Estimate of the total weight of Kepone in the major components of the molluscan fauna of the James River, Virginia.

by

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INTRODUCTION

Contamination of the James River in Virginia with the pesticide Kepone[R] has resulted in its accumulation in the tissues of the fauna inhabiting the river. Most of the Kepone available to the biota in the river is associated with sediments (Schneider and Dawson, 1978) and Haven and Morales-Alamo (1979) have shown that oysters and other bivalve molluscs accumulate Kepone in their tissues when exposed to the pesticide associated with sediments in suspension. It is of interest to compare the quantities of Kepone bound in James River sediments with the quantities bound in the molluscan fauna of the river.

To that end we present here estimates of the Kepone bound in the five major components of the molluscan bivalve fauna of the James River: the oyster *Crassostrea virginica*, the wedge clam Rangia cuneata, the asiatic clam Corbicula manilensis, the hard clam Mercenaria mercenaria and the hooked mussel Brachidontes recurvus. The weight of Kepone in the above species was estimated from the average body burden determined for each species in recent analyses and the estimated biomass of each species based on the most recent density data available to us.

Figure 1 presents a chart of the James River with identification of topographic features mentioned in this report.

METHODS AND RESULTS

I. Crassostrea virginica

Most oysters in the James River are found in the public grounds. The boundaries of public grounds were established in 1894 by Lt. James B. Baylor of the U. S. Coast and Geodetic Survey in a survey conducted for the Virginia Board of Fisheries and are still in effect today. Although private grounds total about 17,000 acres, the number under active cultivation at present is small. The inability to sample private grounds and extreme difficulty in tracing ownership and production records made it impossible for us to include those data in this report. However, the data for public grounds probably represents 95% of the biomass of oysters in the James River. Public grounds between Pig

Point and the mouth of the river were not sampled because the MSX disease has rendered them nonproductive.

The VIMS Department of Applied Science completed a survey of the public grounds in the James River in 1979 in which the bottoms were classified, according to their composition, into the following categories: mud, sand, oyster rock, mud and shell, sand and shell and mud over shell (Haven, Whitcomb and Kendall, MS in preparation). Charts prepared using those data allowed computation of the total acreage of each of the different types of bottom.

Subsequently, random transects, and random stations within those transects, were sampled for oyster density and the data grouped according to bottom type. Those data were considered to be a good estimate of the density of oysters in each of the bottom types and were applied to all acreage of the same bottom type.

Height measurements of oysters in samples from different transects indicated that the frequency distribution by height of oysters varied according to the location of the transects in reference to distance from the mouth of the river. Examination showed that the data for transects could be separated into three groups representing upriver, middle and downriver areas. These were designated, respectively, as areas I, II and III (Figure 2). These groupings were considered necessary because the differences in height frequency distribution affected the number of oysters and weight of meats in one bushel.

The average wet weight of meats of oysters in each of the different height classes was determined empirically in mixed subsamples of oysters from the three areas and used to compute the total wet weight of all oysters in each height class in a one-bushel sample of oysters from each of the three areas (Table 1). The sum of those figures gives the total wet weight of the meats in one bushel of oysters for each area.

The total area (in acres) of each of the three types of bottom considered productive or potentially productive in terms of oyster culture (oyster rock, mud and shell and sand and shell) was extracted from the charts prepared by Haven, Whitcomb and Kendall (MS in preparation). The total acreage given does not include that for muddy and sandy substrate. The estimated density for each bottom type in each area was used to compute the total number of bushels of oysters in all acreage of each bottom type. The estimated wet weight of the meats per bushel of oysters was then used to compute the total wet weight of the meats in that acreage. That, in turn, was multiplied by the mean concentration of Kepone in meats of oysters from each of the three areas (determined from samples analyzed by the Virginia Department of Health and VIMS) to compute an estimate of the weight of Kepone bound in the oysters.

Table 1 and Figure 3 show the height frequency distributions for the three areas. Area I, between Deep Water Shoal and just above Jail Point, contains mostly oysters between 2 and 5 cm in height. Area II, between just below Jail Point to Goodwin Point, just below the mouth of the Pagan River, showed an even distribution of oysters between 1 and 7 cm in height. Area III, between Goodwin Point and Pig Point contained small and large oysters with about half of them falling in the height range of 6 to 9 cm. Figure 2 also shows how the difference in height frequency distribution affected the distribution by weight. The sum total weight of meats in one bushel of oysters was 7.71 Kg in Area I, 5.14 Kg in Area II and 4.75 Kg in Area III (Table 1).

The estimated density of oysters for the different bottom types in the three areas is given in Table 2. The density in oyster rocks was essentially the same in the three areas, averaging 413 bu/acre. Area II seemed to have a lower density than the other two areas in oyster rock as well as in the mud and shell and sand and shell substrates. The difference in the number of samples collected in each area, however, does not allow a definitive comparison.

Density in the mud and shell substrate was almost identical to that in sand and shell in Areas I and II. A similar comparison cannot be made for Area III because sand and shell substrate was not sampled there. However, the similarities cited above have led us to assume that density in sand and shell in Area III is similar to that in mud and shell, or approximately 108 bu/acre. Average density in mud and shell for the three areas was 86 bu/acre and in sand and shell was 80 bu/acre, or about five times less than in oyster rocks.

The densities obtained in this survey are fairly close to estimates based on samples collected from the same areas between 1973 and 1975 by Loesch et al (1975). The two sets of data are shown in Table 3. The data for 1973-75 were extracted from Table 1 of Loesch et al. (1975). A pair of low values for Nansemond Ridge, marked ++, was not included in the data given in Table 3 of the present report. Although the two sets of data were not subjected to comparison by statistical analysis they indicate that the standing crop of oysters in the James River did not change dramatically between 1973-75 and 1979.

Table 4 presents the concentration of Kepone in oyster samples collected and analyzed by the Virginia Department of Health and VIMS during 1978. The data are grouped into the three public ground areas discussed separately in this report. A mean concentration was computed for each area and used in the subsequent calculation of the weight of Kepone bound in oyster meats.

Table 5 summarizes all the information obtained in this survey of the James River public oyster grounds and gives the estimated weight of Kepone associated with oysters. Acreage included in each of the three areas was close to the same in the three areas (5464, 6184 and 4762, respectively, for Areas I, II and III). Area I had the highest density of oysters and the highest total number of bushels (1.3 million). Area III had the next highest density. However, because of the lesser acreage in Area III the total number of bushels was similar in Areas II and III.

Besides having the highest standing crop in terms of bushels of the three areas, Area I also showed the highest total wet weight of oyster meats per bushel (7.71 Kg vs. 5.14 Kg for Area II and 4.75 Kg for Area III). This resulted in a much higher biomass in Area I than Areas II and III (9.78 million Kg in Area I vs. 4.72 million Kg in Area II and 4.45 million Kg in Area III). A slightly higher mean concentration of Kepone in Area I oysters than in those of the other two areas further magnified their significance as reservoirs of Kepone when compared with the other two areas. The estimated weight of Kepone bound in oysters from Area I was 1.57 Kg. In Area II it was 0.47 Kg and in Area III it was 0.49 Kg.

In summary, the 16,410 acres of productive oyster bottom in the Baylor Survey public grounds of the James River hold 3.1 million bushels of oysters with a biomass (wet weight) of 18.9 million Kg. Bound in those oysters are 2.53 Kg of Kepone, most of them in Area I.

II. Brachidontes recurvus (Hooked mussel)

The hooked mussel Brachidontes recurvus is a close associate of the oyster in the James River. It sets on and lives attached to the shell of live oysters and empty shells on oyster beds. These shells practically constitute the only substrate for mussels to grow on in the James River. For that reason, our estimates of the abundance of the hooked mussel in the James River are based on samples collected from live oysters and shells. No mussels were collected from any other kind of substrate and the assumption was made that the number of mussels on any other substrate was negligible.

Bottom substrate was collected with an oyster dredge from natural oyster beds in the James River and separated into subsamples of either one-half or one-fifth of a bushel. The material in each of the subsamples was separated into live oysters, empty shells and cinder (fractionated shells) and the volume of each of the three fractions measured. Hooked mussels were detached from oysters and empty shells and the volume collected from each fraction measured. This gave a measure of the volume of mussels that could be found in a unit volume of oysters or shells.

The volume of mussels collected was split into two equal parts and all mussels in each part were measured to the nearest 1/10 cm. They were then shucked and meats collected in a beaker. Meats were weighed and weights converted to Kg/bu (wet weight). The same meats collected for measurement of wet weight per unit volume were analyzed for concentration of Kepone.

The estimated total number of bushels of oysters and shells presented in part I above for each of the three areas of public grounds outlined in Figure 2 was used for estimation of the total number of bushels of hooked mussels in the same areas. The calculated ratio of bushels of mussels per bushel of oyster or shell was multiplied by the number of bushels of oysters or shells in each area (for each of the three types of oyster-producing bottom substrates) and the sum of the products for oysters and shells was then multiplied by the mean wet weight of meats for each area. Subsequent multiplication of the latter products by the mean concentration of Kepone in mussel meats provided the estimate of the weight of Kepone bound in hooked mussels.

The public ground areas sampled for density and biomass of hooked mussels were the same ones sampled for oysters (Figure 2). Results are presented in the same format used for the data on oysters. The data are given separately for each of the three areas used and within each area they are broken down into the same three types of bottom substrate used in presenting the data on oysters (oyster rock, mud and shell and sand and shell).

Table 6 shows the ratio of the volume of mussels per bushel of oysters and of shells as determined from measurements made on subsamples of bottom substrate from the James River. The greatest concentration of mussels per bushel of oyster or shell was found in Area II and the lowest in Area III. Overall, the mean concentration ranged from 0.01 and 0.18 bushels per bushel of oysters or shell.

