FLOATING TAR AND DISSOLVED/DISPERSED PETROLEUM HYDROCARBONS IN THE NORTHERN GULF OF MEXICO AND THE STRAITS OF FLORIDA

DONALD K. ATWOOD, SUSAN DINKEL-MCKAY

National Oceanic and Atmospheric Administration, U.S.A.

GAIL CASE ROMERO

Naval Oceanographic Research and Development Activity, U.S.A.

and

EDWARD VAN VLEET

University of South Florida

ABSTRACT

As part of the IOCARIBE/CARIPOL Petroleum Pollution Monitoring Project, the U.S.A. has made 393 measurements of floating tar and 114 measurements of dissolved/dispersed petroleum hydrocarbons (DDPH) using CARIPOL described procedures. The majority of these were made in the Northern and Eastern Gulf of Mexico and the Straits of Florida. Results indicate that DDPH and floating tar covary in the study area and that the highest levels of contamination exist in the Southern Straits of Florida between Cuba and the Florida Keys. The lowest levels were found on the Western Florida Shelf and in the Northern Straits of Florida between Southeast Florida and the Bahamas. These results are consistent with beach tar studies along the coast of Florida which show that Western and Northeastern Florida beaches are quite pristine whereas beaches on the windward (SE) side of the Florida Keys are heavily oiled. Intermediate levels of contamination were found in the Northern Gulf of Mexico and the Gulf Loop Intrusion waters which would indicate that beaches along the northern Gulf coast, should have average tar contamination levels of roughly 1 to 20 grams per square meter as compared to 20 to 80 grams per square meter in the Florida Keys.

INTRODUCTION

During the period 1979 through 1984, the U.S.A. made 393 measurements of floating tar and 114 measurements of dissolved/dispersed petroleum hydrocarbons (DDPH) in ocean waters as part of the IOCARIBE/CARIPOL Petroleum Pollution Monitoring Project. The majority of these measurements were made in the Northern and Eastern Gulf of Mexico and in the Straits of Florids. This paper reports the results of these measurements as they relate to petroleum pollution in the region.

METHODS

The methods used in obtaining these measurements are those described in the "CARIPOL Manual For Petroleum Pollution Monitoring" (IOCARIBE/CARIPOL, 1980). Floating tar was collected by towing a one meter wide neuston net along the sea surface using a boom, or ship's crane to keep the net

Carib. J. Sci. 23(1): 73-76 (1987)

out of the ship's wake. Subsequent to the tow, tar was carefully washed from the net, through the cod end into a collection bottle. The tar was subsequently weighed and the area sampled determined from the length of the tow.

DDPH was measured by collecting a one gallon sample from 1 meter depth in such a way as to avoid contamination from the ship. Collection was made using a buoyed glass bottle which had been carefully cleaned with detergent, tap water, acetone and nano-grade hexane (in that order) prior to use. The sample was extracted as soon as possible after collection with two 50 ml aliquots of nano-grade hexane. The combined extracts were evaporated to a volume of <5 ml, transferred to a 5 ml volumetric flask, and then made up to 5 ml for final analysis. The UV fluorescence was then determined, versus chrysene standards, using an excitation wavelength of 310 nm and an emission wavelength of 360 nm. The DDPH concentration was then calculated for the original sample in terms of ug/1 of chrysene equivalents.

Results And Discussion

Results for the Gulf of Mexico and Straits of Florida were considered separately for seven geographic areas, i.e., the Northern Gulf of Mexico, the Mississippi Outflow, the Gulf Loop Intrusion, the Western Florida Shelf, Florida Bay, the Southern and the Northern Straits of Florida. Figure 1 shows the areas delineated for each of these and the latitudinal and longitudinal limits of each are given in Tables 1 and 2.

Table 1 shows the mean result and standard deviation obtained for floating tar for each area as well as for all 393 determinations. Table 2 shows a similar result for DDPH. Standard deviations are about 100% of the mean for DDPH and are often >200% of the mean for the floating tar results. This is typical of this type of measurement and indicates that differences in means must approach an order of magnitude to be considered significant. It is apparent from Tables 1 and 2 that the means of DDPH and floating tar results seem to covary. This is even more apparent when the means are plotted versus each other as shown in Figure 2, however, it is also clear that if the standard deviations were included in the figure, the relationship would be less obvious. Nevertheless, a least squares linear analysis of this data gives a linear correlation coefficient, i.e., r, of 0.84 (coefficient of determination, i.e., square of r, of 0.71) which is a good indication that this relationship between the means of DDPH and floating tar for the areas shown in Figure 1 is real.

