Office of Science
Research Project Summary
May 2010

Routine Monitoring of Toxics in Fish- Year 4 - Atlantic Coastal Inland Region

Authors
Bruce Ruppel and Gary Buchanan[1]
Richard J. Horwitz, Paul F. Overbeck, Jeff Ashley, David Velinsky and Linda Zaoudeh[2]

Abstract

The Routine Monitoring for Toxics in Fish Program is a 5-year, geographically based rotating program to generate data on chemical contaminants in fish for the issuance, update and revision of fish consumption advisories. The monitoring program design is built upon fish contaminant research conducted by NJDEP since the early 1980's. In order to investigate regional patterns in fish contamination the program includes rotating sample collections among geographic regions within the state. In addition to analyze fish contaminant temporal trends and to identify unknown hotspots, re-sampling selected waterbodies and sampling "new" (not previously sampled) locations was part of the sampling regime. This Year 4 study provides the results for the Atlantic Coastal Inland Region. The study design incorporated a variety of considerations, including sampling species that are important to recreational fishing, targeting fish species of specific trophic position that are known to bioaccumulate mercury and/or organic chemical contaminants, consider the target species body lipid content (important in organic contaminants), as well as species longevity and/or lifestyle proximity to bottom sediments. The data generated through this study are useful in developing credible consumption risk assessments, since they include the size ranges and species that are generally targeted by recreational anglers and can be used in an evaluation of contaminant trends in this region and comparable throughout the state. The results show that mercury in fish concentrations varied among species, but typically increased with fish size and are usually higher in predatory fish, such as chain pickerel and largemouth bass. Mercury levels in chain pickerel were highest in waters with pH less than 7, and for largemouth bass in lakes with pH between 5 and 6. The highest mercury concentrations were observed at drainage sites within and marginal to the Pine Barrens. As observed in this and previous studies lower pH waterbodies typically reflect conditions promoting high mercury bioavailability through methylation, and sources of mercury in the environment are both natural and anthropogenic. PCB levels in the fish sampled, however, showed a different contamination pattern with only relatively low to moderate PCB concentrations identified from these same locations. In general, PCBs and OCPs were typically higher in samples of American eel than other fish species examined. DDXs showed high variability within all sites of the study area, with some of the lowest and highest average concentrations observed when compared to previously studied regions. The variations in these xenobiotics (PCBs, OCPs, DDX) may highlight the differing contaminant sources and geo-chemistry of these contaminants, and may also reflect legacy industrial practices of production, disposal and/or use. Although these xenobiotic concentrations were variable among sites, the highest average concentrations were seen in fish from Deal Lake (PCBs and chlordanes), North Branch Metedeconk River (DDXs and chlordanes), Maurice River (PCBs), and several other smaller lakes (DDXs). Although there are large differences in contaminant concentrations in samples within regions, a comparison of fish tissue chemical data among sites from the previous studies on the Passaic and Raritan Regions, and this study show some regional contaminant differences. In general concentrations of mercury were higher in the Atlantic Coastal Region while PCBs were higher in the Raritan Region. Where comparisons between 1992 and 2007datasets for this study were possible, there was no clear trend in contaminant concentrations at previously sampled locations. When comparing these data to available health criteria, with the exception of mercury, few of the samples analyzed exceeded the USFDA action levels for advisories on commercial fish. However, the NJDEP/DHSS use USEPA supported risk-based health criteria, in establishing consumption advisories for recreationally caught fish. These criteria are typically lower than FDA thresholds for mercury, PCBs, dioxins, and OCPs. The majority of the fish samples tested in this study exceeded the various individual NJDEP/DHSS/USEPA contaminant risk-based thresholds and several samples examined exceeded thresholds for multiple contaminants. The data from this study were used by NJDEP/DHSS to develop the most recent fish consumption advisories for a variety of recreationally caught fish in New Jersey.

