Comparison of daytime and nighttime catches of bluefish (Pomatomus saltatrix) made on New Jersey party-boats

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INTRODUCTION

Bluefish (Pomatomus saltatrix) were ranked number one by weight of total recreational landings of marine species in the latest national angling survey (Deuel, 1973). The majority are caught during the summer and fall along the Middle Atlantic coast between Cape Hatteras and Cape Cod. They appear to be particularly abundant along the New Jersey and New York coasts where nearly one-fourth of the entire United States commercial sportfishing fleet is concentrated (Fraser et al., 1977). Along the Middle Atlantic coast party- or charter-boat anglers account for over 50% of the total bluefish catch (Deuel, 1973).

The catch of party- and charter-boats along the New Jersey coast was surveyed by National Marine Fisheries Service personnel of the Northeast Fisheries Center from July 1975 through May 1977 and the methods and some of the results of the survey have been published (Christensen et al., 1976). Preliminary analysis of the data indicated that bluefish catches made at night may have exceeded catches made during the day. However, nighttime sampling effort in that study was inadequate to determine differences in day and night catch rates for bluefish in 1975 and 1976.

This survey, funded by the Mid-Atlantic Fisheries Management Council, was conducted in order to determine the relative proportion of daytime and nighttime party-boat catches.

METHODS

In early June 1978, a survey was made to determine which party-boats along the New Jersey coast from Atlantic Highlands to Point Pleasant Beach were fishing or intending to fish for bluefish. From this survey a list of 14 day-boats and 18 night-boats was compiled and each was assigned a code number. All the vessels docking in Brielle and Point Pleasant Beach were grouped into a sampling unit and assigned to a 2-man sampling team. The boats in Atlantic Highlands and Belmar were also grouped into a sampling unit and assigned to a second 2-man sampling team. Sampling was conducted 4 or 5 days each week by each 2-man team and included 1 or 2 weekend days and 2-4 weekdays.e

Sampling was initiated June 16 and terminated September 16, 1978. Each vessel on the list of day-boats was selected randomly from the list without replacement until all the vessels were chosen once and then a new series of random choices was made for the next sampling period. The schedule of sampling insured that each vessel on the day-boat list was sampled at least once in each 2 week period of the study.

If the vessel sampled during the day made night trips, the same vessel was scheduled for night sampling on the chosen date. Seventeen day trips had previously been set aside for sampling vessels fishing for summer flounder (Paralichthys dentatus). Night trips on those days were made aboard vessels randomly selected from a list which included

vessels that only fished for bluefish at night. If a selected vessel did not sail on the scheduled day or night, an alternate vessel was randomly chosen from those sailing from the same port. During each trip the sampler counted the number of vessels making bluefish trips from the port and conducted interviews aboard the vessel.

Counts of vessels sailing were made to determine the number of fishing tips made by the fleet of vessels included in the survey. On each day the sampler recorded the time of day (day or night), the number of bluefish vessels at the port where the vessel to be sampled was docked and the number of bluefish vessels which sailed from the port that day or night.

The number of vessels sailing from a port appears to be primarily determined by the number of anglers which arrive at a port to go fishing and prevailing or expected weather conditions. It cannot be assumed that the probability of a vessel sailing is independent of the probability of other vessels sailing from the same port on the same day. Therefore, each visit to a port results in counting a cluster of vessels and in this situation the methods of cluster sampling are deemed appropriate (Cochran, 1977).

The proportion of boats sailing and variance were estimated by the formulae:

$$p = \frac{\Sigma a_i}{\Sigma m_i}$$

where: p = proportion of boats sailing

a_i = number of boats which sailed in the i^{th} sampling unit

m_i = number of boats in the i^{th} sampling unit

$$\hat{V}(p) = \frac{1-f}{n} \sum_{i=1}^{n} \frac{(m_i)^2}{\bar{m}} \frac{(p_i-p)^2}{n-1}$$

where: $p_i = \frac{a_i}{m_i}$

$$\bar{m} = \sum_{i=1}^{n} \frac{m_{ie}}{n}$$

n = sample size (number of port counts made)

$f = \frac{n}{N}$

N = (number of ports) x (number of days in the sampling period)