The means shown in Tables 1 and 2 indicate that the highest levels of contamination found in this study are in the Southern Straits of Florida between Cuba and the Florida Keys for both DDPH and floating tar, whereas the lowest levels are on the Western Florida Shelf and in the Northern Straits of Florida. This result is consistent with beach tar studies made along the Florida coast (Romero, et. al., 1981, 1985) which show that Western and Northeastern Florida beaches are quite pristine whereas the windward (SE) beaches of the Florida Keys are heavily oiled. The heavy contamination in the Southern Straits of Florida probably results from two sources, i.e., (1) inputs flowing directly from the Caribbean through the Straits of Yucatan when the Gulf Loop is disconnected from the continuous flow of the Caribbean Current and from the Gulf Loop when it is connected, and (2) the extensive ship traffic that is "funneled" through this strait. It is also possible that a good bit of the inputs are fresh inputs from such operations as shipping, oil production or natural seeps since this would explain the covariance of DDPH and floating tar. Weathered tar which is flowing into the area would not contribute significantly to DDPH. The relatively clean state of the Northern Straits of Florida apparently results from the fact that the prevailing southeast trade winds remove most of the tar found in the southern part of the straits to SE Florida beaches.

h is not clear what the source is for the intermediate tar and DDPH levels found in the Gulf Loop and Northern Gulf of Mexico. Possibilities include inputs from the Caribbean through the Yucatan Strait, local shipping and petroleum operations or natural seeps. Since there are no extensive natural seeps in the immediate area and the covariance of DDPH and floating tar indicates a significant fresh input, shipping and petroleum operations are a good possibility for consideration. The fact that Northern Gulf of Mexico waters have a very high particulate load is also pertinent since these particles can serve to scavenge and scrub out petroleum pollutants. Thus, the levels reported here may not reflect the level of inputs directly.

Northern Gulf coast beaches, e.g., Galveston Beach, have a reputation for being oiled, however, we know of no quantitative study of the extent of beach tar in this area. A comparison to the Florida data indicates that the contamination present in the waters adjacent to the northern Gulf beaches would resuit in contamination of the beaches, but at a level less than in SE Florida. Levels of between 1 to 20 grams per square meter are postulated as compared to 20 to 80 grams per square meter in the Florida Keys.

LITERATURE CITED

IOCARIBE/CARIPOL. (1980). CARIPOL Manual for Petroleum Pollution Monitoring, available from the lntergovernmental Oceanographic Commission, IOC/UNESCO, 7, Place de Fontenoy, Paris 75700, FRANCE.

ROMERO, G. C., G. R. HARVEY and D. K. ATWOOD. (1981). Stranded Tar on Florida Beaches: September 1979-October 1980, Mar. Poll. Bull. 12, 8: 280-284; and Symposium on the Results of the CARIPOL Petroleum Pollution Monitoring Project, University of Puerto Rico Marine Station, La Parguera, P. R., 2 to 6 December 1985.

TABLE 1. – Floating tar

Geographical Area	Latitude Range Lowest	Latitude Range Highest	Longitude Range Lowest	Longitude Range Highest	Average Tar Cone. ($mg.m^{-2}$)	Standard Deviation	Number of Observations
Northern Gulf of Mexico	28°00’	30°30’	84°41’	96°00’	0.6	2.3	69
Mississippi Outflow	28°30’	29°20’	88°30’	90°00’	0.2	0.3	19
Gulf Loop Intrusion	24°00’	28°00’	85°00’	89°00’	2,3	5.7	44
Western Florida Shelf	24°41’	30°00’	82°00’	84°40’	1.1	4.5	153
Florida Bay	24°41’	26°00’	80°29’	81°59’	0.4	1.4	18
Southern Straits of Florida	23°00’	24°40’	80°00’	84°30’	4.7	12.0	52
Northern Straits of Florida	25°00’	27°30’	78°40’	80°30’	1.1	1.9	22
All Data					1.8	6.5	393

TABLE 2. – Dissolved/Dispersed Petroleum Hydrocarbons

Geographical Area	Latitude Range Lowest	Latitude Range Highest	Longitude Range Lowest	Longitude Range Highest	Average Conc. (mg/ℓ)	Standard Deviation	Number of Observations
Northern Gulf of Mexico	28°00’	30°30’	84°41’	96°00’	4.7	5.5	39
Mississippi Outflow	28°30’	29°20’	88°30’	90°00’	4.3	5.6	24
Gulf Loop Intrusion	24°00’	28°00’	85°00’	89°00’	5.8	5.7	17
Western Florida Shelf	24°41’	30°00’	82°00’	84°40’	1.2	1.5	2
Florida Bay	24°41’	26°00’	80°30’	81°59’			0
Southern Straits of Florida	23°00’	24°40’	80°00’	84°00’	10.6	6.9	9
Northern Straits of Florida	25°00’	27°30’	78°40’	80°29’	2.8	2.6	10
All Data					4.5	5.3	114

