# Increasing Sampling Efficiency in Creel Surveys

**Lawrence W. McEachron,** *Texas Parks and Wildlife Department, Rockport, TX 78382*

**Albert W. Green,** *Texas Parks and Wildlife Department, 4200 Smith School Road, Austin, TX 78744*

**Gary E. Saul,** *Texas Parks and Wildlife Department, 4200 Smith School Road, Austin, TX 78744*

*Abstract:* Rising costs and increasing demands for limited marine resources dictate that managers monitor the status and utilization of these resources efficiently. Seventy-two percent to 100% of all weekend sport boat anglers completing a trip from 0700–1800 hours could be interviewed from 1000–1800 hours in Texas bay systems. A comparison of mean daily trailer boat counts suggest that optimum estimates of fishing pressure within a year can be made by stratifying data into 2 periods (13 November to 8 April; 9 April to 12 November).

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The demand for marine resources has increased dramatically in recent years and it will continue to increase in the future. The estimated number of saltwater anglers almost tripled in the 25 years from 1955 to 1980 according to the National Survey of Hunting and Fishing (U.S.D.I. Fish and Wildlife Service 1956, 1982). As a result, it has become increasingly important for managers to monitor the status and utilization of the limited marine resources. This has become increasingly difficult and expensive because of the size and diversity of recreational saltwater fisheries. Creel surveys are used to estimate the harvest of recreationally important fishes. Harvest is typically estimated as the product of catch per unit of effort determined through on-site interviews and fishing pressure determined through roving counts of fishing parties (Grosslein 1962, Lambou 1961, National Marine Fisheries Service 1980).

The Texas Parks and Wildlife Department (TPWD) began a marine sport fishing survey in 1974 of weekend boat anglers who completed their fishing trips during daylight hours (Heffernan et al. 1976, Breuer et al. 1977). Catch rates were determined by conducting angler interviews at boat ramps

and fishing pressure was determined by systematically driving to angler access areas and enumerating boat trailers (Heffernan et al. 1976). The original creel design was partitioned into 4 seasons: fall (September through November), winter (December through February), spring (March through May) and summer (June through August). Personnel and budgetary constraints dictated that creel surveys be conducted during 8-hour interview periods. Therefore, morning-midday and midday-evening survey periods based on day length but not exceeding 8 hours were established. Although this design was effective, anglers did not complete their fishing trips uniformly in time. A preliminary analysis in 1976 indicated that the majority of sport-boat fishermen completed their trips between 1000–1759 hours (Heffernan et al. 1976). In order to increase the efficiency of the creel clerk's time, a study was undertaken to determine the 8-hour interview period between 0700 and 1759 hours which would provide the greatest amount of information. Simultaneously, the roving data was examined to determine if the number of sampling periods could be reduced to increase sampling efficiency while providing more precise estimates of fishing pressure.

The objectives of this study were to: 1) determine the continuous 8-hour period from 0700–1759 hours when the majority of weekend sport boat anglers return from a trip, and 2) determine the number and length of sampling periods within a year that will provide for appropriate stratification and the most precise estimates of fishing pressure.

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## Methods

The number of boating parties completing a trip each hour from 0700–1759 hours was determined at randomly selected boat ramps in each of 7 Texas bay systems (Galveston, Matagorda, San Antonio, Aransas, Corpus Christi, upper Laguna Madre, and lower Laguna Madre) on 103 weekend days from September 1976 through August 1978. Hourly counts from all sites within each of 4 seasons were pooled within bays. Significant differences ($P < 0.05$) in the percent of anglers completing a trip during each hour from 0700–1759 hours among bays and among seasons were determined with a test of independence (Sokal and Rohlf 1969). Four possible 8-hour interview periods between 0700 and 1759 hours (0700–1459, 0800–1559, 0900–1659, and 1000–1759 hours) were compared to determine which period contained the highest percent of boating parties completing a trip.