The biomass (mean wet weight) of hooked mussels ranged between 2.68 to 3.36 Kg/bu (Table 7). The highest mean weight was recorded for mussels from Area I and appeared to increase in a downriver direction. There were more small mussels in Area I than in the other two areas with a resulting lower mean height for mussels in the former area. This difference in height showed dramatically in our estimate of the number of mussels per bushel for each of the three areas. The estimated mean number and range of number per bushel for the three areas was, respectively,: Area I, 41,400 (27,800-53,500); Area II, 17,500 (12,000-26,400); and Area III, 11,700 (11,400-12,000).

The mean concentration of Kepone in hooked mussels collected and analyzed in September and October 1978 decreased in a downriver direction (Table 8). Mussels in Area I had the highest concentration with a mean of 0.21 μg/g and Area III had the lowest at 0.08 μg/g. The concentration in mussels from Area II (0.12 μg/g) was closer to that of mussels from Area III than to that of mussels from Area I.

Samples of bottom substrate collected during the 1979 survey of public grounds in the James River provided information on the density of shells on those bottoms as well as on the density of oysters. Those data have been integrated into Table 9 along with those on the number of hooked mussels per bushel of oysters and shells, wet weight of mussel meats to obtain the weight of Kepone bound in hooked mussel meats.

Our estimates show that there is approximately 0.70 Kg of Kepone bound in the meats of hooked mussels in the James River. Ninety-seven percent of it (0.68 Kg) is found in Areas I and II between the two of which it is divided fairly evenly. This distribution of Kepone results from the lower density of mussels and concentration of Kepone in their meats in Area III. The weight of Kepone in the standing crop of hooked mussels constitutes about 28% of that found in the standing crop of oysters in the James River, which was 2.53 Kg (Table 5).

III. Mercenaria mercenaria (Hard clam)

The upriver limit of the distribution of the hard clam Mercenaria mercenaria in the James River is located at the level of the James River bridge. Several intensive surveys of hard clam populations in the James River have been conducted previously by VIMS (Haven and Loesch, 1972; Haven, Loesch and Whitcomb, 1973; and Haven and Kendall, 1974, 1975). The data from those studies form the basis for this report on the density of hard clams in the James River.

The region between just above the James River bridge and the mouth of the river at Old Point Comfort was divided into 31 plots (Figure 4). The acreage included in each of the plots was measured with a polar planimeter on a NOAA navigation chart. Eighteen of the plots were sampled in the surveys mentioned above and the outlines of their areas are based on those data. The other thirteen plots were not sampled and their areas were delinated following the boundaries of the areas sampled and bottom depth contours. The density of clams in plots not sampled was estimated on the basis of the density in adjoining plots that were sampled, and our familiarity with the areas through conversations with clammers that work them and the nature of the bottom.

The biomass (wet weight) per bushel of clams was estimated from samples of clams which ranged in length between 57 and 100 mm with a mean of 78 mm.

The estimated weight was 6.38 Kg/bu. The average number of clams per bushel was 330.

Concentration of Kepone in hard clams was determined from six samples of clams collected from plot 10 (two samples, 5 August 1977), plot 14 (two samples, 8 December, 1978) and plot 23 (two samples 12 July 1979). The range of Kepone in these samples was 0.01 to 0.063 μg/g with a mean of 0.03 μg/g.

The data on density of hard clams in each of the plots and Kepone associated with the standing crop of hard clams in the James River appear in Table 10. The 31 plots represent an area of 34,579 acres. Based on the classification of Haven and Loesch (1973) for relative density of hard clams (low density = 0-23 bu/acre; medium density = 24-55 bu/acre and high density = ≥56 bu/acre), 61% of the acreage included in the 31 plots sustained a low density of clams, 33% sustained a medium density and only 4% had a high density. The highest densities of hard clams were found off the mouth of the Small Boat Harbor and around the Newport News Middleground (plots 14, 16 and 17).

The estimated total number of bushels in the area covered by the 31 plots is 565,712 The wet weight of the meats in that volume of hard clams is estimated at 3.6 million Kg which, at an average concentration of Kepone of 0.03 mg/Kg, represent a total 0.11 Kg of Kepone bound in the meats of hard clams in the James River.

IV. Rangia cuneata (Wedge clam)

The brackish-water pelecypod Rangia cuneata (the wedge clam) has only recently repopulated the James River (Wass, 1972; Peddicord, 1973). It occupies the oligohaline and lower mesohaline regions of the estuary and in parts of that range constitutes 99% of the benthic biomass (Cain, 1972). The biomass values presented in this report are based almost entirely on the density data collected in 1971-1972 by Diaz (1977). Those data are supplemented with data collected in 1976 by Jordan et al. (1977) around Hog Island.

Stations sampled by Diaz (1977) were located on transects spaced at intervals of five nautical miles from mile 10 (10 nautical miles above the mouth of the river at Old Point Comfort) up to mile 85, just below the City of Richmond. Data from Diaz' transects at miles 25 and 30 were those of Cain and Peddicord (1970). Sampling was done in the fall of 1971, and summer and fall of 1972. The number of samples for each transect during the three sampling dates usually totalled nine but sometimes was only six. At one transect (mile 40) it was only four. No wedge clams were found above the transect at mile 55.

The data for each transect were taken to represent a section extending approximately 2.5 miles above and below the transect location. Each of these sections was separated from each other by a straight line drawn from shore to shore (Figure 5). The area enclosed within each of the sections (excluding creeks, coves or larger tributaries) was measured with a polar planimeter. Densities given in terms of no./m^2 were averaged for each transect and converted to bu/acre by applying appropriate conversion factors.

The average number of clams in one bushel was estimated at 2750 by counting the number in ten 4-qt samples collected from different locations in the James River. The wet weight (biomass) of one bushel of clams was estimated at 7.6 Kg from nine samples of clams totaling 433 clams. The concentration of Kepone in the meats of wedge clams was determined from samples collected at different locations along the length of its distribution in the James River. The measurements of samples falling within the same sections outlined in Figure 5 were grouped together and averaged (Table 11). Where no measurement of the Kepone concentration was available for clams in a section, the value for the adjoining section was used.

The above conversion factor for number per bushel, and estimates of wet weight of the meats and Kepone concentration in the meats were applied to the data of Diaz (1977) and Jordan et al. (1977) and summarized in Table 12 in terms of the total acreage of each river section.

The wedge clam Rangia cuneata is found over a large segment of the James River, from mile 10 at the James River Bridge to mile 57 at Windmill Point (Table 12, Figure 5). It is most abundant, however, between Mulberry Point (mile 23) and Ward Creek (mile 53). The greatest densities and total biomass were found at mile 40 and mile 30 (sections G and E). In a total of 84,790 acres of bottom between the James River Bridge and Windmill Point there are approximately 6 million bushels of wedge clams, representing 47 million Kg of biomass.

Based on the mean concentration of Kepone in the meats of clams from the different sections, the total load of Kepone in the meats and liquor of Rangia cuneata in the James River is estimated to be 3.55 Kg.

V. Corbicula manilensis (Asiatic clam)

The Asiatic clam Corbicula manilensis is also a recent introduction to the fauna of the James River (Diaz, 1974). It's distribution extends from the lower oligohaline zone at Hog Point through the tidal freshwater zone and into the non-tidal freshwater zone above Richmond. Diaz (1977) records its presence in his samples between mile 35 at Jamestown and mile 85, at the fall line in Richmond. However, it has been found by others as far upriver as Lynchburg (Diaz, personal cummunication). Jordan et al. (1977) reported it in their samples collected on the upriver side of Hog Island, at mile 30.

In the course of the present study we collected non-quantitative samples of Asiatic clams with an oyster dredge at different locations in the James River in April 1979, to obtain animals for Kepone analysis. We found none between Burwell Bay and Dancing Point, at mile 40, but found them from Dancing Point to just below Turkey Island, at mile 67. Sampling extended beyond Turkey Island up to mile 72 but no Corbicula were found in that stretch of river.

There are indications that the concentrations of Kepone in bottom sediments above Turkey Island are either nondetectable or very low. This is apparent in data presented by Shupe and Dawson (1978) and Nichols and Trotman (1977). For that reason, and because we were unable to find any clams for Kepone analysis above that point, our estimate of the Kepone load in the standing crop of Corbicula manilensis is restricted to populations found downriver of Turkey Island. The downriver limit at Hog Island was determined by the absence of clams of the species below that point.

Division of the river into sections and determination of the density of Corbicula in each section was done in the same manner outlined for Rangia cuneata data in Section IV of this report. The river sections are the same outlined for Rangia and are identified by the same letters in Figure 6. The data of Diaz (1977) usually included six to eight samples for each transect (all three sampling dates combined). In one instance, at mile 40, they numbered only four. The average number of *Corbicula* clams in one bushel was estimated at 4680 from the samples collected in the spring of 1979 and the wet weight of meats of one bushel of the clams was estimated at 8.4 Kg from the measurements of those samples. The concentration of Kepone in the meats of this species was also estimated from the same samples and are given, grouped into different sections, in Table 13. Means given in Table 13 were applied to adjoining sections for which measurements were not available.

The estimates given in the preceding paragraph for number of clams per bushel, weight of meats in a bushel and mean concentration of Kepone in the meats were applied to the data of Diaz (1977) and Jordan et al. (1977) to determine the total load of Kepone in the standing crop of Corbicula in the James River. They are expressed in terms of bottom acreage in Table 14.

