Analysis of edible tissue from fish collected in coastal waters of the Gulf of Mexico potentially affected by Hurricane Katrina to determine recent exposure to persistent organic pollutants (POPs)

Margaret M. Krahn, Donald W. Brown, Gina M. Ylitalo and Tracy K. Collier
Environmental Conservation Division
Northwest Fisheries Science Center
NOAA Fisheries Service

Summary
Analyses have been completed for the first group of edible tissue samples from fish sampled during the R/V NANCY FOSTER cruise of September 12-16, 2005. The results indicate that Atlantic croaker and bigeye tuna collected soon after Hurricane Katrina contain concentrations of persistent organic pollutants (POPs; e.g., PCBs and DDTs) that were well below the Food and Drug Administration (FDA) regulatory limits for seafood, but did fall within levels subject to fish consumption advice from the U.S. Environmental Protection Agency (EPA). However, the levels of POPs found in fish from the study area were similar to those reported for non-urban areas of the world, e.g., for pollock from remote areas of Alaska (Heintz *et al.*, 2004).

Because levels of POPs were somewhat lower for samples collected inside the Mississippi Sound compared to samples outside the Sound, and because we did not detect a class of brominated flame retardants thought to be associated with urban runoff, our results do not indicate that the concentrations of POPs in the fish tissues were a result of contamination released due to Hurricane Katrina. Unfortunately, there are no "pre-Katrina" measurements available for POPs in fish muscle for these species from the study area.

Introduction
Major concerns following Hurricane Katrina included risks to human health through consumption of contaminated seafood, as well as effects from contaminants on the health of living marine resources. During the cruise of the R/V NANCY FOSTER from September 12-16, 2005, seafood species (i.e., fish, molluscs, crustaceans) were sampled to measure chemical contaminant levels for determining suitability for consumption. The first group of analyses have now been completed that measured POPs in edible tissue of Atlantic croaker and juvenile bigeye tuna captured from coastal waters of the Gulf of Mexico.

POPs include several classes of pesticides and industrial chemicals (e.g., PCBs, chlordanes, DDTs) that can bioaccumulate to relatively high concentrations in top-level predators (e.g., fish and marine mammals) of the marine food web through trophic transfer. POPs enter the marine environment via several sources (e.g., atmospheric transport, terrestrial runoff) and are found in environmental samples from all over the world (de Wit *et al.*, 2004). A large body of evidence links POP exposure to a wide range of deleterious biological effects (e.g., immunosuppression, endocrine disruption) in marine animals (de Wit *et al.*, 2004; O'Hara and O'Shea, 2001). Because so many of

these POPs are toxic to wildlife and humans, a number of these compounds have been banned in the United States (e.g., DDTs 1972; PCBs for new uses 1970; lindane 1983; chlordanes 1988) (AMAP, 1998).

Polybrominated diphenyl ethers (PBDEs) are a class of "emerging" environmental contaminants that are quickly gaining the attention of regulatory agencies (de Wit, 2002). These compounds are added to plastics, textiles, clothing, electronic circuit boards, and other materials as flame retardants. PBDEs often enter the environment through urban runoff and sewage outfalls and have been shown to bioaccumulate in marine animals (de Wit, 2002). Various studies have shown that some PBDE congeners may induce various toxicological effects in laboratory animals, including immune dysfunction, liver toxicity, and thyroid disruption (de Wit, 2002).

Methods

The station identification numbers for Atlantic croaker and bigeye tuna captured during the R/V NANCY FOSTER cruise of September 12-16, 2005, are shown in Figure 1. Muscle samples from two croaker were usually composited to have sufficient tissue for analysis. Then, the samples of Atlantic croaker and juvenile bigeye tuna were extracted and analyzed for POPs using the method of Sloan *et al.* (2005).

