Comparison of Harvest Rates for the Marine Recreational Fishery on the Eastern and Western Sides of Mobile Bay, Alabama, October 1984–September 1985[1]

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Abstract: Creel survey data collected from the marine recreational fishery in Alabama revealed that there were differences in harvest per unit of effort (HPUE) between the eastern and western sides of Mobile Bay. The total recreational landings from Alabama marine waters and adjacent offshore waters was 1,300,000 fish weighing 772,700 kilograms. Of the 2,250,000 angler-hours exerted on the fishery, 1,245,000 angler-hours (55%) were directed at particular species of fish, primarily flounders, red drum, speckled seatrout, Spanish mackerel and king mackerel. HPUE of Spanish mackerel and king mackerel was found to be significantly different ($P \leq 0.10$) between the 2 sides of the bay and comparisons also revealed spatial differences across specific fisheries. The seasonal pattern of HPUE of flounders and red drum significantly ($P \leq 0.10$) shifted from one side of the bay to the other.

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The recreational fishery associated with the marine waters of the state of Alabama is highly visible and contributes substantially to the total harvest of those particular marine fishes considered valuable for both sport and food (Wade 1977). A major area of interest in current Gulf of Mexico marine fisheries practices concerns the management of 5 primary gamefishers: speckled seatrout (*Cynoscion arenarius*); red drum (*Sciaenops ocellata*); Spanish mackerel (*Scomberomorus maculatus*); king mackerel (*Scomberomorus cavalla*); and flounders (*Paralichthys* spp.).[2] Additionally, marine fisheries state agencies have expressed a need for detailed fishery characteristics that describe more localized areas, so that management

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[2]Flounders include gulf flounder (*Paralichthys albigutta*), southern flounder (*P. lethostigma*), and broad flounder (*P. squamilentus*).

options can be directed at smaller, more manageable components of the marine resource. The emphasis of this paper is to compare the spatial distributions and, to a lesser degree, the temporal (seasonal) fluctuations in harvest rate for these gamefishes during the study period, 1 October 1984–30 September 1985.

Wade (1977) made the only previous study specifically of the Alabama marine recreational fishery. The National Marine Fisheries Service (NMFS) has provided estimates of participation, harvest, and effort by recreational anglers in the marine waters of the United States since 1979. The NMFS survey uses a combined approach to collect data and generate estimates. Telephone interviews provide estimates of the number of trips made during a specified time period and intercept surveys provide estimates of what was caught on an average fishing trip during that same period (NMFS 1984). Both Wade's (1977) study and the NMFS survey relied strongly on the use of mail or telephone contact methods, respectively, for sampling purposes. The major drawbacks with the information obtained using these methods are the nonsampling errors associated with recall over time, such as "telescoping," when anglers include events outside the recall period, and "omission," when anglers omit events within the recall period (Malvestuto 1983). Nonresponse error, which occurs when a particular portion of the target population does not return the questionnaire, is another problem associated with mail surveys (follow-up mailings can increase the percentage of responses) (Malvestuto 1983). Also, Wade's (1977) study did not incorporate measures of variability; therefore, an evaluation of the reliability of the conclusions cannot be made. The NMFS survey, though sound in methodology, was aimed more at broad regional trends and the information generated does not incorporate more localized changes that may be of importance for fisheries management by state agencies.

It is general knowledge that the needs and preferences of the fishing public differ greatly on the 2 sides of Mobile Bay. The eastern side of the bay is characterized by an increasingly growing tourist industry, and vacationing anglers, both in-state and out-of-state, contribute substantially to the total effort exerted on the marine resource. In contrast, the western side of the bay is fished most heavily by lower income anglers from the local communities, and the surrounding area draws vacationing anglers only to a minor degree. For this reason, the statistical design incorporated geographical stratification and the contrast between the fishing public on the 2 sides of the bay was expected to affect the characteristics of the fisheries differently.

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Methods

Study Area and Time Frame

The study area was geographically stratified into 2 regions (geostrata), Baldwin County and associated coastline east of Mobile Bay, and Mobile County with associated coastline west of Mobile Bay. The study area comprised all of the estuarine and marine waters of Alabama including offshore waters. The total recreational fishery was divided into 4 major study groups (fisheries): private boats fishing the bays, sounds, inlets, estuaries, and brackish water rivers from the causeway at Mobile south, to include Mississippi Sound (INSHORE BOAT); bank and shoreline fishing (BANK); private boats fishing in the Gulf of Mexico south of Mississippi Sound, outside the bays and other protected waters (OFFSHORE BOAT); and public pier fishing (PIER). Anglers in the PIER and OFFSHORE BOAT study groups were intercepted at access points. Another on-site intercept method, the roving creel survey, was used to contact anglers in the BANK and INSHORE BOAT study groups. For all of the roving samples, each county was further divided into subsections. Baldwin County was partitioned into 8 distinct geographical sections and Mobile County was divided into 6 sections. Thus, spatial sampling units were either defined as geographical sections, (BANK and INSHORE BOAT) or access points (OFFSHORE BOAT and PIER).