Total boat pressure was estimated between 1000–1559 hours on 707

randomly selected days from September 1975 through August 1978 by counting trailers while roving specified routes at a constant speed around each bay system. Total fishing pressure was estimated by adjusting the proportion of sport fishing boaters relative to all sport boaters determined during interview periods (Heffernan et al. 1976). The starting point and direction of travel of each rove was randomly selected. The counts started at 0600 hours in 1974 and at 0900 or 1000 hours in 1975 and 1976 (see Heffernan et al. 1976 for additional details). During all years, counts included the hours of 1000–1559. Data for 0600–0659 hours were deleted from analysis because of insufficient sample size. Each year was divided into 10 equal periods. A 2-way analysis of variance with unequal sample sizes (Overall and Spiegal 1969) was used to test the hypothesis that there were no differences ($P = 0.05$) in mean daily trailer counts among years and among time periods in each bay system. Data were pooled where appropriate, and a sum of squares simultaneous test procedure (Sokal and Rohlf 1969) was used to determine which adjacent time periods were similar in each bay system.

## Results

Most sport-boat anglers completed their trips between 1000 and 1759 hours (Table 1). However, the percent of completed trips varied significantly by time of day, season, and bay system ($\chi^2 = 712$, df $= 288$, $P < 0.05$). The percent of fishing trips completed during 0700–0959 hours was less than the percent of trips completed during any other period in all 7 bay systems. The percent of boaters completing a trip from 1000–1759 hours in each bay system ranged from 72% to 100% but was greater than 84% for each bay each season except for the lower Laguna Madre in summer (Table 2).

Two distinct sampling seasons were defined based on the analysis of mean daily trailer counts. No significant differences ($P > 0.05$) were found in mean daily trailer counts among years within bay systems except for the upper Laguna Madre. Therefore, data were pooled within time periods within each bay system. Generally, adjacent periods from 13 November through 8 April and from 9 April through 12 November were similar ($P > 0.05$) in each bay system. However, overlapping of similar adjacent periods existed in each bay system except Galveston Bay (Table 3). These overlapping periods in some bays in fall (7 October through 18 December) and in spring (3 March through 15 May) are transitional periods in fishing pressure. Mean daily trailer counts during 9 April through 12 November were generally higher (4.08–24.13 trailers/period) than during 13 November through 8 April (0.65–9.18 trailers/period). However, this pattern varied among bay systems. Mean daily trailer counts within a season were not significantly different but collectively, the mean daily trailer counts were significantly different ($P < 0.05$) among seasons.

**Table 1.** Percent of sport-boat fishing parties completing a trip by season and bay system during 1-hour intervals, (Sep 1976–Aug 1978). Coastwide percents are based on unweighted means.

