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Malcolm Baldrige, Secretary
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John V. Byrne, Administrator
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William H. Stevenson, Acting Assistant Administrator for Fisheries

Abstract

The waters off northeastern South America support the large Guianas-Brazil shrimp fishery. Thirteen fishing zones were established for these waters by shrimping interests to identify the general location of shrimp catches and production. In this paper, the 13 fishing zones are subdivided into 65 depth zones, their areas calculated from nautical charts, and presented in tabular form. The sea surface area of the 13 fishing zones covers 217,392 nmi^2 (746,308 km^2). Forty percent of this area is over the continental shelf and 60 percent over water deeper than 100 fm (183 m); only 13 percent of the total area is trawled for shrimp. Areas calculated by depth zones will be of value for estimating fish population density and catch per unit of effort by unit area.

Introduction

The coastal waters off northeastern South America support the Guianas-Brazil shrimp fishery, one of the most productive shrimp fisheries in the Western Hemisphere (Jones and Dragovich, 1977). To determine the locations of shrimp catches for collecting landing statistics from this fishery, 13 fishing zones were established (Anonymous, 1973; Jones and Dragovich, 1973) (Figure 1). Quantitative sea surface area estimates of these fishing zones and their areas of active shrimping are presently not available in the literature; therefore, these estimates are presented in this paper by calculating sea surface areas from nautical charts. Since only a small portion of each of the 13 zones is utilized by the shrimp trawlers, each fishing zone was subdivided by depth categories to identify locations more accurately. The areas measured were: each of the 13 fishing zones, the continental shelf area within each fishing zone and 5 depth zones within each fishing zone (Fig. 1; Table 1A, 1B).

Quantitative areal information on the fishing grounds and their catch statistics are essential in developing population density and fishing intensity data for population analysis (Patella, 1975; Beverton and Holt, 1957). Sea surface area information is also useful to the fishing industry, ecologists, oceanographers, fishery biologists, administrators, and managers in their quantitative studies of the fishery and fishing grounds (Kutkuhn, 1962; Odum, 1963; Raymont, 1963; Rounsefell, 1975, Williams, 1977).

Calculation of sea surface areas

Sea surface areas were calculated by the weight method described by Welch (1948), i.e., cutout map tracings (models) of an unknown area and

a known unit are weighed separately. The unknown area is determined by weight proportion to the known unit area.

Plastic drafting film was selected as the tracing material for models because it can be cut cleanly, has sufficient density for weighing, and is not subject to weight fluctuations from moisture content. Its uniformity in thickness and weight was confirmed by the weight equality of identical sized discs die-cut from various parts of a sheet of drafting film.

The United States Defense Mapping Agency Hydrographic Center navigation charts 24020, 24024, and 24028 of the Atlantic Ocean and coastal areas of the Guianas and North Brazil were overlayed with plastic drafting film. Models were made of the 65 depth zones outlined by the 10, 20, 40, 100 fm (18.3, 36.6, 73.2, 183.0 m) isobaths and the boundaries of fishing zones 69 to 81. The unit area models used for calibration were 1° latitude by 1° longitude quadrangles (1° blocks). Model weights were confirmed three times on an analytical balance to 0.1 mg; this translated to an accuracy 0.24 nmi^2 (0.82 km^2) at 6°N. The areas of fishing and depth zones were calculated.

The Mercator projection used in navigational charts has a variable linear scale that exaggerates measurements at higher latitudes, but near the equator, linear variation is minimal and charts can be used for geographic measurements (Deetz and Adams, 1938). At the latitudes covered in this paper (1°to 9° N), each 1° block is virtually square and equal-area. Block areas decreased from 3,588.03 to 3,545.58 nmi^2 (12,321 to 12,175 km^2) from 1° to 9°, respectively (Bowditch, 1975), but differences in adjacent 1° blocks were too small to be measured on the charts (scale 1:968,600 at lat. 6°N). Maps and charts usually represent the horizontal plane of the earth at mean sea level (Lawrence, 1971) and measurements,

unless otherwise specified, do not allow for topography. Moreover, charts and maps are subject to other variations not mentioned here, and although allowances can be made, it is meaningless to perform calculations to levels beyond limits of scale, accuracy, or significance (Lawrence, 1971). I considered sea surface area based on chart data as an approximation of the seafloor area.

The accuracy of the weight method is dependent on the chart data and scale, uniformity of tracing material, procedural skill and the sensitivity of the analytical balance. The advantages of this method are that the cut-out models can be preserved and rechecked for accuracy or replicate weighings, and the sum of the component parts will equal the whole without adjustments.

