability between net haul series are considered. The techniques for estimating the presmolts has certainly reached a level of reliability so that reasonably small confidence intervals can be obtained with sufficient effort. For example, the four series on the 1969 year class in March and April 1971, and in particular the two acoustic surveys, are in good agreement. The utility of presmolt abundance as a tool for forecasting is still ultimately dependent on the variability in marine survival. This aspect can only be evaluated after several years of returns with accurate presmolt estimates.

LITERATURE CITED

Thorne, R. E. 1972. Hydroacoustic assessment of limnetic-feeding fishes, p. 317-322. *In* J. F. Franklin, L. J. Dempster, and R. H. Waring [eds.], Proceedings--research on coniferous forest ecosystems--a symposium. USDA Forest Serv., Portland, Oregon.

Thorne, R. E., and J. L. Woodey. 1970. Stock assessment by echo integration and its application to juvenile sockeye salmon in Lake Washington. Univ. Washington, Fish. Res. Inst. Circ. 70-2. 31 p.

Table 1. Population estimates of juvenile sockeye salmon based on net hauls and on acoustic surveys, February 1969 to October 1972

Year class	Series	Population estimates (millions) Net hauls	Acoustic survey
1967	February 1969	7.5	8.92 (6.8-11.1)[1]
1968	November 1969	9.1	6.18 (4.3-8.1)
	December 1969	5.2	
	January 1970	6.2	
	February 1970	6.6	3.19 (1.6-4.8)
	March 1970	3.0	
1969	March 1970	7.8	
	June 1970	13.4	
	July 1970	29.3	
	August 1970	32.0	
	October 1970	16.0	
	December 1970	5.5	
	January 1971	10.4	
	March 1971	3.3	3.8 (2.7-4.9)
	April 1971	4.6	3.6 (3.0-4.2)
1970	April 1971	3.1	
	May 1971	3.1	
	June 1971	2.0	
	August 1971	3.6	3.8 (no confidence limits calculated)
	October 1971	3.3	3.3
	December 1971	3.3	1.3 (believed invalid)
	March 1972	3.0	2.0 (1.3-2.7)
	April 1972	1.3	1.0 (0.6-1.4)
	June 1972	0.27	0.37 (0.18-0.56)
	August 1972	0.16	0.15 (0.09-0.21)
	October 1972	0.18	0.14 (0.10-0.18)
1971	March 1972	0.84	0.65 (0.40-0.90)
	April 1972	0.41	0.32 (0.19-0.45)
	June 1972	0.79	2.58 (1.26-3.90)
	August 1972	2.06	1.99 (1.24-2.74)
	October 1972	3.11	2.10 (1.39-2.81)

[1]95% confidence limits of the estimate shown in ( ).