| Season and bay system | Time | | | | | | | | | | | Total trips completed |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | 0700–0759 | 0800–0859 | 0900–0959 | 1000–1059 | 1100–1159 | 1200–1259 | 1300–1359 | 1400–1459 | 1500–1559 | 1600–1659 | 1700–1759 | |
| Fall | | | | | | | | | | | | |
| (1 Sep through 30 Nov) | | | | | | | | | | | | |
| Galveston | 0.0 | 0.0 | 4.6 | 6.9 | 5.4 | 16.2 | 13.1 | 16.1 | 16.1 | 10.0 | 11.5 | 130 |
| Matagorda | 1.1 | 0.0 | 7.7 | 12.1 | 3.3 | 8.8 | 11.0 | 13.2 | 9.9 | 15.4 | 17.6 | 91 |
| San Antonio | 0.0 | 0.0 | 0.0 | 0.0 | 20.0 | 0.0 | 20.0 | 0.0 | 40.0 | 0.0 | 20.0 | 5 |
| Aransas | 0.0 | 8.0 | 8.0 | 12.0 | 16.0 | 12.0 | 16.0 | 8.0 | 4.0 | 4.0 | 12.0 | 25 |
| Corpus Christi | 0.0 | 0.0 | 0.0 | 11.4 | 28.6 | 14.3 | 11.4 | 5.7 | 11.4 | 8.6 | 8.6 | 35 |
| Upper Laguna Madre | 0.0 | 5.0 | 0.0 | 15.0 | 5.0 | 10.0 | 15.0 | 5.0 | 15.0 | 15.0 | 15.0 | 20 |
| Lower Laguna Madre | 2.0 | 5.9 | 3.9 | 0.0 | 1.8 | 3.9 | 21.6 | 17.6 | 7.8 | 17.6 | 7.8 | 51 |
| Coastwide | 0.4 | 2.7 | 3.4 | 8.2 | 12.8 | 9.3 | 15.4 | 9.4 | 14.9 | 10.1 | 13.2 | |
| Winter | | | | | | | | | | | | |
| (1 Dec through 29 Feb) | | | | | | | | | | | | |
| Galveston | 0.0 | 0.0 | 0.0 | 4.8 | 9.5 | 4.8 | 9.5 | 28.6 | 19.0 | 14.3 | 9.5 | 21 |
| Matagorda | 0.0 | 0.0 | 13.3 | 6.7 | 33.3 | 0.0 | 20.0 | 6.7 | 0.0 | 6.7 | 13.3 | 15 |
| San Antonio | 0.0 | 0.0 | 3.0 | 7.7 | 11.5 | 23.1 | 15.4 | 11.5 | 9.6 | 9.6 | 7.7 | 52 |
| Aransas | 0.0 | 0.0 | 0.0 | 4.0 | 4.0 | 20.0 | 24.0 | 2.0 | 22.0 | 14.0 | 10.0 | 50 |
| Corpus Christi | 0.0 | 0.0 | 3.7 | 3.7 | 3.7 | 14.8 | 7.4 | 18.5 | 22.2 | 11.1 | 14.8 | 27 |
| Upper Laguna Madre | 0.0 | 8.6 | 4.3 | 0.0 | 4.3 | 4.3 | 17.4 | 13.0 | 13.0 | 17.4 | 17.4 | 23 |
| Lower Laguna Madre | 3.6 | 0.0 | 10.7 | 5.4 | 5.4 | 10.7 | 12.5 | 12.5 | 10.7 | 17.8 | 10.7 | 56 |
| Coastwide | 0.5 | 1.2 | 5.1 | 4.6 | 10.2 | 11.1 | 15.2 | 13.2 | 13.8 | 13.0 | 11.9 | |

