

CONFIDENCE LIMITS OF TRIP FREQUENCY ESTIMATES AS A FUNCTION OF SAMPLING  
EFFORT FOR THE LARGE PELAGIC RECREATIONAL FISHERY ALONG THE NORTHEAST  
UNITED STATES

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SUMMARY

The precision of estimates for the number of trips an average vessels makes each week is examined as a function of the number of interviews and vessel type (private vs. charter). A bootstrap approach, wherein data from 1989 and 1990 are sampled as though they were the actual population, is used to generate the upper and lower confidence intervals associated with a given sampling intensity. The width of the 90 percent confidence interval for private vessels, which is on the order of twice the mean when the number of interviews is limited to ten per month, decreases asymptotically with the number of interviews: rapidly at first and then leveling off to about half the mean after 50 interviews. A similar trend would apply to charter boat estimates if the charter fleet were large, however the actual number of charter vessels is small and fairly precise estimates can be obtained with relatively few interviews.

RESUME

La précision des estimations du nombre de sorties effectuées par semaine par un navire moyen est examinée en fonction du nombre d'interviews et du type de bateau (privé vs. en location). Une méthode itérative, dans laquelle les données de 1989 et 1990 sont échantillonnées comme si elles représentaient la population actuelle, est utilisée pour calculer des intervalles de confiance supérieures et inférieures, associées à une intensité d'échantillonnage donnée. La couverture de 90% d'intervalle de confiance des bateaux privés, qui est de l'ordre du double de la moyenne lorsque le nombre d'interviews est limité à dix par mois, baisse de façon asymptotique avec le nombre d'interviews; rapidement au départ et ensuite s'atténue à environ la moitié de la moyenne après 50 interviews. Une tendance similaire s'appliquerait aux estimations de bateaux en location si la flottille en location était importante; néanmoins, le nombre de bateaux actuels en location est réduit et des estimations assez précises peuvent être obtenues avec relativement peu d'interviews.

RESUMEN

La precisión de las estimaciones de la media del número de viajes que efectúa un barco cada semana, se examina en función del número de entrevistas y del tipo de barco (de propiedad privada *versus* alquilados). Se aplica un planteamiento de ensayos iterativos de reajuste a partir de submuestras ("bootstrap"), en el que se muestrean los datos de 1989 y 1990 como si fuesen la población real, para generar los intervalos de confianza superiores e inferiores asociados con una intensidad de muestreo dada. La amplitud del intervalo de confianza del 90% para los barcos de propiedad privada, que se encuentra en el orden del doble de la media cuando el número de entrevistas se limita a diez por mes, decrece de forma asintótica con el número de entrevistas; con rapidez al principio, estabilizándose

posteriormente a aproximadamente la mitad de la media después de 50 entrevistas. Sería aplicable una tendencia similar a las estimaciones de los barcos alquilados, si la flota alquilada fuese grande; sin embargo, el número real de barcos alquilados es pequeño, y pueden obtenerse estimaciones bastante precisas con un número relativamente corto de entrevistas.

Introduction

The purpose of this study was to determine the precision of estimates of the mean number of trips per vessel per week (TPVW) as a function of the number of interviews conducted during the month.

The analysis extends Craig Brown's work on the recreational fishery in Virginia (NMFS contribution 91/92-55) by including data from the large pelagic surveys in Connecticut, Rhode Island, Maryland, Massachusetts, New Jersey, and New York.

Methods

The precision of the current estimator for the average number of trips per vessel per week by vessel type (v),

$$\frac{TPVW_v}{N_v} = \frac{\sum_{i=1}^{N_v} TPVW_{i,v}}{N_v}$$

was measured by computing the 90 percent confidence limits from 2000 independent bootstrap estimates. Each individual bootstrap estimate was obtained by randomly drawing  $N_v$  observations with replacement from actual data and then computing the mean (the equivalent to applying the above equation to  $N_v$  interviews in the real fishery). The estimates were then ranked by value in descending order and the upper and lower confidence limits equated with the 100th and 1900th ranked estimates, respectively. The value of  $N_v$  was varied from 10 to 200 in increments of 10 so that the confidence interval could be expressed empirically as a function of the number of interviews.

