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Chemical and Ancillary Data Associated with Bed Sediment, Young of Year Bluefish (*Pomatomus saltatrix*) Tissue, and Mussel (*Mytilus edulis* and *Geukensia demissa*) Tissue Collected after Hurricane Sandy in Bays and Estuaries of New Jersey and New York, 2013–14

Data Series 956

U.S. Department of the Interior
U.S. Geological Survey

Cover. Photographs (from left to right) of U.S. Geological Survey personnel collecting young of year bluefish in Jamaica Bay, New York (Photograph by Daniel Wieczorek, National Oceanic and Atmospheric Administration); ribbed mussel collected from Fire Island, New York (Photograph by Irene Fisher); mussel sampling location at Fort Wadsworth, New York (Photograph by Kelly Smalling). Background: Natural-color image of Hurricane Sandy captured by Geostationary Operational Environmental Satellite 13 at 1:45 p.m. Eastern Daylight Time on October 28, 2012 (Courtesy of National Aeronautics and Space Administration).

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SALLY JEWELL, Secretary

U.S. Geological Survey
Suzette M. Kimball, Acting Director

U.S. Geological Survey, Reston, Virginia: 2015

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Suggested citation:
Smalling, K.L., Deshpande, A.D., Blazer, V.S., Galbraith, H., Dockum, B.W., Romanok, K.M., Colella, K., Deetz, A.C., Fisher, I.J., Imbrigiotta, T.E., Sharack, B., Sumner, L, Timmons, D., Trainor, J., Wieczorek, D., Samson, J., Reilly, T.J., and Focazio, M.J., 2015, Chemical and ancillary data associated with bed sediment, young of year bluefish (*Pomatomus saltatrix*) tissue, and mussel (*Mytilus edulis* and *Geukensia demissa*) tissue collected after Hurricane Sandy in bays and estuaries of New Jersey and New York, 2013–14: U.S. Geological Survey Data Series 956, 18 p., http://dx.doi.org/10.3133/ds956.

ISSN 2327-638X (online)

Dr. Bruce William Dockum
(1948–2015)

This report benefited from the efforts of Dr. Bruce William Dockum of the National Oceanic and Atmospheric Administration (NOAA) Fisheries James J. Howard Laboratory who passed unexpectedly during this study. Dr. Dockum was a consummate professional and a devoted analytical chemist. He paid rigorous attention to detail and meticulously documented his work. The details he attributed to the protocols provided essential information to his colleagues to continue the study. Dr. Dockum served as a mentor to students and colleagues and was well respected for his in-depth knowledge of chemistry. The quality of the analyses reported herein reflects Dr. Dockum's commitment to strive for the highest possible standards. Dr. Dockum's legacy will continue to play an important role in future research of NOAA.

Acknowledgments

The authors would like to thank Jeffrey Pessutti, Ehren Habeck, Peter Plantamura (National Oceanic and Atmospheric Administration Fisheries Sandy Hook Laboratory, New Jersey), Patrick Bowen, and Amy Simonson [U.S. Geological Survey (USGS)], all of whom made significant contributions to the sample collection efforts. We would also like to thank Peter Straub (Stockton College) for assistance with freeze drying of tissue samples and Kim Rogan (Monmouth University) for assistance in measuring and weighing bluefish samples. We thank Kathy Spring and Darlene Bowling (USGS) for preparation of the histopathology slides, as well as Carrie Blakeslee, Jeffrey Cole, and Sophie Weaver (USGS) for assistance with mussel thin-section preparation and aging; Daniel Jones (USGS) for map production, and Alex Fiore and Christopher Leach (USGS) for assistance with the literature review. We are grateful for the timely and thorough reviews provided by Kathleen Conn and Lawrence Feinson (USGS).

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Conversion Factors

International System of Units to Inch/Pound

Multiply	By	To obtain
	Length	
centimeter (cm)	0.3937	inch (in.)
millimeter (mm)	0.03937	inch (in.)
meter (m)	3.281	foot (ft)
kilometer (km)	0.6214	mile (mi)
	Area	
hectare (ha)	0.003861	square mile (mi^2)
square kilometer (km^2)	0.3861	square mile (mi^2)
	Volume	
liter (L)	1.057	quart (qt)
liter (L)	0.2642	gallon (gal)
	Flow rate	
cubic meter per second (m^3/s)	35.31	cubic foot per second (ft^3/s)
	Mass	
gram (g)	0.03527	ounce, avoirdupois (oz)
kilogram (kg)	2.205	pound avoirdupois (lb)

Temperature in degrees Celsius (°C) may be converted to degrees Fahrenheit (°F) as:

$$°F = (1.8 \times °C) + 32.$$

Temperature in degrees Fahrenheit (°F) may be converted to degrees Celsius (°C) as:

$$°C = (°F - 32) / 1.8.$$

Datum

Vertical coordinate information is referenced to the North American Vertical Datum of 1988 (NAVD 88);

Horizontal coordinate information is referenced to the North American Datum of 1983 (NAD 83);

Altitude, as used in this report, refers to distance above the vertical datum.

Supplemental Information

Concentrations of chemical constituents in sediment and tissue are given in micrograms per kilogram (µg/kg).

Abbreviations

Å	angstrom
°C	Celsius
cm	centimeter
g	gram
m	meter
mm	millimeter
na	not applicable
nd	not detected
ng	nanogram
psi	pounds per square inch
µg/kg	microgram per kilogram
µm	micrometer
s	seconds
v	volt

Acronyms

ASE	accelerated solvent extraction
AH	aliphatic hydrocarbon
BHC	benzenehexachloride
CARP	Contaminant Assessment and Reduction Project
DBOFB	dibromoocatafluorobiphenyl
DCM	dichloromethane
E	estimated
EPA	U.S. Environmental Protection Agency
GC	gas chromatography
GPS	global positioning system
HBCD	hexabromocyclododecane
HCB	hexachlorobenzene
HPLC	high performance liquid chromatography
LSC	Leetown Science Center
MS	mass spectrometry
NARL	Northern Appalachian Research Laboratory
NCA	National Coastal Assessment
NIST	National Institute of Standards
N.J.	New Jersey
NOAA	National Oceanic and Atmospheric Administration
NS&T	National Status and Trends
NWIS	National Water Information System
N.Y.	New York
OCP	organochlorine pesticide
PAH	polycyclic aromatic hydrocarbon
PCB	polychlorinated biphenyl
PBDE	polybrominated diphenyl ether
QA/QC	quality assurance/quality control

REMAP	Regional Environmental Monitoring and Assessment Program
RL	reporting limit
RPD	relative percent difference
SD	standard deviation
SRM	standard reference material
SIM	selected ion monitoring
STORET	Storage and Retrieval
TCB	1,2,3-trichlorobenzene
USGS	U.S. Geological Survey
WQDP	Water Quality Data Portal
YOY	young of year

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Abstract

This report describes the methods and data associated with a reconnaissance study of young of year bluefish and mussel tissue samples as well as bed sediment collected as bluefish habitat indicators during August 2013–April 2014 in New Jersey and New York following Hurricane Sandy in October 2012. This study was funded by the Disaster Relief Appropriations Act of 2013 (PL 113-2) and was conducted by the U.S. Geological Survey (USGS) in cooperation with the National Oceanic and Atmospheric Administration (NOAA).

Young of year *Pomatomus saltatrix* (bluefish) were collected from nine sites in New Jersey (N.J.) and New York (N.Y.) including Barnegat Bay, N.J., Sandy Hook Bay, N.J., Jamaica Bay, N.Y., and Great South Bay, N.Y., and analyzed for indicators of health and chemical contamination. At each bluefish sampling location, bed sediment was also collected and analyzed for a suite of contaminants. Resident mussels, *Mytilus edulis* (blue mussels) and (or) *Geukensia demissa* (ribbed mussels), were collected from 11 historic NOAA Mussel Watch Program sites along the N.J. and N.Y. coastlines in the winter/spring of 2014 and analyzed for contaminants. Individual age of a subset of the mussels sampled was also determined at each site.