Results and Discussion

The coastlines of Guyana, Surinam, French Guiana, and Brazil, from latitude 9° to 1° N stretch about 850 nmi (1,565 km); the sea surface area of the 13 fishing zones is 217,329 nmi^2 (746,308 km^2). Forty percent of this area is over the continental shelf (neritic) and 60 percent over water deeper than 100 fm (oceanic). The continental shelf waters within the 13 fishing zones cover about 86,000 nmi^2 (295,324 km^2). For comparison, this area is slightly less than that of the continental shelf waters in the U.S. Gulf of Mexico, which is about 90,000 nmi^2 (309,060 km^2) (Patella, 1975).

The 13 fishing zones off northeastern South America were subdivided into 65 depth zones (Figure 1). The sea surface area of each fishing zone and their component depth zones were calculated to square nautical miles and converted to square kilometers (Table 1A, 1B). The sea surface areas

of the continental shelf off Guyana, Surinam, French Guiana, and a portion of Brazil were calculated by percentages for four depth ranges (Table 2). The continental shelf subdivided by the coastline and four isobaths shows 26 percent from the coast to 10 fm (18.3 m), 15 percent from 10 to 20 fm (18.3 to 36.6 m), 32 percent from 20 to 40 fm (36.6 to 73.2 m), and 27 percent from 40 to 100 fm (73.2 to 183.0 m). Brazil has 44 percent of the total shelf area, Surinam and French Guiana about 20 percent each, and Guyana 17 percent (Table 2). All but a small corner of the continental shelf in zone 81 off Brazil lies within the 200 nmi (371 km) fishery jurisdiction of either Guyana, Surinam, French Guiana, or Brazil. The continental shelf is about 50 nmi (93 km) wide at the northern portion off Guyana (zone 69), gradually expanding to 70 to 100 nmi (130 to 185 km) off Surinam and French Guiana, then further widening to 250 nmi (463 km) at the extreme southeastern end of zone 81, which is off the mouth of the Amazon River. Most of the offshore shrimp trawling and production occurs on a strip of shelf between 20 and 40 fm (36.6 and 73.2 m) in a total area of about 27,500 nmi^2 (94,435 km^2). The 20-40 fm (36.6-73.2 m) strip is rather uniform in width throughout the fishing zones, averaging from 40 to 60 nmi (74 to 111.2 km) and equals 32 percent of the total continental shelf area; 35 percent of this 20-40 fm (36.6-73.2 m) strip lies off Brazil, 27 percent off French Guiana, 23 percent of Surinam, and 14 percent off Guyana.

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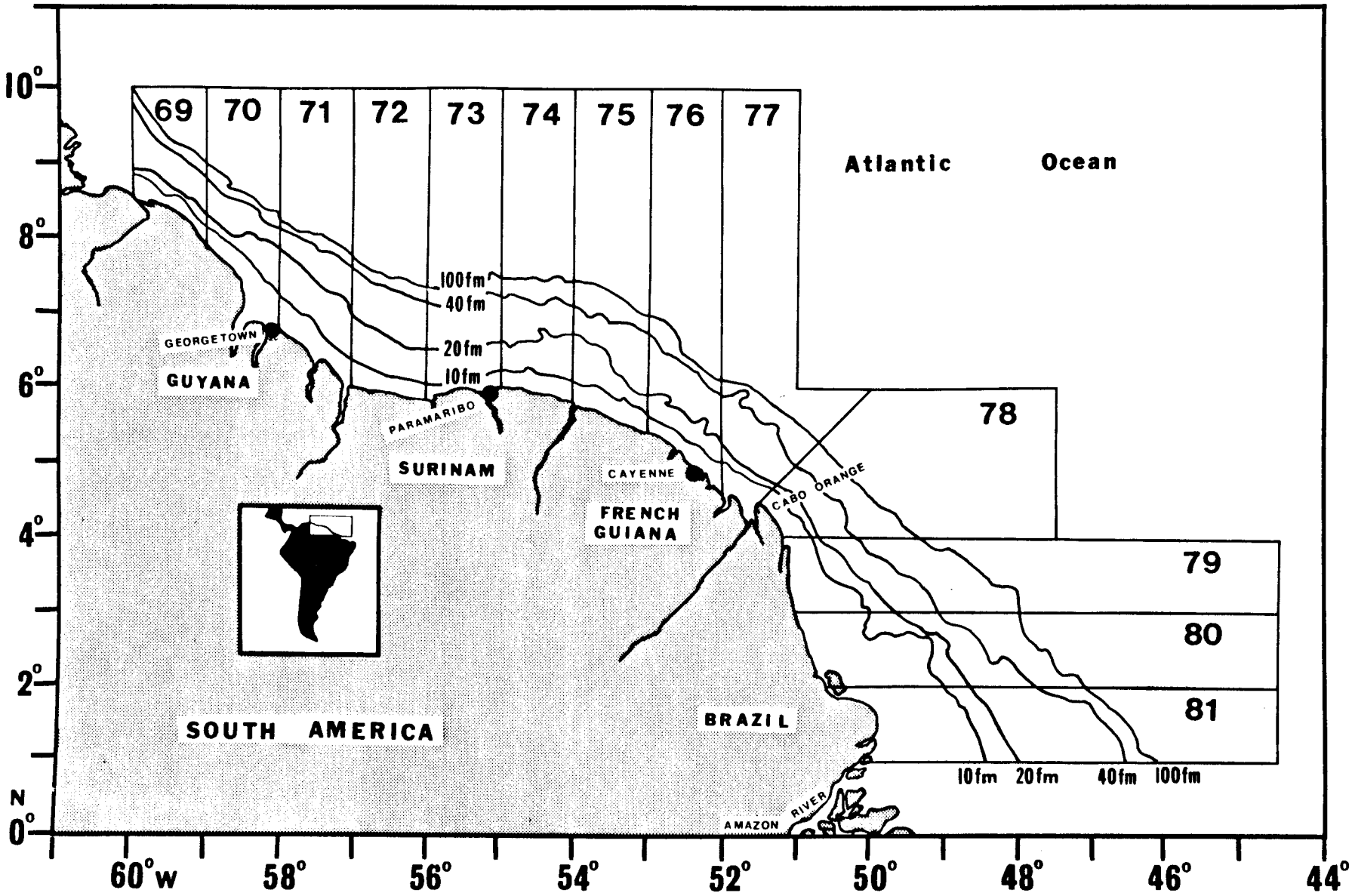