The key assumptions germane to this bootstrap application are that the frequency distribution of trips per vessel-week is similar to that of the real fishery and that the number of vessels is much greater than the number of interviews. Inasmuch as the number of charter vessels is not overwhelmingly greater than the potential number of interviews, it was deemed more realistic to adjust the data to reflect the actual number of charter vessels and then sample it without replacement. The data were adjusted by multiplying the frequency distribution of trips per vessel per week by the estimated number of charter vessels in the fleet divided by the number of vessels represented in the data. The estimates of charter fleet size-- 55 in Connecticut/Rhode Island, 50 in Maryland, 10 in Massachusetts, 155 in New Jersey, and 95 in New York-- are based on the number of unique vessels encountered in the

interviews. Unfortunately, neither the dockside nor the telephone interviews are exhaustive; therefore the fleet size estimates are probably low. Accordingly, the without-replacement bootstrap estimates of the width of the confidence intervals will probably be a little too narrow. The with-replacement estimates, on the other hand, will tend to be a little too wide.

The data used in this study were obtained from telephone interviews made by the National Marine Fisheries Service in Connecticut, Rhode Island, Maryland, Massachusetts, New Jersey, and New York during 1989 and 1990. Only the peak fishing months of June, July, August and September were considered. Data were separated by state and month. If fewer than 15 observations were present in each subset of data, those data were combined with an adjacent subset. Data for Rhode Island and Connecticut were combined (by convention).

### Results

The 90 percent confidence limits of the estimates for the average number of trips per vessel-week generated by sampling with replacement are plotted against the number of interviews in figures 1 through 4. For the sake of brevity, only the results from selected states and months are shown in graphs. The width of the confidence intervals for both private and charter vessels are on the order of one and a half to two times the expected value when only 10 interviews were taken. The gain in precision with additional interviews is rapid initially, but the levels off to roughly one half the expected value after about 70 interviews per sampling period.

Figures 1 through 4 also suggest that more interviews are required to achieve a given precision in charter vessel estimates than to achieve the same precision in private vessel estimates. As discussed previously, however, the size of the charter fleet is not large enough to justify bootstrapping without replacement. Figures 5 and 6 summarize the results when the charter fleet data is sampled without replacement. The curves initially follow the trends in figures 3 and 4 (charter with replacement), but then rapidly decrease to zero as the number of interviews approaches the actual number of vessels in the fleet.

There do not appear to be any important trends between states or months except that the Connecticut/Rhode Island charter fleet consistently exhibits the widest confidence intervals.

### Figure Captions

Figure 1. The estimated number of trips made by private vessels in selected states and months during 1989. The straight line through the middle of each panel represents the actual number of trips made; the adjacent curves represent the associated 90 percent confidence limits of the estimator. The data sets corresponding to each panel are, from left to right, August/September in Connecticut/Rhode Island, August/September in Maryland, August/September in Massachusetts, and June in New Jersey.

Figure 2. The estimated number of trips made by private vessels in selected states and months during 1990. The straight line through the middle of each panel represents the actual number of trips made; the adjacent curves represent the associated 90 percent confidence limits of the estimator. The data sets corresponding to each panel are, from left to right, June/July in Connecticut/Rhode Island, June/July in Maryland, June/July in Massachusetts, and July in New Jersey.

Figure 3. The estimated number of trips made by charter vessels in selected states and months during 1989. The straight line through the middle of each panel represents the actual number of trips made; the adjacent curves represent the associated 90 percent confidence limits of the estimator when the bootstrap procedure was conducted with replacement. The data sets corresponding to each panel are, from left to right, June/July in Connecticut/Rhode Island, June/July in Maryland, August/September in Maryland, and August/September in Massachusetts.

Figure 4. The estimated number of trips made by charter vessels in selected states and months during 1990. The straight line through the middle of each panel represents the actual number of trips made; the adjacent curves represent the associated 90 percent confidence limits of the estimator when the bootstrap procedure was conducted with replacement. The data sets corresponding to each panel are, from left to right, August/September in Connecticut/Rhode Island, June/July in Massachusetts, June in New Jersey, and July in New Jersey.

Figure 5. The estimated number of trips made by charter vessels in selected states and months during 1989. The straight line through the middle of each panel represents the actual number of trips made; the adjacent curves represent the associated 90 percent confidence limits of the estimator when the bootstrap procedure was conducted without replacement. The data sets corresponding to each panel are, from left to right, August/September in Connecticut/Rhode Island, August/September in Maryland, August/September in New Jersey, and June/July in New Jersey.

