THE 1978 SPRING RECREATIONAL CATCH OF ATLANTIC MACKEREL, *SCOMBER SCOMBRUS*, OFF THE MIDDLE ATLANTIC REGION

Atlantic mackerel, *Scomber scombrus*, seasonally migrate through the Middle Atlantic region, usually appearing off Virginia in March with a gradual movement inshore and north until they move out of the area by mid-June. They spend the summer and early autumn north of Cape Cod, only briefly returning to the coastal waters of the Middle Atlantic in late fall, before migrating offshore and south in late December or January (Bigelow and Schroeder 1953). They are primarily available to recreational anglers along the Middle Atlantic coast during the spring migration. As Christensen et al.[1] found, the autumn catch of Atlantic mackerel in New Jersey in 1975 was <1% of the catch the following spring. Recreational catches declined from an estimated 32,000 t in 1970 (Deuel 1973) to 5,000 t in 1976 (Christensen et al. footnote 1). Although the recreational catch estimates lack measures of accuracy and reliability, the decline follows the steady decline in total stock from 2.4 million t in 1969 to 469,000 t in 1978 (Anderson 1979).

An estimate of total landings and age composition of the catch is necessary for assessment and management of the stock. This survey was initiated by personnel of the Northeast Fisheries Center (NEFC) Sandy Hook Laboratory, National Marine Fisheries Service (NMFS) in cooperation with State personnel from the Delaware Division of Fish and Wildlife, the New Jersey Division of Fish, Game and Shellfisheries, and the New York State Department of Environmental Conservation at the request of the Mid-Atlantic Fisheries Management Council. Although the request was to determine the 1978 recreational catch of Atlantic mackerel between Virginia and New York, Virginia and Maryland were not included in the survey as the Atlantic mackerel fishing season had already begun in those states.

Methods

Sampling

A list of inlets, grouped into five regions including Delaware, southern New Jersey, northern New Jersey, coastal Long Island, and Long Island Sound (Table 1) was prepared for the Middle Atlantic coastline (Figure 1). Inlets were randomly selected for weekly sampling from the list of inlets within the regions where Atlantic mackerel were known or anticipated to be present. The list indicating availability of Atlantic mackerel in an area was primarily determined by telephone conversations with marina owners and commercial sportfishing vessel operators advertising in two weekly fishing magazines, *The Fisherman*[2] and *The Long Island Fisherman*.[3] These observations were then confirmed during subsequent on-site interviews with vessel operators. In this way it was possible to concentrate sampling efforts in regions where Atlantic mackerel were available and to determine the lengths of the regional seasons.

Personnel from cooperating State agencies confined sampling to their respective states and worked primarily weekdays while NEFC personnel sampled in all regions both weekends and weekdays following the movement of Atlantic mackerel northward. Data collected before Atlan-

[1] Christensen, D. J., B. L. Freeman, and S. C. Turner. 1976. The United States recreational fishery for Atlantic mackerel. Int. Comm. NW Atl. Fish., Res. Doc. 76/XII/142, ser. no. 4038, 7 p.

[2] *The Fisherman for the New Jersey, Delmarva, and Hatteras fisherman*. NJF Publishing Corp., Sag Harbor, N.Y.

[3] *The Long Island Fisherman*. LIF Publishing Corp., Sag Harbor, N.Y.

TABLE 1.—Summary of sampling activity and dates of Atlantic mackerel availability in regions along the Middle Atlantic coast in 1978.