The survey period for this study was from 1 October 1984–30 September 1985. Given low fishing pressure, lack of sampling personnel, and unknown precision on estimates of effort, harvest, and HPUE, the first half of the year was stratified into 2 3-month seasons: fall (October–December 1984) and winter (January–March 1985). The heavy fishing pressure associated with the marine waters of Alabama occurs during the spring and summer months and for this reason, the second half of the year was stratified into 6 1-month blocks (April–September 1985).

Survey Design

The survey was concerned with only those recreational anglers using the "hook and line" method of capture. Cast net, gill net, and trammel net fishermen were not incorporated into the sampling design because these people used fishing as a means of income and therefore their harvests were defined as commercial.

The basic sampling framework was discussed in detail by Malvestuto (1983). The survey design incorporated stratified, multi-stage probability sampling, which allowed comparisons between fisheries across geographical strata (counties) and across seasonal time blocks. Within any given season or month, as the case may be, the primary sampling units (PSUs) were defined as 12-hour fishing days which were stratified into weekdays and weekend days. Each day was divided into 3, 4-hour periods: 0600–1000 hours; 1000–1400 hours; and 1400–1800 hours. For sampling purposes, the 3 time periods in each day were equally weighted. The spatial units (access points or geographical sections) were weighted proportional to the projected fishing pressure exerted within each unit. A sampling unit within a day, or secondary sampling unit (SSU), was the combination of a 4-hour time period

and a spatial unit. For the INSHORE BOAT and BANK fisheries, the probability of choosing any given SSU was the product of the time period probability and the geographical section probability. The PIER and OFFSHORE BOAT probabilities were determined by multiplying the time period probabilities by the associated access point probabilities.

Each season in the first half of the survey year (fall 1984 and winter 1985) was randomly assigned 50 SSUs. Each month in the second half of the year (April–September 1985) was allocated 50 SSUs. Typically, during the fall and winter seasons, the inland waters and bays are fished more heavily than the offshore waters, therefore, the BANK and INSHORE BOAT fisheries were allocated 15 SSUs each per seasonal time block; whereas, the PIER and OFFSHORE BOAT fisheries received 10 SSUs each per season. Fifteen SSUs per 1-month time block were assigned to the PIER and OFFSHORE BOAT fisheries from April through September, and the BANK and INSHORE BOAT fisheries each received 10 SSUs per month, based on the same rationale. The pier fishery survey was terminated in Mobile County after August 1985 because of irreparable damage to the public fishing piers caused by Hurricane Elena.

Additionally, a household mail survey was conducted using pre-addressed, pre-paid, mail-in postcards. The focus of this survey was to sample the recreational boat owners that fished in the Gulf of Mexico who launched their vessels from private docks and ramps. Cards were mailed to a random sample of 10% of the registered boat owners in Mobile and Baldwin counties. The postcard outlined a map of the offshore fishery study area to help ensure that recipients understood the geographical region of interest.

Data Analysis

Apple IIe microcomputers were used to enter and store data on disks and the information was then uploaded to an IBM 3033 mainframe computer located on the Auburn University campus. The Statistical Analysis System (SAS 1982) was used to perform all statistical tests. All comparisons that were different at $P \leq 0.10$ were considered to be significant.

Procedures for obtaining expanded estimates of harvest rate, HPUE, were as per Malvestuto et al. (1978) and Malvestuto (1983). HPUE for the individual species was tested by ANOVA procedures using daily estimates as replicates. HPUE estimates were calculated from total angler effort and based on a per hour unit of effort. In this paper N-HPUE refers to the number of fish harvested per hour and W-HPUE represents the kilograms of fish harvested per hour.

The information collected from the mail survey of private dock and ramp owners was incorporated into the OFFSHORE BOAT study group to most accurately describe the magnitude of that fishery. The mail survey randomly sampled boat owners from both counties, that is, it did not incorporate geographical stratification. Consequently, total harvest estimates in number and weight for individual species could not be separated according to geostrata and thus statistical comparisons of offshore harvest between the 2 sides of the bay could not be made. The

removal of offshore harvest estimates precluded statistical tests of total harvest across geostrata because of the possibility of misinterpretation of results. This would be particularly true for species such as king mackerel and Spanish mackerel which were predominantly harvested from the offshore waters. HPUE estimates for the offshore fishery were obtained from the creel survey of ramps and marinas which allowed this variable to be statistically tested across geostrata.

