Release of the Carcinogen Benzo (a) pyrene from Environmentally Contaminated Mussels

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It is now well established that polycyclic aromatic hydrocarbons, including potent carcinogens, can be found in a variety of marine organisms, including those which may be used for human consumption. Studies in this laboratory (DUNN and STICH 1975) have shown that the occurrence of the carcinogen benzo(a)pyrene (B(a)P) in mussels (Mytilus edulis or Mytilus californianus) may be a good indicator for the contamination of bodies of water with polycyclic aromatic hydrocarbons (PAH). In interpreting the results of measurements of chemical contaminents in mussels or other organisms, it is important to know the residence time of the compound in the species under investigation. The present communication describes the release of B(a)P from contaminated mussels on transfer into clean circulating water.

Approximately 600 mussels (M. edulis, size 4 to 6 cm) were removed from a concrete bridge abutment at a point 2 to 3 m from a barricade of creosoted timbers. Previous analysis had shown mussels from this location to be contaminated with PAH derived from creosote (DUNN and STICH 1975). The mussels were cleaned externally, and divided into three groups. One group, consisting of 6 samples of 10 mussels each, was analyzed immediately, while a second group of 6 samples was maintained alive out of water at an air temperature of 15°. The third group, consisting of the remaining mussels, was placed in two fiberglass tanks (size 50 l), and maintained with a constant flow of sea water (temperature 7 to 9°, two changes per hour) drawn from the outer Vancouver harbour, an area in which native mussels are contaminated with B(a)P to the extent of approximately 2 µg/kg wet weight. At intervals, 4 to 6 samples of 10 mussels each were removed from the tanks for analysis.

Samples of 10 mussels each were shucked, and the tissues drained of excess fluid, and frozen for subsequent analysis. The total tissue from each sample (generally about 20 g wet weight) was analyzed for B(a)P using a modification of the procedures of HOWARD et al. (1966). B(a)P was measured fluorimetrically in hexadecane using the baseline technique of KUNTE (1967) to estimate the height of one of the peaks in the

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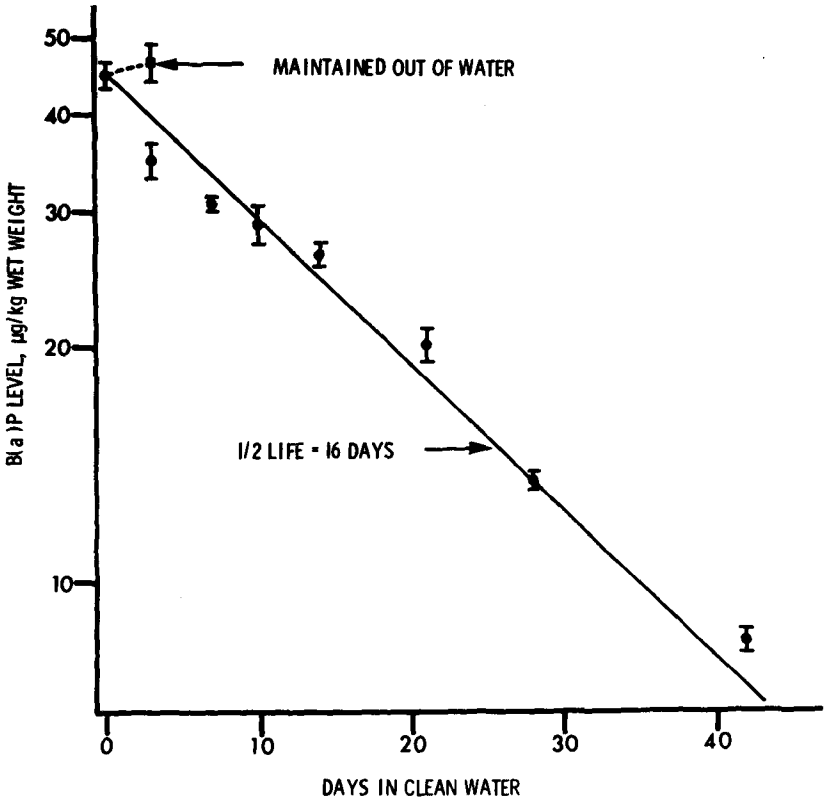

Figure 1. Release of Benzo(a)pyrene from Mussels
Data are the Mean ± S.E.M. of 4 to 6 samples.