Figure 6. The estimated number of trips made by charter vessels in selected states and months during 1990. The straight line through the middle of each panel represents the actual number of trips made; the adjacent curves represent the associated 90 percent confidence limits of the estimator when the bootstrap procedure was conducted without replacement. The data sets corresponding to each panel are, from left to right, June/July in Connecticut/Rhode Island, June/July in Maryland, August/September in Maryland, and August/September in New Jersey.

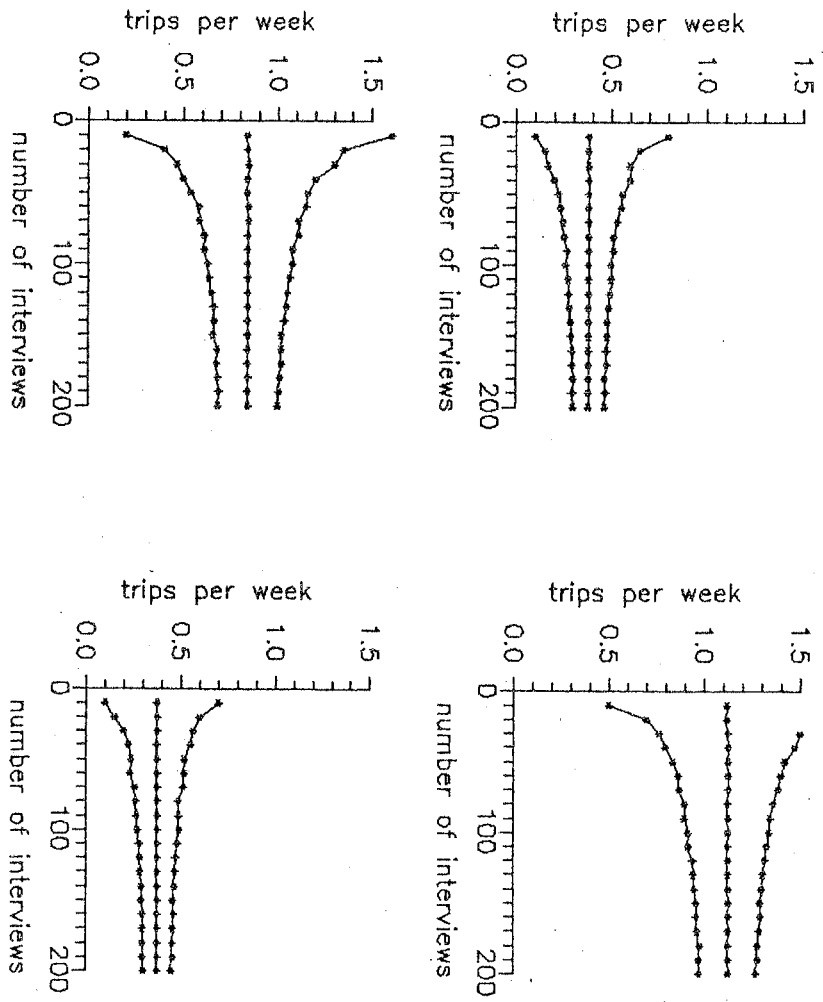


Figure 1.