Region	Inlets included in region	No. of sampling days in region	Period mackerel were available	No. of days mackerel were present	
				Weekdays	Weekends
I - Delaware	Indian River	24	4 Apr.-8 May	25	10
II - Southern New Jersey	Roosevelt Cape May Hereford Townsend Corson Great Egg Absecon Beach Haven	19	8 Apr.-12 May	25	10
III - Northern New Jersey	Barnegat Manasquan Shark River Sandy Hook	22	15 Apr.-14 May	20	10
IV - South Shore Long Island	Rockaway East Rockaway Jones Fire Island Shinnecock Montauk	21	29 Apr.-28 May	20	10
V - North Shore Long Island	Greenport Mattituck Mt. Sinai Port Jefferson Stony Brook Nissequogue Northport Huntington Oyster Bay Hempstead Manhasset Bay Little Neck Bay City Island	27	5 May-8 June	25	10

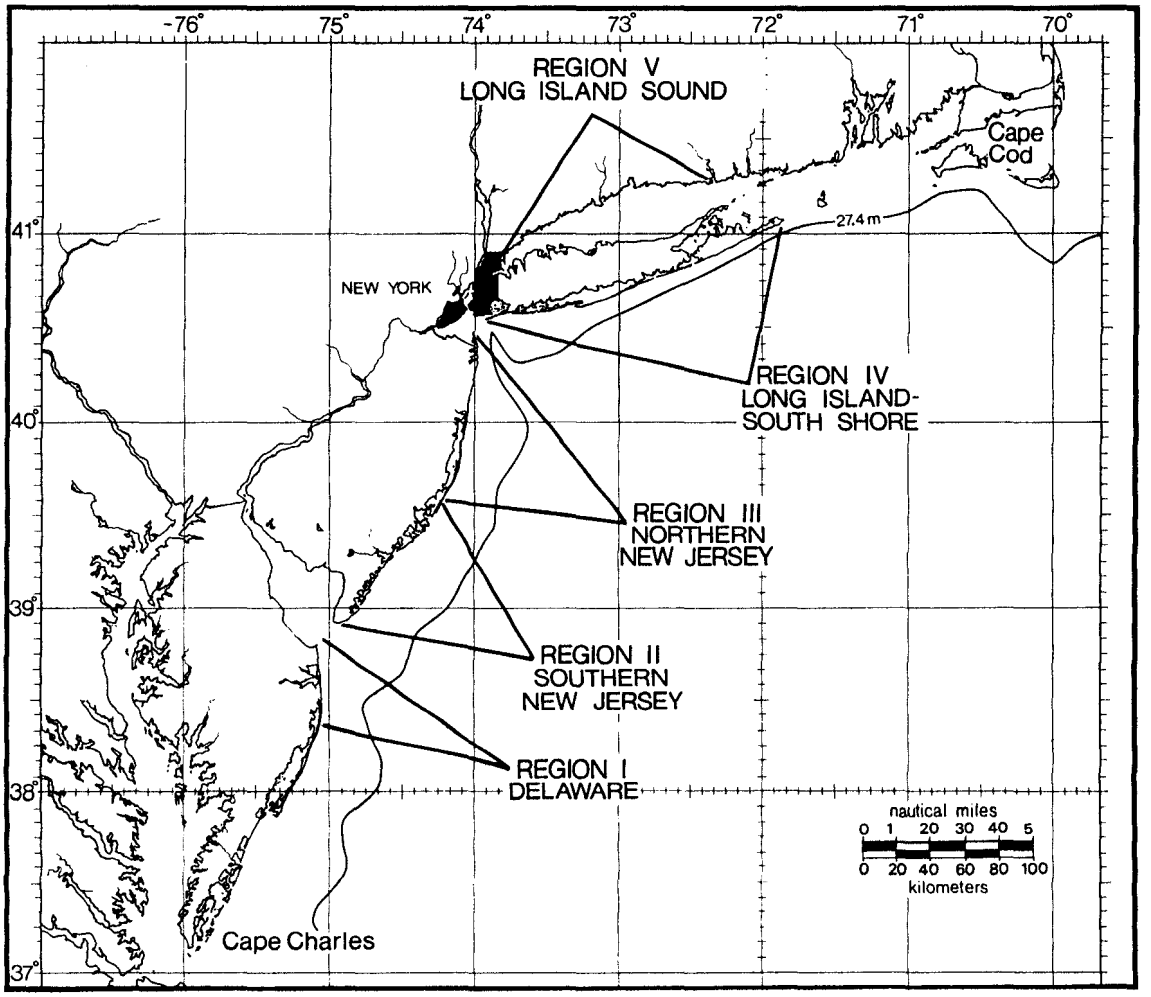

FIGURE 1.—Survey regions along the Middle Atlantic coast for recreational catch of Atlantic mackerel.