Introduction

In the early 1980's, research on New Jerseys' fish found chemical contaminant concentrations exceeding the risk-based health criteria utilized by the State of New Jersey. The DHSS and NJDEP issued statewide, regional, and lake-specific fish consumption advisories for a variety of fish species. Subsequent studies have provided more data on mercury, polychlorinated biphenyls (PCBs), selected organochlorine pesticides (OCPs), and other organic contaminants (e.g., PBDEs, dioxins and furans). The results of these fish contaminant studies are used to amend existing advisories or, if necessary, develop new advisories, to assist the NJDEP in evaluating trends in contaminant concentrations, to enhance waterbody assessments, and to determine necessary, additional research and monitoring. Over the years there has been a clear need for a continuous monitoring program for toxic chemicals in fish to regularly assess the status and trends of fish contamination and related consumption advisories in New Jersey waters. In July 2002, the NJDEP and the Academy of Natural Sciences of Philadelphia (ANSP) began a Routine Monitoring Program for Toxics in Fish. Due to the large number of water bodies in the State, the sampling program is based on a rotating assessment of contamination of five regions of the State on a five-year cycle:

1. Passaic River Region (2002-2003);
2. Marine/Estuarine Coastal Region (2004-2006);
3. Raritan River Region (2006-2007);
4. **Atlantic Coastal Inland Region (2007-2008); and**
5. Upper and Lower Delaware River Region.

In each region, previously sampled and new sites are sampled, so that coverage of water bodies increases over time and temporal comparisons of trends can be done. Sampling in the Passaic Region, Marine/Estuarine Region, and the Raritan River Region have been completed. This project summary reports findings of the fourth year of the cycle, the Atlantic Coastal Inland Region, which involved freshwater fishes sampled in 2007.

Study Design

Stations were selected to include both previously-sampled sites and sites with no fish contaminant data. Fish samples selected include predatory species that are either under consumption advisories on a statewide, regional and waterway-specific basis for mercury (Hg), PCB and/or dioxin contamination or are regularly consumed by recreational anglers within the State. Chain pickerel and largemouth bass have been the primary species monitored, but additional species were selected at specific sites on the basis of their importance in the fishery at that site. Ten species of freshwater fish were sampled.

Scientific Name	Common Name	Scientific Name	Common Name
Esox niger	chain pickerel	*Ameiurus catus*	white catfish
Ictalurus punctatus	channel catfish	*Ameiurus natalis*	yellow bullhead
Micropterus salmoides	largemouth bass	*Ameiurus nebulosus*	brown bullhead
Morone Americana	white perch	*Anguilla rostrata*	American eel
Perca flavescens	yellow perch	*Cyprinus carpio*	common carp

Samples from 31 sites were selected by a stratified random sampling design, modified to include unique lakes and divided into two substrata (sites previously sampled and not previously sampled). The allocation of numbers of sites per stratum and substratum were chosen to provide approximately equal overall sampling rates among each stratum. Waterbodies within the Atlantic Coastal drainage, from Sandy Hook south and the Delaware Bay drainage were among the site sampled in this project. Locations selected were defined as: 1) lakes and impoundments greater than 15 acres with public access, as listed in the latest version of NJ Places to Fish; 2) rivers greater than 12 miles long and without any impoundment in the sampling frame and/or 3) estuarine rivers and associated brackish ponds.

Sampling Station	County	Prev. Samp.	Sampling Station	County	Prev. Samp.
Atlantic City Reservoir (Lower)	Atlantic	1995	Metedeconk River North Branch	Ocean	1992
Atsion Lake	Burlington	1992	Parvin Lake	Salem	1992
Batsto Lake	Burlington	1992	Pohatcong Lake	Ocean	1992
Cedar Lake	Cumberland	1996	Shenandoah Lake	Ocean	1992
Cedarville Ponds	Cumberland		Stow Creek Canton	Salem	
Deal Lake	Monmouth		Swimming River Reservoir	Monmouth	
East Creek Lake	Cape May	1992	Turn Mill Pond	Ocean	
Enno Lake (Bennetts Pond)	Ocean		Union Lake	Cumberland	
Harrisville Lake	Burlington	1992	Wading River	Burlington	
Horicon Lake	Ocean		Wilson Lake	Gloucester	
Lake Absegami	Burlington		Spring Lake	Monmouth	
Lake Manahawkin	Ocean				
Lake Nummy	Cape May	1992			
Lake Oswego	Burlington				
Lefferts Lake	Monmouth				
Lenape Lake	Atlantic	1992			
Manasquan Reservoir	Monmouth	1992			
Maple Lake (east of Dorothy)	Atlantic				
Marlu Lake (Thompson Park)	Monmouth				
Maurice River	Cumberland	1998			
Menantico Sand Ponds	Cumberland				

Field and Laboratory Procedures

Specimens were collected by standard fisheries field methods and/or by other legal methods. The primary technique used was boat electrofishing (freshwater ponds). Eel pots, angling, backpack electrofishing, and gill netting were also used and some specimens were collected by personnel of New Jersey Division of Fish and Wildlife (NJFGW). All procedures for field handling, transporting, recording, storage, cleaning sampling gear and wrapping specimens were consistent with ANSP standard operating procedures (SOP). Chainofcustody forms completed for each collection trip and used to track sample transfers from other collection groups and all laboratory transfers. Samples were maintained with complete sample documentation consistent with the quality assurance and quality control (QA/QC) plan. In addition, measurements of pH, conductivity, dissolved oxygen and water temperatures were made at the time of sampling. Tissue preparation of fish followed common preparation methods for consumption. The selected fish specimens were of an individual fillet with skin off for American eel and catfish species and with skin on and scales removed for all other species. Fillets were homogenized according to clean methods and procedures and stored frozen until thawed and dried for extraction.

