MFR PAPER 1170

Water Surface Area Within Statistical Subareas Used in Reporting Gulf Coast Shrimp Data

FRANK PATELLA

ABSTRACT—The water surface area (in hectares) of 21 statistical subareas was calculated for 5-fathom intervals using compensation planimeters of the polar type. A statistical analysis was done to determine the standard error and to set confidence limits on calculated values. The areas calculated are compatible with depth zones used in reporting Gulf Coast Shrimp Data and should be of value in estimating catch per unit effort per unit area.

INTRODUCTION

An essential part of analysis of any fishery is development of data on density of population and "effective fishing intensity" (Beverton and Holt, 1957). Fundamental to obtaining these data is the determination of the area over which fishing takes place, or from which fishery statistics are reported, or both.

Coastal waters adjacent to the five states bordering the Gulf of Mexico have been divided into 21 statistical subareas (Fig. 1) by the National Marine Fisheries Service (Kutkuhn, 1962). Monthly catches of shrimp (Penaeidae) recorded in the Gulf Coast Shrimp Data[1] are reported by statistical subareas, species, size class, and depth zone at 5-fathom intervals. The combination of subarea and depth zone will be referred to herein as subsubarea after Kutkuhn (1962).

[1]Current Fishery Statistics, National Marine Fisheries Service, NOAA.

Frank Patella is with the Galveston Facility, Gulf Coastal Fisheries Center, National Marine Fisheries Service, NOAA, Galveston, TX 77550.