tic mackerel arrived or after they departed from a region were omitted from subsequent analysis. Boat counts were made at each inlet to determine the number of vessels sailing through the inlet, and interviews were conducted concurrently at associated marinas, docks, and launching ramps to determine the catch per vessel. There were no adequate data available on which to base proportions of interviews among different types of fishing vessels. Therefore, as many interviews as possible were made with all vessel types as they returned to port.

Inlet vessel counts were made of party, charter, and private boats. Charter boats are commercial sportfishing vessels which are usually reserved in advance by a group of fishermen for their exclusive use for a negotiated single fee. Party boats (head boats) are commercial sportfishing vessels filled on a first-come, first-served basis at an established fee per person. Party boats were subdivided into full- and half-day categories based on their daily activity schedules. Full-day party boats make a single day trip of about 7-9 h duration while half-day party boats make a morning and afternoon trip each of which is usually 4-5 h in duration. Private boats are noncommercial sportfishing vessels. The term sportfishing does not exclude the passengers or crew from selling part or all of their catch.

Estimation of Fishing Effort

NEFC and Delaware personnel counted boats either from 0500 to 1300 h or 1300 to 2000 h.

Morning counts and afternoon counts were summed to determine daily counts. New Jersey personnel counted boats passing through inlets for entire days while New York personnel concentrated efforts obtaining interviews and did not make inlet counts.

Inlets in the survey area were grouped into three size classes (small, a; medium, b; large, c) according to the maximum expected numbers of each type of vessel using the inlet. The mean and variance of the number of vessels sailing daily through inlets in each class was determined separately for weekend days and weekdays as boat traffic was frequently much greater on weekends. The mean and variance for weekend days and weekdays were combined using the following formulae (Cochran 1977):

$$\bar{s}_i = \frac{10\,\overline{we}_i + 23\,\overline{wd}_i}{10 + 23}$$

where $\bar{s}_i$ = estimated mean number of vessels sailing daily in inlet class i, where $i = a, b, c$

$\overline{we}_i$ = estimated mean number of vessels sailing daily on weekend days in inlet class i

$\overline{wd}_i$ = estimated mean number of vessels sailing daily on weekdays in inlet class i

10 = mean number of weekend days in season

23 = mean number of weekdays in season

and the estimated variance of $\bar{s}_i$ is:

$$\hat{v}(\bar{s}_i) = \left(\frac{10}{10+23}\right)^2 \hat{v}(\overline{we}_i) + \left(\frac{10}{10+23}\right)^2 \hat{v}(\overline{wd}_i)$$

where $\hat{v}(\bar{s}_i)$ = estimated variance of mean number of vessels sailing daily in inlet class i

$\hat{v}(\overline{we}_i)$ = estimated variance of mean number of vessels sailing daily on weekend days in inlet class i

$\hat{v}(\overline{wd}_i)$ = estimated variance of mean number of vessels sailing daily on weekdays in inlet class i

10 and 23 = constants as above.

The mean, variance, and confidence interval of the number of vessels of each type sailing daily in all inlet classes was determined by combining the means and variances according to the following formulae (Cochran 1977):

$$\bar{s} = \frac{N_a\bar{s}_a + N_b\bar{s}_b + N_c\bar{s}_c}{N_a + N_b + N_c}$$

where $\bar{s}$ = mean number of vessels sailing daily through all inlets where the vessel type occurs