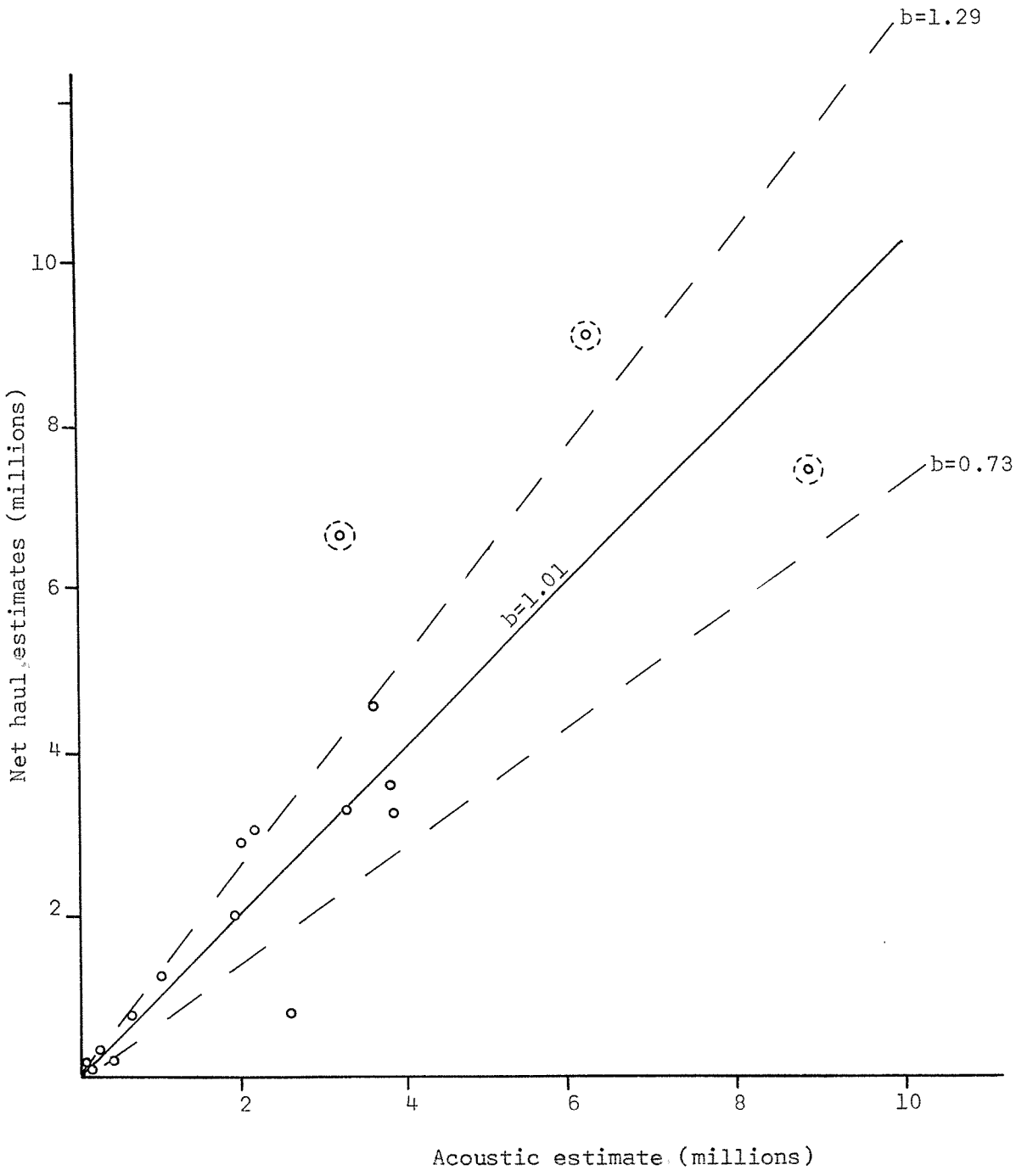

Fig. 1. Comparison of net haul and acoustic estimates. February February 1969-February 1970 series indicated by ⊙.