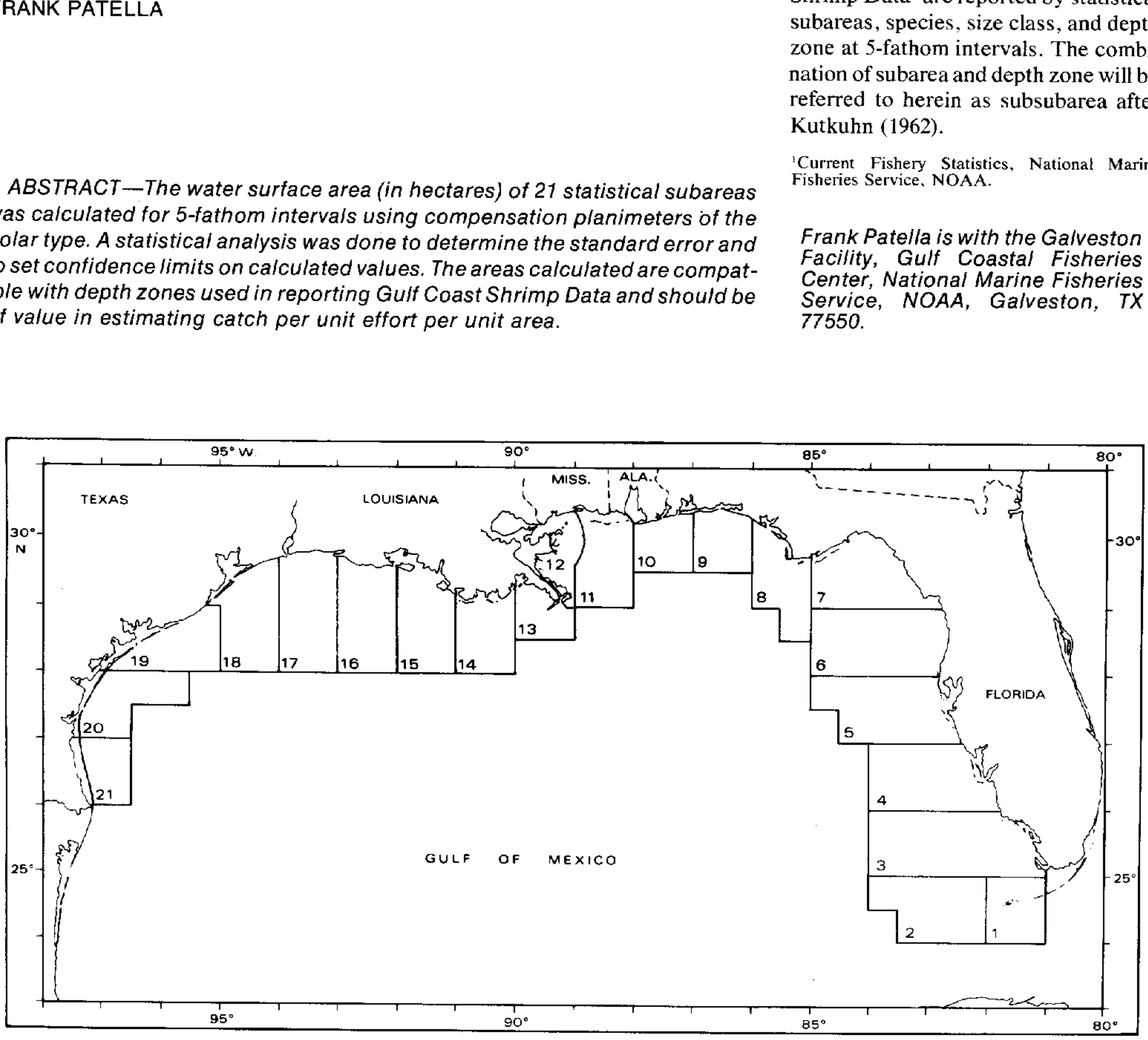

Figure 1.—Statistical subareas used in reporting Gulf Coast Shrimp Data (after Kutkuhn, 1962).

The amount of water surface area within each depth zone within each of the 21 subareas was determined with planimeter to make these data available for use with the Gulf Coast Shrimp Data on catch and fishing effort in the estimation of catch per unit effort per unit area. Water surface area can be taken as an approximation of the bottom surface area for coastal waters of the Gulf of Mexico because the bottom gradient is gradual, viz., 0.587-meter depth per kilometer horizontal distance from shore (Curray, 1960). These data also may be of use to current and future studies of abundance and distribution of other fisheries resources along the Gulf coast, especially those concerning impact of energy-related development.

Table 1.—Conversion factors (hectares per planimeter unit) used to convert average planimeter units to area in hectares for each subsubarea within each subarea.

Statistical subarea[1]	Conversion factor hectares per planimeter unit	Central latitude of 1° block[2]		Chart number[3]
		Degrees	Minutes	
1, 2	233,621.8	24	30	1113
3	230,171.7	25	30	1113
4	228,667.8	26	30	1113
5S	223,087.5	27	30	1113
5N	231,329.7	28	00	1114
6	229,198.5	28	30	1114
7	227,736.7	29	00	1114
8, 13E	228,798.2	29	00	1115
9, 10	224,562.6	30	00	1115
11, 12	226,063.2	29	30	1115
13W, 14, 15, 16, 17	228,507.7	29	00	1116
18	228,556.1	29	00	1117
19	231,151.6	28	30	1117
20	236,176.4	27	30	1117
21	239,892.6	26	30	1117

[1]See Figure 1. N, S, E, and W indicate Northern, Southern, Eastern, and Western portions, respectively, of certain subareas.
[2]Position of the center of the statistical subarea.
[3]National Ocean Survey 1100 Series offshore navigational charts.

METHODS

Water surface areas were measured with a planimeter on tracings of National Ocean Survey 1100 Series offshore navigational charts (Mercator projections). Initially, the statistical subareas were transferred onto a tracing paper overlay. Then the depth zone contour lines were added at 5-fathom intervals. All odd-numbered depth contours were drawn after interpolation of positions between appropriate soundings from each chart. All 10-fathom contours up to 50 fathoms were traced directly from the charts. Each subsubarea was traced three times with either an Aristo [2]1130 or Bruning-Ott planimeter, and the three planimeter readings were averaged. Both are compensation planimeters of the polar type.

Conversion of planimeter measurements to hectares required several steps.

1) For each statistical subarea, the length (longitudinally) and width (latitudinally) of a 1° block were taken from oceanographic tables (LaFond, 1951) at the parallel that passed through the center of the statistical subarea. Multiplication of the length and width gave the area, in square kilometers, of the 1° block. Square kilometers were converted to hectares.

2) For each statistical subarea, the 1° block was traced three times with planimeter, and the three values were averaged.