**Table 1.** Continued.

| Season and bay system | Time | | | | | | | | | | | Total trips completed |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | 0700–0759 | 0800–0859 | 0900–0959 | 1000–1059 | 1100–1159 | 1200–1259 | 1300–1359 | 1400–1459 | 1500–1559 | 1600–1659 | 1700–1759 | |
| Spring | | | | | | | | | | | | |
| (1 Mar through 31 May) | | | | | | | | | | | | |
| Galveston | 1.2 | 6.0 | 3.6 | 9.5 | 11.9 | 13.1 | 16.7 | 14.3 | 9.5 | 8.3 | 6.0 | 84 |
| Matagorda | 3.3 | 0.0 | 10.0 | 13.3 | 12.2 | 12.2 | 7.7 | 11.1 | 10.0 | 11.1 | 8.9 | 90 |
| San Antonio | 0.0 | 3.4 | 12.1 | 17.2 | 8.6 | 3.4 | 12.1 | 19.0 | 6.9 | 5.2 | 12.1 | 58 |
| Aransas | 1.9 | 0.0 | 5.6 | 13.0 | 20.4 | 14.8 | 13.0 | 11.1 | 5.6 | 7.4 | 7.4 | 54 |
| Corpus Christi | 2.4 | 0.0 | 0.0 | 12.2 | 19.5 | 17.1 | 14.6 | 7.3 | 4.9 | 4.9 | 17.1 | 41 |
| Upper Laguna Madre | 0.0 | 3.1 | 4.6 | 6.2 | 10.8 | 7.7 | 18.5 | 10.8 | 6.2 | 13.8 | 18.5 | 65 |
| Lower Laguna Madre | 0.0 | 3.8 | 2.6 | 5.1 | 14.1 | 16.7 | 10.2 | 9.0 | 9.0 | 5.1 | 24.3 | 78 |
| Coastwide | 1.2 | 2.3 | 5.5 | 10.9 | 13.9 | 12.1 | 13.2 | 11.8 | 7.4 | 8.0 | 13.5 | |
| Summer | | | | | | | | | | | | |
| (1 Jun through 31 Aug) | | | | | | | | | | | | |
| Galveston | 1.1 | 1.8 | 5.6 | 11.1 | 14.5 | 20.1 | 10.8 | 10.8 | 8.9 | 8.2 | 7.1 | 269 |
| Matagorda | 0.7 | 2.7 | 5.4 | 7.5 | 10.2 | 11.6 | 17.0 | 10.9 | 12.2 | 9.5 | 12.2 | 147 |
| San Antonio | 1.8 | 2.4 | 7.9 | 8.5 | 13.3 | 21.2 | 6.7 | 5.4 | 10.3 | 11.5 | 10.9 | 165 |
| Aransas | 2.0 | 4.0 | 7.0 | 10.0 | 12.9 | 14.8 | 16.8 | 13.9 | 7.0 | 3.0 | 9.0 | 101 |
| Corpus Christi | 0.0 | 0.0 | 1.2 | 8.6 | 16.0 | 13.6 | 9.9 | 13.6 | 11.1 | 7.4 | 18.5 | 81 |
| Upper Laguna Madre | 0.0 | 0.0 | 0.0 | 20.0 | 17.1 | 11.4 | 5.7 | 14.3 | 11.4 | 14.3 | 5.7 | 35 |
| Lower Laguna Madre | 2.6 | 6.5 | 18.2 | 15.6 | 9.1 | 14.3 | 1.3 | 6.5 | 5.2 | 7.8 | 13.0 | 77 |
| Coastwide | 1.2 | 2.5 | 6.5 | 11.6 | 13.3 | 15.3 | 9.7 | 10.8 | 9.4 | 8.8 | 10.9 | |

**Table 2.** Percent of sport-boat fishing parties completing a trip during each of 4 different 8-hour time periods by bay system and season.

| Bay system | Time | | | |
|---|---|---|---|---|
| | 0700–1459 | 0800–1559 | 0900–1659 | 1000–1759 |
| Galveston | | | | |
| Fall[a] | 62.02 | 78.30 | 88.38 | 95.63 |
| Winter | 57.13 | 76.18 | 90.47 | 100.00 |
| Spring | 76.19 | 84.52 | 86.90 | 89.28 |
| Summer | 75.84 | 83.64 | 89.96 | 91.44 |
| Matagorda | | | | |
| Fall | 57.15 | 65.94 | 81.32 | 91.21 |
| Winter | 80.00 | 80.00 | 86.67 | 86.67 |
| Spring | 69.99 | 76.66 | 87.77 | 86.66 |
| Summer | 65.97 | 77.53 | 84.33 | 91.13 |
| San Antonio | | | | |
| Fall | 40.00 | 80.00 | 80.00 | 100.00 |
| Winter | 73.08 | 82.70 | 92.32 | 96.16 |
| Spring | 75.87 | 79.32 | 84.49 | 84.49 |
| Summer | 67.26 | 75.74 | 84.84 | 87.87 |
| Aransas | | | | |
| Fall | 80.00/ | 84.00 | 80.00 | 84.00 |
| Winter | 54.00 | 76.00 | 90.00 | 100.00 |
| Spring | 79.62 | 83.33 | 90.74 | 92.59 |
| Summer | 81.18 | 86.13 | 85.14 | 87.12 |
| Corpus Christi | | | | |
| Fall | 71.43 | 82.86 | 91.43 | 100.00 |
| Winter | 51.84 | 74.06 | 85.17 | 96.28 |
| Spring | 73.17 | 75.61 | 80.49 | 97.56 |
| Summer | 62.96 | 74.07 | 81.48 | 98.77 |
| Upper Laguna Madre | | | | |
| Fall | 55.00 | 70.00 | 80.00 | 95.00 |
| Winter | 52.18 | 65.22 | 73.91 | 86.95 |
| Spring | 61.54 | 67.69 | 78.46 | 92.30 |
| Summer | 68.57 | 80.00 | 94.29 | 100.00 |
| Lower Laguna Madre | | | | |
| Fall | 66.66 | 72.54 | 84.31 | 88.23 |
| Winter | 60.71 | 67.85 | 85.71 | 85.71 |
| Spring | 61.54 | 70.51 | 71.79 | 93.59 |
| Summer | 74.02 | 76.61 | 77.91 | 72.72 |
| Coastwide | | | | |
| Fall | 61.75 | 76.23 | 83.63 | 93.44 |
| Winter | 59.31 | 74.57 | 86.32 | 93.11 |
| Spring | 71.13 | 76.81 | 82.95 | 90.92 |
| Summer | 70.83 | 79.10 | 85.42 | 89.86 |