Separate estimates were made for night and day sailing rates and for weekend days and weekdays. The mean proportions sailing daily and nightly were estimated by combining their respective weekend day and weekday means and variances by the following formulae:

$$p = \frac{27}{93} p_{we} + \frac{66}{93} p_{wde}$$

where: p = proportion of boats sailing during entire season

p_{we} = proportion sailing on weekend dayse

p_{wd} = proportion sailing on weekdayse

93 = total number of days in season

27 = number of weekend days in season

66 = number of weekdays in season

$$\hat{V}(p) = (\frac{27}{93})^2 \hat{V}(p_{we}) + (\frac{66}{93})^2 \hat{V}(p_{wd})$$

where: $\hat{V}(p)$ = estimated variance of proportion of boats sailing during entire season

$\hat{V}(p_{we})$ = estimated variance of proportion of boats sailing on weekend days.

$\hat{V}(p_{wd})$ = estimated variance of proportion of boats sailing on weekdayse

After determining the number of vessels sailing samplers boarded the previously selected vessel, collected data and conducted fishermen interviews. Data collected aboard the vessel included location of fishing sites, number of fishermen, departure and return times, water temperature, general weather observations, fork lengths of bluefish measured to the nearest cm and numbers of other species caught. As anglers quit fishing or during the return trip to the dock, they were interviewed to determine their total catches for the trip. Individual catches were summed to determine the total catch for each vessel trip. On some trips it was not possible to interview every angler so the total number of fish caught aboard the vessel was estimated by the formulae:

$$c = \frac{NF}{NI} \times NAe$$

where: c = total catch of vessel

NF = total catch of interviewed anglers

NI = number of anglers interviewed

NA = number of anglers on vessel

Examination of the distribution of the numbers of fish caught per vessel indicated that there were 3 distinct time periods during the summer in which the weekly mean catch rate per vessel for day trips was near, well below, or well above the overall mean for the survey. The first time period ran from June 16 through July 17 with weekly means near the overall mean catch per vessel. From July 17 through August 24 the weekly mean catch rates were only about 60 percent of

the overall seasonal mean. From August 25 to September 16 the weekly mean catch rates were about 130 percent of the overall mean. Therefore, the catch data were stratified into 3 time periods. The night catch data followed the same pattern and was also stratified into the same 3 time periods.

The catch per vessel data was found to have a lognormal distribution. Therefore, the total number of bluefish caught on each vessel trip was converted to its natural log and the mean and variance of the logs were calculated. The mean and variance were calculated and retransformed by the following formulae (Aitchison and Brown, 1957):

$$\bar{c} = e^{\left(\bar{L} + \frac{(n-1)}{n} \frac{1}{2} \hat{V}(\bar{L})\right)}$$

where: $\bar{c}$ = mean catch per vessel trip

$\bar{L}$ = mean natural log of catch per vessel trip

$\hat{V}(\bar{L})$ = variance of natural logs of catch per vessel trip

n = number of vessel trips on which interviews were made

$$\hat{V}(\bar{c}) = \left(\frac{\bar{c}}{n}\right)^2 \{\hat{V}(\bar{L}) + \frac{1}{2} (\hat{V}(\bar{L}))^2\}$$

where: $\hat{V}(\bar{c})$ = variance of catch per vessel trip

The seasonal mean catch per vessel trip, seasonal variance of catch per vessel trip and 95% confidence interval were calculated by combining the means and variances from the 3 time periods for days or nights using the formulae:

$$\bar{c} = \frac{32(\bar{c}_a) + 38(\bar{c}_b) + 23(\bar{c}_c)}{93}$$

where: $\bar{c}$ = seasonal mean catch per vessel trip

$\bar{c}_a, \bar{c}_b, \bar{c}_c$ = mean catch per vessel trip in time periods a,b, and c respectively

32,38,23 = number of days in time periods, a,b, and c respectively

93 = total number of days in time periods a,b, and c respectively

$$\hat{V}(\bar{c}) = (\frac{32}{93})^2 \hat{V}(\bar{c}_a) + (\frac{38}{93})^2 \hat{V}(\bar{c}_b) + (\frac{23}{93})^2 \hat{V}(\bar{c}_c)$$

where: $V(\bar{c})$ = variance of seasonal mean catch per vessel trip

$V(\bar{c}_a), V(\bar{c}_b), V(\bar{c}_c)$ = variance of catch per vessel trip in time periods a,b, and c respectively