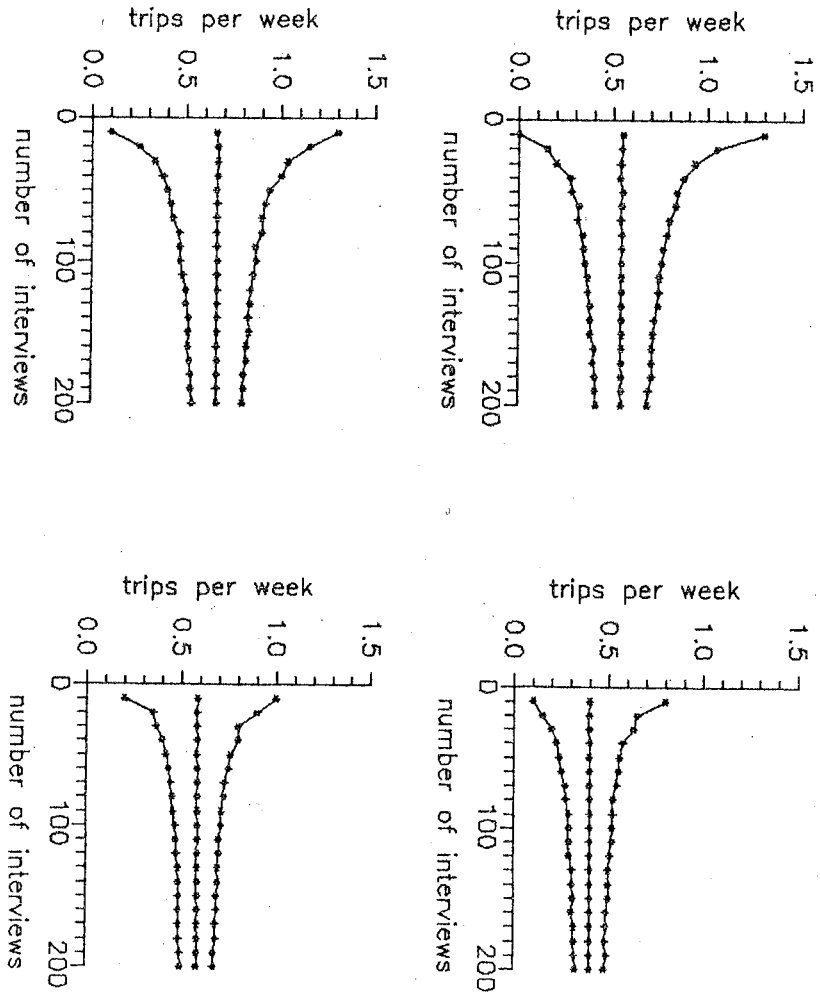


Figure 2.

Figure 3.