[a] Fall = 1 Sep through 30 Nov; Winter = 1 Dec through 29 Feb; Spring = 1 Mar through 31 May; Summer = 1 Jun through 31 Aug.

**Table 3.** Mean daily trailer counts by sample period and bay system.

| Bay system | 1 Sep–6 Oct | 7 Oct–12 Nov | 13 Nov–18 Dec | 19 Dec–24 Jan | 25 Jan–2 Mar | 3 Mar–8 Apr | 9 Apr–15 May | 16 May–20 Jun | 21 Jun–27 Jul | 28 Jul–31 Aug |
|---|---|---|---|---|---|---|---|---|---|---|
| Galveston | 7.06A[a] | 8.82A | 2.71B | 0.65B | 2.22B | 3.41B | 4.82C | 10.41C | 9.17C | 8.84C |
| Matagorda | 14.42A | 7.64AB | 4.22B | 6.42B | 2.10B | 4.94B | 8.92BC | 13.56C | 13.54C | 10.64C |
| San Antonio | 14.09A | 11.07AB | 8.53AB | 9.18AB | 3.15B | 5.65B | 10.29BC | 14.58C | 24.13C | 15.27C |
| Aransas | 7.49A | 10.16A | 4.57B | 3.96B | 2.53B | 3.59B | 4.60BC | 8.65BC | 8.28C | 6.87C |
| Corpus Christi | 10.01A | 9.91A | 6.98B | 2.76B | 3.66B | 6.42BC | 4.08BC | 8.64C | 13.43C | 12.08C |
| Upper Laguna Madre | 8.81AB | 8.32AB | 4.20B | 3.87B | 4.62BC | 8.03BC | 10.76C | 12.08C | 12.21C | 10.85C |
| Lower Laguna Madre | 9.53AB | 9.07AB | 4.89B | 3.55B | 3.20B | 7.11BC | 9.26C | 12.46C | 12.33C | 8.37C |

[a] Means followed by the same letter are not significantly ($P > 0.05$) different.

## Discussion

When discussing sampling problems in creel surveys, Lambou (1961) and Otto (1971) emphasized that fishermen were not distributed homogeneously in time or space. This study demonstrates that marine sport-boat anglers do not complete their trips uniformly in time within or among bay systems. Sport-boat anglers in the lower Laguna Madre complete their fishing trips earlier in the day than do anglers in other bay systems. However, of the 4 possible 8-hour interview periods from 0700–1759 hours, the period of 1000–1759 hours incorporated 72% to 100% of all interviews at a site in each bay system. Therefore, the most efficient use of a creel clerk's time, which provides the maximum information in a given 8-hour interview period, was accomplished by establishing a 1000–1759 sampling period. Data collected during this period can be used to adjust total boat pressure to estimate sport fishing pressures.