Chemistry and Analytical Methods

A total of 223 samples were analyzed. Total mercury was measured on 220 samples. Lipid content, PCBs and selected organo-chlorine pesticides (OCPs) were measured on 136 of the samples, selected to include species most likely to show bioaccumulation of these substances and/or important in recreational fisheries. Polybrominated diphenyl ethers (PBDEs) were measured on 10 samples and dioxins/ furans were analyzed on 10 of the samples analyzed for PCBs and OCPs. Mercury analyses were performed using acid digestions in a microwave digestion system and a Perkin Elmer Fimms 400 Cold Vapor AA. The PCBs, Co-Planar PCBs, Organochlorine Pesticides underwent Soxhlet extractions, gel permeation chromatography (GPC) and were analyzed by solid-liquid chromatography. Organochlorine pesticides (OCPs) were identified and quantified based on a known calibration standards and both congener-specific PCBs and OCPs were analyzed using 610 Method and Agilent 6890 gas chromatograph equipped with a ^{63}Ni electron capture detector and a 5% phenylmethyl silicon capillary column. QA/QC included an analysis of 10% of the samples, an evaluation of surrogate recoveries, calculation of blank-based detection limits, use of NIST standard reference materials and ANSP involvement in NIST's annual inter-laboratory comparison to assess accuracy and precision in quantifying PCBs and OCPs, duplicate analysis, and spike recoveries. Polybrominated Diphenyl Ethers, Dioxin and Furans and four of the dominant co-planar PCBs were preformed at Geochemical and Environmental Research Group (GERG) at Texas A&M University (Dr. Terry Wade). All samples were extracted and spiked with surrogate PCB 77 by ANSP, shipped overnight to GERG to be separated on charcoal/silica gel columns and run using High Resolution Gas Chromatography/Low Resolution Mass Spectrometry (HRGC/LRMS). In addition, a subset of thirty-eight extracts was used to quantify polybrominated diphenyl ethers (PBDEs) using gas chromatograph (Hewlett Packard 5890A, or equivalent. Selected samples for dioxin/furans were also analyzed at Texas A&M University, GERG using methods based on GERG SOP -9722 and 9719. All data and information obtained were submitted to and generated by ANSP were rigorously documented and underwent independent external quality assurance and ANSP staff review.

Risk Assessment Risk

The USFDA promulgates guidelines for the consumption of fish by issuing action levels to take legal action to remove products from the commercial market. While fish caught by recreational anglers do not fall under FDA purview, the action levels are often used as a benchmark for the concentrations above which ingestion is not recommended. Because recreational anglers tend to fish at specific waters their repeated exposure to these chemical contaminants may be greater than the population at large. The USEPA and NJDEP, both use risk -based assessments to develop contaminant specific consumption criteria for recreationally caught fish. These risk-based criteria are often lower than those of USFDA action levels. In addition, NJDEP consumption advisories are often based on a both cancer risk levels and non-cancer risks, and distinct advisories are typically issued for different groups at risk.

Discussion

This study is the first mercury to extensively re-sample waterbodies in and near the Pine Barrens, following the original 1992 investigation. As was seen in the previous study, fish from these sites consistently have higher mercury concentrations (based on length-standardized comparisons within species) than fish from other regions in the state. Mercury concentrations in chain pickerel were typically higher than the previous studies of northern New Jersey and of the Raritan River drainage. The tendency for higher bioaccumulation of mercury of fish in the Pine Barrens may be attributed to aspects of water chemistry and hydrology, which favor methylation of mercury. For