King mackerel is an offshore species and was not found in the bank fishery or in the inshore boat fishery, hence it was removed from these fisheries for all ANOVA tests concerning HPUE rather than use daily zero-values. Spanish mackerel which was not found in the bank fishery was also removed from this fishery for analysis purposes.

Results and Discussion

Table 1 shows estimates of total fishing effort, harvest in number and weight, and HPUE in number and weight, for all species sampled during the survey for each fishery for both sides of Mobile Bay. The data indicate that when all species are viewed together, there were few geographical contrasts. Total bank fishing effort was significantly higher on the western side of the bay (Mobile County). For the descriptors of interest, only W-HPUE (HPUE in weight) for the offshore fishery changed significantly across geostrata (0.60 kg/hour in the west and 0.40 kg/hour in the east). Information generated from the creel survey showed that the majority of anglers that fished this resource preferred, or "targeted" particular species. Ap-

Table 1. Estimates of total fishing effort, harvest in number (N-HARVEST) and kilograms (W-HARVEST), and harvest rate in number (N-HPUE) and kilograms (W-HPUE) for each fishery on the 2 sides of Mobile Bay, Alabama (October 1984–September 1985). Relative standard errors (R.S.E.) are included as a measure of precision and express the standard error as a percentage of the estimate.

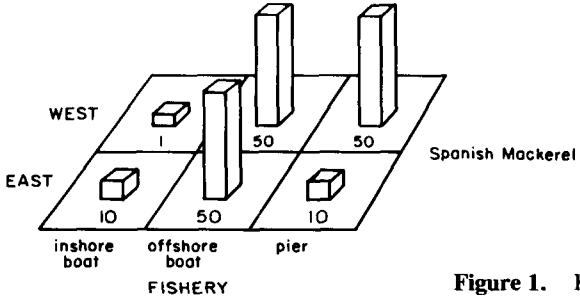
	Bank		Inshore Boat		Pier		Offshore Boat[a]	
	Bald.	Mo.	Bald.	Mo.	Bald.	Mo.	Bald.	Mo.
Effort								
Angler-hrs	170,600*	251,600*	180,800	227,400	110,400	105,300	1,201,700	
R.S.E.	13	9	16	23	6	10	17	
Harvest								
N-HARVEST	131,500	194,500	161,000	286,600	32,600	41,000	436,000	
R.S.E.	21	27	27	34	15	15	24	
W-HARVEST	32,400	40,300	63,400	78,600	14,800	16,000	521,800	
R.S.E.	21	20	28	30	17	14	30	
N-HPUE	0.80	0.80	0.90	1.30	0.30	0.40	0.50	0.40
R.S.E.	13	10	9	38	13	10	9	14
W-HPUE	0.20	0.20	0.40	0.40	0.14	0.14	0.40*	0.60*
R.S.E.	13	17	61	7	15	8	9	12

*Significant difference ($P \leq 0.10$) between the 2 sides of the bay within a particular fishery.
[a]Baldwin County and Mobile County were grouped together in the offshore boat fishery for harvest estimates, but remained separate for HPUE estimates (see Methods).

proximately 63% of the total intended effort was directed at the 5 primary gamefishes of concern here.

When the geostrata were viewed on a species-by-species basis, there were several significant contrasts between the 2 sides of the bay. Results of the analysis of variance for harvest rate of Spanish mackerel showed that anglers on the western side of the bay harvested approximately twice as many fish per hour (0.10) than anglers that fished the eastern side (0.04). The W-HPUE for Spanish mackerel was also significantly higher on the western side (0.04 kg) than on the eastern side (0.02 kg). Estimates of HPUE for king mackerel also significantly differed between geostrata. Again, the western side of the bay exhibited higher rates for number (0.01) and weight (0.03) than the eastern side, 0.002 and 0.01, respectively.