3) For each statistical subarea, division of the calculated area of the 1° block by the average planimeter value for the block produced a conversion factor in terms of hectares per planimeter unit. These conversion factors are summarized in Table 1.

[2]Reference to trade names does not imply endorsement by the National Marine Fisheries Service, NOAA.

Table 2.—Water surface area (hectares[1]) within statistical subsubareas used in reporting Gulf Coast Shrimp Data.

Statistical subarea	Depth zone (subsubarea)											
	Meters: 0-9.1 Fathoms: 0-5	9.1-18.3 5-10	18.3-27.4 10-15	27.4-36.6 15-20	36.6-45.7 20-25	45.7-54.9 25-30	54.9-64.0 30-35	64.0-73.2 35-40	73.2-82.3 40-45	82.3-91.4 45-50	91.4 [2]50	Total
1	314,688.6	137,603.2	11,914.7	3,971.6	3,737.9	4,672.4	4,672.4	4,906.1	7,242.3	8,176.8	548,777.6	1,050,363.6
2	83,870.2	130,594.6	228,715.7	164,236.1	63,778.8	75,459.8	95,317.7	226,145.9	43,220.0	27,333.9	823,283.2	1,961,955.9
3	439,167.6	424,897.0	336,280.9	368,735.1	202,781.3	252,498.4	303,136.1	288,635.3	86,544.6	44,883.5	283,801.7	3,031,361.5
4	112,733.2	311,445.5	288,578.8	285,834.7	227,981.8	273,715.4	208,316.4	151,606.8	76,375.0	69,515.0	128,282.6	2,134,385.2
5	109,081.6	210,373.7	216,911.4	248,681.0	263,911.4	335,080.8	147,786.1	111,432.2	105,581.9	53,430.0	471,794.4	2,274,064.5
6	326,607.9	299,945.2	407,285.7	577,426.7	255,861.2	207,271.1	128,656.4	92,520.6	31,324.6	22,207.9	97,867.8	2,446,975.1
7	483,257.3	503,981.3	411,064.7	253,773.8	29,225.5	—[3]	—	—	—	—	—	1,681,302.6
8	76,343.1	73,673.0	258,159.9	225,212.9	124,923.8	69,250.4	68,715.0	24,481.4	28,599.8	25,396.6	297,131.1	1,271,887.0
9	4,240.8	14,895.2	155,323.2	110,035.7	94,915.9	54,867.4	34,733.1	36,902.4	40,645.8	20,136.5	354,058.9	920,754.9
10	18,937.4	91,695.6	164,678.5	187,285.2	113,404.1	33,235.3	33,909.0	22,831.3	21,632.1	9,056.6	134,962.1	831,627.2
11	59,380.0	234,504.4	169,095.3	150,632.7	137,672.5	88,465.3	75,882.6	42,499.9	24,867.0	20,646.4	318,448.5	1,322,094.6
12	79,271.3	16,805.5	2,561.3	1,055.7	1,130.3	300.7	113.0	45.2	—	—	—	101,283.0
13	65,660.8	74,039.3	37,173.4	37,859.1	39,687.7	37,402.5	32,834.9	22,167.8	21,710.5	30,167.1	300,852.0	699,555.1
14	98,790.7	235,059.0	131,316.5	93,535.1	92,164.0	82,872.9	57,887.9	50,575.6	30,163.0	35,265.6	247,549.2	1,155,179.5
15	438,124.7	170,923.8	156,680.9	108,465.7	91,478.5	77,692.6	95,820.1	71,979.9	58,801.9	55,374.3	136,800.7	1,462,143.1
16	221,424.0	299,955.2	262,630.8	260,041.8	105,417.5	142,056.4	138,857.3	90,564.5	55,070.4	44,245.9	83,496.7	1,703,760.5
17	129,031.4	524,806.8	434,925.6	156,223.9	136,266.0	104,352.6	151,957.6	109,073.6	47,682.7	34,504.7	35,881.0	1,864,705.9
18	79,919.2	513,641.0	268,553.4	189,777.0	194,576.7	163,874.7	119,916.5	40,836.1	685.7	25,671.4	—	1,597,451.7
19	64,415.0	240,090.2	371,999.2	249,643.7	138,998.4	100,012.4	29,663.7	7,010.8	5,623.9	—	—	1,207,457.3
20	23,617.6	103,445.3	182,014.1	157,057.3	125,251.4	133,281.4	166,818.5	94,470.6	93,053.5	51,094.4	212,242.3	1,342,346.4
21	17,512.2	88,112.6	101,635.3	118,826.0	190,155.7	98,276.8	75,966.8	35,904.7	28,468.0	26,467.4	59,414.2	840,739.7

