

RELATIONSHIP OF CHARTER/PRIVATE VESSEL SAMPLING LEVELS TO THE VARIANCE OF  
THE EFFORT ESTIMATORS FOR THE VIRGINIA ROD AND REEL PELAGIC FISHERY

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RESUMEN

SUMMARY

The variance of effort estimators at various sampling levels (numbers of phone contacts by boat type) was examined in order to develop a sampling design to estimate catches in the handline and rod and reel fishery off Virginia. Hypothetical populations of effort values (trips per boat during a week) for both private and charter vessels were derived from examination of empirical data. Bootstrap samples were drawn from these distributions to simulate different levels of effort sampling; the means and 90 percent confidence limits of the sample means were calculated. These suggest that the true mean effort value for the private fleet could be estimated (with 90 percent certainty) within about  $\pm 50$  percent, if 45 captains are contacted, and  $\pm 30$  percent if the sampling level is 100. The true mean effort value for the charter fleet could be estimated (with 90 percent certainty) within about  $\pm 15$  percent with 45 contacts, and  $\pm 4$  percent if 75 boats were contacted.

RESUME

La variance des estimations de l'effort à plusieurs niveaux d'échantillonnage (nombre de contacts par téléphone par type de bateau) a été examinée afin de développer un schéma d'échantillonnage pour estimer les prises de la pêcherie à la ligne à main et à la canne et moulinet au large de la Virginie. Les populations hypothétiques des valeurs de l'effort (sorties par bateau pendant une semaine) des bateaux privés et en location ont été tirées de l'examen des données empiriques. Des échantillons itératifs ont été dessinés à partir de ces distributions pour simuler les différents niveaux de l'échantillonnage de l'effort; les moyennes et les limites de confiance de 90% de la moyenne de l'échantillon ont été calculées. Elles suggèrent que la vraie valeur de l'effort moyen de la flottille privée pourrait être estimée (avec 90% de certitude) dans environ  $\pm 50\%$  si 45 capitaines étaient contactés et  $\pm 30\%$  si le niveau de l'échantillonnage est 100. La vraie valeur moyenne de l'effort de la flottille en location pourrait être estimée (avec 90% de certitude) dans environ  $\pm 15\%$  avec 45 contacts et  $\pm 4\%$  si 75 bateaux étaient contactés.

Se examinó la varianza de los estimadores de esfuerzo en varios niveles de muestreo (número de contactos telefónicos por tipo de barco), con el objetivo de desarrollar un proyecto de muestreo para estimar las capturas de las pesquerías de línea de mano y caña-carrete frente a Virginia. Se dedujeron, a partir del examen de datos empíricos de valores de esfuerzo sobre poblaciones hipotéticas (viajes/barco durante una semana), tanto para los barcos de propiedad privada como para los alquilados. Se extrajeron muestras de los ensayos iterativos a partir de submuestras ("bootstrap") de estas distribuciones, para simular diversos niveles de esfuerzo de muestreo; se calcularon las medias y los límites de confianza del 90% de la media de la muestra. Estos sugieren que el verdadero valor medio del esfuerzo para la flota privada podría estimarse (con un 90% de certeza) entre aproximadamente  $\pm 50\%$  si se establece contacto con 45 capitanes, y  $\pm 30\%$  si el nivel de muestreo es 100. El verdadero valor medio del esfuerzo para la flota alquilada podría estimarse (con un 90% de certeza) entre aproximadamente  $\pm 15\%$  con 45 contactos, y  $\pm 4\%$  si se establece contacto con 75 barcos.

**Purpose:** To examine the variance of the effort estimators at various sampling levels (numbers of phone contacts by boat type) to assist in the development of a sampling design.