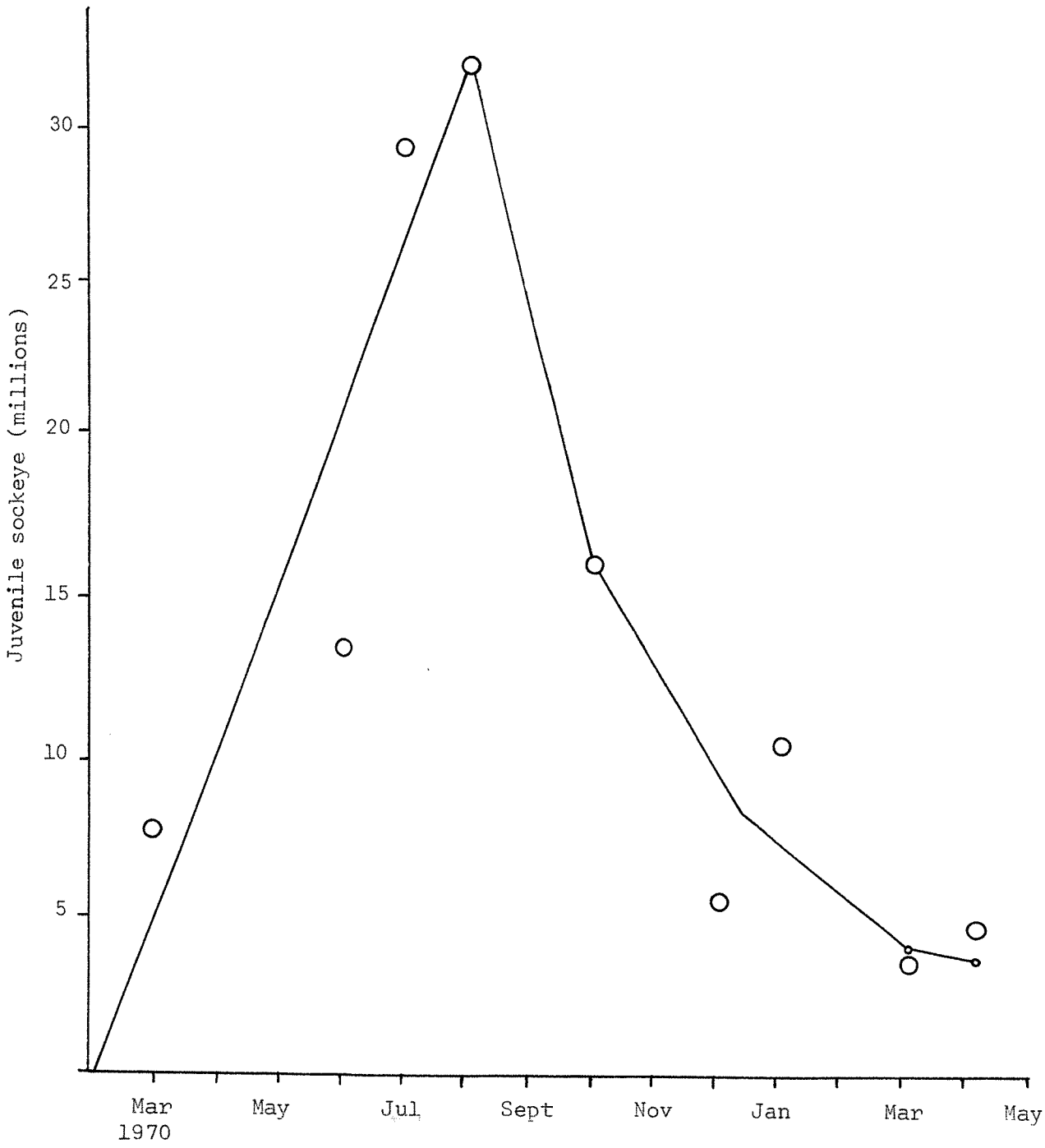

Fig. 2. Acoustic and net haul estimates of the 1969 year class sockeye salmon during lake residence. Acoustic estimates denoted by small circles.