Corbicula manilensis was most abundant in sections K and L, between Windmill Point (mile 56) and Turkey Island (Table 14). Its density below Ward Creek (in sections I to E) was considerably lower. There are an estimated 44,340 acres of river bottom in the segment of the James River included between sections E and L (Table 14, Figure 6). In that acreage, the estimated total number of bushel of Corbicula is 6.6 million. That number of bushels translates into a total wet weight of meats of 55.2 million Kg.

Application of the mean concentration of Kepone in the meats of clams from the different sections to the weight of the meats results in a total Kepone load in the meats of 6.37 Kg. The greatest quantities of Kepone bound in the meats of Corbicula manilensis are located in sections K and L, between miles 57 and 67 in the vicinity of Hopewell. A combination of slightly higher concentration of Kepone in the meats combined with very high density of clams to make sections K and L outstanding in that respect.

Comparison of the average total weight of Kepone for each section with the mean overall total for all sections shows that sections K and L contain about 84% (5.35 of 6.37 Kg) of all the Kepone bound in Corbicula. Sections J, K and L, comprising a stretch of river 15 nautical miles long and 9,700 acres of bottom (22% of the total acreage between Hog Island and Turkey Island) contains 96% of the Kepone bound in Corbicula in the James River. The quantity of Kepone in Corbicula in sections E, F and G, between Dancing Point and Hog Island is very small, 0.05 Kg, and in sections H and I, between Dancing Point and Ward Creek it is only 0.24 Kg.

DISCUSSION

The distribution of the species of bivalves for which biomass was estimated in this report covers the James River from the mouth to just above Hopewell. In that range those species constitute the major fraction of the molluscan biomass present.

The hard clam Mercenaria mercenaria is restricted to the higher salinity waters of the river mouth and the James River Bridge. The oysters Crassostrea virginica and the hooked mussel Brachidontes recurvus range from the mouth to about 24 nautical miles upriver to Deep Water Shoal. The distribution of Rangia cuneata overlaps with that of the oysters at the downriver end and extends from mile 9 to mile 57. The range of Corbicula manilensis covers much of the range of Rangia and extends downriver to about the upriver limit of oysters. Although the distribution limit of Corbicula upriver goes well beyond Richmond, our biomass estimate does not include any area beyond Turkey Island.

Our estimates show that the standing crop in terms of bushels and wet weight biomass of Corbicula and Rangia were highest among the five species. The total number of bushels in each of those two species was greater than that of oysters by around three million bushels and greater than those of Brachidontes and Mercenaria by an even larger margin (around 5 and 6 million bushels, respectively). The combined standing crop in bushels of Corbicula and Rangia constituted 71% of the total for the five species.

Wet weight biomass estimates for Corbicula and Rangia were also much greater than those for the other three species by an even greater margin than was estimated for the standing crop in bushels. Wet weight of the meats of each of the two species was two to three times as great as that of oysters, 10 to 11 times greater than that of Brachidontes and 13 to 15 times greater than that of Mercenaria.

The abundance of Rangia is more a factor of the greater range of its distribution than of the density of its occurrence throughout that range. That range included a total of 84.7 thousand acres which is approximately 3.5 times the acreage covered by oysters. In the case of Corbicula, however, the great abundance estimated is the direct result of extremely high mean densities in the river section between miles 52 and 67 (sections J, K and L). Those densities ranged between 447 and 696 bu/acre in that 15-mile stretch of the James River.

The extremely high biomass of Rangia and Corbicula when compared to that of oysters, mussels and hard clams is not only a projection of their greater abundance but also of the greater wet weight of their meats per unit volume and their greater numbers per bushel. The meats of Rangia and Corbicula individuals usually weighed about twice as much as oysters of the same height. The average number of Rangia and Corbicula per bushel was estimated at 2750 and 4680, respectively, while the average number of oysters per bushel for all three areas of the public grounds was 1,858.

The presence and abundance of *Rangia* and *Corbicula* in specific sections of the James River, where they have penetrated salinity regimes beyond their normal tolerance range, is subject to fluctuations as salinity varies with changes in freshwater runoff (Diaz, 1977). Thus, although *Rangia* can be found as far downriver as the James River Bridge its presence there cannot be expected to be consistent. The same can be said for the presence of *Corbicula* in the vicinity of Hog Island. However, the bulk of the biomass of these two species is located within their normal salinity range and variations at the extremes will affect our estimates very little.

Although the biomass estimates for *Rangia* and *Corbicula* are greater than that given for oysters they are subject to greater variability. Examination of the data of Diaz (1977) will show that there was considerable variability in the number of *Rangia* and *Corbicula* from sample to sample between stations at most of the transects. Our estimates are based on the average for the combined stations and sampling dates at each transect and are considered fairly conservative. It is to be expected that future sampling at any one location may differ significantly from those based on the data of Diaz (1977). However, the overall estimate given for the whole river is considered to be a reasonable approximation to the actual quantities to be found there.

The estimate of biomass for oysters is more precise than those for Rangia and Corbicula. Crassostrea populations in the James River are well established within their range and, barring catastrophic occurrences such as a disease outbreak, can be expected to remain fairly constant, unlike the opportunistic newcomers Rangia and Corbicula. Furthermore, the estimates for oysters are based on more extensive data.

The relatively high biomass estimated for the hooked mussel Brachidontes recurvus is primarily a function of the great quantity of substrate available to it on the oyster and shell beds in the James River. The total number of bushels of shells was estimated to be five times that estimated for oysters: 20.5 million bushels of shells against 4.2 million bushels of oysters. The hooked mussel has been very successful in occupying this habitat and the extensive availability of prime substrate provided the base for a large population of the species.

The range of the hard clam Mercenaria mercenaria is more restricted by salinity than is the case for the other four species. Its populations are limited to the lower reaches of the river. Although its range also includes some of the widest parts of the river much of it does not provide the proper substrate. Therefore, the estimated standing crop in terms of bushels of hard clams is considerably lower than that estimated for the other four species. The estimated biomass was also the lowest of the five species.

The estimates of the load of Kepone in the tissues of the five species of bivalve molluscs included in this report show that Corbicula manilensis constitutes by far the greatest reservoir of Kepone of the five. This is primarily so by virtue of its abundance and high yield of meats per bushel. The estimated total Kepone of 6.37 Kg represents almost half (48%) of that bound in the total biomass of all five species. Rangia ranked second with 3.55 Kg followed closely by the oyster with 2.53 Kg. Brachidontes recurvus populations showed a total load of 0.70 Kg. The lowest quantity of Kepone in meats was estimated for the hard clam Mercenaria mercenaria, 0.11 Kg. The relatively small biomass of hard clams, added to the relatively low average concentration of Kepone in their meats (0.03 mg/Kg) accounted for that low estimate.

The combined total estimate of Kepone bound in the meats of all five species is 13.26 Kg. This is a fairly low figure when compared to estimates of the Kepone bound in bed sediments of the James River, which have been given as between 9,600 to 19,000 Kg (Dawson, Shupe and Weimer, 1978). Most of the Kepone bound in meats (9.92 Kg) is not directly subject to human consumption since it is associated with the clams Corbicula manilensis and Rangia cuneata.

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Table 1. Number, weight and percent frequency distribution by height of oysters in one-bushel samples from three areas of Baylor Survey public grounds in the James River. Based on samples collected July-August 1979.

Height Class (cm)	No. Oysters	Pct. Frequency by No.	Total Wet Wt. All Oysters in Class (Kg)	Pct. Frequency by Wt.
AREA I (Transects 907-1053)				
0 - 1.0	0	0	0	0
1.1- 2.0	72	2.2	0.04	0.5
2.1- 3.0	530	16.3	0.35	4.5
3.1- 4.0	1358	41.8	1.75	22.7
4.1- 5.0	559	17.2	1.30	16.9
5.1- 6.0	354	10.9	1.45	18.8
6.1- 7.0	260	8.0	1.70	22.0
7.1- 8.0	94	2.9	0.88	11.4
8.1- 9.0	20	0.6	}0.24	}3.11
9.1-10.0	0	0		
Totals/bu	3247		7.71	
AREA II (Transects 1054-1169)				
0 - 1.0	34	2.0	0.01	0.2
1.1- 2.0	228	13.4	0.12	2.3
2.1- 3.0	244	14.3	0.16	3.1
3.1- 4.0	261	15.3	0.34	6.6
4.1- 5.0	281	16.5	0.65	12.6
5.1- 6.0	326	19.1	1.33	25.9
6.1- 7.0	213	12.5	1.39	27.0
7.1- 8.0	96	5.6	0.90	17.5
8.1- 9.0	8	0.5	}0.24	}4.7
9.1-10.0	12	0.7		
10.1-11.0	0	0	--	--
Totals/bu	1703		5.14	
AREA III (Transects 1170-1395)				
0 - 1.0	0	0	0	0
1.1- 2.0	19	3.0	0.01	0.2
2.1- 3.0	39	6.2	0.03	0.6
3.1- 4.0	31	5.0	0.04	0.8
4.1- 5.0	41	6.6	0.09	1.9
5.1- 6.0	49	7.8	0.20	4.2
6.1- 7.0	130	20.8	0.85	17.9

Table 1 (Contd.)

Height Class (cm)	No. Oysters	Pct. Frequency by No.	Total Wet Wt. All Oysters in Class (Kg)	Pct. Frequency by Wt.
7.1- 8.0	127	20.4	1.18	24.8
8.1- 9.0	95	15.3	2.02	42.5
9.1-10.0	49	7.8		
10.1-11.0	24	3.9		
11.1-12.0	13	2.1	0.33	6.9
12.1-13.0	6	0.9		
13.1-14.0	1	0.2		
14.1-15.0	0	0	--	--
Totals/bu	624		4.75	

Table 2. Density of oysters for three types of bottoms in samples collected at random along transects over three areas of Baylor Survey public grounds[1] in the James River. May-September 1979.