N_a, N_b, N_c = number of inlets in inlet classes a, b, and c

$\bar{s}_a, \bar{s}_b, \bar{s}_c$ = mean number of vessels sailing daily through inlet classes a, b, and c

$$\hat{v}(\bar{s}) = \left(\frac{N_a}{N_a+N_b+N_c}\right)^2 \hat{v}(\bar{s}_a) + \left(\frac{N_a}{N_a+N_b+N_c}\right)^2 \hat{v}(\bar{s}_b) + \left(\frac{N_a}{N_a+N_b+N_c}\right)^2 \hat{v}(\bar{s}_c)$$

where $\hat{v}(\bar{s})$ = estimated variance of $\bar{s}$

$\hat{v}(\bar{s}_a), \hat{v}(\bar{s}_b), \hat{v}(\bar{s}_c)$ = estimated variance of $\bar{s}_a$, $\bar{s}_b$, and $\bar{s}_c$

$$CI = \bar{s} \pm 1.96\sqrt{\hat{v}(\bar{s})}$$

where CI = 95% confidence interval about $\bar{s}$.

Estimation of Catch Rates

Interviews were made at dock sites, marinas, and launching ramps to determine vessel catches. Vessel catches were determined rather than individual angler catches since most private boat and charter boat anglers share their total catches. In addition, while some party boat anglers may fish as individuals, it is common practice for family or social groups to share a common fish container making it impossible to determine the exact catch per angler. During interviews the type of vessel, fishing location, interview site location, number of Atlantic mackerel caught, and fork lengths (FL) of Atlantic mackerel were recorded.

Inspection of the distribution of catch per vessel indicated a lognormal distribution. Therefore, the catch numbers were first converted to natural logs and then the means and

variances were calculated for each vessel type over the entire survey area. The log mean and log variance for each vessel type was transformed, and the 95% confidence interval about the retransformed mean was calculated according to the following formulae (Aitchison and Brown 1957):

$$\bar{c} = \exp\left(\bar{L} + \tfrac{1}{2}\left(\frac{n-1}{n}\right)\hat{v}(\bar{L})\right)$$

where $\bar{c}$ = mean catch per vessel
$\bar{L}$ = mean natural log of catch per vessel
$\hat{v}(\bar{L})$ = estimated variance of natural logs to catch per vessel
n = number of vessels interviewed

The variance of $\bar{c}$, $\hat{v}(\bar{c})$, is approximated by:

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

and

$$\bar{c} \pm 1.96\sqrt{\hat{v}(\bar{c})}$$

is a 95% confidence interval about $\bar{c}$.

Estimated Total Catches

The mean catch per inlet per day, its variance assuming $\bar{s}$ and $\bar{c}$ were independent, and 95% confidence intervals were calculated for each vessel type using the following formulae:

$$\overline{sc} = \bar{s} \times \bar{c}$$

where $\overline{sc}$ = mean catch per inlet per day
$\bar{s}$ = mean trips per inlet per day
$\bar{c}$ = mean catch per vessel

$$\hat{v}(\overline{sc}) = (\bar{s})^2\,\hat{v}(\bar{c}) + (\bar{c})^2\,\hat{v}(\bar{s}) + \hat{v}(\bar{c})\,\hat{v}(\bar{s})$$

where $\hat{v}(\overline{sc})$ = estimated variance of catch per inlet per day
$\hat{v}(\bar{s})$ = estimated variance of trips per inlet per day
$\hat{v}(\bar{c})$ = estimated variance of catch per vessel

$$\text{CI} = \overline{sc} \pm 1.96\sqrt{\hat{v}(\overline{sc})}$$

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

The total estimated catch (TSC) per vessel type and the 95% confidence interval about the estimate were calculated as follows:

$$TSC = \left[\overline{sc} \pm 1.96\sqrt{\hat{v}(\overline{sc})}\right] \times 33NI$$

where TSC = total estimated catch
NI = number of inlets where vessel type occurred
33 = number of days in fishing season

The total estimated catch and confidence interval for the total survey area and all vessel types were determined by summing the estimated catches and extracting the square root of the sum of the squares of the variances of all four vessel types.