Bed sediment samples were analyzed for a suite of organic contaminants including 34 polychlorinated biphenyl (PCB) congeners, 28 polybrominated diphenyl ether (PBDE) congeners, 24 organochlorine pesticides (OCPs), 53 polycyclic aromatic hydrocarbons (PAHs) and alkylated PAHs, 33 aliphatic hydrocarbons (AHs), and 10 petroleum biomarkers (steranes and hopanes). Bed sediment collected from the Navesink River (Sandy Hook, N.J.), Metedeconk River (Barnegat Bay, N.J.), and Toms River (Barnegat Bay, N.J.) had the highest concentrations of contaminants compared to the other sites.

Bluefish and mussel tissue collected throughout the study area was analyzed for 34 PCB congeners, 28 PBDE congeners, and 24 OCPs. Thirty-three PCB congeners, 22 PBDE congeners, and 24 OCPs were detected in the bluefish analyzed. The highest median concentrations of total PCBs were present in tissue from Jamaica Bay, N.Y., whereas the highest median concentrations of total PBDEs and total OCPs were present in tissue from Sandy Hook Bay. Of the OCPs detected, *p,p'*-DDE was found in 99 percent (%) of the tissue samples and at the highest median concentrations compared to the other OCPs.

Fish health assessments were conducted on 20 fish from the 4 bays. Results indicate that the sex ratio and the mean total length varied by site. Physical fish damage, such as lesions and parasites, was observed in fish from all four bays. The most common parasite observed visually was the presence of *Livoneca redmanii*, an ectoparasitic gill isopod, which can cause localized gill erosion. The prevalence of the gill isopod infestation ranged from 20% at Great South Bay, N.Y., to 35% at Jamaica Bay, N.Y.

Twenty three PCB congeners, 9 PBDE congeners, and 20 OCPs were detected in composite mussel samples collected throughout the study area. The co-eluting PCB congeners 153 and 132, PBDE 47, 99, and 100, and *p,p'*-DDE were detected in samples from each site. The highest median concentrations of PCBs and PBDEs were present in mussels from Raritan Bay, N.Y., whereas the highest median concentrations of OCPs

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were present in mussels from Fire Island Inlet, N.Y., and Shark River, N.J. *Mytilus edulis* (blue mussels) and *Geukensia demissa* (ribbed mussels) were thin-sectioned and aged. The blue mussels collected ranged in age from 4 to 13 years, and the ribbed mussels ranged in age from 3 to 12 years.

Introduction

Hurricane Sandy made landfall along the New Jersey (N.J.) coastline in late October 2012, causing widespread physical, environmental, social and economic impacts to much of coastal N.J. and New York (N.Y.). Many elements of the built and natural environment were compromised by the resulting storm surge, winds, and rain, including (but not limited to) residential structures, industrial manufacturing and storage facilities, wastewater-treatment facilities, and known contaminated sites. The debris and disturbance resulting from the storm were considered possible threats to vulnerable coastal ecosystems because of the potential for mobilization of contaminants from disturbed sediments and compromised facilities. Public-health agencies responded immediately to address acute effects of Hurricane Sandy, but the potential long-term human and ecological impacts resulting from the introduction of contaminants from compromised infrastructure, weathering debris, and redistribution of contaminated sediments are unknown. During 2013–14, reconnaissance sampling was conducted to characterize the presence of persistent sediment-bound contaminants (Fischer and others, 2015) and tissue-bound contaminants. This study, which was conducted by the U.S. Geological Survey (USGS) in cooperation with the National Oceanic and Atmospheric Administration (NOAA), will lead to an understanding of the persistence and accumulation of contaminants in bed sediment and tissue, which will help USGS and NOAA scientists further assess the impacts of Hurricane Sandy on ecosystem health and establish a new baseline for sediment- and tissue-bound contaminants in the aftermath of a major coastal storm.

Remote imagery and inundation mapping indicate that, most if not all, bays and estuaries along the New Jersey shore, New York/New Jersey Harbor Complex, and the southern shore of Long Island, N.Y., were affected by storm-surge or river flood waters. Young of year (YOY) bluefish and mussels were selected for study on the basis of the availability of pertinent historical contaminant information, as well as their value as important aquatic resources. The estuaries and bays selected represent the storm-affected area, are considered valuable nursery and breeding grounds for both resident and pelagic aquatic resources, and were prioritized on the basis of the presence of pertinent historical tissue-contaminant data in order to facilitate a comparison of pre- and post-Hurricane Sandy effects.

Following Hurricane Sandy, the USGS developed a science plan (Buxton and others, 2013) designed to coordinate USGS activities within the agency, as well as with other Federal partners, to guide continued data collection and analysis in support of ongoing recovery and restoration efforts. The activities outlined in the plan were organized into five themes including (1) coastal topography and bathymetry; (2) impacts to coastal beaches and barriers; (3) impacts of storm surge and estuarine and bay hydrology; (4) impacts on environmental quality and persisting contaminant exposures; and (5) impacts to coastal ecosystems, habitats, and fish and wildlife.

The overall objective of the project was to provide a regional perspective of the potential environmental health effects associated with human and ecological exposures to storm-derived contaminants in areas affected by Hurricane Sandy. The specific objectives of the theme 4 tissue-reconnaissance effort were to (1) assess changes in concentrations of selected organic compounds in resident fish and mussels collected before and after Hurricane Sandy, (2) evaluate metrics of fish and habitat health throughout the study area, and (3) evaluate the age of mussels collected throughout the study area and assess the change in trace-element concentrations in mussel shells over time. The data presented in this report specifically address the objective of theme 4 and will be used to determine the ecological implications of contaminants mobilized by Hurricane Sandy on valuable recreational and commercial aquatic resources throughout New Jersey and New York by comparing tissue contaminant body burdens before and after the storm. This report also includes information on finfish health following Hurricane Sandy and provides a new baseline with regards to contaminants and health in the region. This study was funded through the Disaster Relief Appropriations Act of 2013 (PL 113-2).

Purpose and Scope

This report describes the study design, documents the methods of bed sediment and tissue collection and analysis, presents the quality-assurance data and analyses, and provides the chemical and histological data for the reconnaissance study of the impacts of Hurricane Sandy on human and ecological exposure to tissue-bound contaminants. During 2013–14, YOY bluefish were collected from 9 sites in 4 bays, and mussels were collected from 11 sites throughout the study area. Bluefish and mussel tissue was analyzed for 34 polychlorinated biphenyl (PCB) congeners, 28 polybrominated diphenyl ether (PBDE) congeners, and 24 organochlorine pesticides (OCPs). Histology results for fish health assessments are reported, as well as mussel chronology results. Bed-sediment samples were also collected from 10 sites throughout the study area and analyzed for a suite of organic contaminants, including 34 PCB congeners, 28 PBDE congeners, 24 OCPs, 53 polycyclic aromatic hydrocarbons (PAHs) and alkylated PAHs, 33 aliphatic hydrocarbons (AHs), and 10 petroleum biomarkers (steranes and hopanes). This report summarizes the data associated with the theme 4 tissue-bound contaminant reconnaissance study.

Study Design

YOY *Pomatomus saltatrix* (bluefish) and *Mytilus edulis* (blue mussel) and (or) *Geukensia demissa* (ribbed mussel) were collected and analyzed for indicators of estuarine health and chemical contamination throughout the study area. These species were selected because they are residents of the affected estuaries, have associated historical chemical data from previous local and regional monitoring programs, and in the case of bluefish, are valuable recreational aquatic resources that are consumed by humans. New Jersey and New York coastal bays are considered "essential fish habitat" for YOY bluefish (Able and others, 2003). Their residence in contaminated estuaries during critical periods of growth, their high lipid content, and their piscivory make bluefish likely to acquire high levels of contaminants that biomagnify up the food chain (Williams, 2006; Deshpande and Dockum, 2013). Bed-sediment samples were collected at the fish sampling sites, as a habitat indicator, and analyzed for a suite of contaminants.