B(a)P fluorescence emission spectrum. An aliquot of radioactively labelled B(a)P was added to each tissue sample before processing, and losses of B(a)P during the procedures were determined by measuring the amount of radioactivity in the final fluorimetry sample. All values reported are corrected for losses of compound during processing.

Figure 1 shows the release of B(a)P from PAH contaminated mussels on transfer from a polluted area to tanks with clean circulating water. The amount of B(a)P, initially 45 µg/kg wet weight, declined approximately exponentially over the 6 weeks of the experiment, with an overall half-life of 16 days. There was some fluctuation in the rate of depuration, but the effect was not large. Mussels maintained out of water for 3 days starting on the day of transfer remained alive with tightly closed shells, paralleling their behaviour in nature during exposure at low tides. There was no statistically significant change in the B(a)P content of these mussels, compared with a decrease of over 20% in the B(a)P content of mussels in the tanks during this period. This suggests, in

agreement with the findings of LEE et al. (1972) that mussels cannot metabolize B(a)P, or at least that any metabolism, if present, ceases on removal of the mussels from water. The fact that field samples of mussels maintained for several days out of water without special treatment show no change in B(a)P content suggests that these bivalves may have special advantages for monitoring programs involving sampling at areas remote from storage facilities or laboratories.

The release of PAH from mollusks contaminated by chronic exposure to polluted water in the environment may be slower than the release of these compounds from organisms heavily loaded by acute exposure in the laboratory. LEE et al. (1972) found that mussels loaded during a 4 hour exposure with 7,000 µg naphthalene/kg tissue dry weight (1,400 µg/kg wet weight, assuming tissue is 80% water) released 79% of the compound in three days (half-life of 1.3 days, assuming exponential loss). In similar experiments with the clam Rangia cuneata, NEFF and ANDERSON (1975) found that clams which had accumulated 5,700 or 7,200 µg B(a)P/kg wet weight over a 24 hour exposure, rapidly released the compound on transfer of the organisms into clean water. The rate of release of B(a)P was quite variable, but half-lives were on the order of 2 to 5 days. In contrast, in the experiment reported here, mussels contaminated by chronic exposure to the extent of 45 µg B(a)P/kg wet weight released the compound with a half-life of over two weeks. Similarly DiSALVO et al. (1975), measuring the total aromatic content of naturally contaminated mussels, have found that this class of compounds is released with a half-life of 4 to 5 weeks when the mussels are transferred to clean water.

The slower release of aromatic hydrocarbons from less highly contaminated mollusks may reflect compartmentalization of these hydrocarbons within the tissue, as has been suggested for aliphatic hydrocarbons. FOSSATO (1975) has found that mussels contaminated with 250,000 µg aliphatic hydrocarbons/kg wet weight rapidly released a large proportion of the hydrocarbons with a half-life of approximately 3.5 days. A fraction of the hydrocarbon content however was retained by the mussels, and released only very slowly.

The residence time of B(a)P in mussels makes these mollusks attractive as bioaccumulators in monitoring programs for this and other carcinogens. The retention time is long enough to provide a substantial integrating effect, but short enough that changes in environmental contamination over a period of weeks will be reflected in changes in the tissue content of B(a)P. On the other hand, it is apparent that short depuration periods (1 to 3 days) commonly used to eliminate bacterial contamination from edible shellfish before marketing have little effect on the tissue content of the carcinogen B(a)P in mussels. This has significant public health implications for areas of the world (e.g. the lagoon of Venice), where mussels are cultivated for human consumption in potentially polluted areas (FOSSATO 1975).

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