Substrate Type[2] / Area Designation (Transect Nos.)	No. Samples[3]	Total Area Sampled (acres)	Total Volume Oysters (bu)	Density (bu/acre)
OYSTER ROCK				
Area I (969-1044)[4,5]	6	0.0010	0.46	460
Area II (1057-1167)	66	0.0112	4.54	405
Area III (1353-1374)	4	0.0007	0.33	471
All Transects	76	0.0129	5.33	413[6]
MUD AND SHELL				
Area I (969-1044)	39	0.0066	0.75	114
Area II (1057-1167)	152	0.0258	2.01	78
Area III (1353-1374)	7	0.0012	0.13	108
All Transects	198	0.0336	2.89	86[6]
SAND AND SHELL				
Area I (969-1044)	5	0.0008	0.10	125
Area II (1057-1167)	45	0.0076	0.57	75
Area III (1353-1374)	0	--	--	--
All Transects	50	0.0084	0.67	80[6]

Total No. Samples = 503 (179 samples consisted of sand or mud only, where no oysters were found).

[1] 1894 survey by Lt. James B. Baylor, U.S.C.G.S., for Va. Bd. of Fisheries.

[2] Substrate types described in text.

[3] Each sample corresponded to one patent-tong grab of 7.29 ft^2 (= 17 X 10^{-5} acres).

[4] Outline of areas appears on Figure 1. Transect numbers from Teledyne Hastings-Raydist positioning system grid.

[5] Transects given bracket only the transects sampled and not the whole area.

[6] Based on totals for all transects.

Table 3. Comparison of James River oyster density (bu/acre) estimates from the present survey and from samples collected between 1973 and 1975 by Loesch et al. (1975).

1973-75 Estimates			1979 Estimates	
AREA I				
Horsehead	A[1]	197		
	B	199	Oyster Rock	460
			Mud and shell	114
Point of Shoals	A	164	Sand and shell	125
	B	137		
		Mean = 174		Mean = 233
AREA II				
Wreck Shoal				
Inshore	A	64		
	B	20	Oyster Rock	405
Middle	A	210	Mud and shell	78
	B	102	Sand and shell	75
Offshore	A	356		
	B	196		
		Mean = 158		Mean = 186
AREA III				
Thomas Rock	A	172		
	B	179		
Gun Rock	A	250		
	B	173		
White Shoal	A	446	Oyster Rock	471
	B	210	Mud and shell	108
			Sand and shell	108[2]
		Mean = 238		Mean = 229

[1]A = 1973-74 data; B = 1974-75 data.

[2]Density for sand and shell assumed to be equal to density for mud and shell.

Table 4. Kepone concentration (mg/kg) in meats of oysters (*Crassostrea virginica*) collected at different stations in the James River. Jan-Nov. 1978. Data obtained by the Virginia Department of Health.

	AREA I				AREA II		AREA III					
1978	Horsehe d	Swash Hole	Deep Wate Shoal	Point of Shoals	Jail Point	Wreck Shoal	Mouth Nansemond River	Nansemond Ridge	Naseway Shoals	Ballard's Marsh	Miles Watch House	White Shoal
Jan		0.30	0.26	0.31	0.19		0.17	0.14	0.15	0.19	0.18	
Feb		0.20	0.13	0.24	0.12		0.10	0.11	0.06	0.15	0.05	
Mar		0.21	0.22	0.32	0.25		0.16	0.15	0.18	0.18	0.17	
Apr		0.22	0.17	0.20	0.10		0.08	0.08	0.08	0.11	0.08	
May		0.08	0.09	0.07	0.03		0.06	0.07	0.04	0.08	0.07	
Jun		0.10	0.12	0.10	0.10		0.13	0.10	0.09	0.11	0.10	
Jul		0.21	0.20	0.04	0.10		0.06	0.17	0.07	0.21	0.08	
Aug	0.13	0.19	0.20	0.17	0.11		0.10	0.11	0.09	0.12	0.13	0.03*
			0.15*	0.13*		0.08*						
			0.09*	0.05*		0.07*						
			0.10*	0.03*		0.05*						
			0.01*	0.16*		0.07*						
			0.01*	0.09*		0.09*						
Sep	0.12	0.38	0.15	0.16	0.06		0.25	0.07	0.07	0.14	0.07	0.08*
			0.19*	0.18*		0.09*						
Oct		0.28	0.26	0.15	0.08		0.12	0.13	0.08	0.17	0.13	
Nov	0.09	0.24	0.18	0.21	0.18		0.10	0.10	0.11	0.15	0.09	0.07*
			0.11*	0.11*		0.07*						

Mean conc. for Area I = 0.16 Kg

Mean conc. for Area II = 0.10 mg/Kg

Mean conc. for Area III = 0.11 mg/Kg

*VIMS observations

Table 5. Estimate of number of bushels, weight of meats and weight of Kepone in meats of the oyster Crassostrea virginica on different substrates in Baylor Survey public grounds of the James River (divided into three areas).

Area Designation (Transect Numbers)[1] / Substrate Type	No. Acres[3]	Est. Density[4] (bu/acre)	Total No. Bushels (Millions)	Total Wet Wt. Meats[5] (Millions of kg)	Mean Conc. Kepone[6] (mg/kg)	Total Wt. Kepone (kg)
AREA I (Trans. 907-1053)					0.16	
Oyster Rock	1812	460	0.833	6.422		1.03
Mud and Shell	1962	114	0.224	1.727		0.28
Sand and Shell	1690	125	0.211	1.627		0.26
Totals	5464		1.268	9.776		1.57
AREA II (Trans. 1054-1169)					0.10	
Oyster Rock	1348	405	0.546	2.806		0.28
Mud and Shell	3237	78	0.252	1.295		0.13
Sand and Shell	1599	75	0.120	0.617		0.06
Totals	6184		0.918	4.718		0.47
AREA III (Trans. 1170-1395)					0.11	
Oyster Rock	1171	471	0.551	2.617		0.29
Mud and Shell	2475	108	0.267	1.268		0.14
Sand and Shell	1116	108[7]	0.120	0.570		0.06
Totals	4762		0.938	4.455		0.49
TOTALS ALL AREAS	16,410		3.124	18.949		2.53

Table 5. (Contd.)

[1]Outline of areas appears on Figure 1. Transect numbers from Teledyne Hastings-Raydist positioning system grid.

[2]Substrate types described in text.

[3]Estimated from recent survey by Haven, Whitcomb and Kendall (MS in preparation).

[4]From Table 2.

[5]From Table 1.

[6]From Table 4.

[7]Random sampling did not include sand and shell substrate. Data showed oyster density to be similar to that of mud and shell substrate and that figure was used here.

Table 6. Mean number of bushels of the hooked mussel *Brachidontes recurvus* in a bushel of oysters or shells estimated from samples of bottom substrate collected from oyster beds at different locations in the James River. September to October 1978.

Location sampled	Date	No. Samples	Mean bu mussels/ bu oysters	Mean bu mussels/ bu shells
AREA I				
Horsehead	26 Oct	2	0.256	0.076
Point of Shoals	26 Oct	3	0.0001[2]	0.023
Mean for Area I[1]		5	0.128	0.049
AREA II				
Wreck Shoal	11 Sept	4	0.192	0.213
	26 Oct	2	0.152	0.096
Mean for Area II[1]		6	0.179	0.174
AREA III				
White Shoal	3 Oct	3	0.102	0.041
Brown Shoal	18 Oct	3	0.033	0.0001[2]
Nansemond Ridge	18 Oct	3	0.0001[2]	0.0001[2]
Mean for Area III[1]		9	0.045	0.014

1 Computed by combining values of all samples from area.

2 0.0001 indicates volume to small to measure.

Table 7. Wet weight of the meats of the hooked mussel *Brachidontes recurvus* in samples of bottom substrate collected from oyster beds in the James River. September to October 1978.

Location sampled	Date	Height of mussels (cm) Range (mean)	Wet wt. of meats (Kg/bu) Mussels on oysters	Mussels on shells	Combined	Mean (all values)
AREA I						
Horsehead	26 Oct	0.8-3.4 (1.8)			2.35 2.15	
Point of Shoals	26 Oct	0.3-6.1 (1.4)			3.93 5.02	
						3.36
AREA II						
Wreck Shoal	11 Sept	0.5-5.1 (2.4)	3.36 2.91 3.14 3.47	3.46 2.81 2.80 3.01		
	26 Oct	0.3-3.9 (2.3)			2.01 1.84	
						2.88
AREA III						
White Shoal	3 Oct	0.6-4.6 (2.0)	3.31	2.69		
Brown Shoal	18 Oct	1.2-4.1 (2.4)			2.26 2.45	
						2.68

Table 8. Kepone in meats of hooked mussels (*Brachidontes recurvus*) from the James River. Collected September-October 1978.

Location	Date	Kepone Conc. (μg/g)	Mean
AREA I[1]			
Horsehead	26 Oct	0.21	
		0.24	
Point of Shoals	26 Oct	0.13	
		0.26	0.210
AREA II			
Wreck Shoal	11 Sep	0.16	
		0.13	
		0.14	
		0.13	
		0.13	
		0.12	
		0.11	
		0.06	
	26 Oct	0.14	
		0.13	0.125
AREA III			
White Shoal	3 Oct	0.12	
		0.12	
Brown Shoal	18 Oct	0.05	
		0.02	0.077

[1]Area designation used in presentation of oyster data.