Resident mussels have long been considered effective indicators of ecosystem health and have been used in national monitoring studies for more than 2 decades by NOAA's Mussel Watch Program (Kimbrough and others, 2008). Mussels were chosen as a representative species for this study because contaminant levels in their tissues respond to changes in ambient environmental levels, accumulation occurs with very little metabolic transformation, historical (pre-Hurricane Sandy) data for the study area are available (Kimbrough and others, 2008).

Study Area

The study area consists of bays and estuaries adjacent to lands in New Jersey and New York that were inundated by Hurricane Sandy. YOY bluefish were collected from 9 sites in 4 bays throughout the study area, including 3 sites in Barnegat Bay, N.J., 2 sites in Sandy Hook Bay, N.J., 2 sites in Jamaica Bay, N.Y., and 2 sites in Great South Bay, N.Y. (fig. 1). Bed sediment was collected at similar sites in conjunction with the fish sampling at 10 locations (fig. 2). Mussels were collected from 11 historic NOAA Mussel Watch Program sites throughout the study area (fig. 3).

Detailed information on the YOY bluefish and mussel sampling sites is given in table 1. Detailed information on the bed sediment sampling sites is given in table 2.

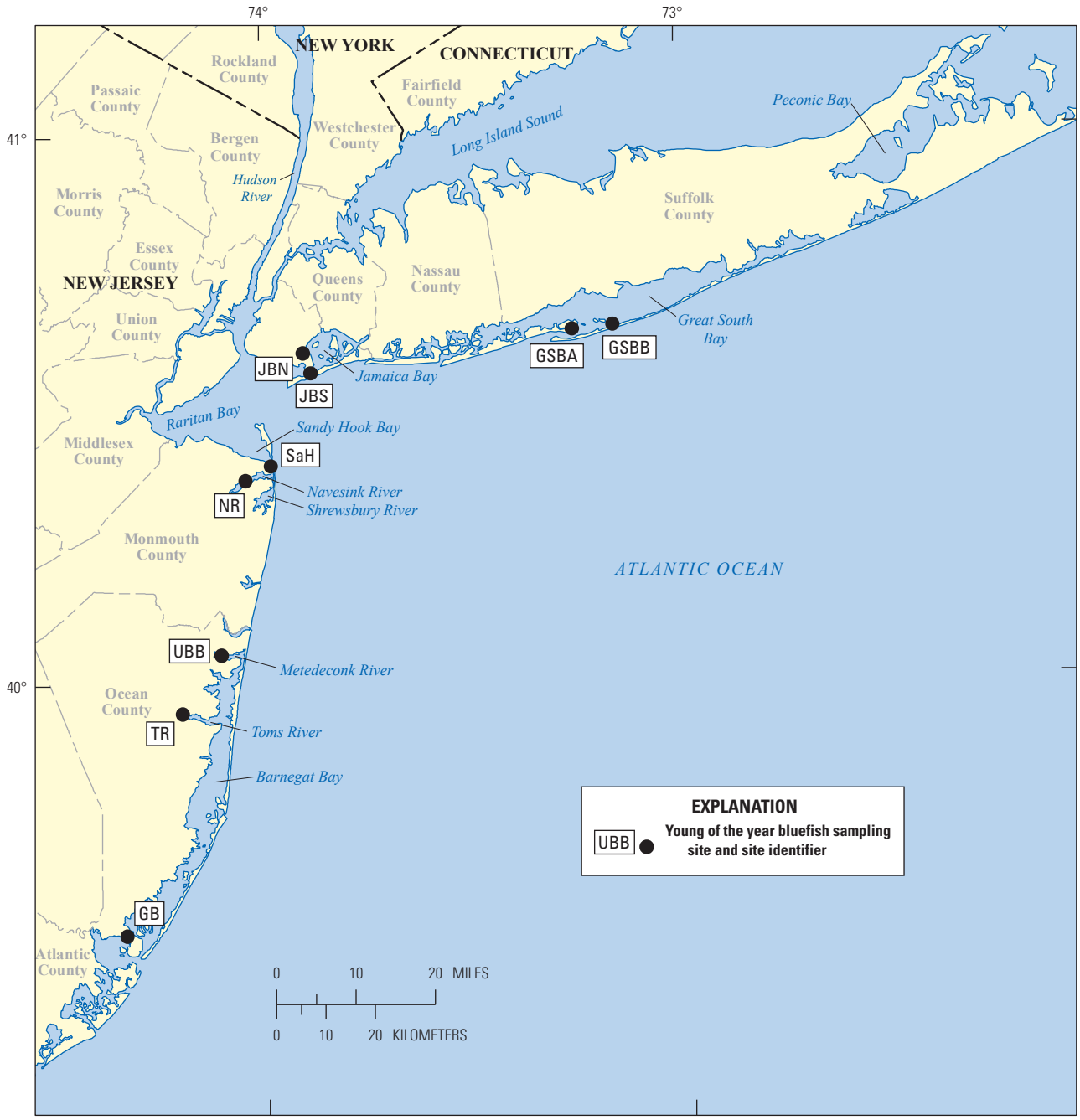
Historical Data

Data on contaminated YOY bluefish and mussel tissue previously collected in the study area were reviewed and compiled to examine the ecological effects of Hurricane Sandy in historical context using methods similar to those described for the historical sediment data compilation in Fischer and others (2015). Federal, State, local, and institutional sources of data were consulted, an extensive literature search was conducted, and data were retrieved. These data together with previously published interpretations will aid in future evaluations of changes in contaminant levels over time. The most temporally and spatially extensive and readily available regional estuarine tissue monitoring dataset for the study area was assembled by the NOAA's National Status and Trends Mussel Watch Program (http://ccma.nos.noaa.gov/about/coast/nsandt/musselwatch.aspx). NOAA's Mussel Watch Program represents the longest running continuous contaminant monitoring program for U.S. coastal waters (Kimbrough and others, 2008). Scientists from the Mussel Watch Program have been analyzing chemical and biological trends in sediment, bivalves, and some fish since 1986. The contaminants that are routinely monitored include PAHs, PCBs, OCPs, trace elements, and PBDEs. Monitoring for PBDEs began at selected sites in 2004 (Kimbrough and others, 2009). Another valuable regional research study conducted by NOAA Fisheries Sandy Hook Laboratory assessed the accumulation of PBDE congeners in YOY bluefish along the U.S. coastline prior to Hurricane Sandy (Deshpande and Dockum, 2013). A few interstate, State, local, and institutional programs also have collected tissue-quality data related to a wide range of chemical contaminants in parts of the study area. For example, the Contaminant Assessment and Reduction Project (CARP; http://www.carpweb.org/main.html), a consortium of industries and regulatory agencies, studied metals and organic contaminants entering the New York/New Jersey Harbor and Raritan Bay.

Data Retrieval

Tissue-contaminant data were retrieved from the following sources to determine the number and types of tissue samples collected prior to the post-Hurricane Sandy sampling effort in the study area, including U.S. Environmental Protection Agency's (EPA) Regional Environmental Monitoring and Assessment Program (REMAP), EPA's National Coastal Assessment (NCA) Program (http://www.epa.gov/emap/nca/html/data/index.html), and the NOAA Mussel Watch Program (http://ccma.nos.noaa.gov/about/coast/nsandt/download.aspx). The EPA NCA data portal provides access to NCA data by state, water body, data source, biogeographical province, and (or) year. The National Status and Trends (NS&T) Data Portal provides access to NOAA data from the Mussel Watch Program, as well as other NS&T biological studies (Benthic Surveillance and Bioeffects). All of the data were organized and archived in a Microsoft® Access database at the USGS New Jersey Water Science Center. The values in parentheses reported herein represent individual data results obtained from the database queries.