Lengths, Weights, and Age Composition of Catches

A total of 2,778 Atlantic mackerel were measured to the nearest centimeter fork length to determine the length frequencies of the catch. Each length was converted to a weight using the formula $\log_{10}$ weight = $-5.2314 + 3.0796 \log_{10}$ length (Wilk et al. 1978), and a mean weight was calculated for all vessel types. The mean weight was multiplied by the total estimated number caught to determine the total weight of the catch.

For age composition analysis, Atlantic mackerel were obtained in April from recreational and commercial fishermen fishing primarily along the New Jersey coast and transported to the NEFC Sandy Hook Laboratory where they were measured to the nearest centimeter fork length and sexed. The heads were removed, frozen, and sent to the NEFC Woods Hole Laboratory, NMFS, for otolith removal and aging. Aging was accomplished by placing intact otoliths in black trays, imbedding them in clear epoxy resin, and counting annular rings using reflected light at 25-75× magnification under a binocular microscope. The number of fish from the length-frequency sample of 2,778 measured at each centimeter length was multiplied by the percentage age composition at that length increment to determine the number of fish caught in each age-group at each centimeter increment. The numbers at each age were summed from all length increments and divided by the total number of fish measured to determine the percentage composition of each age in the recreational catch. The percentage composition at each age was multiplied by the total estimated Middle

Atlantic catch to determine the estimated total recreational catch by age-class in the Middle Atlantic region.

Results and Discussion

Privately owned boats were by far the most numerous type observed using inlets during the survey (Table 2). The mean catch per vessel was lowest for private boats, intermediate for half-day party and charter boats, and highest for full-day party boats (Table 2). Full-day party boats anglers caught the most Atlantic mackerel during the season followed in decreasing order by anglers aboard private boats, half-day party boats, and charter boats (Table 3). The total estimated number of mackerel caught in the survey area was 6,792,000±2,415,000.

The mean fork length of all Atlantic mackerel measured during the survey was 37.9 cm and the calculated mean weight was 0.515 kg/fish. The total estimated weight caught was 3,498 ±1, 244 t.

The survey was initiated after Atlantic mackerel had already progressed north into waters off Delaware and southern New Jersey. Therefore, it was too late to survey catches in the southern portion of the Middle Atlantic region. Maryland has a single inlet at Ocean City with a few party boats, a modest number of charter boats, and facilities for private boats. Virginia has several locations such as Chincoteague, Wachapreague, and Quinby along the coast of the Delmarva Peninsula where some charter and private boats have ocean access, and two inlets (Rudee and Lynnhaven) near the mouth of Chesapeake Bay where a few party boats and a number of charter and private boats have ocean access to fish for Atlantic mackerel. The catch made from Delaware's only two coastal inlets was about 8% of the Delaware and New Jersey total. Assuming similar levels of effort and catch at the six inlets in Maryland and Virginia, the Maryland and Virginia catches were approximately 25% of the New Jersey and Delaware total. The combined catch within the Delaware and New Jersey regions was about 34% of the catch (3,498 t) of the three-State area surveyed or 1,189 t. Thus, the total estimated catch for Virginia-New Jersey was 125% of 1,189 t or 1,486 t.

TABLE 2.—Average number of trips and catches of Atlantic mackerel by sportfishing vessels during the Middle Atlantic coast survey, 1978.

Vessel type	Mean trips per inlet per day	95% confidence interval	Mean catch per vessel trip	95% confidence interval
Party boats:				
Full-day	3.87	±1.37	1,425	±542
Half-day	3.92	±1.75	352	±154
Charter boats	2.82	±1.11	346	±106
Private boats	56.41	±7.25	45	±8

The number of party and charter boats in New York was found to be approximately equal to the combined fleets in Connecticut through Maine (Fraser et al. 1977). Assuming similar levels of Atlantic mackerel caught by commercial sportfishing vessels and private vessels in Connecticut-Maine, New York catches accounted for 50% of the North Atlantic regional catch (New York-Maine) (Deuel 1973). The New York portion of the Delaware, New Jersey-New York catch was about 66% or 2,309 t of the 3,498 t total catch. Therefore, the Connecticut-Maine catch was assumed to also be 2,309 t, giving a New York-Maine total of 4,617 t. The total recreational catch of Atlantic mackerel taken by boat in the Virginia-Maine area was estimated to be 6,103 t of which 3,795 t was caught in the New York-Virginia area.