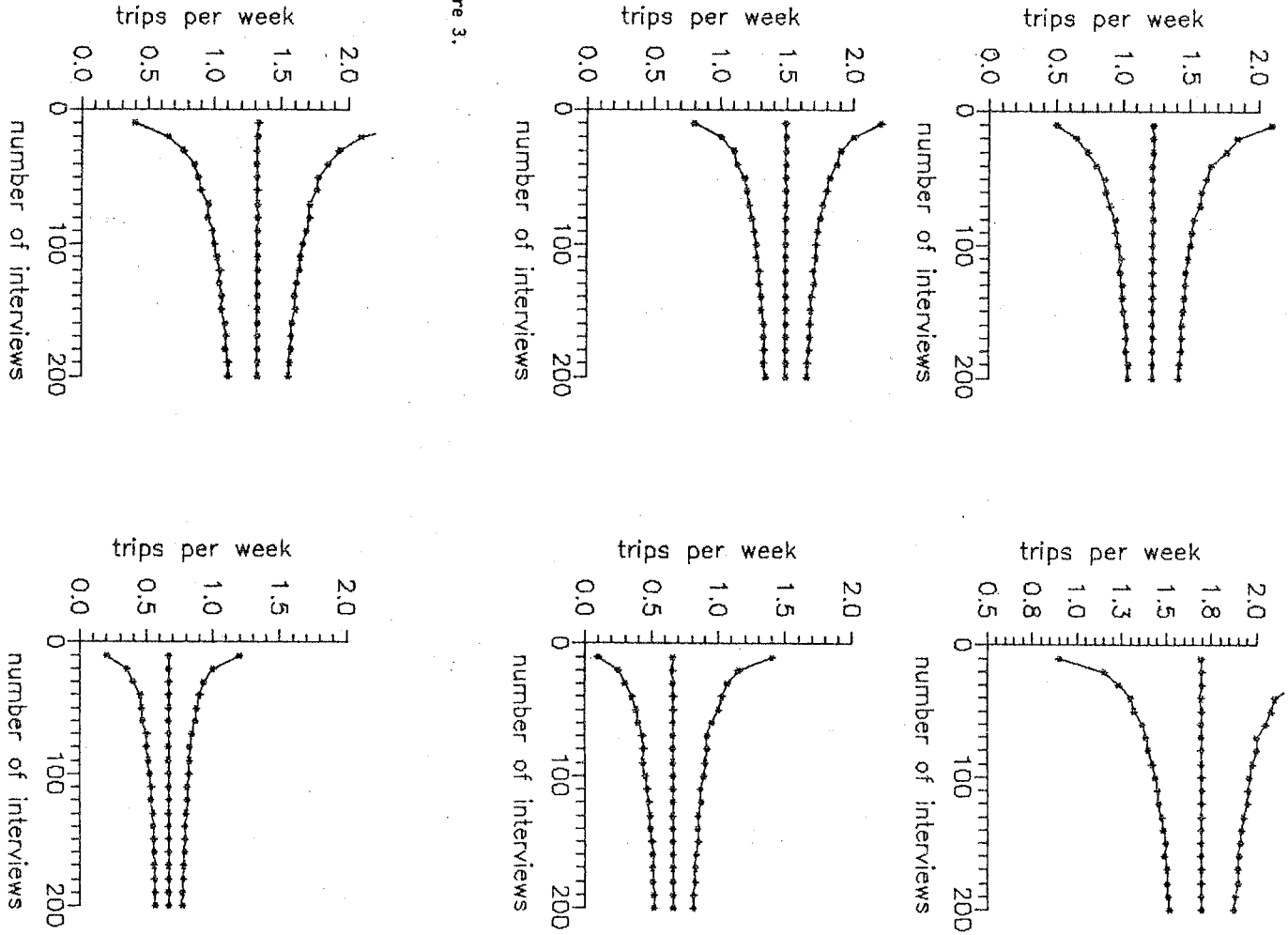
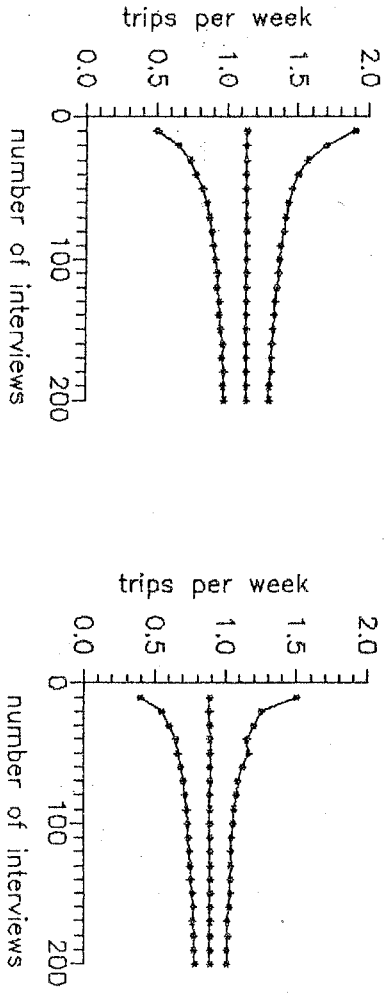


Figure 4.



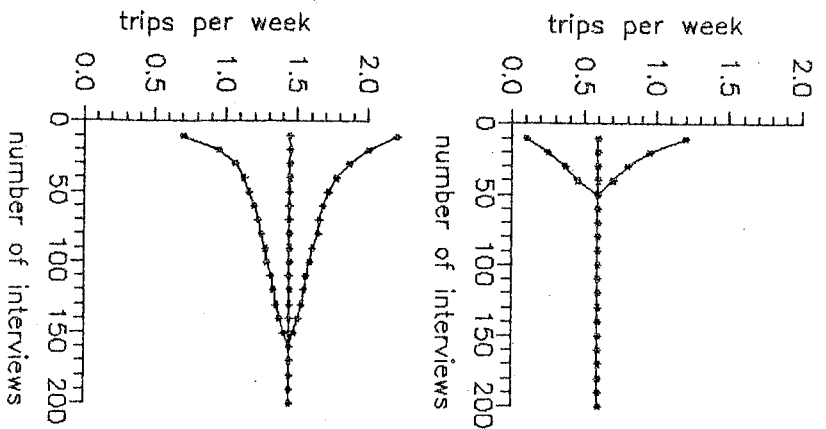
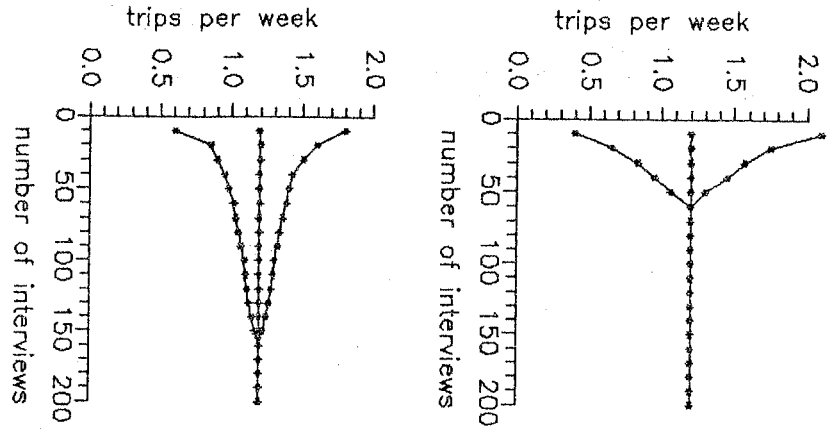