The EPA NCA data portal was queried by state (New Jersey and New York) and data source (National Coastal Assessment-Northeast and REMAP Region 2 2003), and data on concentrations of chemicals in tissues were then downloaded. A total of 3,753 (3,100 organic results and 653 trace-element



Base from U.S. Geological Survey 1:24,000 scale digital data
Universal Transverse Mercator Zone 18N
North American Datum of 1983 (NAD83)

Figure 1. Young of year *Pomatomus saltatrix* (bluefish) sampling sites along the New Jersey and New York coastline. Young of year bluefish were collected from 9 sites in 4 bays in New Jersey (N.J.) and New York (N.Y.), including 3 sites in Barnegat Bay, N.J., 2 sites near Sandy Hook, N.J., 2 sites in Jamaica Bay, N.Y., and 2 sites in Great South Bay, N.Y. Detailed site information is given in table 1.

Base from U.S. Geological Survey 1:24,000 scale digital data
Universal Transverse Mercator Zone 18N
North American Datum of 1983 (NAD83)

Figure 2. The 10 sampling sites where bed sediment was collected as part of the young of year *Pomatomus saltatrix* (bluefish) tissue reconnaissance along the New Jersey and New York coastline. Detailed site information is given in table 2.

Base from U.S. Geological Survey 1:24,000 scale digital data
Universal Transverse Mercator Zone 18N
North American Datum of 1983 (NAD83)

Figure 3. Mussel sampling sites along the New Jersey and New York coastline. Mussels were collected from 11 historic National Oceanic and Atmospheric Administration Mussel Watch Program sites. Detailed site information is given in table 1.

results) individual data records for New Jersey were returned for samples collected from 2000 to 2004. Species included whole *Cynoscion regalis* (weakfish, 374); carcass, filet, offal, and whole *Morone americana* (white perch, 2,024); filet, offal, and whole *Paralichthys dentatus* (summer flounder, 299); carcass, filet, and whole *Sparidae* (porgies, 375); and carcass, filet, offal, and whole *Stenotomus chrysops* (scup, 681). A total of 16,455 (13,788 organic compounds and 2,667 trace elements) individual data records for New York were returned for samples collected from 2000 to 2005. Species included whole *Cynoscion regalis* (weakfish, 145); filet and whole *Morone americana* (white perch, 428); filet, offal, and whole *Paralichthys dentatus* (summer flounder, 7,365); filet and whole *Pseudopleuronectes americanus* (winter flounder, 2,285); and filet, offal, and whole *Stenotomus chrysops* (scup, 5,418). Data on the catfish species *Ameiurus catus* (white catfish), *Ameiurus nebulosu* (brown bullhead), and *Ictalurus punctatus* (channel catfish) were available for the study area but were discarded in the data retrieval because of the differences in life histories between catfish and pelagic estuarine fish sampled post-Hurricane Sandy.

The NS&T Data Portal was used to obtain tissue data by state. A total of 3,776 (3,262 organics and 514 trace elements) data records were returned for New Jersey samples collected from 1985 to 2012. Species included the mussel *Mytilus edulis* (3,110) and liver samples from winter flounder *Pseudopleuronectes americanus* (664). Samples were collected from Absecon Inlet (1,534), Barnegat Light (1,576), and Raritan Bay (666). A total of 16,636 (14,590 organic and 2,046 trace elements) data records for New York were returned for samples collected from 1985 to 2012. Species include the oyster *Crassostrea virginica* (340), the mussels *Geukensia demissa* (487) and *Mytilus edulis* (15,165), liver samples from the winter flounder *Pseudopleuronectes americanus* (664), and liver samples from the white perch *Morone americana* (56). Samples were collected from the Great South Bay (296), Hudson/Raritan Estuary (6,291), Moriches Bay (1,866) and New York Bight (4,701).

Literature Search

Peer-reviewed scientific articles containing chemical and biological data collected for bluefish and mussels prior to Hurricane Sandy (October 2012) were identified using the Google Scholar Internet search engine. Each search included three classes of search terms: location, medium, and class of contaminant. Locations included many of the major bays along the Atlantic coastline in New Jersey and New York. The location search terms included Barnegat Bay–Little Egg Harbor, Raritan Bay, Newark Bay, New York Harbor, Jamaica Bay, South Oyster Bay, Great South Bay, and Peconic Bay. The medium was tissue and included bluefish and mussels. Class of contaminant included PCBs, PBDEs, and pesticides.

Each search used a unique set of search terms to identify references. The search date and number of references retrieved were recorded. All search results were reviewed by the senior scientist involved in this element, and the articles containing all search terms that were deemed relevant to the study were downloaded and summarized for future interpretative products. The number of articles retrieved and the number of relevant articles are shown in tables 3 and 4 for YOY bluefish and mussels.

Methods

Site Selection

Sampling locations were selected on the basis of the availability of historical tissue data (Deshpande and Dockum, 2013; Kimbrough and others, 2008) in order to facilitate a future comparison of pre- and post-Hurricane Sandy effects. Four bays, representing a range of land uses and storm impacts (Fischer and others, 2015), most with historical (pre-Hurricane Sandy) data that spanned the New Jersey and New York coastline were selected for the YOY bluefish and sediment sampling (fig.1 and fig. 2). The sites selected for the YOY bluefish collection are in close proximity to those sampled previously by NOAA (Deshpande and Dockum, 2013). Eleven mussel sampling sites were selected on the basis of historical NOAA Mussel Watch Program sites (fig. 3). The availability of pre-Hurricane Sandy data is shown in tables 3 and 4.

Sample Collection and Processing

YOY bluefish were collected by hook and line during August–September 2013 by USGS and NOAA personnel (table 1). The location of each sampling site was determined using a Global Positioning System (GPS). Field conditions, such as air and water temperature, specific conductance, pH, and salinity, and weather conditions were recorded. At each site, crews randomly selected approximately 40 fish ranging from 110 to 250 millimeters (mm) for analysis. Ten individuals were randomly selected for histopathology per site, and the remaining 30 fish, where available, were preserved for future tissue chemistry analysis. The 10 fish selected per site (20 per bay) for histopathology were kept alive on the boat in aerated 5-gallon buckets. The remaining 30 fish collected for chemical analysis were placed in whirl pack bags on ice and transported to the NOAA laboratory where they were stored frozen at -80 degrees Celsius (ºC). Of those preserved for chemical analysis, 12–15 were randomly selected, and the remaining fish were archived for potential future analysis. Prior to analysis, the length and weight of the 12–15 randomly selected bluefish samples from each site were recorded (table 5).

Fish selected for histopathology were processed within 1 hour of collection. Fish were euthanized with Finquel (MS222; Argent Laboratories, Redmond, Washington), measured to the nearest mm, and bled from the caudal vein using heparinized 3-cubic centimeter (cc) syringes with 23-gauge needles. Fish were visually inspected for any visible abnormalities, then dissected, and small pieces of the liver, kidney, and gonads were removed and placed in RNAlater® (Sigma Aldrich, St Louis, Missouri) for future molecular analyses. The remaining portions of liver, kidney, and gonad, as well as gills and heart, were removed and preserved in Z-fix™ (Anatech LTD, Battle Creek, Michigan) for histopathological analyses at the USGS Leetown Science Center (LSC). Blood was placed in heparinized Vacutainer® tubes containing sodium heparin and placed on wet ice for overnight shipment to the LSC. Upon arrival at the LSC, blood was centrifuged at 1000 X gravity for 10 minutes (min), and plasma was removed and frozen at -80 ºC for future analyses.

Bed-sediment samples were collected from a boat at 10 sites with a Petite Ponar using standard methods (Hladik and others, 2009; Radtke, 2005; EPA, 2001). All bed-sediment samples were collected within 1 week of the fish sampling from August to September 2013 (table 2). The location of each sampling site was determined using a GPS. Field conditions, such as air and water temperature, specific conductance, pH, and salinity, and weather conditions were recorded. Only the upper 2 centimeters (cm) of sediment was retained for analysis to standardize sample collection in an attempt to capture sediment-quality conditions after the hurricane. Sediment particles in overlying water from the grab sample were allowed to settle, then water was gently drawn off with a suction pump and tubing. A clean, methanol-rinsed stainless steel or Teflon ® spoon was used to remove the upper 2 cm of sediment (or entire volume if 2 cm or less was collected) from the sampler. Sediment was placed in a clean methanol-rinsed glass or stainless steel mixing bowl until at least 1 gallon of sediment was obtained. If a gallon of sediment could not be collected from a single grab, or if an excessive amount of large debris (greater than 2 cm) or particles were present, a second grab sample was collected and processed. Between sampling sites, the grab samplers were rinsed with seawater from the site, and sampling spoons, bowls, and other equipment were washed with de-ionized water and rinsed with methanol. All equipment was field rinsed with site water before it was used at each sampling site.