**Methodology:** Hypothetical populations of effort values (trips per boat during a week) for both private and charter vessels were derived from examination of empirical data. The mean trips per week for each sampled boat are shown by wave in Table 1. To evaluate the worst case scenario, samples with an adequate number of observations and the highest variances were selected (June and July 1989 for private, June and July 1987 for charter). For each boat type, ignoring normality assumptions, the sample distributions had no significant differences within or between months June and July. A single frequency distribution of effort values was therefore constructed for each boat type. This distribution contained 388 observations for private boats (Fig. 1), but only 37 observations for charter boats. Each charter boat observation was duplicated, resulting in a frequency distribution (Fig. 2) with a sample size (74 observations) thought to approximate the charter boat fleet size (expected to be 70-100 boats). Since these distributions served as hypothetical populations, frequency values had to be interpolated (assigned a value midway between the flanking values) when there were no observations for a given level of effort within the observed range. Values were interpolated for the 4 trips per boat level (4 observations added for private) and the 5 trips per boat level (5 observations added for charter).

To simulate different levels of effort sampling, bootstrap samples were drawn from these distributions. For example, at the sampling level of 20 for private boats, 20 observations were drawn randomly and with replacement from the hypothetical distribution and a sample mean was calculated. This process was repeated 1000 times for each sampling level. Since sample sizes tended to be a larger fraction of the charter boat population (thought to number close to the hypothetical population of 79 vessels), samples were drawn without replacement.

**Results:** The accompanying figures show the declines in variance of the sample means with increasing sampling levels for private (Fig. 3) and charter (Fig. 5) boats. For both boat types, dramatic reductions in variance occur as sample size is increased from 20 to 45 phone contacts. Substantial declines in variance also result when sample size is increased further to 100 contacts for private boats and 75 contacts for charter boats (almost the entire hypothetical population). Of note is the fact that the variances levels for charter boats tend to be an order of magnitude greater than those of private boats.

Also shown are the mean and 90% confidence limits of the sample means at each level of sampling for private (Fig. 4) and charter (Fig. 6) boats. The mean of the sample means is slightly higher than that of the empirical data in each case due to addition of observations at the 4 and 5 trips per week level, respectively. These figures suggest that the true mean effort value for the private fleet could be estimated (with 90% certainty) within about +/- 50% if 45 captains are contacted and +/- 30% if the sampling level is 100. Similarly, the true mean effort value for the charter fleet could be estimated (with 90% certainty) within about +/- 15% with 45 contacts and +/- 4% if the sampling were a near census contacting 75 boats.

**List of Figures:**

Figure 1. Frequency distribution of trips per week for a hypothetical population of private boats in the Virginia fishery. This distribution was created using sampled data for June and July 1989, with the addition of four observations at the 4 trips per week level.

Figure 2. Frequency distribution of trips per week for a hypothetical population of charter boats in the Virginia fishery. This distribution was created using sampled data for June and July 1987, with the addition of five observations at the 5 trips per week level. Doubling the number of observations at each effort level resulted in a hypothetical population of the approximate size of the true population.

Figure 3. Relationship of the variance of the private boat sample means to the size of the samples drawn randomly from the hypothetical population. For each sample size level, 1000 samples were drawn.

Figure 4. Relationship of the mean and confidence limits of the private boat sample means to the size of the samples drawn randomly from the hypothetical population. For each sample size level, 1000 samples were drawn.

Figure 5. Relationship of the variance of the charter boat sample means to the size of the samples drawn randomly without replacement from the hypothetical population. For each sample size level, 1000 samples were drawn.

Figure 6. Relationship of the mean and confidence limits of the charter boat sample means to the size of the samples drawn randomly from the hypothetical population. For each sample size level, 1000 samples were drawn.

Table 1

Mean Trips per Week observed in June and July for vessels sampled in the Virginia Large Pelagic Survey 1987-1991