Results generated from the comparison of the fisheries (study groups) showed that there were significant differences in HPUE of Spanish mackerel and king mackerel. Anglers on the western side of the bay who fished the offshore waters harvested markedly more Spanish mackerel per hour (0.20) than anglers that fished from boats inshore (0.003) and twice as many fish per hour as anglers that fished from public piers (0.10). A similar trend, but with much lower rates, was observed for N-HPUE of Spanish mackerel on the eastern side of the bay where the rate from the offshore fishery (0.10) was 5 times greater than either the pier or inshore boat fisheries (0.02). The W-HPUE across fisheries for Spanish mackerel was also significantly



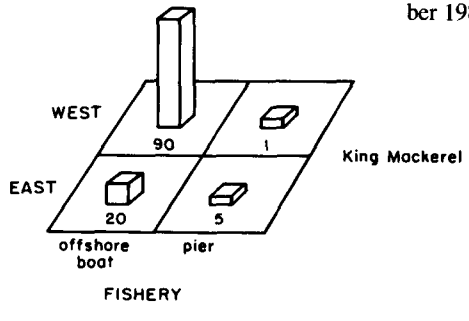


Figure 1. Kilograms per hour (W-HPUE x 1,000) of Spanish and king mackerel harvested from each fishery on the eastern and western sides of Mobile Bay, Alabama (October 1984–Setpember 1985).

different between the 2 sides of the bay and the trend was similar to that of N-HPUE (Fig. 1).

For king mackerel, anglers that fished offshore on the western side of the bay harvested more fish per hour (0.04) than anglers that fished the eastern side (0.005). Conversely, N-HPUE estimates showed that anglers who fished from public piers on the eastern side of the bay harvested 0.0004 fish per hour, as compared to 0.0001 fish per hour on the western side. Fig. 1 shows that W-HPUE of king mackerel across fisheries significantly differed from one side of the bay to the other, where the highest and lowest rates of fishing success were found in the offshore fishery and pier fishery, respectively, on the western side. It should be mentioned that the pier fishery contributed only 0.1% to the total number of king mackerel harvested for the year and 0.4% to the total weight harvested; all other king mackerel were harvested from the offshore boat fishery.

The significant differences for HPUE discussed thus far applied only to Spanish mackerel and king mackerel. These 2 species were found predominantly in the offshore waters and only occasionally ventured into bays, inlets, and other protected waters. Flounders, speckled seatrout, and red drum are inshore species and were found in the greatest numbers within the protected waters; no significant differences between geostrata were found for these 3 inshore gamefishes when testing the varibles N-HPUE and W-HPUE.

Seasonal estimates of N-HPUE, however, significantly differed between the two geostrata for the inshore species of flounder and red drum. Fig. 2 shows that the harvest rate of flounders on the eastern side remained constant throughout the year, at approximately 0.04 fish per hour, with the exception of the winter, when no fish were harvested. In contrast, anglers on the western side of the bay harvested the most flounders per hour in the winter and harvest rates remained relatively constant, averaging 0.03 flounders per hour, in the other seasons.

The harvest rate (N-HPUE) for red drum fluctuated throughout the survey year between the 2 sides of the bay (Fig. 2). On the eastern side, more fish were harvested per hour in the fall than for all other seasons combined; there were extremely low harvest rates during the winter and spring with a moderate increase during the summer. Anglers on the western side of the bay harvested no red drum in the fall, and harvest rate was very low in the winter and spring but then peaked in the summer (Fig. 2). There were no significant seasonal differences found in HPUE for the other inshore species, speckled seatrout, across geostrata.

There were seasonal differences between the two sides of the bay for W-HPUE for king mackerel. Fig 3 shows that anglers in the east did not harvest any king mackerel in the fall or winter, and subsequently harvested 0.003 kg per hour in the spring and 0.02 kg per hour in the summer. In contrast, W-HPUE for king mackerel on the western side peaked in the fall and drastically declined in the winter, when no fish were harvested. The rate increased again in the spring and continued to climb through the summer towards the fall peak. Anglers on the western side of the bay harvested more kilograms of king mackerel per hour than on the eastern side

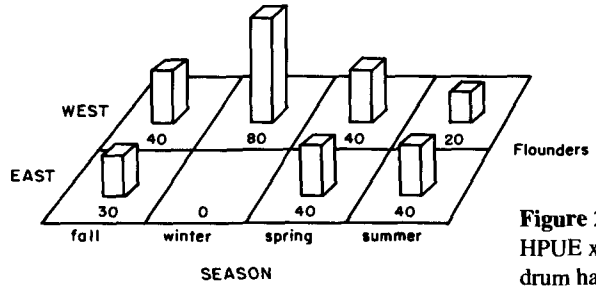
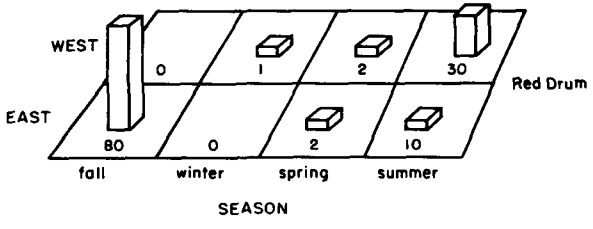


Figure 2. Number per hour (N-HPUE x 1,000) of flounders and red drum harvested in each season on the eastern and western sides of Mobile Bay, Alabama (October 1984–September 1985).