The total sample collected from one or more grabs was homogenized prior to filling individual pre-cleaned sampling containers for the different analyses. Sub-samples were analyzed for a suite of physical, chemical, biological, and toxicological constituents and properties to determine the type, concentration, potential sources, and biological activity or inhibition of contaminants present and are described in detail in Fischer and others (2015). A sub-sample was also collected for the analysis of PCBs, PBDEs, OCPs, PAHs, AHs, and petroleum biomarkers by the NOAA Fisheries Sandy Hook Laboratory. Details on the analyses conducted are described in the "Analytical Methods" section of this report. All samples were stored in an ice-filled cooler while on the boat and during transport back to the office. All samples were stored frozen at -20 ºC and were placed on ice and shipped overnight to the laboratory.

Resident mussels (blue and ribbed) were collected along the New Jersey and New York coastline from December 2013 to April 2014 (table 1) using previously published methods (Lauenstein and others, 1993). At each site approximately 100 individual mussels were collected from 2 to 3 stations approximately 25 meters (m) apart. Mussels ranging in length from 2 to 8 cm, depending on species and the availability of mussels at each site, were collected by hand, rinsed with seawater to remove any residual debris, and placed in 5-gallon buckets. Only mussels with tightly closed shells were collected. All mussels were collected from the shoreline from rocks, pilings, and marsh sediment. *Mytilus edulis* (blue mussels) were collected from 8 of the 11 sites, whereas *Geukensia demissa* (ribbed mussels) were collected from 3 of the 11 sites (table 1). Both species were observed and collected at the site in Jamaica Bay, N.Y. (HRJB).

After collection, the mussels were removed from the bucket and placed in two separate 1-gallon Ziploc bags using gloved hands (50 in each bag). The bags were labeled A and B, representing replicate samples which consisted of 50 randomly pooled mussels from the 2–3 stations at each site. All samples were placed in a cooler on ice, transported back to the laboratory, and stored frozen at -20 ºC prior to processing and analysis.

In the laboratory, mussels were thawed, and the shells were opened using a methanol rinsed spatula. The tissue was removed with methanol rinsed forceps and placed into a 500-milliliter (mL) baked amber jar. Each 500-mL jar represented a composite tissue sample from a single replicate collected from a site. The tissue samples were frozen at -20 ºC and shipped on ice to the NOAA laboratory for analysis. Forty to 80 shells of various sizes were washed to remove excess tissue and debris, placed in 1-gallon Ziploc bags and shipped to the LSC Northern Appalachian Research Laboratory (LSC-NARL) for chronology.

Analytical Methods

Semi-Volatile Compounds in Sediment

All bed sediment samples were analyzed at the NOAA Fisheries Sandy Hook Laboratory for six classes of selected persistent organic contaminants by using previously published methods (Kimbrough and others, 2009; Sloan and others, 2004; Deshpande and others, 2000; Packer, 2001; Mills and others, 1999; Sloan and others, 1993). The target compounds included 34 PCB congeners, 24 OCPs, 28 PBDE congeners, 53 PAHs and alkylated PAHs, 33 AHs, and 10 petroleum biomarkers (steranes and hopanes).

An aliquot of wet sediment sample (9–18 grams) was weighed and mixed with Hydromatrix (diatomaceous earth) in a mortar with a pestle until the mixture was free flowing. The sediment-Hydromatrix mixture was transferred to a 100-mL accelerated solvent extraction (ASE) cell and extracted with dicholormethane (DCM) using a Dionex ASE-300 system (Thermo Fisher Scientific, Waltham, Massachusetts). Each sample was extracted two times at a temperature of 120 °C and at a pressure of 1,500 pounds per square inch (psi) for a total time of about 20 min. Prior to extraction, method surrogates and internal standards for PCBs, OCPs, PBDEs, PAHs, AHs, and petroleum biomarkers (steranes and hopanes) were added to each cell. Following extraction, about 20 grams (g) of anhydrous sodium sulfate was added to each vial to remove the residual water. A separate portion (between 1 and 3 g) of each sediment sample was used to determine the percent moisture.

Sulfur, which is common in estuarine sediments and interferes with chromatographic results, was removed from the extracts using 40 g of activated copper granules (Sigma-Aldrich, St. Louis, Missouri) and tumbled overnight. The copper was activated by mixing the granules with concentrated hydrochloric acid for 20 minutes. The acid was then carefully decanted, and the copper was washed three times with methanol followed by three washes with DCM. Following sulfur removal, the extracts were concentrated to 1 mL using a TurboVap (Zymark Corporation, Hopkinton, Massachusetts), exchanged to hexane, and reduced again to a final volume of 1 mL.

A modified REMAP cleanup procedure using 7.5-percent activated silica was used to remove residual matrix from the samples (EPA, 1998). The silica was previously activated at 400 ºC in a muffle furnace overnight, deactivated with water, and tumbled overnight. A total of 12.2 g of 7.5-percent deactivated silica was added to a glass column and rinsed with 30 mL of hexane. The sample extract was added to the column and eluted with 50 mL of hexane, followed by 40 mL of 60:40 by volume DCM: hexane. Each cleaned sample extract was reduced to 1 mL, exchanged to hexane, and reduced again to approximately 0.5 mL for analysis. Internal standards for PCBs, OCPs, PBDEs, PAHs, AHs, and petroleum biomarkers (sterane and hopanes) were added to each cell. Finally, the volume of each sample was adjusted to 1 mL, and the sample was split into five equal portions for analysis.

Target compounds were analyzed by using an Agilent 5890 gas chromatograph (GC) coupled to an Agilent 5973 mass spectrometer (MS) operating in the select ion monitoring (SIM) mode. PCB congeners, OCPs, PAHs, AHs, and petroleum biomarkers (steranes and hopanes) were analyzed by using a DB-5 0.25-mm x 60-m capillary column. PBDE congeners were analyzed by using a Restek 1614 0.25-mm x 15-m PBDE column. Sample extracts were also analyzed for hexabromocyclododecane (HBCD) on the Restek 1614 column. As the GC does not separate the three HBCD congeners, a total HBCD congener concentration is reported. The reporting limit (RL) for PCBs, OCPs, PBDEs, PAHs, and AHs was 1.0 microgram per kilogram (µg/kg) dry weight. The RL for each petroleum biomarker was 4.2 µg/kg dry weight.

Semi-Volatile Compounds in Tissue

All tissue samples (YOY bluefish and mussels) were analyzed at the NOAA Fisheries Sandy Hook Laboratory for three classes of selected persistent organic contaminants by using previously published methods (Deshpande and others, 2000; Deshpande and Dockum, 2013). Individual whole bluefish (cut into 15–20 mm thick pieces) and mussel homogenates were freeze dried prior to extraction. Freeze-dried tissues were pulverized in a blender with diatomaceous earth (Hydromatrix, Dionex Corporation, Sunnyvale, California). Prior to extraction, recovery surrogates were added to the freeze-dried, pulverized homogenates and then extracted with DCM by using either a Dionex Model 300 Accelerated Solvent Extractor (ASE; Thermo Fisher Scientific, Waltham, Massachusetts) or a Soxhlet extraction apparatus (Organomation, Berlin, Massachusetts).