Table 9. Estimate of the number of bushels, weight of meats and weight of Kepone in meats of the hooked mussel Brachidontes recurvus collected from oysters and shells in the Baylor Survey public grounds in the James River. Divided into three areas and into the three types of oyster-producing bottoms. September to October 1978.

Area Designation[1] / Substrate Type	Bu. Mussels /Acre	No. Acres	Est. Total Bushels Oysters (Millions)	Est. Total Bushels Mussels on Oysters (Millions)	Est. Total Bushels Shells (Millions)	Est. Total Bushels Mussels on Shell[2] (Millions)	Total Wet Wt. Mussel Meats (Millions of Kg)[3]	Mean Kepone Conc. in Mussel Meats[4] (mg/Kg)	Total Wt. Kepone in Mussels Meats (Kg)
AREA I								0.210	
Oyster Rock	139	1812	0.833	0.107	2.953	0.145	0.847		0.18
Mud and Shell	63	1962	0.224	0.029	1.934	0.095	0.417		0.09
Sand and Shell	44	1690	0.211	0.027	0.972	0.048	0.252		0.05
Totals	82[5]	5464	1.268	0.163	5.859	0.288	1.516		0.32
AREA II								0.125	
Oyster Rock	297	1348	0.546	0.098	1.736	0.302	1.152		0.14
Mud and Shell	135	3237	0.252	0.045	2.285	0.397	1.273		0.16
Sand and Shell	105	1599	0.120	0.021	0.846	0.147	0.484		0.06
Totals	179[5]	6184	0.918	0.164	4.867	0.846	2.909		0.36
AREA III								0.077	
Oyster Rock	38	1171	0.551	0.025	1.421	0.020	0.121		0.01
Mud and Shell	16	2475	0.267	0.012	1.898	0.026	0.102		0.01
Sand and Shell	12	1116	0.120	0.005	0.590	0.008	0.035		0.003
Totals	22[5]	4762	0.938	0.042	3.909	0.054	0.258		0.02
TOTALS ALL AREAS	94[5]	16,410	3.124	0.369	14.635	1.188	4.683		0.70

Table 9 (Contd.)

[1]Same areas presented in Figure 1.

[2]Based on values in Table 6.

[3]For mussels on oysters and shells combined. Based on mean weights per bushel of mussels given in Table 7.

[4]From Table 8.

[5]Mean.

Table 10. Estimate of number of bushels, wet weight of meats and weight of Kepone in meats of the hard clam *Mercenaria mercenaria* in plots surveyed between 1970 and 1974 in the James River.

Source of Data (Footnotes)	Plot No.	No. Acres	Clam Density (Bu/Acre)	Total No. (Bushels)	Total Wet Wt. Meats (Millions of Kg)[6]	Total Wt. Kepone (g)[7]
-	1	508	(0.3)[5]	152	0.001	0.03
1	2	4321	6.9	29,815	0.190	5.70
-	3	427	(0.3)[5]	128	0.001	0.03
1	4	1221	40.0	48,840	0.311	9.33
1	5	1928	36.1	69,601	0.444	13.32
-	6	528	(0.3)[5]	158	0.001	0.03
2	7	5410	1.1	5,951	0.038	1.14
2	8	71	0	0	0	0
2	9	242	5.5	1,331	0.008	0.24
2	10	2352	12.1	28,459	0.181	5.43
-	11	305	(1.0)[5]	305	0.002	0.06
3	12	610	11.0	6,710	0.043	1.29
3	13	1126	0.3	338	0.002	0.06
3	14	1323	62.0	82,026	0.523	15.69
3	15	109	6.0	654	0.004	0.12
3	16	680	65.0	44,200	0.282	8.46
3	17	183	58.0	10,614	0.068	2.04
-	18	1075	(25.0)[5]	26,875	0.171	5.13
-	19	698	(25.0)[5]	17,450	0.111	3.33
-	20	1474	(25.0)[5]	36,850	0.235	7.05
-	21	890	(5.0)[5]	4,450	0.028	0.84
-	22	1202	(5.0)[5]	6,010	0.038	1.14
-	23	2266	(25.0)[5]	56,650	0.361	10.83
-	24	488	(25.0)[5]	12,200	0.078	2.34
4	25	571	16.08	9,182	0.058	1.74
-	26	1486	(5.0)[5]	7,430	0.047	1.41
4	27	1473	24.12	35,529	0.227	6.81
-	28	691	(25.0)[5]	17,275	0.110	3.30
4	29	386	10.05	3,879	0.025	0.75
4	30	352	3.35	1,179	0.007	0.21
4	31	183	8.04	1,471	0.009	0.27
TOTALS		34,579		565,712	3.604	108.12 ≈(0.11 Kg)

[1]Haven, D. S., J. G. Loesch and J. P. Whitcomb. 1973. An investigation into commercial aspects of the hard clam fishery and development of commercial gear for the harvest of molluscs. Final Report, Contract 3-124-R with the Virginia Marine Resources Commission, for the National Marine Fisheries Service. 119 pp. Virginia Institute of Marine Science, Gloucester Point, Virginia.

Table 10 (Contd.)

[2]Haven, D. and P. Kendall. 1975. A survey of commercial shellfish in the vicinity of Newport News Point and Pig Point in the lower James River. Final Report to McGaughy, Marshall and McMillan - Hazen and Sawyer. In: Fang, C. S. (Project Manager): Oceanographic, Water Quality and Modeling Studies for the Outfall from a Proposed Nansemond Waste Water Treatment Plant, Volume 4. p. 1-28 and summary. Special Report No. 86 in Applied Marine Science and Ocean Engineering. Virginia Institute of Marine Science, Gloucester Point, Virginia.

[3]Haven, D. S. and J. G. Loesch. 1972. Hampton Roads corridor survey report for the Virginia Department of Highways. Final Report. 12 pp + 6 tables. Virginia Institute of Marine Science, Gloucester Point, Virginia.

[4]Haven, D. and P. Kendall. 1974. A final report to the Virginia Department of Highways on hard clam (Mercenaria mercenaria) populations in the vicinity of the Hampton Roads Bridge-Tunnel (I-64). 15 pp + 6 tables + 18 figures. Virginia Institute of Marine Science, Gloucester Point, Virginia.

[5]Density given represents a guess-estimate based on familiarity with the area and data from surrounding areas.

[6]Based on a mean wet weight of 6.38 Kg/bu. Determined empirically.

[7]Based on a mean concentration of Kepone in meats of 0.03 mg/Kg. Determined empirically.

Table 11. Kepone concentration in samples of *Rangia cuneata* collected from the James River between April 1977 and May 1979.

Source	Approx. Distance From Mouth (miles)	Date Collected	No. Clams	Height (cm) Mean	Height (cm) Range	Kepone (µg/g)
BW Buoy J17 (Inshore)	19	17 May 1979	9	3.1	2.8-3.5	0.08
			9	3.0	2.5-3.4	0.08
Inshore of Reserve Fleet	20	17 May 1979	10	3.3	3.0-3.7	0.07
			10	3.4	2.8-4.2	0.07
Deep Water Shoal[1]	24	18 May 1978	5	5.0	4.1-5.4	0.10
			4	5.1	4.9-5.4	0.08
		9 Jun 1978	5	5.0	4.2-6.4	0.07
			5	4.6	4.1-5.3	0.09
		21 Jun 1978	6	5.0	4.5-5.7	0.09
			6	4.9	4.6-5.3	0.06
		27 Jul 1978	8	3.9	3.8-4.2	0.10
			8	4.0	3.8-4.4	0.12
		10 Aug 1978	9	3.9	3.7-4.2	0.12
			9	4.1	3.9-4.5	0.14
Opposite Skiffes Creek (Across channel)	25	23 Apr 1979	10	3.7	3.2-4.4	0.08
			10	3.6	2.9-4.5	0.08
Cobham Bay Downriver	30	19 Apr 1977	3	-	-	0.11
		14 Dec 1978	6	3.1	2.7-3.4	0.07
			7	3.0	2.8-3.2	0.06
Off Jamestown Is.	31	3 Nov 1977	-	-	-	0.53
		5 Apr 1979	10	4.1	3.6-4.4	0.06
			10	4.3	3.7-4.7	0.07
Near channel, opposite Chickahominy R.	40	15 Dec 1978	9	3.1	2.6-3.6	0.07

Table 11 (Contd.)

Source	Approx. Distance From Mouth (miles)	Date Collected	No. Clams	Height (cm)		Kepone (μg/g)
				Mean	Range	
Off Dancing Point	41	17 Apr 1979	8	4.2	3.5-5.5	0.06
			8	4.1	3.5-5.1	0.08
			8	4.1	3.4-4.8	0.07
Across from Chippokes Pt.	45	23 Apr 1979	4	3.5	3.3-3.7	0.06
			6	3.7	3.6-3.8	0.11
Trees Point	46	23 Apr 1979	10	3.5	2.5-4.6	0.09
			10	3.5	2.2-4.5	0.12
Off Milton	50	1 May 1979	8	3.2	2.3-4.5	0.13
			8	3.2	2.2-4.2	0.12
Channel, between Weyanoke	51	1979	6	4.1	3.9-4.2	0.02
Pt. and Dunnmore	51	10 Apr 1979	-	-	-	0.05

[1]Clams from Rappahannock River held in wire trays on the bottom at this station.

Table 12. Estimate of number of bushels, weight of meats and weight of Kepone in meats of the wedge clam *Rangia cuneata* in sections of the James River delineated around transects sampled in 1971-72 by Diaz (1977). Density data obtained primarily from Diaz (1977).