[1]One hectare = 0.00386 square statute miles.
[2]Represents all remaining area of the statistical subarea beyond 50 fathoms.
[3]— = Exceeds subarea depth range.

4) Multiplication of the average number of planimeter units in each subsubarea by the corresponding hectares per planimeter unit for the appropriate subarea (Table 1) gave the estimated hectares in each subsubarea.

RESULTS AND DISCUSSION

The estimated water surface areas of statistical subsubareas are shown in Table 2. There were at least three sources of error in estimating these areas: 1) possible errors in the original charts; 2) possible errors in delineating statistical subareas and depth contours; and 3) possible errors in the planimeter measurements. There were no measures of the first two types of errors. With regard to planimeter measurements, Willers (1948) states that the back and forth oscillations of free hand tracing with a planimeter cancel each other.

In the course of this work, 225 groups of triplicate planimeter readings were analyzed to determine the precision of the measurements. To determine whether or not calculated means and variances of the triplicates were independent, the means and variances were transformed to logarithms (base 10), and a correlation analysis of $\log_{10}$(variance) vs. $\log_{10}$ (mean) was conducted (see Taylor, 1961). Though the correlation coefficient, $r = 0.18$, differed significantly ($P<0.05$) from zero, the correlation was not a strong one, and it was not considered to be of practical significance. Therefore, a single-classification analysis of variance was conducted on the 225 triplicates to estimate a pooled variance of 0.0000125 planimeter units. This gives a standard error (for a triplicate mean) of 0.00204 planimeter units which can be converted to hectares with factors in Table 1 and used to set confidence limits on values in Table 2, if desired.

ACKNOWLEDGMENTS

I am grateful to John Grady, National Marine Fisheries Service Gulf Coastal Fisheries Center, Panama City Facility, Panama City, Fla., who made helpful suggestions and assisted in the planimeter work. Charles Caillouet, National Marine Fisheries Service Gulf Coastal Fisheries Center, Galveston Facility, Galveston, Tex., suggested the project and assisted in statistical analysis.

LITERATURE CITED

Beverton, R. J. H., and S. J. Holt. 1957. On the dynamics of exploited fish populations. Fish. Invest. Minist. Agric., Fish. Food (G.B.), Ser. 2, 19, 533 p.

Curray, J. R. 1960. Sediments and history of holocene transgression, continental shelf, northwest Gulf of Mexico. *In* F. P. Shepard, F. B. Phleger, and T. H. Van Andel (editors), Recent sediments, northwest Gulf of Mexico, p. 221-266. Am. Assoc. Pet. Geol., Tulsa, Okla.

Kutkuhn, J. H. 1962. Gulf of Mexico commercial shrimp populations - trends and characteristics, 1956-59. U.S. Fish Wildl. Serv., Fish. Bull. 62:343-402.

LaFond, E. C. 1951. Processing oceanographic data. U.S. Navy Hydrogr. Off., Publ. No. 614, Wash., D.C., 114 p.

Taylor, L. R. 1961. Aggregation, variance and the mean. Nature (Lond.) 189:732-735.

Willers, F. A. 1948. Practical analysis, graphical and numerical methods. Dover Publ., N.Y., 422 p.

MFR Paper 1170. From Marine Fisheries Review, *Vol. 37, No. 12, December 1975. Copies of this paper, in limited numbers, are available from D825 Technical Information Division, Environmental Science Information Center, NOAA, Washington, DC 20235. Copies of* Marine Fisheries Review *are available from the Superintendent of Documents, U.S. Government Printing Office, Washington, DC 20402 for $1.10 each.*