ASE extractions were performed in two consequent cycles. The conditions for extraction of each cycle were temperature at 120 °C, pressure at 1,500 psi, heating time of 6 min, static time of 5 min, flush percent 100, and purge time of 90 seconds. Soxhlet extractions were performed overnight for about 18 hours. Following extraction, anhydrous sodium sulfate was added to each extract to remove any residual water. The extract was decanted and concentrated using a TurboVap. The bulk polar interfering compounds of biological origin were removed from the target analytes by using florisil/silica/alumina glass column chromatography. Twenty percent of the glass column cleaned extract, by volume, was used for the gravimetric determination of the lipids.

Lipids and other interferences from the extract were removed on a styrene–divinylbenzene polymer-based semi-preparatory, size-exclusion high performance liquid chromatography column (Phenogel 10, 600 mm x 21.20 mm, 100 pore size, 10 µm particle size; Phenomenex, Torrance, California) by using a Hewlett Packard 1050 high performance liquid chromatograph (HPLC; Agilent, Palo Alto, California; λ= 254 nanometers [nm]). HPLC fractions containing the target analytes were collected as per the previously calibrated time intervals by using a Foxy Fraction Collector (ISCO, Lincoln, Nebraska). The HPLC fraction was exchanged to hexane and concentrated to less than 1 mL, and each final extract was split into three separate vials for analysis of PCBs, OCPs, and PBDEs.

Target analytes were analyzed by using an Agilent 6890 GC coupled to an Agilent MS operating in SIM mode. PCB congeners and OCPs were analyzed by using a DB 5 0.25-mm ID x 60-m capillary column. PBDE congeners were analyzed by using a Restek 1614 0.25-mm x 15-m PBDE column. Sample extracts were also analyzed for hexabromocyclododecane (HBCD) on the Restek 1614 column. Analyte concentrations are expressed as µg/kg on a weight wet basis. Reporting limits for PCBs, OCPs, and PBDEs are summarized in table 6.

Quality Assurance/Quality Control

Concentrations of contaminants in bed sediments and tissues were validated against a comprehensive set of performance-based quality assurance/quality control (QA/QC) criteria, including laboratory blanks, replicate samples (field), standard reference materials (SRMs), and surrogate recovery. All environmental and QA/QC data were reviewed by laboratory chemists and project staff prior to data release.

For bed sediment, the QA/QC data available included the results of analyses of laboratory blanks, concurrent field replicates, SRM 1941b (Organics in Marine Sediment), and SRM 1944 (NJ/NY Waterway Sediment) with the batch of environmental samples. Recovery surrogates, including dibromoocatafluorobiphenyl (DBOFB), Ronnel, PCB 198, 6-F-PBDE47, d_8-napthalene, d_{10}-acenapthene, d_{12}-benzo[a] pyrene, d_{12}-pyrene, and 5-α-androstane, were added to each sediment sample prior to extraction. Surrogate recoveries were considered acceptable if they fell within the range established by EPA for soils and sediments (EPA, 2008).

For the tissue samples, QA/QC data available included the results of analyses of laboratory blanks, field replicates (mussels only), and SRM 1946 (Lake Superior Fish Tissue). Recovery surrogates DBOFB, Ronnel, PCB 198, and 6-F-PBDE 47 were added to each tissue sample prior to extraction, whereas 1,2,3-trichlorobenzene (TCB) and PCB 192 were added to the samples after extraction prior to HPLC lipid removal. Surrogate recoveries for tissue samples were considered acceptable if recoveries ranged from 65–130%. If compounds were detected in the laboratory blanks at greater than the RLs, the environmental samples were censored on the basis of the following criteria: if the environmental concentration was less than 3 times the blank value, then that value was changed to a non-detect and not reported; if the environmental concentration was greater than 3 times the blank value, then the reported concentration was coded with an "E"; and if the environmental concentration was greater than 10 times the blank value, then the actual concentration was reported without censoring.

Young of Year Bluefish Histopathology

Tissues collected for histopathology were trimmed into cassettes, dehydrated through a series of alcohols, routinely processed for light microscopy, and embedded into paraffin. Tissues were cut at 5 micrometers (µm), placed on glass slides, and stained with hematoxylin and eosin (H&E) (Luna, 1992). Slides were examined for any microscopic tissue abnormalities.

Mussel Shell Chronology

Mussel shells were measured from the umbo through the longest axis of the mussel using digital calipers and were embedded in EpoThin epoxy resin (Buehler, Lake Bluff, Illinois). Embedded shells were sectioned through the umbo, again through the longest axis, using an Allied TechCut4 diamond blade saw (Allied, Rancho Dominguez, California). *Mytilus edulis* (blue mussel) sections were mounted to standard microscope slides, and *Geukensia demissa* (ribbed mussel) shells were mounted on either standard slides or custom 12- x 4-cm glass slides using Devcon 2-ton epoxy (Devcon, Solon, Ohio). Once mounted, shells were sectioned again to a thickness of approximately 0.25 mm. Mounted sections were sanded using a graded sandpaper (320 grit, 600 grit, 800 grit) and polished with 1-µm polycrystalline diamond suspension (Allied, Rancho Dominguez, Calif.), followed by a 0.04-µm colloidal silica suspension (Allied, Rancho Dominguez, Calif.). Slides were stained in Mutvei's solution (1% acetic acid 25% gluteraldehyde mixed with alcian blue) for 50 min at 37 ºC. Annuli were enumerated by teams of at least three people until consensus was reached using a dissecting microscope at 65x. Digital photographs were taken of each slide and annotated.

Results

The results of the chemical contaminant analyses of bed sediment, bluefish, and mussels, as well as bluefish histology and mussel chronology are described in this section.

Polychlorinated Biphenyl Congeners in Bed Sediment

Thirty-three individual PCB congeners were analyzed in 12 bed-sediment samples from 10 sites by the NOAA Fisheries Sandy Hook Laboratory. Twenty-eight PCB congeners were detected in the sediment samples collected during the study with concentrations ranging from 0.07 to 12.1 µg/kg dry weight and a median concentration of 0.7 µg/kg dry weight (table 7). The co-eluting congeners PCB 153 and 132 were detected most frequently and in 83% of the samples collected. The concentration of total PCBs (sum of all congeners detected) ranged from 0.07 to 130 µg/kg dry weight with a median of 1.4 µg/kg dry weight. Sediment collected from NOAA1 (Navesink River, N.J.) had the greatest number of PCBs detected (28) at some of the highest concentrations.

Polybrominated Diphenyl Ether Congeners in Bed Sediment

Twenty-seven individual PBDE congeners were analyzed in 12 bed-sediment samples from 10 sites by the NOAA Fisheries Sandy Hook Laboratory. Five PBDE congeners and HBCD were detected in sediment samples collected during the study with concentrations ranging from 0.36 to 24.7 µg/kg dry weight and a median concentration of 1.7 µg/kg dry weight (table 8). PBDE 47 was detected most frequently and in 92% of the samples collected. The concentration of total PBDEs (sum of all congeners detected without HBCD) ranged from 0.79 to 25.9 µg/kg dry weight with a median of 3.4 µg/kg dry weight.

Organochlorine Pesticides in Bed Sediment

Twenty-six OCP compounds were analyzed in 12 bed-sediment samples from 10 sites by the NOAA Fisheries Sandy Hook Laboratory. Sixteen OCPs were detected in sediment samples collected during the study with concentrations ranging from 0.2 to 35.5 µg/kg dry weight and a median concentration of 4.5 µg/kg dry weight (table 8). *p,p'*-DDE, the primary degradate of DDT, was detected most frequently and in 67% of the samples collected. The concentration of total OCPs (sum of all compounds detected) ranged from 0.8 to 120 µg/kg dry weight with a median of 20.1 µg /kg dry weight. The greatest number of OCPs were detected in sediment collected from NOAA1 (Navesink River, N.J.) and NOAA4 (Toms River, N.J.).