A total of 278 Atlantic mackerel were aged from samples collected during the survey. The ages were found to range from 2 to >11 yr with considerable overlap of age-classes at >36 cm FL (Table 4). The range of all fish measured during the survey was 27-44 cm FL (Table 5) and the mean was 37.9 cm. It is apparent from the estimated total catch by ages (Table 5) that fish caught by recreationsl anglers came mainly from the older age-groups. The remnants of the

TABLE 3.—Summary of catches of Atlantic mackerel made by sportfishing vessels encountered during the 1978 survey of the Middle Atlantic coast.

Vessel type	Mean catch per inlet per day	95% confidence interval	Number of inlets where vessel type occurred	Total estimated catch	95% confidence interval
Party boats:					
Full-day	5,515	±3,673	19	3,458,000	±2,303,000
Half-day	1,380	±604	8	364,000	±159,000
Charter boats	976	±483	9	290,000	±143,000
Private boats	2,538	±658	32	2,680,000	±695,000
Total				6,792,000	±2,415,000

TABLE 4.—Percentage age at length of Atlantic mackerel aged from samples collected during the 1978 spring sportfishing season along the Middle Atlantic coast.

		Age (years)										
Fork length (cm)	No.	2	3	4	5	6	7	8	9	10	11	>11
27	1	100.0										
28	1	100.0										
29	1	100.0										
30	1		100.0									
31	1			100.0								
32	11		27.3	72.7								
33	38		5.3	73.7	21.0							
34	57		12.3	63.2	19.3	5.3						
35	41		7.3	41.5	43.9	7.3						
36	29		6.9	13.8	6.9	37.8	13.9		20.7			
37	42		4.8	11.9	7.1	21.4	11.9		23.8	2.4	14.3	2.4
38	29				3.4	13.8	24.1	3.4	20.7	3.4	31.0	
39	21							9.5	38.1	4.8	33.0	14.3
40	4								25.1		50.0	25.0
41	1										100.0	
Total	278											

TABLE 5.—Numbers, percentage age composition, mean length at age of recreationally caught Atlantic mackerel, and estimated recreational catch in metric tons from New York through Virginia during 1978.

	Age (years)											
Fork length (cm)	2	3	4	5	6	7	8	9	10	11	>11	Total
27	1											1
28	2											2
30		2										2
32		1	3									4
33		1	17	5								23
34		8	42	13	4							67
35		9	51	55	9							124
36		18	35	18	96	35		53				255
37		28	69	41	124	69		138	14	83	14	580
38				25	100	176	25	151	25	226		728
39							55	221	28	194	83	581
40								72		143	72	287
41										94		94
42											24	24
43											5	5
44											1	1
Total	3	67	217	157	333	280	80	635	67	740	199	2,778
Percentage of total	0.1	2.4	7.8	5.7	12.0	10.1	2.9	22.9	2.4	26.6	7.2	100.1
Mean length at age, cm	27.7	35.8	35.4	36.0	36.9	37.5	38.7	38.7	38.2	38.9	—	—
Estimated total catch (t) by age	4	92	296	214	455	383	109	867	92	1,011	272	3,795