This method involves: (1) extraction of tissue using an accelerated solvent extraction procedure, (2) clean-up of the entire methylene chloride extract on a single stacked silica gel/alumina column, (3) separation of POPs from the bulk lipid and other biogenic material by high-performance size exclusion liquid chromatography, and (4) analysis on a low resolution quadrupole GC/MS system equipped with a 60-meter DB-5 GC capillary column. The instrument was calibrated using a set of ten multi-level calibration standards of known concentrations. Following this procedure, a total of 40 PCB, 10 PBDE congeners, and 24 chlorinated pesticides were determined in these samples. In this report, Sum PCBs is the sum of congeners 17, 18, 28, 31, 33, 44, 49, 52, 66, 70, 74, 82, 87, 95, 99, 101/90, 105, 110, 118, 128, 138/163/164, 149, 151, 153/132, 156, 158, 170, 171, 177, 180, 183, 187/159/182, 191, 194, 195, 199, 205, 206, 208, 209; Sum DDTs is the sum of o,p'-DDD, p,p'-DDD, o,p'-DDE, p,p'-DDE, o,p'-DDT and p,p'-DDT; Sum Chlordanes is the sum of oxychlordane, *gamma*-chlordane, nona-III-chlordane, *alpha*-chlordane, *trans*-nonachlor, and *cis*-nonachlor; Sum hexachlorocyclohexanes (HCHs) includes the sum of *alpha*-, *beta*-, and *gamma*-HCH isomers, and finally, Sum PBDEs is the sum of congeners 28, 47, 49, 66, 85, 99, 100, 153, 154, 183. Total lipid in the fish muscle samples were measured by a TLC/FID method (Ylitalo *et al.*, 2005).

Results

A summary of the results obtained from analyses for POPs in Atlantic croaker and bigeye tuna are presented in Table 1; results for each of the samples and individual analytes, as well as Quality Assurance tables, are available in Appendix 1. From Table 1, it is apparent that most POP groups (i.e., the sums of PCBs, DDTs, chlordanes, HCHs and PBDEs) in the Atlantic croaker and bigeye tuna had mean concentrations that ranged in the low parts-per-billion (ng/g). The highest mean concentration for "sum PCBs"

(15 ng/g) was found for bigeye tuna (station number 8). Atlantic croaker (station number 11) and bigeye tuna had similar mean concentrations for "sum DDTs" (about 2 ng/g) that were higher than concentrations in Atlantic croaker from station number 10. "Sum chlordanes" were highest in Atlantic croaker from station number 10 (about 1 ng/g), "sum HCHs" were below limits of quantitation (LOQs) for all samples and only the bigeye tuna samples contained any "sum PBDEs" (0.7 ng/g).

The FDA has published regulatory guidelines for seafood safety, which are as follows (wet weight): PCBs, 2,000 ng/g; DDTs, 5,000; chlordanes, 300 ng/g (National Academy of Sciences, 1991). There are no FDA guidelines available for HCHs or PBDEs. All the fish tissues analyzed in the current study had concentrations well below the FDA regulatory guidelines. However, the EPA also issues risk-based guidance for consuming fish containing PCBs, and some of the samples had levels of PCBs that would fall within the EPA guidance (EPA, 1999; EPA, 2005). The EPA and FDA are discussing how to coordinate scientific assessments for risks posed by PCBs in fish.

Conclusions

The results of the current study indicated that Atlantic croaker and bigeye tuna collected soon after Hurricane Katrina contained concentrations of POPs well below FDA regulatory guidelines, but did fall within levels subject to fish consumption advice from the EPA. However, the levels of POPs found in fish from the study area were similar to those reported for non-urban areas of the world, e.g., for pollock from remote areas of Alaska (Heintz *et al.*, 2004).

Because levels of POPs were somewhat lower for samples collected inside the Mississippi Sound compared to samples outside the Sound, and because we did not detect a class of brominated flame retardants thought to be associated with urban runoff, our results do not indicate that the concentrations of POPs in the fish tissues were a result of contamination released due to Hurricane Katrina. Unfortunately, there are no "pre-Katrina" measurements available for POPs in fish muscle from these species from the study area.

