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M E. Bender

J. L. Hyland

T. K. Duncan

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EFFECT OF AN OIL SPILL ON BENTHIC ANIMALS IN THE LOWER YORK RIVER, VIRGINIA[1]

M. E. Bender
J. L. Hyland
T. K. Duncan

Division of Environmental
Science & Engineering
Virginia Institute of Marine Science[2]
Gloucester Point, Virginia 23062
U. S. A.

Introduction

Although considerable study has been centered upon intertidal organisms with respect to their response to oil spills, most investigations have been conducted on exposed rocky intertidal habitats (1). Few studies are available which describe the response of benthic animal communities in mid-Atlantic estuaries and particularly in its largest estuary, Chesapeake Bay. This study documents both from field survey data and laboratory bioassay studies the effects of an accidental oil spill on the intertidal benthic communities of the Lower York River, Virginia.

Field Study

On 5 May 1971, a number of slicks of oil (cracking residue thinned with No. 2 fuel oil to the consistency of No. 6 fuel oil) washed onto the sand beaches and Spartina marshes near the mouth of the York River. To assess the effect that this event had on the intertidal organisms of these beaches, a series of transects was established at three locations in this area and sampled during July and December of 1971, March of 1972 and April of 1973. One transect of samples (station no. 2) was collected where a slick came ashore, while two transects of samples were taken in unaffected areas (stations no. 1 and no. 3). Station no. 1 is approximately 1.14 nautical miles upriver from no. 2 and no. 3 is approximately 0.79 nautical miles downriver from no. 2 (fig. 1).

The procedure on each transect involved making a subjective determination of the width of the intertidal zone and then setting up five equally spaced sub-

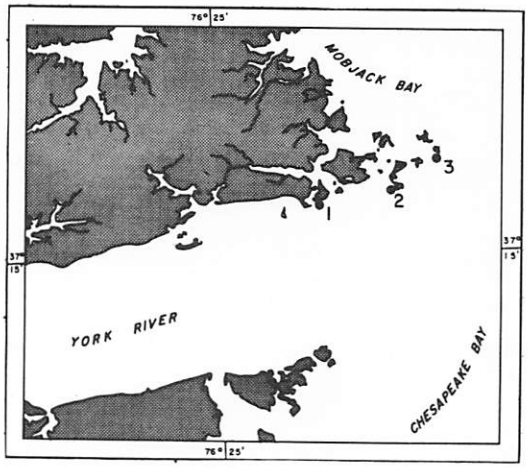

Figure 1. Location of Sampling Stations

stations within this zone. A series of ten samples was then taken to a depth of 15 cm with a plexiglass corer (0.0069 m^2) at each substation. The cores were sieved through a 1.0 mm screen and the material remaining on the screen was preserved in formalin that had been diluted with seawater and returned to the laboratory for identification and enumeration.

During the study period, 94 species of benthic organisms were collected. The major fauna were distributed as follows: 29 species of polychaetes; 28 of crustaceans and 23 of molluscs.

To numerically describe the faunal assemblages, several techniques of community structure analysis were employed. These included species richness, evenness, information theory diversity, and the use of Sorenson's quotient of similarity (2).

The number of species, individuals, and values for richness, evenness and diversity calculated on the samples during the study are tabulated in table I. Figures 2 and 3 show the change in richness and diversity as a function of time. Figure 4 graphically depicts the change in Sorenson's similarity quotient as a function of station comparisons and time.

The effect of the spill is most evident when comparing numbers of species or species richness. The control stations averaged 33 species in July after the spill while the spill station had only 14. The effects of the spill were prolonged through the next two sampling periods, in December 1971 and March 1972. Recovery in terms of both species richness and faunal similarity was shown in the April 1973 study period. However, the number of individuals remained lower at the spill station than at the control stations, suggesting that complete recovery had not yet occurred. The groups

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Table I. Community Composition Parameters

	Station 1				Station 2				Station 3			
	7-71	12-71	3-72	4-73	7-71	12-71	3-72	4-73	7-71	12-71	3-72	4-73
No. Indi.	482	536	300	231	88	107	144	153	611	2481	1757	3753
No. Sp.	32	34	35	21	14	19	13	22	34	60	46	37
Richness	5.02	5.25	5.96	3.67	2.90	3.85	2.41	4.17	5.14	7.55	6.02	4.39
Diversity	3.02	3.21	3.63	3.00	3.28	3.21	1.85	3.25	3.02	4.04	3.29	2.67
Evenness	0.60	0.63	0.71	0.68	0.86	0.76	0.50	0.73	0.59	0.68	0.60	0.51