$$CI = \bar{c} \pm 1.96 \sqrt{\hat{V}(\bar{c})}$$

where: CI = 95% confidence interval about $\bar{c}$

The mean seasonal catch per vessel per day or per night was estimated by multiplying the seasonal proportion of vessels sailing times the mean catch per vessel trip and the variance and confidence intervals were calculated by the formulae:

$$\overline{pc} = p \times \bar{c}$$

where: $\overline{pc}$= mean catch per vessel per day

p = proportions of vessels sailing

$\bar{c}$ = mean catch per vessel trip

$$\hat{V}(\overline{pc}) = (p)^2 \hat{V}(\bar{c}) + (\bar{c})^2 \hat{V}(p) + \hat{V}(p) \hat{V}(\bar{c})$$

where: $\hat{V}(\overline{pc})$ = estimated variance of catch per vessel per day

$\hat{V}(\bar{c})$ = estimated variance of catch per vessel trip

$\hat{V}(p)$ = estimated variance of proportion of vessels sailing

$$CI = \overline{pc} \pm 1.96\sqrt{\hat{V}(\overline{pc})}$$

where: CI = 95% confidence interval about $\overline{pc}$

The mean catch per vessel per day and confidence intervals were multiplied by the number of days in the season (93) and by the number of vessels in the fleet (14 day-boats or 18 night-boats) to estimate the total seasonal catch for day-boats and night-boats and confidence intervals about the total catches.

The difference between mean catch per vessel per night trip and mean catch per vessel per day trip was tested at the .01 level of significance using the students t-test.

Bluefish were measured to the nearest cm fork length and each length was converted to a weight using the formula $\log_{10}wt = -4.23676 + e2.62067 \log_{10}Ln$. This regression formula was calculated from 3,091e lengths and weights measured during a 1975 survey of party- and charter-boats in New Jersey. The calculated mean day and night weights were multiplied by the respective day and night total seasonal catches to estimate the total seasonal catches by weight.

The occurrences of minor species in the catch observed during interviews were used as proportions to estimate the seasonal catch of minor species. Since each vessel trip resulted in a cluster of observations on the occurrence of a minor species the cluster analysis (Cochran, 1977) method previously described for determining proportion

of vessels sailing was applied to determine the proportion of each minor species in the catch except that:

P = seasonal proprotion of a minor species in the catch

a_i = number of a minor species observed in the i^{th} trip

m_i = number of all fish observed in the i^{th} trip

n = sample size (number of trips on which observations were made)

N = (numbereof boats) x (number of days in the sampling period)e

The mean catch of each minor species per vessel per day was determined by the following formulae:

$$\bar{y} = P \times \overline{pc}$$

where: $\bar{y}$ = estimated mean catch of a minor species per vessel per day

P = seasonal proportion of a minor species in the observed catch

$\overline{pc}$ = estimated mean catch of all fish per vessel per day

$$\hat{V}(\bar{y}) = P^2 \hat{V}(\overline{pc}) + \overline{pc}^2 \hat{V}(P) + \hat{V}(\overline{pc}) \hat{V}(P)$$

where: $V(\bar{y})$ = estimated variance of mean catch of a minor species per vessel per day

$V(P)$ = estimated variance of the proportion of a minor species in the observed catch

$V(\overline{pc})$ = estimated variance of mean catch of all fish per vessel per day

$$CI = \bar{y} \pm 1.96\sqrt{\hat{V}(\bar{y})}$$

where: CI = 95% confidence interval about $\bar{y}$

The mean catch and confidence intervals of each minor species per vessel per day were multiplied by 93 and 14 or 18 to determine the

seasonal day and night catches respectively. The day and night catches were then added to determine the total seasonal catches.

RESULTS AND DISCUSSION

During the 93 day survey period, 14 bluefish day-boats and 13 night-boats were located with a maximum potential of making 1302 and 1674 bluefish chumming trips respectively. The actual night-trip potential was somewhat less than 1674 trips since several vessels did not schedule trips on Sunday nights or scheduled trips only Wednesday through Saturday nights. A total of 111 port counts were made to determine the proportion of vessels sailing during the day and at night. The seasonal proportion of vessels sailing (Table 1) were .8189 ± .0462 for day-boats and .7413 ± .0465 for night-boats. Thus, the total trips made during the 93 day season was 1066 ± 60 day-trips and 1214 ± 78 night-trips respectively.