Section[1]	Naut. Miles From Mouth[2]	No. Acres (Thousands)	Mean No/m^2 [3]	Mean Bu/Acre	Total No. Bushels (Millions)	Total Wet Wt. Meats[4] (Millions of Kg)	Mean Conc. Kepone in Meats (mg/Kg)	Total Wt. Kepone in Meats (Kg)
A	9 -12.5 (10)	8.43	1.55	2.29	0.019	0.144	0.07	0.01
B	12.5-17.5 (15)	14.43	6.67	9.81	0.141	1.072	0.07	0.07
C	17.5-22.5 (20)	14.34	18.78	27.64	0.396	3.010	0.07	0.21
D	22.5-27.5 (25)	10.97	33.83[5]	49.80	0.546	4.150	0.09	0.37
E	27.5-32.5 (30)	10.60	68.06[5]	100.20	1.062	8.071	0.07	0.56
F	32.5-37.5 (35)	7.49	43.33	63.80	0.478	3.633	0.07	0.25
G	37.5-42.5 (40)	10.55	167.5	246.59	2.601	19.768	0.07	1.38
H	42.5-47.5 (45)	3.64	142.12	209.24	0.762	5.791	0.10	0.58
I	47.5-52.5 (50)	2.36	45.17	66.49	0.157	1.193	0.09	0.10
J	52.5-57.5 (55)	1.98	10.00	14.72	0.029	0.220	0.09	0.02
TOTALS		84.79			6.191	47.052		3.55

Table 13. Kepone concentration in *Corbicula manilensis* clams collected from stations in the James River - 1977-1979.

Station Location	Miles From Mouth	Date Collected	Kepone Concentration (µg/g)	Mean
Off Chickahominy R.	40	14 Dec 1978	0.06	
Dancing Point	41	17 Apr 1979	0.128	0.09
Buoy 74[1]	46	23 Apr 1979	0.098	
			0.087	0.09
Buoy 74C[1]	50	1 May 1979	0.15	
			0.10	
Buoy 76[1]	52	10 Apr 1979	0.078	
			0.078	0.10
Buoys 124-126[1]		14 Sep 1977	0.16	
		19 Sep 1977	0.18	
		10 Apr 1979	0.021	0.12

[1]NOAA Chart No. 12251 (13th Ed., Sep. 17, 1977).

Table 14. Estimate of number of bushels, weight of meats and weight of Kepone in meats of the Asiatic clam <u>Corbicula</u> <u>manilensis</u> in sections of the James River delineated around transects sampled in 1971-72 by Diaz (1977). Density data obtained primarily from Diaz (1977).

Section[1]	Naut. Miles From Mouth[2]	No. Acres (Thousands)	Mean No/m^2 [3]	Mean Bu/Acre	Total No. Bushels (Millions)	Total Wet Wt. Meats (Millions of Kg)[4]	Mean Conc. Kepone in Meats (mg/Kg)	Total Wt. Kepone in Meats (Kg)
E	27.5-32.5 (30)	10.60	2.21[5]	1.91	0.020	0.168	0.09	0.01
F	32.5-37.5 (35)	7.49	2.17	1.87	0.014	0.118	0.09	0.01
G	37.5-42.5 (40)	10.55	3.25	2.81	0.030	0.252	0.09	0.02
H	42.5-47.5 (45)	3.64	78.87	68.20	0.248	2.083	0.09	0.19
I	47.5-52.5 (50)	2.36	32.50	28.10	0.066	0.554	0.10	0.05
J	52.5-57.5 (55)	1.98	516.50	446.63	0.885	7.434	0.10	0.74
K	57.5-62.5 (60)	3.51	804.67	695.82	2.445	20.538	0.12	2.46
L	62.5-67.5 (65)	4.21	787.86	681.28	2.865	24.066	0.12	2.89
TOTALS		44.34			6.573	55.213		6.37

Table 14 (Contd.)

[1]Section letters refer to areas so designated in Figure 5 .

[2]Stations sampled by Diaz (1977) were located along transects at the distance given in parentheses.

[3]Based on data of Diaz (1977); Mean no. clams/bu = 4680, determined empirically.

[4]Mean wet weight per bushel = 8.4 Kg, determined empirically.

[5]This value from data of Jordan et al. (1977).

Table 15. Summary of total biomass and Kepone load in the five major species of molluscan bivalves in the James River. Based on data collected between 1971 and 1979.

Species	Distribution of Areas Sampled in River	Bottom Acreage Included (Thousands)	Total No. Bushels (Millions)	Total Biomass Wet Wt. (Millions of Kg)	Total Kepone in Meats (Kg)
Crassostrea virginica	Public Grounds Miles 5-24	16.41	3.124	18.949	2.53
Brachidontes recurvus	Publ. Oyst. Grounds Miles 5-24	16.41	1.557	4.683	0.70
Mercenaria mercenaria	Miles 0-10	34.58	0.566	3.604	0.11
Rangia cuneata	Miles 9-57	84.79	6.191	47.052	3.55
Corbicula manilensis	Miles 27-67	44.34	6.573	55.213	6.37
	TOTALS		18.011	129.501	13.26

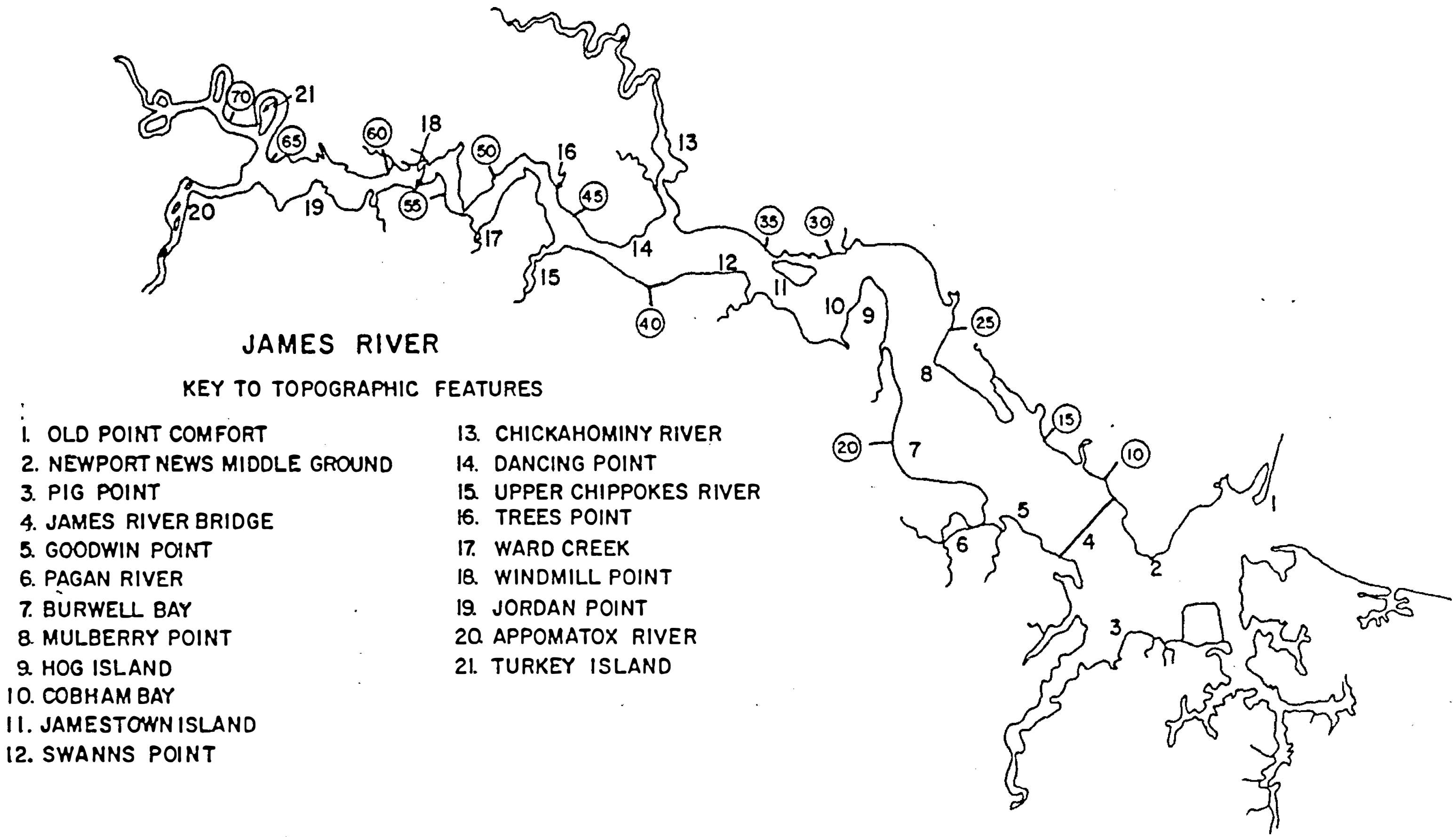

Figure 1. Topographic features of James River mentioned in this report. Circled numbers mark distance from mouth in nautical miles.