Polycyclic Aromatic Hydrocarbons in Bed Sediment

Fifty-three PAH and alkylated PAH compounds were analyzed in 12 bed-sediment samples from 10 sites by the NOAA Fisheries Sandy Hook Laboratory. Of the 34 PAHs measured, 33 were detected in sediment samples collected during the study with concentrations ranging from 0.7 to 2,290 µg/kg dry weight and a median concentration of 16.7 µg/kg dry weight (table 9). Thirteen PAHs were detected in all samples collected, including benz[a]anthracene, benzo[a]pyrene, benzo[b]fluoranthene, benzo[e]pyrene, benzo[ghi]perylene, benzo[j]fluoranthene, benzo[k]fluoranthene, biphenyl, chrysene, fluoranthene, indeno[123-cd]pyrene, perylene, and pyrene. The concentration of total PAHs ranged from 76.4 to 13,300 µg/kg dry weight with a median of 437 µg/kg dry weight. Of the 19 alkylated PAHs measured, 17 were detected in sediment samples collected during the study with concentrations ranging from 0.63 to 164 µg/g dry weight and a median of 7.8 µg/kg dry weight. 2-methylnapthalene was the only alkylated PAH that was detected in 100% of the sediment samples collected. The concentration of total alkylated PAHs ranged from 3.9 to 747 µg/kg dry weight with a median of 33.6 µg/kg dry weight (table 9). The greatest number of PAHs and alkylated PAHs were detected in sediment from NOAA1 (Navesink River, N.J.), NOAA3 (Metedeconk River, N.J.) and NOAA4 (Toms River, N.J.).

Aliphatic Hydrocarbon and Petroleum Biomarkers in Bed Sediment

Thirty-three AHs and 10 petroleum biomarkers were analyzed in 12 bed-sediment samples from 10 sites by the NOAA Fisheries Sandy Hook Laboratory. All 33 AHs were detected in sediment collected during the study, and concentrations ranged from 3.4 to 60,300 µg/kg dry weight with a median concentration of 93.0 µg/kg dry weight (table 10). Sixteen AHs were detected in 100% of the samples collected and included many of the mid- to long-chain AHs measured (C18–C34). Total AH concentrations in sediment ranged from 520 to 122,000 µg/kg dry weight with a median of 5,450 µg/kg dry weight. The highest observed AH concentration was measured in sediment collected from NOAA4 (Toms River, N.J.).

All 10 petroleum biomarkers were detected in sediment collected during the study with concentrations ranging from 0.5 to 673 µg/kg dry weight and a median of 13 µg/kg dry weight (table 11). The total concentration of petroleum biomarkers in the sediment ranged from 16.7 to 2,660 µg/kg dry weight with a median concentration of 151 µg/kg dry weight. Concentrations of petroleum biomarkers were the highest in sediment collected from NOAA1 (Navesink River, N.J.), NOAA3 (Metedeconk River, N.J.) and NOAA4 (Toms River, N.J.).

Polychlorinated Biphenyl Congeners in Tissue

Thirty-three individual PCB congeners in 131 individual YOY bluefish samples collected from 9 sites in 4 bays were analyzed at NOAA Fisheries Sandy Hook Laboratory. All 33 PCB congeners were detected in at least one of the bluefish samples with concentrations ranging from 0.01 to 322 µg/kg wet weight (table 12) and a median concentration of 1.3 µg/kg wet weight. Thirteen PCBs were detected in greater than 90% of the samples, including PCB 49, 52, 66, 95, 99, 101, 110, 118, 138, 149, 153+132, 180, and 187. Concentrations of the co-eluting congeners PCB 153 and 132 were highest in YOY bluefish from all sites; the median was 9.5 µg/kg wet weight. The concentration of total PCBs (sum of all congeners detected) ranged from 8.1 to 1,700 µg/kg wet weight with a median of 53.2 µg/kg wet weight. The highest median concentrations of total PCBs, by bay, were observed in Jamaica Bay, N.Y. (80.4 µg/kg), followed by Sandy Hook Bay, N.J. (62.5 µg/kg), Great South Bay, N.Y. (35.9 µg/kg), and Barnegat Bay, N.J. (33.3 µg/kg).

Thirty-three individual PCB congeners in 16 composite mussel samples collected from 11 sites were analyzed at NOAA Fisheries Sandy Hook Laboratory. Twenty-three PCB congeners were detected in at least one of the samples collected during the study with concentrations ranging

from 0.35 to 18.3 µg/kg dry weight (table 13) and a median concentration of 3.8 µg/kg dry weight. The co-eluting congeners PCB 153 and 132 were detected in 100% of the mussels collected and at the highest median concentration (12.4 µg/kg dry weight) compared to the other PCB congeners. PCB 101 and 138 were the only other congeners detected in greater than 90% of the samples. Other frequently detected congeners included PCB 99, 110, and 118, which were all detected in greater than 80% of the samples collected. Composite mussel samples collected from Raritan Bay (HRRB) and Fire Island (LIFI) had the greatest number of congeners detected (20) at some of the highest concentrations, whereas samples collected from Atlantic City (AIAC) and Barnegat Light (BIBL) had the fewest number of congeners detected (3 and 2, respectively) at some of the lowest concentrations (table 14). The concentration of total PCBs (sum of all congeners measured) ranged from 7.1 to 122 µg/kg dry weight with a median of 71.7 µg/kg dry weight.

Polybrominated Diphenyl Ether Congeners in Tissue

Twenty-seven individual PBDE congeners in 131 individual YOY bluefish samples collected from 9 sites in 4 bays were analyzed at the NOAA Fisheries Sandy Hook Laboratory. Twenty-one PBDE congeners and HBCD were detected in bluefish samples collected during the study with concentrations ranging from 0.01 to 731 µg/kg wet weight (table 14) and a median concentration of 0.64 µg/kg wet weight. PBDE 47 and 100 were detected most frequently and in 77% and 72% of the samples collected, respectively. HBCD was detected infrequently (5% of the samples), but when it was detected concentrations were high and ranged from 6.3 to 731 µg/kg wet weight (table 14). The concentration of total PBDEs (sum of all congeners detected) ranged from 0.01 to 741 µg/kg wet weight with a median of 14.5 µg/kg wet weight. The highest median concentrations of total PBDEs, by bay, were in YOY bluefish samples from Sandy Hook, N.J. (21.0 µg/kg), followed by Jamaica Bay, N.Y. (15.0 µg/kg), Great South Bay, N.Y. (13.3 µg/kg), and Barnegat Bay, N.J. (10.2 µg/kg).

Twenty-seven individual PBDE congeners in 16 composite mussel samples collected from 11 sites were analyzed at NOAA Fisheries Sandy Hook Laboratory. Nine PBDE congeners were detected in at least one of the composite samples collected during the study with concentrations ranging from 0.06 to 174 µg/kg dry weight (table 15) and a median of 3.5 µg/kg dry weight. PBDE 47, 99, and 100 were detected in 100% of the samples, and PBDE 47 and 99 were detected at the highest median concentrations (59.4 and 40.7 µg/kg dry weight, respectively). The number of PBDEs detected depended on the site and ranged from 4 in Barnegat Bay, N.J. (AIAC and BIBL), to 9 in Jamaica Bay, N.Y. (HRJB), and Moriches Bay, N.Y. (MBTH). The highest median concentrations were observed in mussels collected from Raritan Bay, N.J. (HRRB), and Fire Island Inlet, N.Y. (LIFI). The concentrations of total PBDEs (sum of all congeners detected) ranged from 14.6 to 336 µg/kg dry weight with a median of 120 µg/kg dry weight.