Sampling personnel went aboard 90 day-boats and 104 night-boats carrying 2854 day-anglers with a mean of 32 per trip and 3265 night-anglers with a mean of 31 per trip. The samplers interviewed 2303 or 81% of the day-anglers and 2480 or 76% of the night-anglers. The total catches of day-boats ranged from 1 to 609 bluefish per trip with a mean of 144.75 (Table 1) and the total catches of night-boats ranged from 2 to 689 bluefish per trip with a mean of 215.98 (Table 1).

The mean catch per vessel per day, the product of the proportion sailing daily and catch per trip, was 118.53 and 160.10 for day-boats and night-boats respectively (Table 2). The total catch of bluefish

for the 93 day season was 154,331 ± 41,688 for day-boats and 268,010 ± 63,240 for night-boats (Table 2). The total catch for the season was 422,341 bluefish of which 36.5% was caught by day-anglers and 63.5% was caught by night-anglers. The night catch was 173.7% of the day catch. The difference between day and night catches was significant at the .01 level.

The length frequencies of 5,458 day-caught and 6,527 night-caught bluefish are presented in Figure 1. The sample sizes represent 57% and 45% of all the bluefish caught by the day-anglers and night-anglers which were interviewed. There appears to be little difference in size between day-caught and night-caught bluefish on a seasonal basis.

The mean weights of bluefish, estimated from the lengths converted to weights, were 2.5947 kg (5.7203 lbs) for day-caught fish and 2.6428 kg (5.8264 lbs) for night-caught fish. The estimated total weight of bluefish caught was 400 metric tons (MT) (882,825 lbs) and 708 MT (1,561,527 lbs) for day-boats and night-boats respectively.

The observed day and night catches of 18 minor species and estimated seasonal total catches with 95% confidence intervals are listed in Table 3. The catch of all other species was slightly less than 1.5% of the catch of bluefish. With the exception of most sharks and red hake, the other species of fish occurred most frequently in the day catch. All the scombrids, except Atlantic bonito, occurred only in the day catch. Atlantic bonito was the most abundant other

species in the catch accounting for over 60% of the total catch of species other than bluefish.

It is obvious from this analysis that any survey of marine recreational fishing activity along the Middle Atlantic coast must include estimates of nighttime effort and catch. For the most important single species, bluefish, the night catch of party-boats greatly exceeds day catch within the study area. While small in comparison to bluefish catches, the catch of other species at night is also significant.

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Table 1. Estimated proportion of vessels sailing daily, estimated catch per vessel trip, and 95% confidence intervals.

Boat Type	Proportion Sailing Daily	95% Confidence Interval	Catch Per Trip	95% Confidence Interval
Day	.8189	±.0462	144.75	±38.22
Night	.7413	±.0465	215.98	±49.10

Table 2. Estimated catch per vessel per day, number of vessels in the fleets, estimated total catches in the 93-day survey period, and 95% confidence intervals about daily and total catch estimates.

Boat Type	Catch Per Vessel Per Day	95% Confidence Interval	Number of Vessels	Total Estimated Catch (93 days)	95% Confidence Interval
Day	118.53	±32.02	14	154,331	41,688

TABLE 3. Observed and estimated catches of 18 minor species and 95% confidence intervals about estimated total catch.

Species	Observed Catch		Estimated Seasonal Catch			
	Day	Night	Day	Night	Total	95% CI
Atlantic bonito *Sarda sarda*	230	28	3496	515	4011	±2394
Little tunny *Euthynnus alletteratus*	41	0	623	0	623	± 636
Black sea bass *Centropristis striata*	37	3	562	55	617	± 135
Dusky shark *Carcharhinus obscurus*	5	25	76	460	526	± 492
Sandbar shark *Carcharhinus milberti*	2	7	30	129	159	± 172
Dolphin *Coryphaena hippurus*	6	2	91	37	128	± 222
Summer flounder *Paralichthys dentatus*	5	1	76	18	94	± 105
Weakfish *Cynoscion regalis*	2	4	43	57	87	± 185
Smooth dogfish *Mustelus canus*	3	1	46	18	64	± 158
Blue shark *Prionace glauca*	0	3	0	55	55	± 150
Red hake *Urophycis chuss*	1	2	15	37	52	± 100
Skipjack tuna *Euthynnus pelamis*	2	0	30	0	30	± 44
Silver hake *Merluccius bilinearis*	0	15	0	18	18	± 37
Clearnose skate *Raja eglanteria*	0	1	0	18	18	± 37
Tiger shark *Galeocerdo cuvieri*	1	0	15	0	15	± 29
Bluefin tuna *Thunnus thynnus*	1	0	15	0	15	± 29
Goosefish						