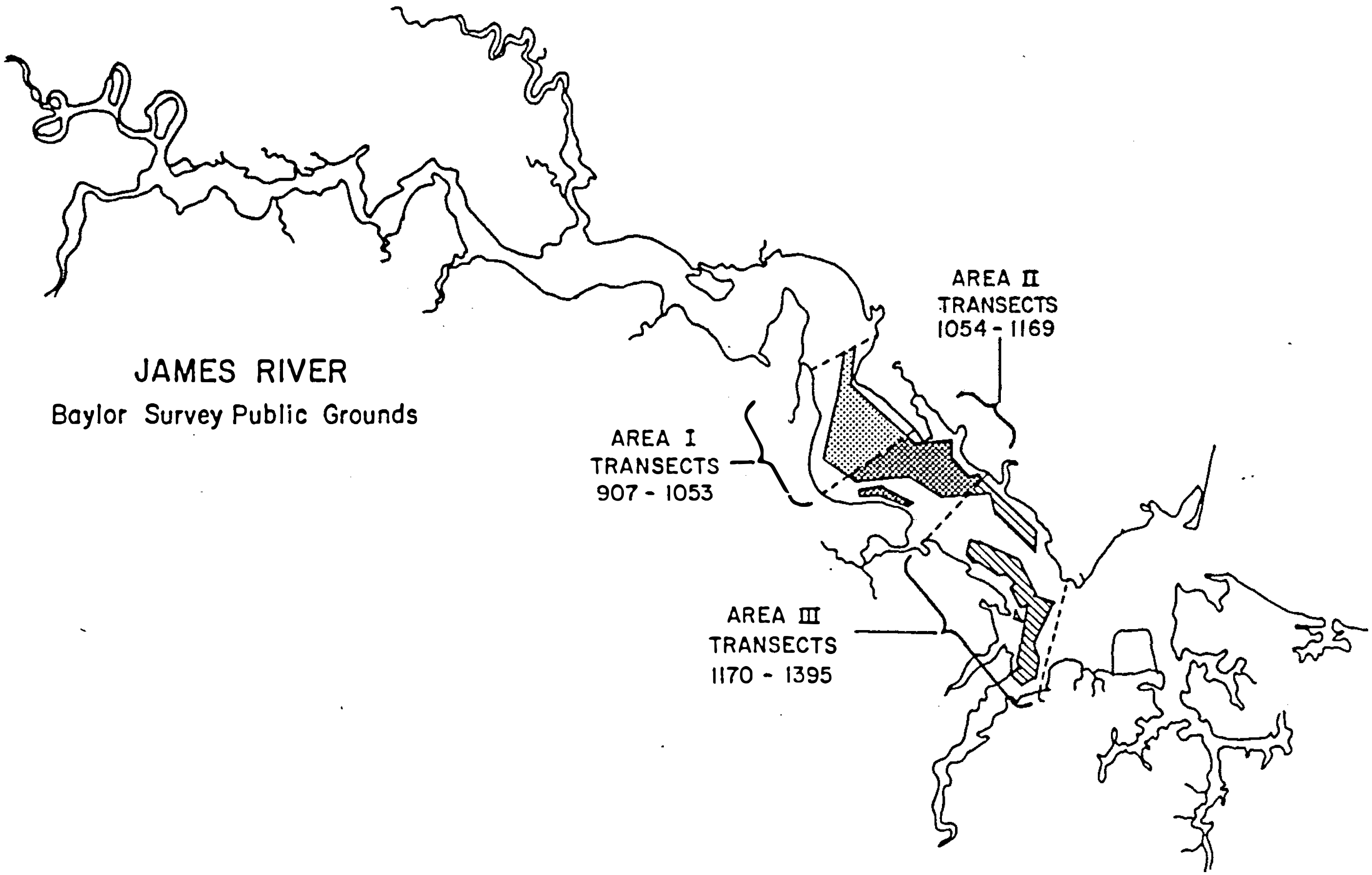

Figure 2. Baylor Survey oyster public grounds in the James River between Pig Point and Deep Water Shoal. Division into three areas based on oyster height frequency distributions. Transect numbers from Teledyne Hastings-Raydist positioning system grid.

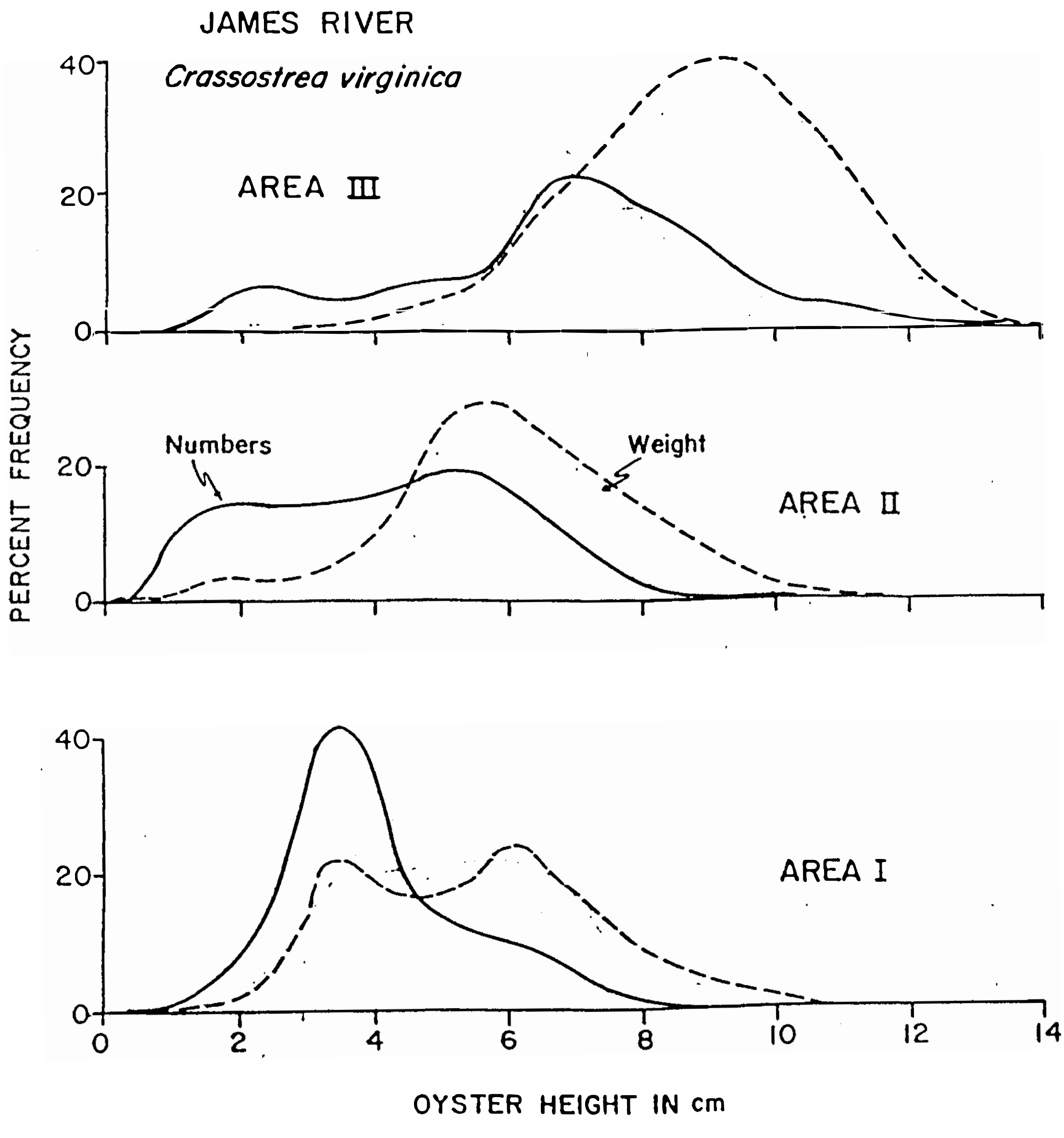

Figure 3. Percent frequency distribution of oyster height by numbers and wet weight of meats in three areas of public grounds in the James River.

