UNITED STATES DEPARTMENT OF COMMERCE
National Oceanic and Atmospheric Administration
NATIONAL MARINE FISHERIES SERVICE
Silver Spring, MD 20910

MEMORANDUM TO: Eric Schwaab
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and
John Oliver
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FROM: /s/ John E. Stein, Ph.D.
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SUBJECT: Metabolism of PAHs by Teleost Fish – Scientific Findings

A broad foundation of science has been established documenting that all teleost fish (fish with a backbone such as grouper, snapper, croaker, tunas have a well-developed capacity to metabolize polycyclic aromatic hydrocarbons (PAHs), a major toxic component of crude oil, including DWH MC252 oil. Because of this efficient metabolism, there is a very low potential for PAHs to accumulate in muscle, and consequently low potential for transfer of PAHs up the food chain to human consumers. The metabolites that are formed are hydrophilic, more water soluble, and do not accumulate either but rather are excreted via bile. Efficient metabolism of PAHs by species other than teleosts is not universal. For example, bivalves such as oysters and clams have a low capacity to metabolize PAHs, whereas crustaceans such as shrimp have an intermediate metabolic capacity. The following discussion will be limited to the PAH metabolism by teleost fish.

Teleost fish have a high capacity to metabolize PAHs because they have high levels of cytochrome P-450 family of enzymes in tissues, particularly liver, that oxidatively biotransform PAHs to hydroxylated metabolites. The cytochrome P-450 dependent enzyme system is often referred to as phase I metabolism. Teleost fish also have well-developed phase II enzyme systems that can make the hydroxylated metabolites more water soluble. Phase II metabolism occurs by the conjugation of certain molecules (e.g., sulfate, glucuronic acid or glutathione,) to the hydroxylated metabolites. The consequence of the action of both the phase I and II enzyme systems is to transform the lipophilic PAHs into hydrophilic compounds that can be eliminated. The major site for metabolism is the liver. Following conjugation with, for example, glucuronic acid the PAH conjugate is secreted into bile which is then excreted by the fish via the intestine. Based on these scientific findings, an analytical method was developed that allowed detection of PAH metabolites in bile isolated from the gall bladder of teleost fish. Thus, although muscle tissue will have very low levels of PAHs and metabolites, analysis of bile can be used to assess the level of exposure of teleost fish to PAHs.

There is a rich and comprehensive set of biochemical, physiologic and molecular genetic studies demonstrating that, across teleost species, the phase I and II enzyme systems are present and expressed at levels that leads to highly efficient metabolism of PAHs found in crude oil. In addition, previous field

investigations of teleost fish sampled from areas highly impacted by an oil spill have shown that in all finfish species sampled and analyzed—even when fish show high levels of exposure as evidenced by high concentrations of PAH metabolites in bile—the muscle tissue contained low levels of PAHs. Therefore, there is low risk for accumulation of PAHs in muscle and low risk for exposure of humans to PAHs through consuming the muscle tissue of teleost fish. It must be noted here that for teleost fish the metabolism is not all benign. The carcinogenicity of PAHs, such as benzo[a]pyrene, arises from the biotransformation to reactive metabolites that then react with constituents of cellular DNA and lead to genotoxic events that are a precursor to development of cancer. This is a necessary but not sufficient step in expression of carcinogenicity of certain PAHs, and thus there are marked species differences in susceptibility to genotoxicity of carcinogenic PAHs.

The scientific findings presented above lead to the following conclusions: (1) teleost fish of commercial and recreational importance all have a well-developed capacity to biotransform PAHs to compounds that can be readily eliminated; (2) efficient metabolism leads to very low potential for PAHs to accumulate in the edible muscle tissue; (3) very low concentrations of PAHs in muscle means very low risk of exposure to PAHs that are a health concern for humans consuming finfish. Together these findings lead to the conclusion that in monitoring the safety of seafood from teleost fish in response to the DWH MC252 spill there is very low risk of a false negative occurring during the monitoring program. In other words, it is very unlikely that there will be an incorrect finding of low risk of human exposure when, in fact, there is an actual risk from PAH exposure.