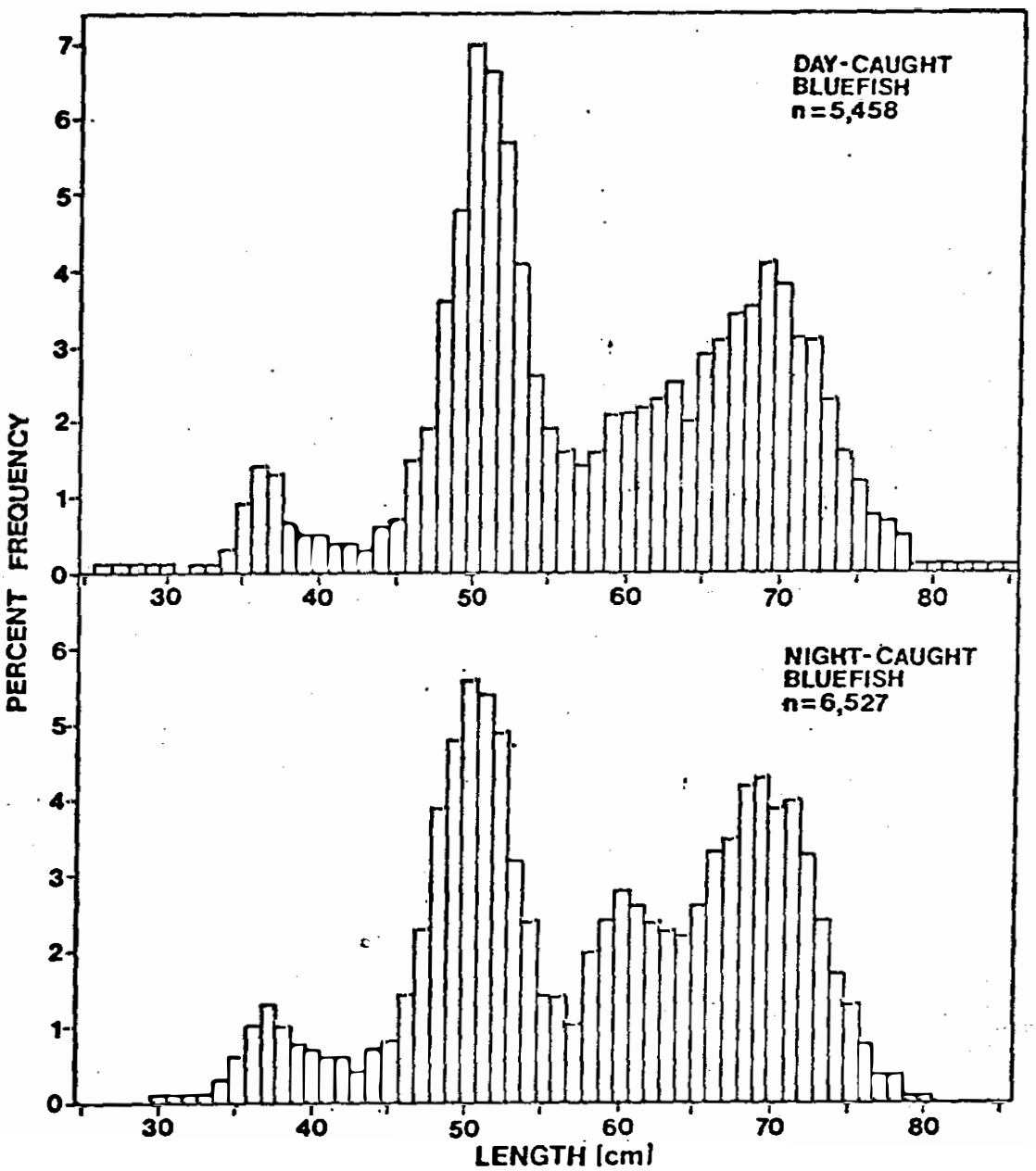

Figure 1. Length frequencies of day-caught and night-caught bluefish.