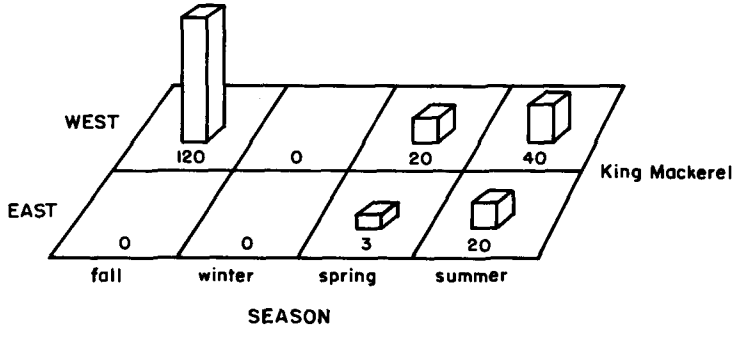


Figure 3. Kilograms per hour (W-HPUE x 1,000) of king mackerel harvested in each season on the eastern and western sides of Mobile Bay, Alabama (October 1984–September 1985).

for every season except winter, when there were no fish harvested on either side (Fig. 3).

To summarize:

(1) For all fisheries combined, fishing success was higher on the western side of the bay than on the eastern side for Spanish and king mackerel.

(2) Harvest rates of Spanish mackerel were significantly higher on the western

side of the bay relative to the east for the pier fishery, but higher on the eastern side for the inshore boat fishery.

(3) Harvest rates of king mackerel for the offshore fishery on the western side of the bay were significantly higher than on the eastern side.

(4) Harvest rates of flounders during most of the year were higher on the western side of the bay.

(5) A strong red drum fishery was observed in the fall and summer on the eastern side of the bay and only during the summer on the western side.

Estimates of harvest rate and effort are important descriptors of a fishery that can be used as indicators of the effect that fishing pressure has on stock densities. Total effort (angler-hours) on the western side of the bay was observed to be greater than, or equal to, the eastern side for all comparisons emphasized here. The offshore fishery was unable to be stratified geographically because of the mail survey and thus was not incorporated into the estimates of total effort (see Methods). Unfortunately, effort information for king and Spanish mackerel is of little value without the offshore fishery estimates of fishing pressure. However, the effort for the pier fishery was observed to be approximatey equal on the 2 sides of the bay, but the western side had significantly higher harvest rates of Spanish mackerel than the eastern side. The suggestion is that there were greater stock densities of Spanish mackerel or perhaps the species were more vulnerable (catchability higher) from piers on the western side of the bay.

N-HPUE for flounders on the western side of the bay was greater than, or equal to, estimates on the eastern side for every season except the summer (Fig. 2), despite higher observed total effort estimates on the western side for all of the seasons. This suggests higher stock densities, perhaps due to more productive biological conditions or more optimum habitat on the western side of the bay that would enable flounder populations to withstand higher levels of exploitation. This is supported by Bault (1972) who found that, in general, waters on the western side of Mobile Bay (west of the Mobile Ship Channel) had higher annual average concentrations of micronutrients than areas associated with the eastern side.

It is possible that differences in the characteristics of the angling public on the 2 sides of the bay contributed to the statistical differences in harvest rate for the 5 gamefishes documented by the survey. However, cursory analysis of intended effort data showed that there were only slight differences in species preferences between the eastern and western sides of the bay. Further socio-economic characterization of the angling public would be needed before any valid relationships of this sort can be made. Biological factors, in addition to the possible sociological contrasts, certainly played a role in the differences found. The patterns of HPUE of these gamefishes on each side of the bay suggest the occurrence of migrational trends (seasonal and geographical) and species specific behavioral characteristics. The spatial and temporal differences found indicate that Alabama's marine resource is not a homogeneous entity, but actually consists of smaller fishery systems that can behave differently; thus, management decisions concerning regulations may best be consid-

ered in a site and time specific framework. Additional information is needed regarding the life histories and stock identification of these marine fishes inhabiting Alabama waters. Because the marine system represents such a vast expanse, manipulation of the fish stocks has been viewed as a futile attempt at management. However, if fishery characteristics can be adequately documented over more localized areas, then, along with information regarding anglers' attitudes and economic benefits from fishing, more informed management plans tailored to specific situations may increase the probability of success.

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