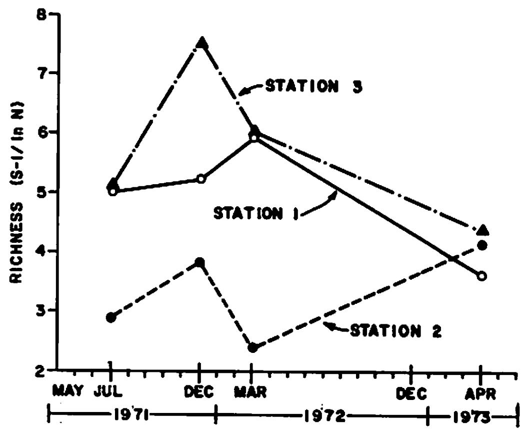

Figure 2. Species Richness

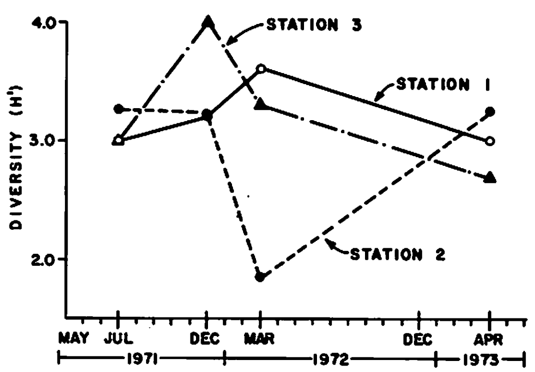

Figure 3. Species Diversity

most seriously affected by the spill were the crustaceans and polychaetes.

Laboratory Studies

After preliminary analysis of the field data showed a significant effect of the oil on intertidal organisms in the Lower York River, it was decided to con-

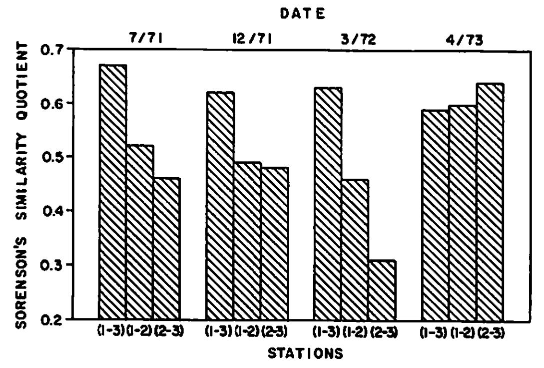

Figure 4. Sorenson's Similarity Quotient

duct acute bioassays with the oil and attempt to relate the toxicities to the effects observed in the field. Unfortunately, no samples of the oil spilled had been taken; therefore, it was decided to assay Bunker C because of its close resemblance to the oil spilled and because of its extensive use as vessel, industrial and utility fuels.

The test organisms included *Spiochaetopterus costarum oculatus* (Polychaeta), *Nereis succinea* (Polychaeta), *Nassarius obsoletus* (Gastropoda), *Modiolus demissus* (Bivalvia), *Edotea triloba* (Isopoda), *Gammarus mucronatus* (Amphipoda) and *Pagurus longicarpus* (Decapoda). The organisms were chosen because they appeared as York River dominants (3), (4) and because they represented major taxonomic divisions of York River intertidal macrofauna.

Only the toxicity of the water-accommodated components of Bunker C rather than the residue, was assessed in the study. The dosing apparatus used was a closed continuous flow system, where pumps delivered various dilutions of an equilibrated oil in water solution to flasks in which the test animals were placed. Quantitative estimates of the oil were made using infrared spectroscopy (5).

The test organisms were subjected to five concentrations of oil with a control. The tests were conducted for 48 hours at salinities ranging from 12 to 18‰. Duplicate tests were conducted with each organism. The total dissolved organic content of the equilibrated oil and water solution was 5.53 ppm. Frankenfeld (5) previously reported only 1.9 ppm water extractable organic compounds from a No. 6 fuel oil. The difference between the two results may be that during his study, solutions of oil and water were not agitated. In this study mechanical agitation was used. However, no "solutions" were tested before all visible oil had appeared to float to the surface.

In the replicated experiments neither N. obsoletus, E. triloba, N. succinea, nor M. denissus showed mortality which could be attributed to the presence of oil, while in all assays G. mucronatus, P. longicarpus and S. costarum oculatus displayed patterns of mortality from which TL_{50} values could be determined. The 48 hour TL_{50} values were 0.42 ppm for G. mucronatus, 0.62 ppm for P. longicarpus and 4.92 for S. costarum oculatus.

Further details concerning the bioassay tests can be found in Hyland (6).

Discussion

The four species which were not affected by accommodated oil in the laboratory also did not reveal population depressions following the oil spill in the river. The tolerance displayed by N. obsoletus and M. demissus may reflect a general resistance of molluscs to acute oil toxicity as suggested by Mironov (7) and Moore, Dwyer and Katz (8). It should be mentioned, however, that molluscs may be susceptible to other adverse effects, e.g. as Scarrat, Sprague, Wilder and Zitko (9) have demonstrated the ability of M. modiolus to concentrate various fractions of Bunker C. In addition the toxicity of dissolved oils should be tested for larval molluscs before such a generalization should be made.

It is not understood why Edotea was tolerant to the oil, since the two other crustaceans tested were quite sensitive, both having TL_{50}'s under 1 ppm. Unfortunately, our field sampling techniques did not allow for the capture of the hermit crab (P. longicarpus) which was shown to be the most sensitive species. Spiochaetopterus for which acute toxicity was shown exhibited the most drastic population reduction in the field study.

Species richness and faunal similarity appeared to give a better indication of the effects of the oil than did the informational diversity calculations.

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