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MONITORING TOXAPHENE CONTAMINATION IN A GEORGIA ESTUARY

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INTRODUCTION

This report summarizes research progress during the second year of a three year grant between the University of Georgia Marine Institute and Hercules, Inc.

The report does not attempt to recapitulate the data from the first year of study. For details of the first year's work, reference is made to Technical Report Series No. 72-2: Survey of Toxaphene Levels in Georgia Estuaries, Georgia Marine Science Center, Skidaway Island, Georgia. Copies of the first report may be obtained by writing the address given on the frontispiece of this report.

ACKNOWLEDGMENTS

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METHODS

Field sampling has been continued in the ten quadrats established by use of random coordinates. These collection sites (Figure 1) are the same areas studied during the preceding year. During the second year, collections were made at intervals of four weeks or less; sampling methodology has been consistent with those used during the previous year.

Toxaphene concentrations were determined as previously reported using the techniques of Wilson (1969). The computation of species diversity was according to the techniques of Sorensen (1948), Margalef (1958), Mehinick (1964), and Odum (1971).

RESULTS

The results of this second year of work center on several areas of concentration. Efforts have been made to quantify more accurately the flux of toxaphene through the salt marsh cordgrass *Spartina alterniflora*, to consider the species diversity of Terry Creek (quadrat 029), to evaluate toxaphene concentrations in selected fauna and flora, and to contrast these concentrations with the previous year's results. Research results have been disseminated through presentations at scientific and technical meetings, journal publication, and testimony presented to several state and federal agencies.

The results of toxaphene analysis of *Spartina alterniflora* demonstrated that toxaphene accumulates in the leaves of the plant. Figure 2 depicts the distribution of this compound in sediments and *Spartina* from
Figure 1. Study area, showing ten quadrats.
FIGURE 2
CONCENTRATION OF TOXAPHENE (IN PARTS PER MILLION) IN SPARTINA ALTERNIFLORA AND SURROUNDING SEDIMENTS COLLECTED FROM TERRY CREEK MARSH

SEED HEADS
\[ \bar{x} = 4.93 \]
\[ N = 2 \]
\[ S = 1.92 \]

LEAVES
\[ \bar{x} = 36.30 \]
\[ N = 10 \]
\[ S = 4.51 \]

SEDIMENT
\[ \bar{x} = 32.56 \]
\[ N = 4 \]
\[ S = 22.15 \]

ROOTS
\[ \bar{x} = 1.91 \]
\[ N = 1 \]

RHIZOMES
\[ \bar{x} = 1.24 \]
\[ N = 1 \]
the Terry Creek marsh (near the toxaphene discharge point). Although the sediments have a high concentration (32 ppm), the only part of the plant accumulating toxaphene was the leaves (36 ppm). Seed heads have relatively low concentrations and, therefore, may not be a great source of contamination for marsh birds which feed upon them.

Figure 3 portrays toxaphene concentration in *Spartina* collected from all sites other than Terry Creek. The results again demonstrate that toxaphene can be concentrated in the leaves of *Spartina* when it occurs in the marsh sediment. (See Appendix I for detailed description of toxaphene content of sediments in Terry Creek area.) This "labeling" of *Spartina* with toxaphene suggests that it may serve as a "natural" tag for detecting transfer through the detritus food chain.

The quantities of toxaphene found in anchovies collected from several collection sites during the two years of the study show a significant reduction in levels during the second year in this potential detritivore (Figure 4).

In contrast, toxaphene levels in a carnivorous fish, *Fundulus heteroclitus*, are shown in Figure 5. Not only are there significant decreases in levels during the second year, but the concentrations are much lower than in the anchovy. This was not expected since it has been reported that killifish consume anchovies and thus trophic magnification would be anticipated. It appears, however, from this single link in the food web that such is not the case. Lotrich (1972) has demonstrated that *Fundulus heteroclitus* tends to remain within a small area during its life span. Some specimens he observed never moved more than 500 yards away from a given point. Thus these fish are probably permanent residents of Terry Creek.
FIGURE 3
SUMMARY OF THE CONCENTRATION OF TOXAPHENE (IN PARTS PER MILLION) IN SPARTINA ALTERNIFLORA AND SURROUNDING SEDIMENTS, COLLECTED FROM ALL LOCATIONS WITHIN THE BRUNSWICK STUDY AREA

SEED HEADS
6.85
3.01

LEAVES
17.14 1.53
4.29 1.40
2.57 0.47
2.52 0.32
2.15 0.26
2.10 <0.25
2.10 <0.25
2.10 <0.25

SEDIMENT
63.72
42.42
17.27
6.85
2.07
1.29
1.02
0.81

ROOTS
1.91
RHIZOMES
1.24
FIGURE 4
CONCENTRATION OF TOXAPHENE IN THE ANCHOVY
ANCHOA SP FROM DIFFERENT GEOGRAPHIC COLLECTION SITES

= 1970 - 1971

= 1971 - 1972
FIGURE 5
CONCENTRATION OF TOXAPHENE IN THE KILLIFISH FUNDULUS HETEROCLITUS FROM DIFFERENT GEOGRAPHIC COLLECTION SITES

= 1970 - 1971

= 1971 - 1972

TOXAPHENE IN PPM

29 60 78
QUADRAT
FIGURE 6

CONCENTRATION OF TOXAPHENE IN WHITE SHRIMP PENAEUS SETIFERUS FROM DIFFERENT GEOGRAPHIC COLLECTION SITES

SHRIMP HEADS

TOXAPHENE IN PPM

QUADRAT

SHRIMP MUSCLE

TOXAPHENE IN PPM

QUADRAT
Another economic and health concern has been that of potential toxaphene contamination of seafood. Figure 6 displays toxaphene content of shrimp heads (top portion of the figure) with shrimp abdomen or muscle (the economically useful portion of the shrimp) shown in the lower portion of the figure. Low toxaphene concentrations are found in the muscle contrasted to the head and thorax portions of the shrimp. The toxaphene appears to be concentrated in the white shrimp heads and thorax by a factor of about ten times that found in the edible abdominal portions.