References

AMAP. 1998. Persistent organic pollutants. Arctic Monitoring and Assessment Programme (AMAP), Oslo, Norway. xii+859pp.

de Wit, C., Fisk, A., Hobbs, K., Muir, D., Gabrielsen, G., Kallenborn, R., Krahn, M.M., Norstrom, R. and Skaare, J. 2004. AMAP Assessment 2002: Persistent Organic Pollutants in the Arctic. Arctic Monitoring and Assessment Program, Oslo, Norway. xvi + 310pp.

de Wit, C.A. 2002. An overview of brominated flame retardants in the environment. Chemosphere 46(5):583-624.

EPA. 1999. Polychlorinated biphenyls (PCBs) update: Impact on fish advisories. U.S. Environmental Protection Agency, Washington, D.C. 7pp.

EPA. 2005. Chemical-specific Fact Sheets, http://epa.gov/waterscience/fish/chemfacts.html.

Heintz, R., Krahn, M.M., Ylitalo, G.M. and Morado, F. 2004. Organochlorines in walleye pollock from the Aleutian Islands and Southeastern Alaska. In proceedings of: Lowell Wakefield Symposium on the Sea Lions of the World, Anchorage, Alaska, USA.

National Academy of Sciences. 1991. Seafood Safety. National Academy Press, Washington, D.C. 432pp.

O'Hara, T.M. and O'Shea, T.J. 2001. Toxicology. p. 471-520. In: L.A. Dierauf and F.M.D. Gulland (eds.) CRC handbook of marine mammal medicine (Second edition). CRC Press, Boca Raton, FL.

Sloan, C.A., Brown, D.W., Pearce, R.W., Boyer, R.H., Bolton, J.L., Burrows, D.G., Herman, D.P. and Krahn, M.M. 2005. Determining aromatic hydrocarbons and chlorinated hydrocarbons in sediments and tissues using accelerated solvent extraction and gas chromatography/mass spectrometry. p. 631-51. In: G.K. Ostrander (eds.) Techniques in Aquatic Toxicology. 2. CRC Press, Boca Raton, FL, USA.

Ylitalo, G.M., Yanagida, G.K., Hufnagle Jr, L. and Krahn, M.M. 2005. Determination of lipid classes and lipid content in tissues of aquatic organisms using a thin layer chromatography/flame ionization detection (TLC/FID) microlipid method. p. 227-37. In: G.K. Ostrander (eds.) Techniques in Aquatic Toxicology. 2. CRC Press, Boca Raton, FL, USA.

Table 1. Concentrations of persistent organic pollutants measured in edible tissue (muscle) of Atlantic croaker and bigeye tuna collected in coastal waters of the Gulf of Mexico affected by Hurricane Katrina.

			(ng/g, wet weight ± SD)				
Species	**Station Number[2]**	**Composites per Station[1]**	**Sum PCBs[3]**	**Sum DDTs[3]**	**Sum Chlordanes[3]**	**Sum HCHs[3]**	**Sum PBDEs[3]**
Atlantic croaker	10	7	2.5 ± 1.2	0.8 ± 0.4	1.1 ± 0.5	<LOQ	<LOQ
Atlantic croaker	11	10	4.9 ± 2.1	2.4 ± 1.3	0.2 ± 0.3	<LOQ	<LOQ
Bigeye tuna	8	4	15 ± 8.8	2.2 ± 1.6	0.1 ± 0.1	<LOQ	0.7 ± 0.6

[1]Each composite contained muscle tissue from two fish; the composites from each station were averaged for this table.

[2]Stations are shown on the map in Figure 1.

[3]Individual compounds summed are given in the Methods section. When calculating averages, if a concentration for a composite was "less than the limit of quantitation" (<LOQ), it was set = 0.