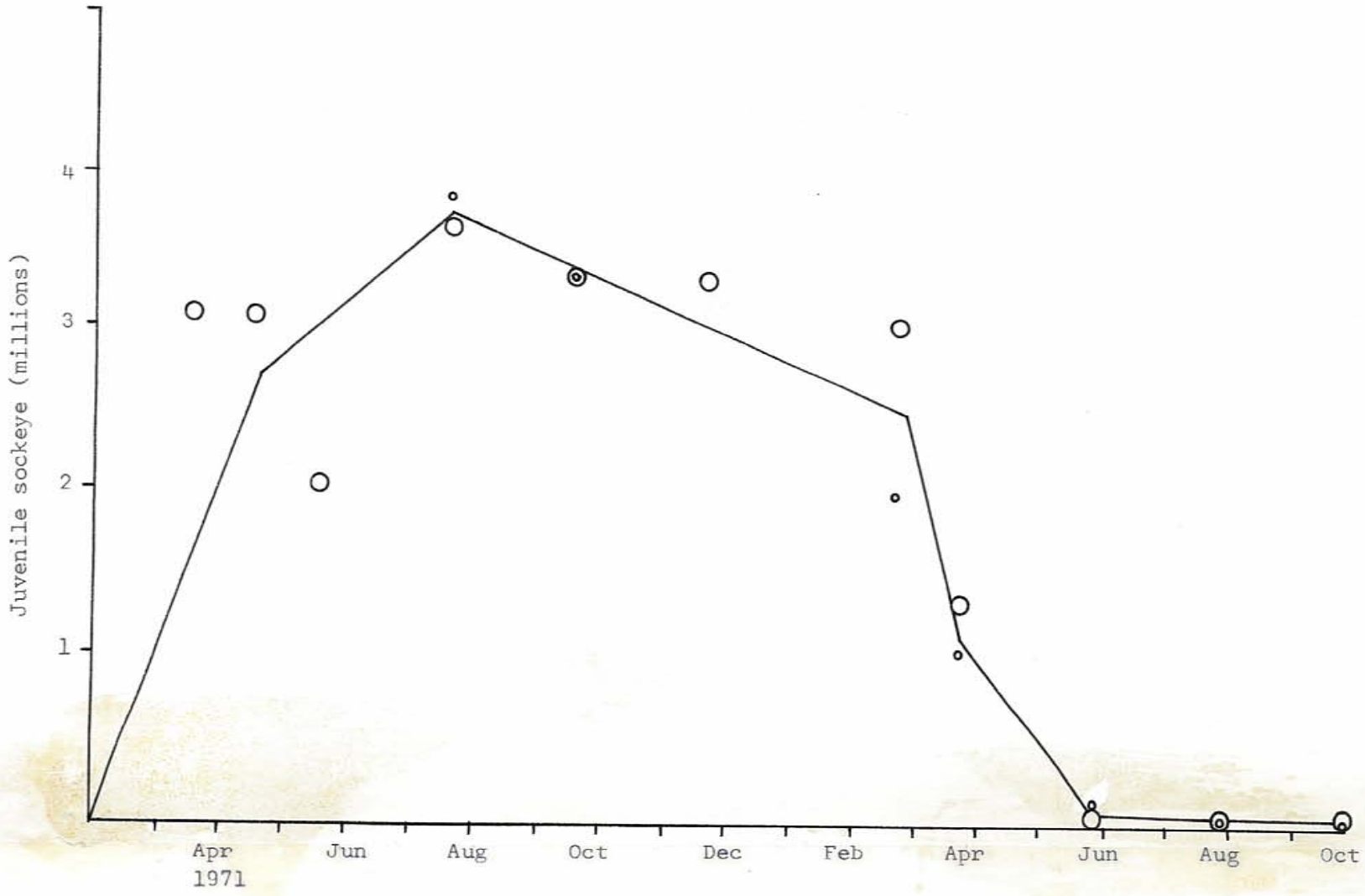

Fig. 3. Acoustic and net haul estimates of 1970 year class sockeye salmon during lake residence. Acoustic estimates denoted by small circles.

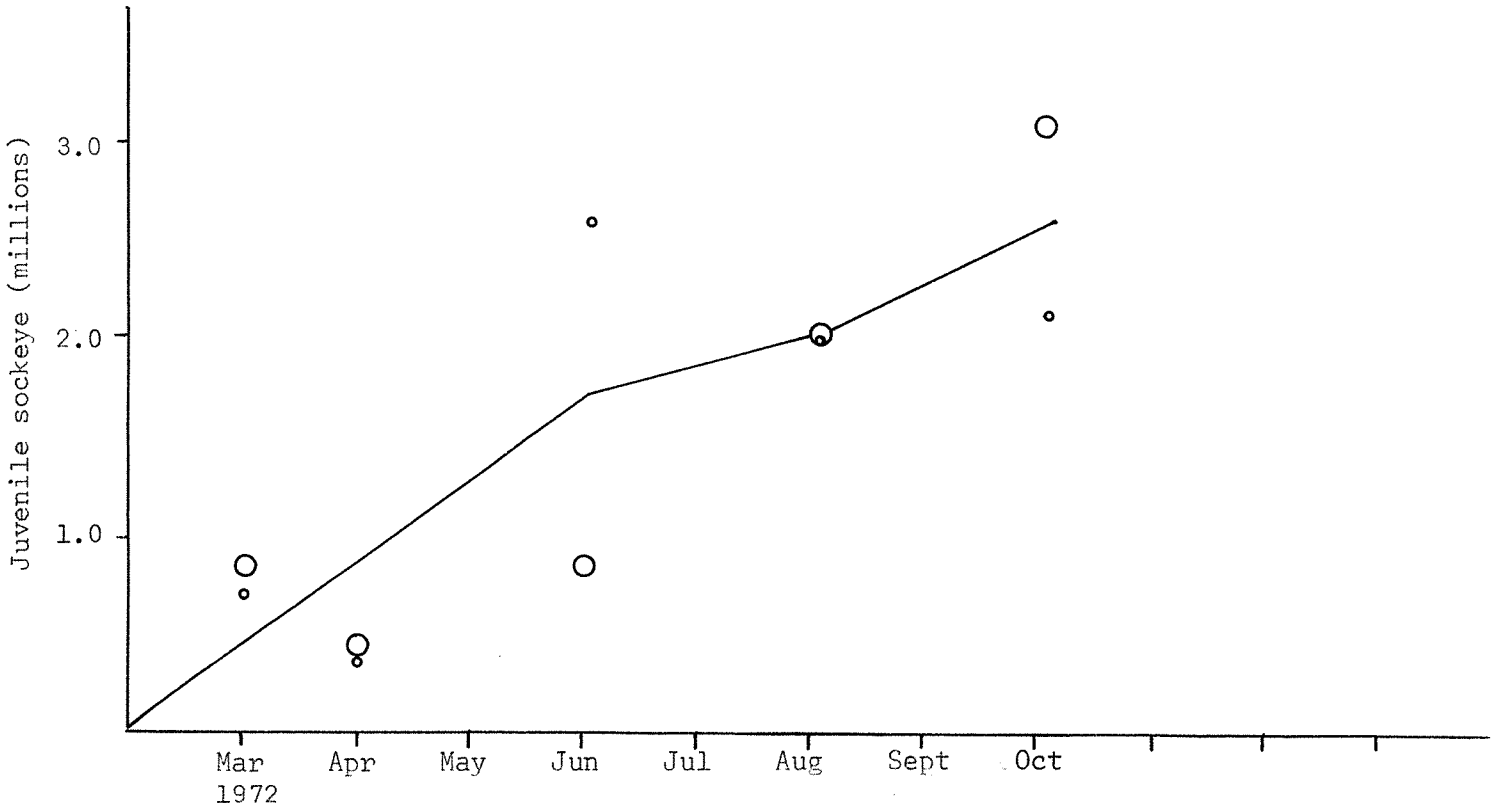

Fig. 4. Acoustic and net haul estimates of 1971 year class sockeye salmon, March 1972 through October 1972. Acoustic estimates denoted by small circles.