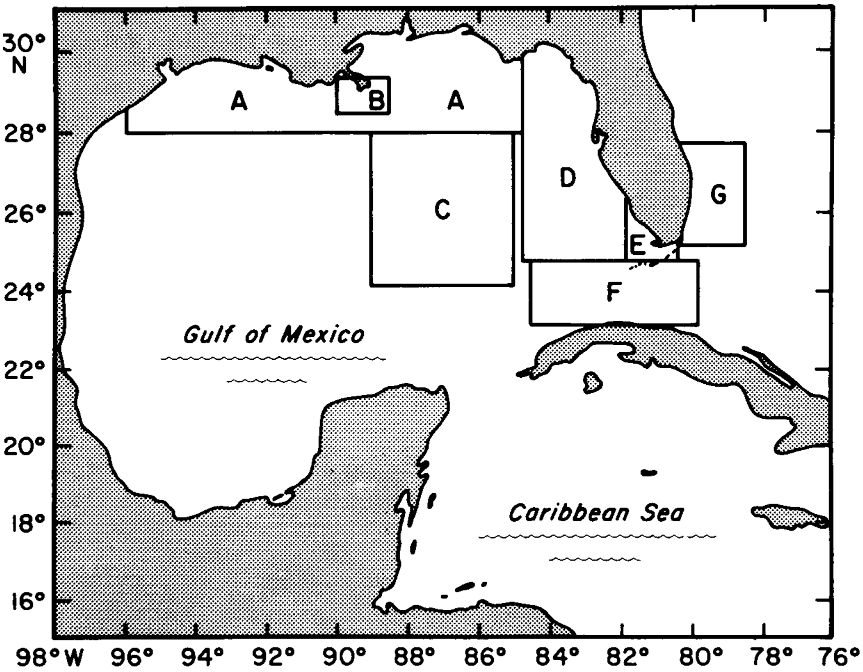

FIGURE 1. – Location of geographic areas chosen for analysis of Floating tar and DDPH data; A) Northern Gulf of Mexico, B) Mississippi Outflow, C) Gulf Loop intrusion, D) Western Florida Shelf, E) Florida Bay, F) Southern Straits of Florida and G) Northern Straits of Florida.

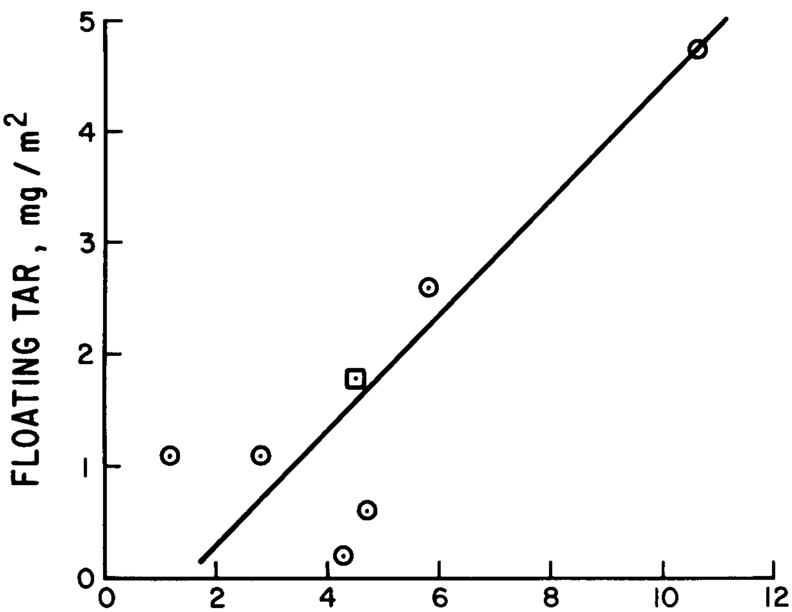

FIGURE 2. – Mean values for floating tar in mg per square meter plotted versus mean values for DDPH in ug per liter as chrysene equivalents. Circles represent means for geographic areas identified in Fig. 1, the square represents overall means for data reported.