Figure 5.

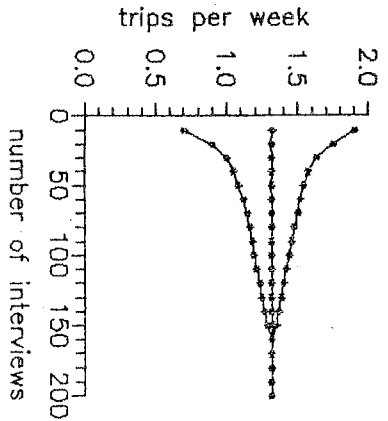
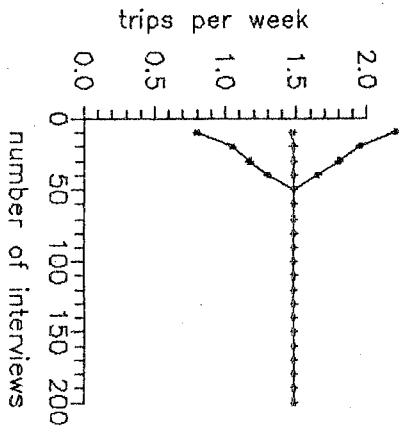
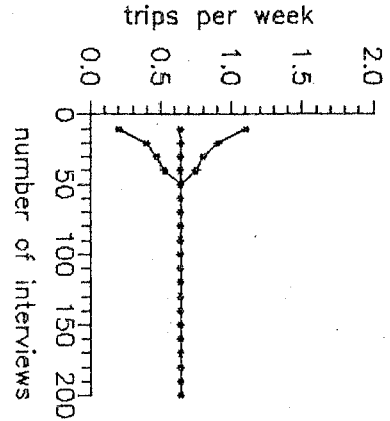
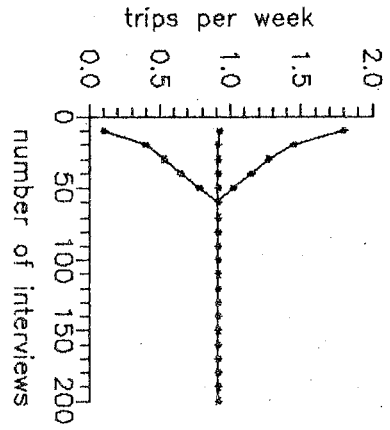
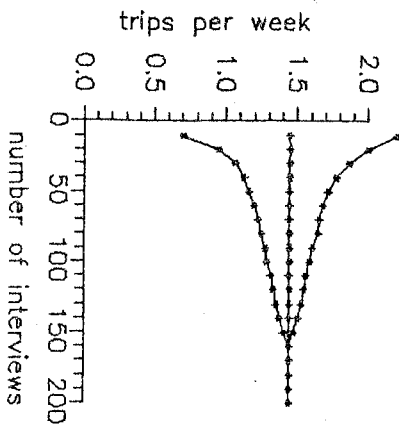
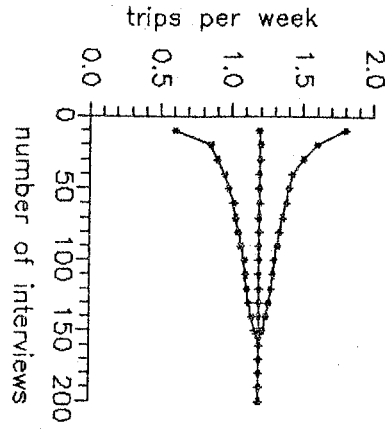


Figure 6.