large 1967 and 1969 year classes (Anderson 1979) which were 11 and 9 yr old in 1978 still contributed nearly 50% of the recreational catch. The percentage age composition of the total stock in 1978 was estimated to be 23.1, 17.0, 22.7, 25.2, 7.0, 1.4, 1.2, 0.8, 0.8, 0.5, 0.4, and 0.1 for ages 1 through 11 and >11 (Anderson 1979). Comparisons of the two age composition estimates indicates all age-groups older than 5 compose 5.1% of the stock and 84.1% of the recreational catch. The mean fork length of age-class 3 through 5 fish was only 2.2 cm less than the mean fork length of all fish measured during the recreational survey. Therefore, it does not seem probable that the hook-and-line fishery is size selective between age-classes >2 yr old. The stock assessment (Anderson 1979) was based partially on NMFS research vessel trawl surveys which did not include sampling inside the 27.4 m (15 fathom) contour. As most recreational fishing is done inshore of the 27.4 m contour, it is possible that older Atlantic mackerel concentrate inshore. This would result in a delay in recruitment into the recreational fishery until age 6 or greater.

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SIZE AND POSSIBLE ORIGIN OF SAILFISH, *ISTIOPHORUS PLATYPTERUS*, FROM THE EASTERN ATLANTIC OCEAN[1]

Although Morrow and Harbo (1969) considered the sailfish, *Istiophorus platypterus*, to be a single worldwide species, other workers believe that the Atlantic and Pacific forms are separate species (Nakamura et al. 1968; Nakamura 1974). It has long been recognized that Indo-Pacific specimens, particularly those found along the coasts of Panama and Mexico, attain a much greater size than do their Atlantic counterparts. In addition, the form of the spinous dorsal fin differs in fish from the two ocean areas. The International Game Fish Association (IGFA), which keeps detailed and precise records of the largest fish caught in various sportfishing categories, maintains separate records for Indo-Pacific and Atlantic sailfish. At present, the largest sailfish caught by sportfishing gear in the Pacific weighed 100.2 kg, and of the 14 different line test categories recorded by IGFA, only two record Pacific sailfish weighed <70 kg. In contrast, the largest Atlantic specimen weighed 58.1 kg and over half of the record catches were <50 kg (International Game Fish Association 1980). Morrow and Harbo (1969) stated that it was probable that improved nutrition, better conditions for growth, or some other favorable environmental condition was responsible for the attainment of the greater size in Indo-Pacific sailfish.

Size data for Atlantic sailfish caught by the Japanese longline fishery in various areas of the Atlantic have recently become available in the annual publications of the International Commission for the Conservation of Atlantic Tunas.[2] These data show that unusually large sailfish also occur in the Atlantic, specifically in the eastern Atlantic off the coast of Africa between lat. 0° and 20° S (Figure 1; Areas F, G). Size frequencies from the region indicate fish of substantially greater size than from any of the other areas in the Atlantic where size data from sailfish caught by the longline fishery were available (Figure 2). I calculated the weights of eastern Atlantic specimens using length-weight relationships developed by various authors (Table 1). The results (Table 2) show increasing variation in calculated weights as fish length increases; however, regardless of which

[1]Southeast Fisheries Center Contribution No. 80-05M.

[2]International Commission for the Conservation of Atlantic Tunas, Madrid, Data Records Vol. 10, p. 303-304 and Vol. 11, p. 267-270.

TABLE 1.—Coefficients of the length-weight relationship for western Atlantic sailfish (Lenarz and Nakamura 1974; Jolley 1974) and eastern Pacific sailfish (Kume and Joseph 1969; Wares and Sakagawa 1974). All lengths are from posterior rim of orbit to fork except Jolley, which is from orbit to origin of caudal keels. Calculated weights will be in kilograms except for Lenarz and Nakamura which will be in pounds.

Author	No. of specimens	Size range	$\log_{10} a$	b
Lenarz and Nakamura (1974)	244	15.8-62.5 in	−3.895	3.158
Jolley (1974) Male	182	76-156 cm	−5.784	3.342
Female	230	47-164 cm	−4.941	2.950
Kume and Joseph (1969)	28	134-205 cm	−3.936	2.416
Wares and Sakagawa (1974)	802	115-222 cm	−4.360	2.628