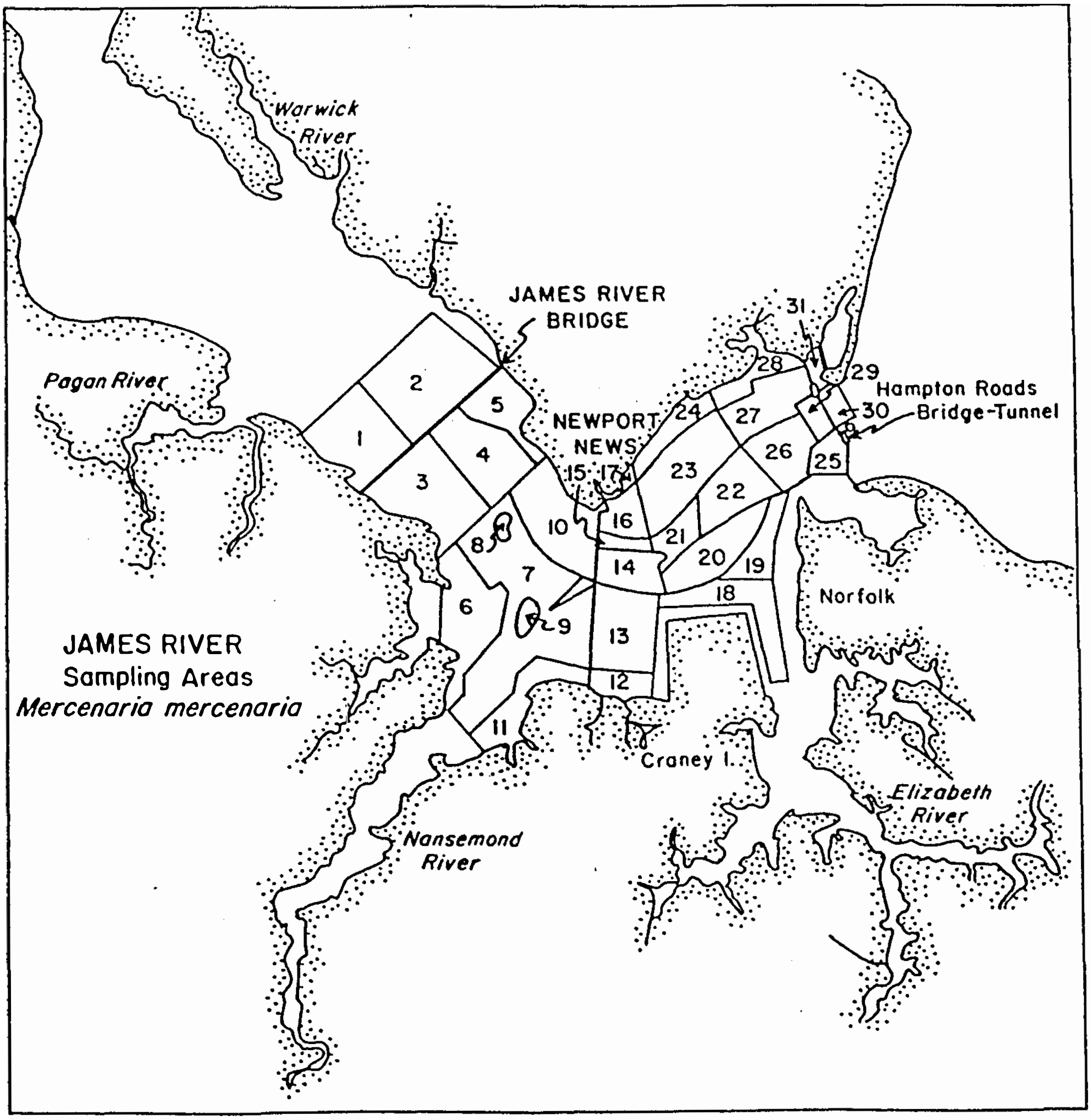

Figure 4. Division of lower James River into system of numbered plots used to estimate bottom acreage and standing crop of the hard clam Mercenaria mercenaria.

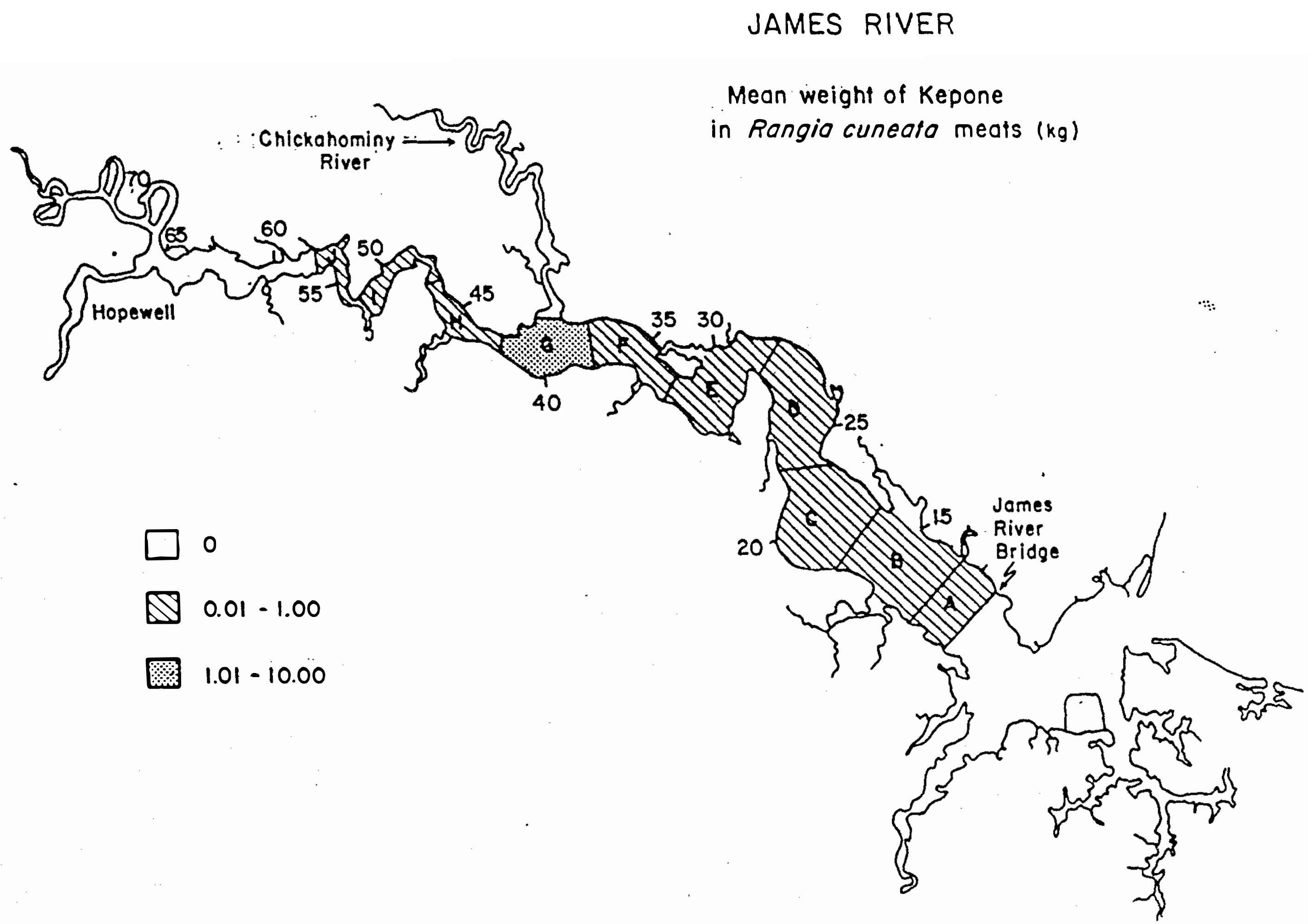

Figure 5. Distribution of estimated weight of Kepone bound in meats of the wedge clam Rangia cuneata in the James River. Each section is centered around the transects sampled by Diaz (1977).

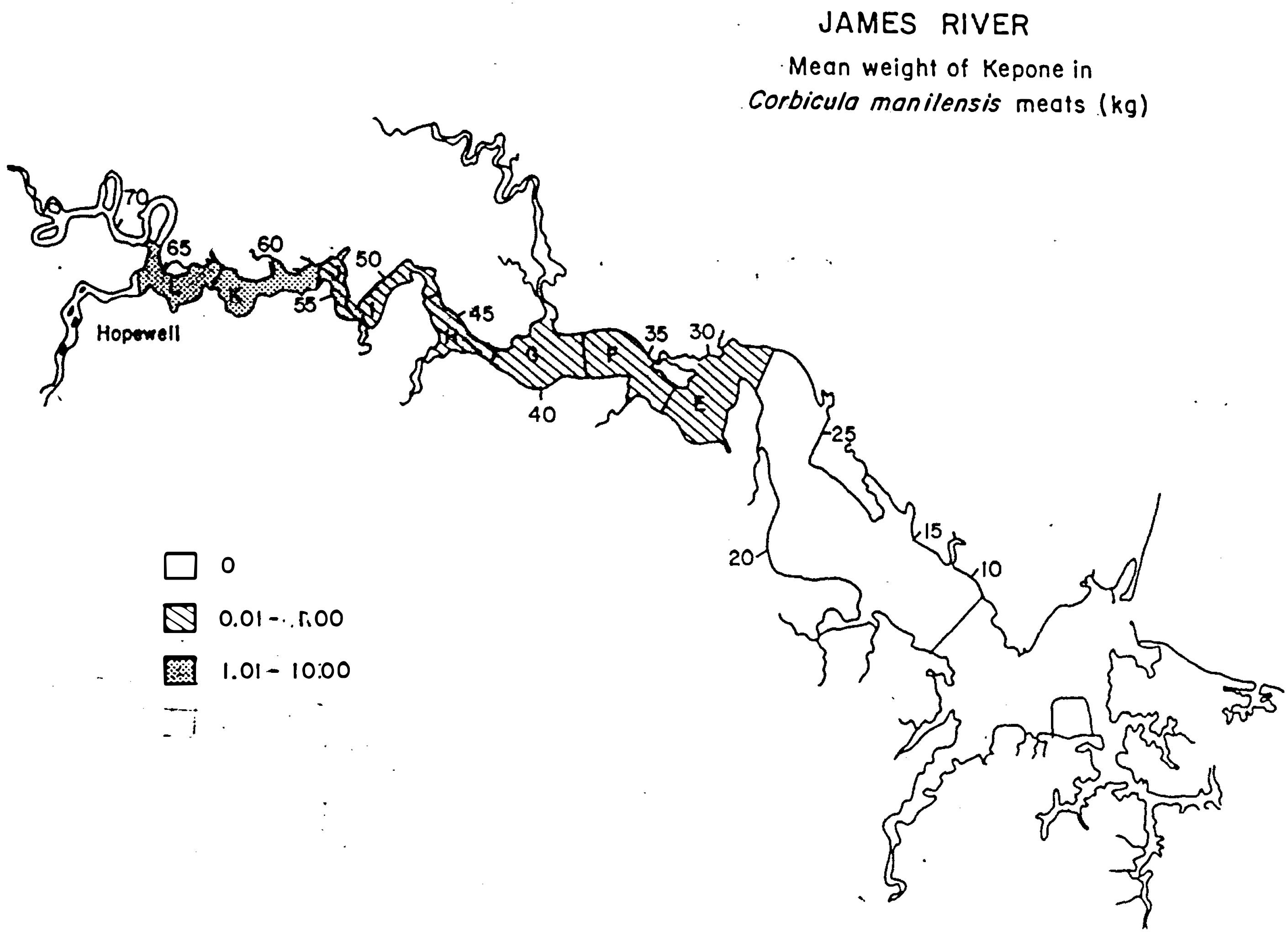

Figure 6. Distribution of estimated weight of Kepone bound in meats of the asiatic clam Corbicula manilensis in the James River. Each section is centered around the transects sampled by Diaz (1977).