this study, the stratified random site selection design employed was a modification of the original 1992 study and several sites were selected on the basis of 1992 results. The random selection allows inference about contaminant levels within each stratum; however, mercury concentrations did not differ significantly among most strata, so the particular stratification may not be useful in partitioning variability in contamination. Since, mercury contamination varied significantly among groups defined by measured pH, pH would be a better basis for stratification than geographic location. In general, there were no consistent changes in mercury content between earlier and recent collections, although differences at a few sites were evident. Concentrations of mercury (and other contaminants) typically increase with fish age but more difficult to determine. Fish length measurements provide a surrogate to age, particularly within water bodies, however, in comparisons among water bodies; differences in growth rates may weaken overall length-age relationships. Growth rates of many species of fish are likely to be relatively low in Pine Barrens waters, particularly for species like largemouth bass, which do not thrive in low pH water. As a result, fish of a given size from these waters may be considerably older than similar-sized fish from other areas. One of the goals of the study is to locate sites with unusually high concentrations of contaminants that may indicate historical or current point-source contamination. In this study again and in 1992, fish from the Upper Atlantic City Reservoir were sampled and found to have very high mercury concentrations. Higher mercury concentrations were also observed in 2007 at Wilson Lake and samples from the North Branch Metedeconk River and Deal Lake had high concentrations of several organic contaminants. The source of these contaminants is not known.

Conclusion

The study included a number of groups of fish that typically bioaccumulate certain heavy metal and organic contaminants. These groups were selected because of high trophic position (e.g., largemouth bass and chain pickerel), lipid content and longevity (e.g., American eel) and/or association with sediment (American eel, white catfish and channel catfish). These data are relevant to risk assessment, since they include sizes and species that are targeted by anglers and several conclusions can be drawn from the study.

- With the exception of mercury, few of the samples exceeded high FDA action levels, however, a large number of samples exceeded various risk-based thresholds used by NJDEP and in some cases, and the same specimens exceeded thresholds for multiple contaminants.
- Mercury concentrations varied among species and usually increased with size within species but were typically higher in larger, predatory fish such as chain pickerel and largemouth bass.
- The highest mercury concentrations were seen in the Atlantic drainage sites, in or near the Pine Barrens, which reflects conditions promoting high bioavailability through methylation.
- Mercury concentrations were lower in waterbodies with pH greater than 7 than in waterbodies with pH between 4 and 7. While, for chain pickerel, there was no clear pattern in mercury concentrations among waterbodies with pH between 4 and 7, for largemouth bass, highest concentrations were seen in lakes with pH between 5 and 6.
- Where comparisons were possible, there was no clear trend in mercury concentrations between 1992 and 2007datasets.
- Mercury concentrations in Manasquan Reservoir were lower in 2007 than in 1992, which may reflect “aging” of the reservoir. Fish in new reservoirs often have higher mercury concentrations, ultimately due to the amount of decaying organic matter from flooded terrestrial vegetation
- In waterbodies where concentrations of PCBs and OCPs were measured, concentrations of PCBs, DDXs and chlordanes were typically higher in American eels.
- Concentrations of PCBs and OCPs were variable among sites. The highest average concentrations were seen in fish from Deal Lake (PCBs and chlordanes), North Branch Metedeconk River (DDXs and chlordanes), Maurice River (PCBs), and several other lakes (DDXs).
- Comparisons among sites from the Passaic, Raritan Regions and this study area show some regional differences although there are large differences within regions.
- PCBs and DDX showed a different contaminant pattern, with relatively low to moderate PCB concentrations in fish from most of the study area and high variability DDX within the study area. These differences highlight different sources and chemistry of these contaminants where PCB patterns may reflect industrial patterns of production and use and the weak geographic pattern of DDX concentrations may reflect local sources of production and use.

- The New Jersey Department of Environmental Protection (NJDEP) and the New Jersey Department of Health and Senior Services (DHSS) employ risk-based health criteria for establishing consumption advisories for mercury, PCBs, dioxins, and OCPs in recreationally caught fish. These criteria are typically lower than FDA thresholds for advisories for commercial fish. The NJDEP/DHSS have developed fish consumption advisories for New Jersey using the data from this study and other regions studied of the routine monitoring program.

Prepared By

[1] New Jersey Department of Enivronmental Protection, Office of Science (NJDEP/OS)

[2] Academy of Natural Sciences, Philadelphia (ANSP)

RESEARCH PROJECT SUMMARY

Please send comments or requests to:
Office of Science
P.O.Box 420, Trenton, NJ 08625
Phone: 609 984-6070
Visit the DSRT web site @ www.state.nj.us/dep/dsr

Office of Science
Dr. Gary Buchanan, Manager

STATE OF NEW JERSEY
Chris Christie, Governor

Department of Environmental Protection
Bob Martin, Commissioner