Year	Boat Type	Wave Start		N	Mean	Std.Dev.	
		mon	day				
1987	CHARTER	6	1	2	0.00	0.00	
		6	15	10	3.10	2.02	
		6	22	6	2.17	2.79	
		6	29	2	1.50	2.12	
		7	6	6	2.83	2.64	
		7	13	4	2.50	3.32	
		7	20	3	1.33	2.31	
		7	27	4	3.21	3.18	
			TOTAL		37	2.45	2.44
	PRIVATE	6	1	44	0.24	0.46	
		6	15	36	0.56	0.77	
		6	22	42	0.33	0.79	
		6	29	46	0.41	0.65	
		7	6	42	0.48	0.80	
		7	13	46	0.50	0.69	
		7	20	46	0.39	0.54	
		7	27	45	0.18	0.39	
		TOTAL		347	0.38	0.65	
1988	CHARTER	6	1	1	2.58	-	
		6	20	3	1.67	1.53	
		6	27	3	3.00	3.61	
		7	4	1	2.00	-	
		7	11	0	-	-	
		7	18	4	1.50	1.73	
		7	25	1	2.50	-	
			TOTAL		13	2.08	1.93
		PRIVATE	6	1	4	0.18	0.37
	6		20	27	0.37	0.56	
	6		27	27	0.37	0.56	
	7		4	29	0.59	0.68	
	7		11	31	0.52	0.77	
	7		18	26	0.31	0.47	
	7		25	24	0.25	0.39	
			TOTAL		168	0.40	0.60

Table 1 cont.

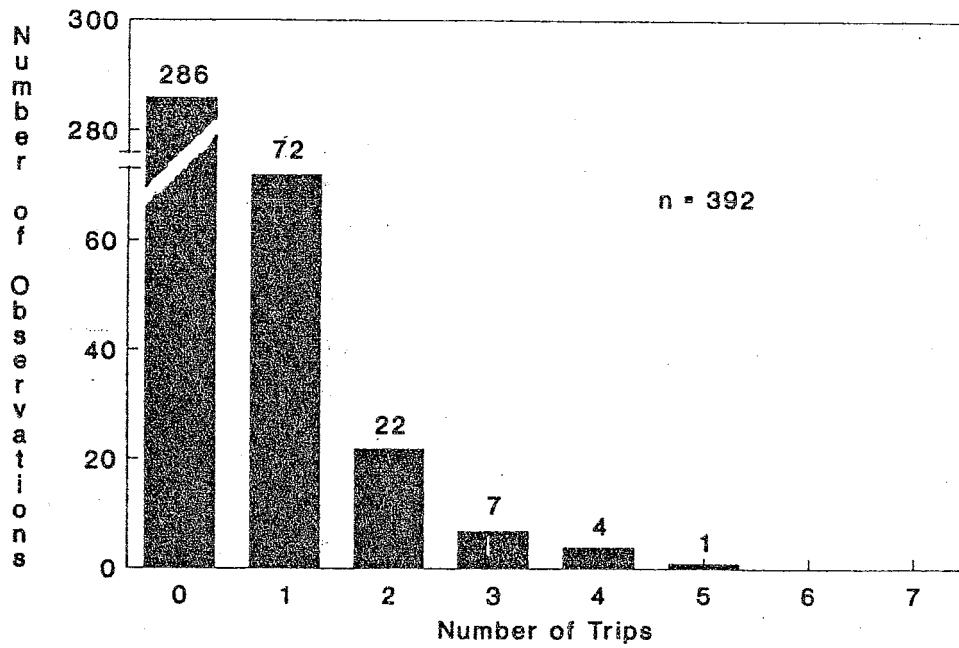
Year	Boat Type	Wave mon	Start day	N	Mean	Std.Dev.
1991	CHARTER	6	3	1	0.00	-
		6	10	0	-	-
		6	17	1	3.00	-
		6	24	0	-	-
		7	1	2	3.00	1.41
		7	8	1	3.00	-
		7	15	2	1.00	1.41
		7	22	1	0.00	-
		7	29	1	0.00	-
		TOTAL		9	1.56	1.59
	PRIVATE	6	3	45	0.22	0.52
		6	10	45	0.33	0.67
		6	17	48	0.31	0.55
		6	24	20	0.25	0.44
7		1	20	0.65	0.93	
7		8	49	0.18	0.44	
7		15	42	0.26	0.54	
7		22	53	0.15	0.36	
7		29	25	0.18	0.32	
	TOTAL		348	0.26	0.54	
TOTAL	CHARTER	-	-	135	1.62	1.94
	PRIVATE	-	-	1552	0.33	0.63

Table 1 cont.