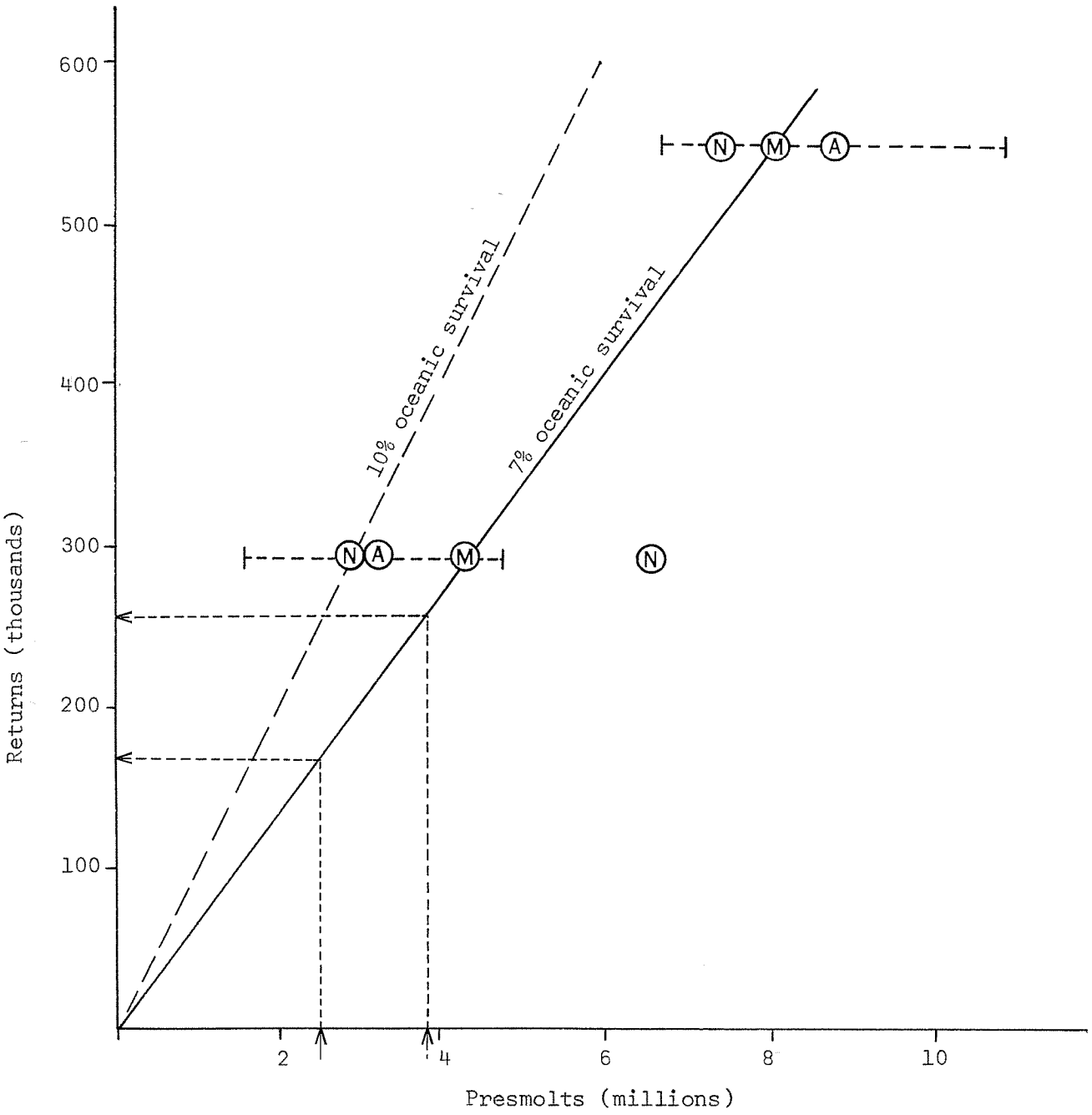

Fig 5. Comparison of net haul(N), acoustic (A), and mean (M) presmolt population estimates with subsequent returns.