Figure 1. The Atlantic Ocean off northeastern South America showing fishing zones 69 to 81. Depth zones within fishing zones are outlined by the coastline, isobaths at 10, 20, 40, and 100 fm, and the zone boundaries.

Table 1A. Sea surface areas off northeastern South America by fishing zones and depth zones.

Country	Fishing zones	Depth zones in fathoms					
		0-10	10-20	20-40	40-100	100 +[1]	Totals
		Square Nautical Miles					
Guyana	69	1,066	385	1,055	1,353	2,257	6,116
	70	1,713	1,188	1,220	709	4,915	9745
	71	1,435	2,110	1,632	585	7,123	12,885
Surinam	72	1,019	1,485	2,491	907	8,657	14,559
	73	993	1,143	1,928	1,266	9,029	14,359
	74	1,153	1,107	2,011	1,219	9,014	14,504
French	75	1,155	1,176	2,503	1,247	9,801	15,882
Guiana	76	1,065	745	2,648	826	12,512	17,796
	77	795	319	2,374	1,846	17,083	22,417
Northern	78	709	314	866	2,655	18,745	23,289
Brazil	79	2,004	677	1,936	5,196	13,732	23,545
	80	4,406	1,332	1,828	3,811	10,795	22,172
	81	5,119	1,089	5,080	1,242	7,530	20,060
Totals		22,632	13,070	27,572	22,862	131,193	217,329

[1]These depth zones extend from the 100 fm isobath to the boundaries of each fishing zone.

Table 1B. Sea surface areas off northeastern South America by fishing zones and depth zones.

Country	Fishing zones	Depth zones in meters					Totals
		0-18.3	18.3-36.6	36.6-73.2	73.2-183	183+[1]	
		Square Kilometers					
Guyana	69	3,661	1,322	3,623	4,646	7,751	21,003
	70	5,882	4,080	4,189	2,435	16,878	33,464
	71	4,928	7,246	5,604	2,009	24,460	44,247
Surinam	72	3,499	5,099	8,554	3,115	29,728	49,995
	73	3,410	3,925	6,621	4,347	31,006	49,309
	74	3,959	3,801	6,906	4,186	30,954	49,806
French	75	3,966	4,038	8,595	4,282	33,657	54,538
Guiana	76	3,657	2,558	9,093	2,836	42,966	61,110
	77	2,730	1,095	8,152	6,339	58,663	76,979
Northern	78	2,435	1,078	2,974	9,117	64,370	79,974
Brazil	79	6,882	2,325	6,648	17,843	47,156	80,854
	80	15,130	4,574	6,277	13,087	37,070	76,138
	81	17,579	3,740	17,445	4,265	25,861	68,890
Totals		77,718	44,881	94,681	78,507	450,520	746,307

[1]These depth zones extend from the 100 fm (183 m) isobath to the boundaries of each fishing zone.

Table 2. Sea surface area over the continental shelf off northeastern South America by country and depths.

Country	Fishing zones	Depth zones in fathoms				
		0-10	10-20	20-40	40-100	Total 0-100
		Percentage				
Guyana	69 70 71	4.9	4.3	4.5	3.1	16.8
Surinam	72 73 74	3.7	4.3	7.5	3.9	19.4
French Guiana	75 76 77	3.5	2.6	8.7	4.6	19.4
Northern Brazil	78 79 80 81	14.2	4.0	11.3	14.9	44.4
Totals		26.3	15.2	32.0	26.5	100.0