Year	Boat Type	Wave mon	Start day	N	Mean	Std.Dev.
1989	CHARTER	6	1	10	0.51	0.50
		6	12	10	0.50	0.71
		6	19	4	0.00	0.00
		6	26	3	2.00	2.00
		7	3	3	2.00	2.00
		7	10	4	0.25	0.50
		7	17	2	4.00	2.83
		7	24	7	0.86	0.90
		7	31	2	0.50	0.71
		TOTAL		45	0.85	1.28
	PRIVATE	6	1	23	0.25	0.50
		6	12	41	0.41	0.84
		6	19	46	0.43	0.69
		6	26	47	0.40	0.65
7		3	45	0.42	0.78	
7		10	47	0.23	0.43	
7		17	47	0.45	0.75	
7		24	44	0.16	0.43	
7		31	48	0.40	0.94	
	TOTAL		388	0.36	0.70	
1990	CHARTER	6	4	2	0.50	0.71
		6	18	7	1.57	1.40
		6	25	6	1.83	1.33
		7	2	3	1.33	2.31
		7	9	3	3.67	3.21
		7	16	2	2.00	1.41
		7	23	4	0.00	0.00
		7	30	4	1.75	2.36
			TOTAL		31	1.58
	PRIVATE	6	4	33	0.20	0.30
		6	18	39	0.51	0.68
		6	25	18	0.56	0.86
		7	2	47	0.19	0.45
		7	9	44	0.23	0.74
7		16	48	0.27	0.54	
7		23	37	0.11	0.39	
7		30	35	0.40	0.74	
		TOTAL		301	0.29	0.60

Fig. 1

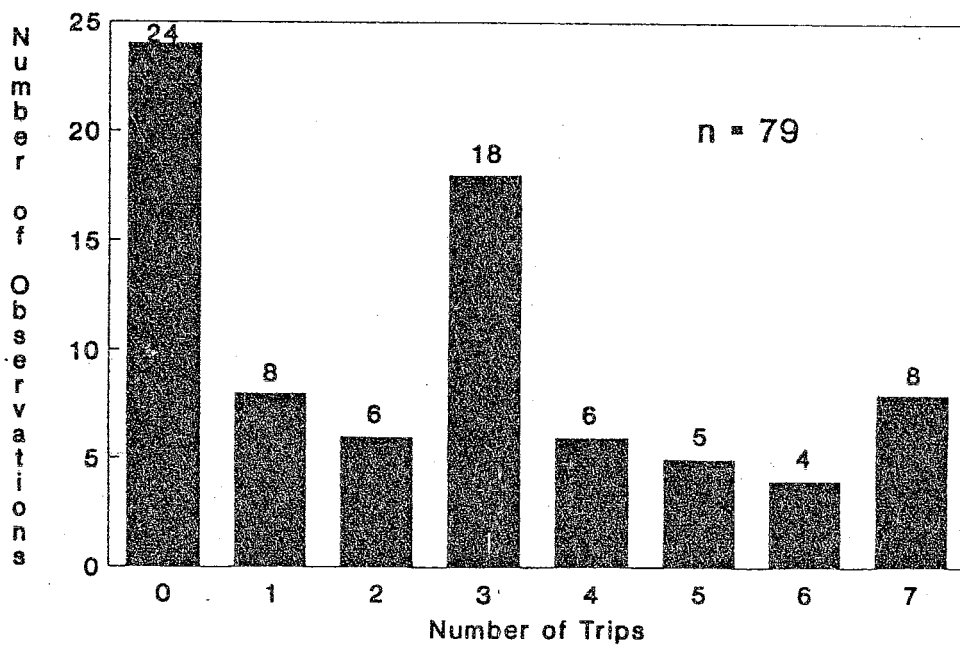
Hypothetical Effort Distribution  
for Private Fleet



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Fig. 2

Hypothetical Effort Distribution  
for Charter Fleet



(assuming highest observed variance)