Additionally, this study indicates a 2-season stratification for estimating fishing pressure should be used in TPWD marine creel surveys. Basically, the 2 seasons are a combination of summer-fall and winter-spring and may have general applicability. Malvestuto et al. (1978) reported distinct summer (April–October) and winter (November–March) periods on West Point Reservoir, Georgia, based on the precision of estimates of catch and effort. Brown (1970) reported that the December–March period received the least fishing in 12 Oklahoma lakes, and Von Geldern Jr. (1972) indicated a seasonal trend in fishing pressure on Folsom Lake, California, with low pressure in winter, high pressure in spring, and intermediate pressure in summer and fall. These studies, along with the present study, emphasize the need to critically examine pressure data in order to determine the optimum yearly sampling periods in creel surveys. Reducing the number of sampling periods and treating bay systems similarly reduces computational requirements associated with multiple strata and increases sampling efficiency while providing more precise estimates of fishing pressure and harvest. Additionally, this information can be used to initiate non-uniform probability sampling within creel surveys (Kish 1965).

## Literature Cited

Breuer, J. P., R. L. Benefield, M. G. Weixelman, A. R. Martinez, and I. Nava. 1977. Survey of finfish harvest in selected Texas bays Segment II. Texas Parks Wildl. Dep., Coastal Fish. Branch, Proj. Rep. 2-231-R-2. Austin, Texas.

Brown, B. E. 1970. Implications from the Oklahoma state lake creel survey to improve creel survey design. Proc. Annu. Conf. Southeast. Assoc. Game and Fish Comm. 24:577–590.

Grosslein, M. D. 1962. Estimation of angler harvest on Oneida Lake, New York. Ph.D. Dissertation. Cornell Univ., Ithaca, N.Y.

Heffernan, T. L., A. W. Green, L. W. McEachron, M. G. Weixelman, P. C. Hammerschmidt, and R. A. Harrington. 1976. Survey of finfish harvest in selected Texas bays. Texas Parks Wildl. Dep., Coastal Fish. Branch, Proj. Rep. 2-231-R-1. Austin, Texas.

Kish, Leslie. 1965. Survey sampling. John Wiley and Sons, New York, N.Y. 643pp.

Lambou, V. M. 1961. Determination of fishing pressure from fishermen or party counts with a discussion of sampling problems. Proc. Annu. Conf. Southeast. Assoc. Game & Fish Comm. 15:380–401.

Malvestuto, S. P., W. D. Davies, and W. L. Shelton. 1978. An evaluation of the roving creel survey with nonuniform probability sampling. Trans. Am. Fish. Soc. 107(2):255–262.

National Marine Fisheries Service. 1980. Marine recreational fishery statistics survey, Atlantic and Gulf coast, 1979. U.S. Dep. Commerce. 139pp.

Otto, R. S. 1971. Design of a creel survey for the striped bass sport fishery along the central Maine coast. M.S. thesis. Dep. of Zool., Univ. Maine, Orono.

Overall, J. E. and D. K. Spiegal. 1969. Concerning least square analysis of experimental data. Pschyol. Bul. 72(5):311–322.

Sokal, R. R. and J. Rohlf. 1969. Biometry. W. N. Freeman and Co., San Francisco, Calif.

United States Department of the Interior, Fish and Wildlife Service. 1956. National Survey of Fishing and Hunting 1955. U.S. Gov. Printing Office, Washington, D.C.

United States Department of the Interior, Fish and Wildlife Service and United States Department of Commerce, Bureau of the Census. 1982. 1980 National Survey of Fishing, Hunting, and Wildlife-Associated Recreation. U.S. Gov. Printing Office, Washington, D.C.

Von Geldern, C. E. Jr. 1972. Angling quality at Folsom Lake, California, as determined by a roving creel census. Calif. Fish & Game 58(2):75–93.