The toxaphene content of different organisms collected in the same quadrat during each of the two years of the study is presented in Figure 7. Again there is a significant decrease in toxaphene levels from 1970-1971 to 1971-1972. Here, too, the trophic magnification of toxaphene was expected. The carnivorous fish: spot, croaker and star drum contained only small amounts of toxaphene contrasted to representatives lower on the food chain which were considered \textit{Littorina} snails and mullet). These fish, however, may not have been indigenous to Terry Creek and may have wandered in (and out) of the area and may (or may not) have been feeding in the area at the time of collection.

Other toxaphene concentrations measured included 1.4 ppm in fiddler crabs collected from several sites. The low concentration of toxaphene relative to that in \textit{Spartina} leaves (36 ppm) suggests that the fiddler crabs are not a component of the \textit{Spartina} detritus food chain and indeed may not be detritivores.

In summary, a total of nearly 150 organisms were evaluated for toxaphene content during the second contract year. In all results considered,
FIGURE 7

SIGNIFICANT CONCENTRATIONS OF TOXAPHENE IN ORGANISMS COLLECTED IN THE SAME GEOGRAPHIC LOCATION DURING THE FIRST AND SECOND YEARS OF STUDY

TOXAPHENE IN PPM

- 60 CROAKER
- 29 LITTORINA
- 78 MULLET
- 000 OYSTER
- 33 SPOT
- 26/34 STAR DRUM

1970-1971
1971-1972
the levels of toxaphene were considerably lower in 1971-1972 than in the preceding year.

A preliminary study of the changes in species diversity and abundance of Terry Creek has been initiated. Table 1 depicts the species diversity by two different diversity computations and also includes an index of similarity. If one compares the monthly values for the two different years, the 1970-1971 collections appear to have a higher diversity index than the 1971-1972 collections. This results because sometimes the number of individuals were very few, equaling the number of species. When this occurs, an artificially high index of diversity results. If the data for the entire year are combined, the index for 1971-1972 is higher than that for 1970-1971. This indicates a significant increase in species diversity in Terry Creek during the past two years.

Another way of considering the same problem is to compare the total cumulative number of different species collected from monthly trawls from Terry Creek (Figure 8). During 1970-1971, the cumulative number of different species was three, while during 1971-1972, the total number was ten. Finally, a measure of the biomass of Terry Creek provides insight into the quantity of living material residing in the creek. Figure 9 displays the comparison between biomass included in trawl collections of 1970-1971, and 1971-1972. Noting that this is a semi-log plot of the biomass vs month of the year, a considerably higher biomass was detected during the second year of the study.

During the past year some of the results of the research have been submitted for publication. Scientific papers dealing with this research
Table 1. Species diversity and index of similarity of trawl catch from Terry Creek for two different contract years. Diversity is based on two different diversity indices: \( d_1 = S - 1 / \log N \) (Margalef, 1958) and \( d_2 = S / \sqrt{N} \) (Mehinick, 1964; and Odum, 1971) where \( d = \) diversity index, \( S = \) number of species, and \( N = \) number of individuals. Index of Similarity (s) is based on Sorensen (1948) where \( s = 2C / (A + B) \) and \( A = \) number of species in sample A, \( B = \) number of species in sample B, and \( C = \) number of species common to both samples.

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<td>August</td>
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<tr>
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<tr>
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</tr>
<tr>
<td>June</td>
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<td>1.687</td>
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<tr>
<td>Year's sample combined</td>
<td>0.7006</td>
<td>3.3945</td>
<td>0.46</td>
<td>0.112</td>
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</table>
FIGURE 8

- - - - = 1970-1971
- - - - - = 1971-1972
FIGURE 9
TERRY CREEK TRAWL COLLECTIONS
(QUADRAT 029) BIOMASS (WET WEIGHT)
OF LIVE FISH COLLECTED

- = 1970 - 1971
- = 1971 - 1972

BIOMASS
OF FISH
WET WEIGHT
IN GRAMS

JUL AUG SEP OCT NOV DEC JAN FEB MAR APR MAY JUN
have also been presented at several national meetings during the past year. A summary of these presentations includes:


Oral testimony related (in part) to this research has also been presented to the Savannah District, U. S. Army Corps of Engineers; and the U. S. Department of Interior, Fish and Wildlife Service.

FUTURE RESEARCH

The present plan for the next contract year will attempt to complete several facets of research initiated earlier. A comparison of species diversity for each of the collection sites and for each of the collection dates will be run using the IBM 360/65 computer programmed for the computation of seven different species diversity indices. The collection sites within the study area will be compared with the Duplin River estuary.
Research will continue on the distribution of toxaphene in selected fauna and flora collected from the study area to provide additional comparisons between each of the three year periods. A further attempt is being made to define more precisely the role of *Spartina alterniflora* (the salt marsh cordgrass) in the flux of toxaphene from the sediments into the surrounding biota through the estuarine food chain. This work will be better documented if we are able to utilize $^{36}$Cl labeled toxaphene to initiate in vitro studies of the uptake of toxaphene from the sediment into the plant. These laboratory studies should serve as guidelines for future in depth studies of the flux of toxaphene through the estuarine food web. Using radionuclide labeling ($^{36}$Cl labeled toxaphene) and quantitative gas chromatography, future research should document the fate of toxaphene in the estuary.
LITERATURE CITED

Lotrich, V. 1972. Personal communication.