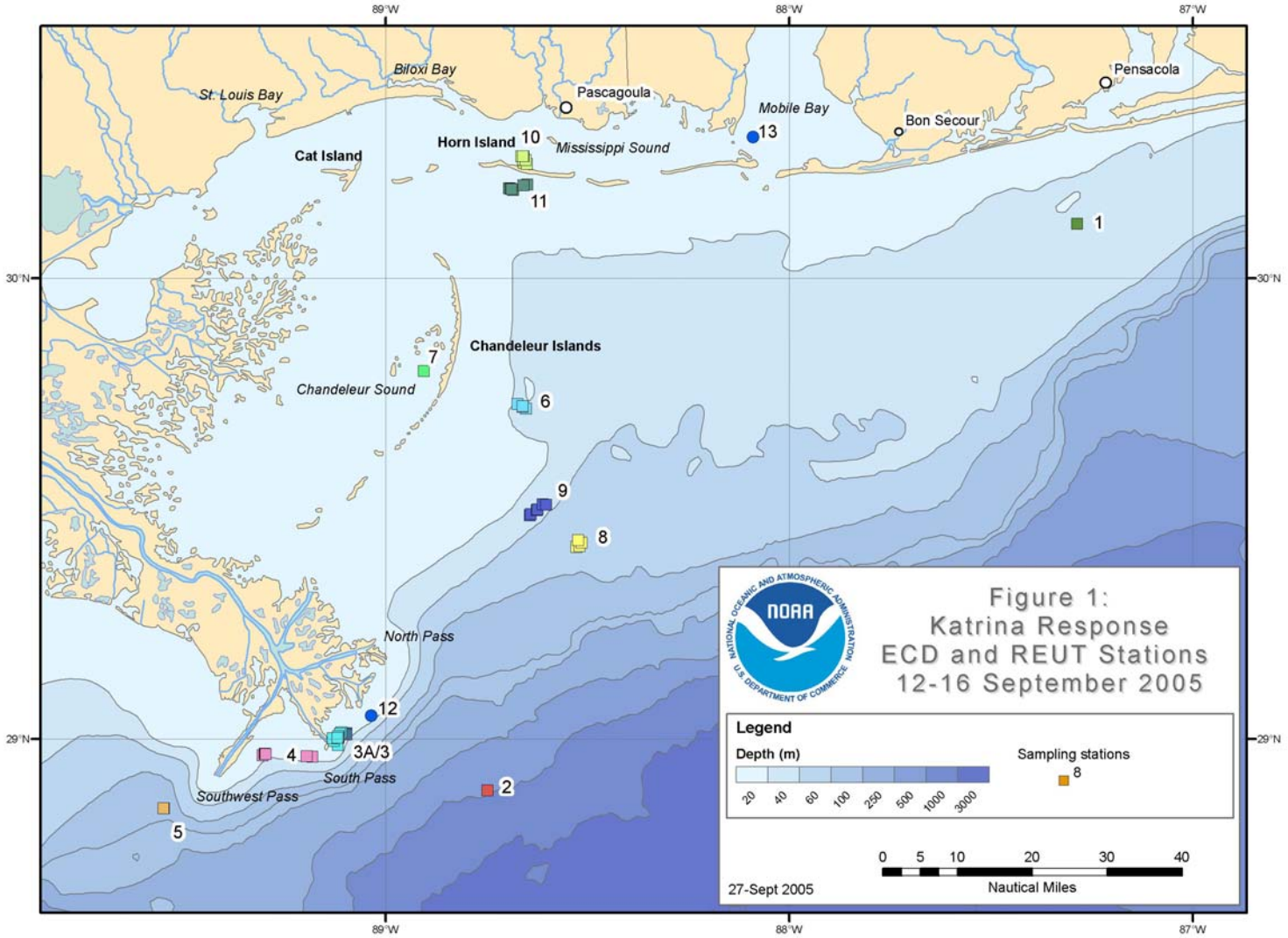

Figure 1. Stations (numbers 1-11) sampled during the R/V NANCY FOSTER cruise of 12-16 September 2005.