Fig. 3 PRIVATE BOAT SAMPLING  
bootstrapping with replacement

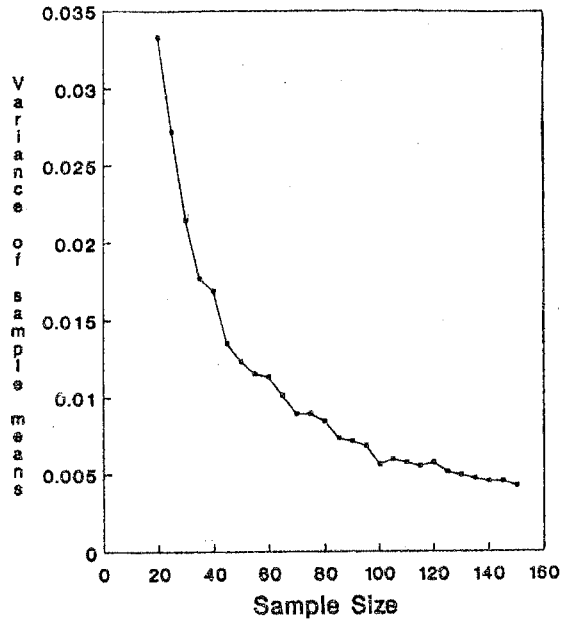


Fig. 5 CHARTER BOAT SAMPLING  
bootstrapping without replacement

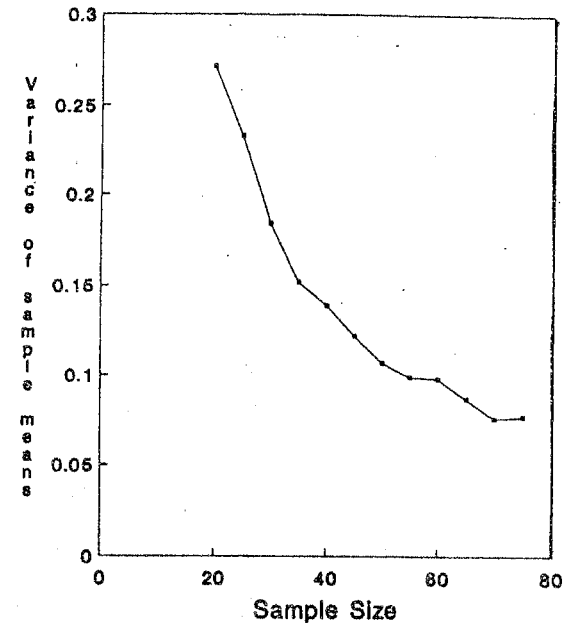


Fig. 4 PRIVATE BOAT SAMPLING  
bootstrap sampling with replacement

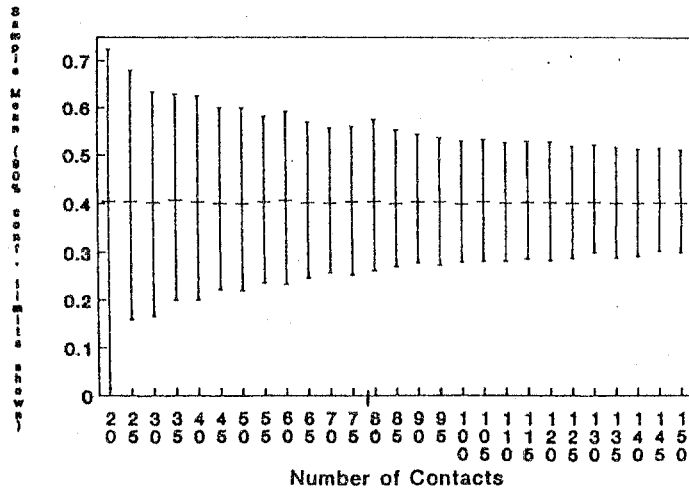


Fig. 6 CHARTER BOAT SAMPLING  
bootstrap samples drawn without replacement