Organochlorine Pesticides in Tissue

Twenty-six OCP compounds were analyzed in 131 individual YOY bluefish samples collected from 9 sites in 4 bays by the NOAA Fisheries Sandy Hook Laboratory. Twenty-five OCPs were detected in bluefish samples collected during the study with concentrations ranging from 0.01 to 207 µg/kg wet weight (table 16) and a median concentration of 1.7 µg/kg wet weight. Five compounds were detected in greater than 90% of the samples—lindane, a-chlordane, trans-nonachlor, *p,p'*-DDD, and *p,p'*-DDE. *p,p'*-DDE was not only detected in 99% of the samples but was detected at the highest median concentration (9.9 µg/kg wet weight) compared to the other OCPs. The concentrations of total DDTs (sum of *o,p'*-DDT, *p,p'*-DDT, *o,p'*-DDE, *p,p'*-DDE, *o,p'*-DDD, *p,p'*-DDD and its degradates detected) ranged from 1.7 to 323 µg/kg wet weight with a median of 13.8 µg/kg wet weight. Total DDTs were similar between bays but were highest in Jamaica Bay, N.Y. (15.4 µg/kg), followed by Sandy Hook Bay, N.J. (14.2 µg/kg), Great South Bay, N.Y. (13.4 µg/kg), and Barnegat Bay, N.J. (12.2 µg/kg). The concentrations of total OCPs (sum of all compounds measured) ranged from 0.01 to 523 µg/kg wet weight with a median of 32.5 µg /kg wet weight. The highest median concentrations of total OCPs by bay were in YOY bluefish from Sandy Hook Bay, N.J. (47.2 µg/kg), followed by Barnegat Bay, N.J. (34.3 µg/kg), Jamaica Bay, N.Y. (28.9 µg/kg), and Great South Bay, N.Y. (24.8 µg/kg).

Twenty-six OCP compounds in 16 composite mussel samples collected from 11 sites were analyzed at NOAA Fisheries Sandy Hook Laboratory. Twenty OCPs were detected in at least one of the composite samples collected during the study with concentrations ranging from 0.35 to 102 µg/kg dry weight (table 17) and a median of 4.7 µg/kg dry weight. Three compounds were detected in greater than 90% of the samples—lindane (94%), *p,p'*-DDD (100%), and *p,p'*-DDE (100%). Endosulfan sulfate and oxychlordane were detected infrequently but had some of the highest median concentrations. The number of OCPs detected depended on the site and ranged from 2 in Barnegat Bay, N.J. (BIBL), to 14 in Raritan Bay, N.J. (HRRB). The concentrations of total DDTs (sum of *o,p'*-DDT, *p,p'*-DDT, *o,p'*-DDE, *p,p'*-DDE, *o,p'*-DDD, *p,p'*-DDD and its degradates detected) ranged from 4.6 to 70.7 µg/kg dry weight with a median of 29.8 µg /kg dry weight. The highest median concentrations were observed in mussels collected from Fire Island Inlet, N.Y. (LIFI) and Shark River, N.J. (NYSR). The concentrations of total OCPs (sum of all compounds detected) ranged from 4.8 to 190 µg/kg dry weight with a median of 18.3 µg/kg dry weight.

Quality Assurance/Quality Control

No PCBs, PBDEs or petroleum biomarkers were detected at greater than the RL in the laboratory blank analyzed with the respective environmental bed-sediment samples. One OCP, 7 PAHs, and 21 AHs were detected at greater than the RL in the laboratory blank analyzed with the respective environmental samples.

Recovery surrogates were added to each sample to measure method performance. For PCBs and OCPs, mean recoveries with standard deviations of DBOFB, Ronnel, and PCB 198 used as recovery surrogates were 79 ± 22%, 67 ± 13%, and 112 ± 13%, respectively. For PBDEs, mean recovery with standard deviation of 6-F-PBDE47 used as a recovery surrogate was 80 ± 23%. For PAHs mean recoveries with standard deviations of d_8-napthalene, d_{10}-acenapthene, d_{12}-benzo[a] pyrene, and d_{12}-pyrene used as recovery surrogates were 26 ± 8%, 38 ± 8%, 73 ± 6%, and 53 ± 16%, respectively. For AHs and petroleum biomarkers, mean recovery with standard deviation of 5-α-androstane used as a recovery surrogate was 76 ± 7%.

Two field replicates (NOAA2 and NOAA3) were analyzed to assess the variability of the field collection and laboratory analysis. The analysis of the two field replicates yielded a total of 114 paired concentration comparisons (detections in both samples) and 32 unpaired comparisons (detections in one of the two samples). A breakdown by compound class is as follows: PCBs included 14 paired and 3 unpaired comparisons, PBDEs included 1 paired and 1 unpaired comparison with all reported detections near the RL, OCPs included 10 paired and 4 unpaired comparisons, PAHs included 47 paired and 6 unpaired comparisons, AHs included 48 paired and 7 unpaired, and petroleum biomarkers included 11 paired and 4 unpaired comparisons. The median relative percent differences (RPDs) for the field replicates for PCBs, PBDEs, OCPs, PAHs, AHs, and petroleum biomarkers were 51%, 48%, 98%, 33%, 64%, and 73%, respectively with greater than 89% of the replicates from all compound classes having a RPD less than 100%.

Concentrations of semi-volatile organic compounds in SRM 1941b and SRM 1944 are reported in table 18. The percent recoveries based on NIST certified values for PCBs, OCPs, PAHs, and petroleum biomarkers in SRM 1941b ranged from 65 to 126 % with a median of 100%, from 97 to 128% with a median of 100%, from 24 to 128% with a median of 75%, and from 70 to 123% with a median of 86%, respectively. The percent recoveries based on NIST certified values for PCBs, OCPs, and PAHs in SRM 1944 ranged from 69 to 130% with a median of 101%, from 86 to 130% with a median of 120%, and from 28 to 129% with a median of 92%, respectively. All reported PCB, OCP, and petroleum biomarker concentrations fell into the acceptable concentration range, based on the 95% confidence intervals of the true value. In SRM 1941b, 10 compounds (4 PCBs and 6 OCPs) had NIST certified values that were at or below the laboratory RLs and were not detected. Six of the PAHs measured fell outside the acceptable concentration range, based on the 95% confidence interval of the true value. The standard reference material used did not contain PBDEs or AHs. Values were considered estimates and coded "E" if they were less than the RL or were qualified owing to blank contamination. All other data were considered to be of acceptable quality on the basis of the QA/QC results.

Seven laboratory blanks were analyzed with the bluefish samples. No PCBs or OCPs were detected in the laboratory blanks at concentrations greater than the RLs when analyzed with the respective environmental samples. PBDE 47 was detected in 5 of the 7 blanks at greater than the RL. PBDE 49+71 and 99 were detected in 4 of the 7 blanks at greater than the RLs, and PBDE 100 was detected in 1 of the 7 blanks at greater than the RL. One laboratory blank was analyzed with the batch of mussel samples. No PCBs or OCPs were detected in the laboratory blank at greater than the RLs. Two PBDEs, PBDE 49+71 and 99, were detected in the laboratory blank at greater than the RLs.

Recovery surrogates were added to each sample to measure method performance. For PCBs and OCPs in bluefish samples, mean recoveries with standard deviations of 1,2,3-TCB, DBOFB, Ronnel, PCB 192, and PCB 198 used as recovery surrogates were 85 ± 31%, 70 ± 17%, 71 ± 25%, 95 ± 17%, and 89 ± 19%, respectively. For PBDEs, mean recovery with standard deviation of 6-F-PBDE 47 used as a recovery surrogate was 100 ± 34%. For PCBs and OCPs in mussel samples, mean recoveries with standard deviations of 1,2,3-TCB, DBOFB, Ronnel, PCB 192, and PCB 198 used as recovery surrogates were 97 ± 25%, 70 ± 11%, 35 ± 22%, 117 ± 20%, and 90 ± 11%, respectively. For PBDEs, mean recovery with standard deviation of 6-F-PBDE 47 used as a recovery surrogate was 101 ± 18%.

Twelve to 15 individual bluefish were collected per site and analyzed; therefore, no field or laboratory replicates were collected or analyzed. Five field replicates were analyzed with the composite mussel samples to assess the variability of the field collection and laboratory analysis. The analysis of the five field replicates yielded a total of 138 paired concentration comparisons (detections in both samples) and 33 unpaired comparisons (detections in one of the two samples). A breakdown by compound class is as follows: PCBs included 66 paired and 15 unpaired comparisons, PBDEs included 28 paired and 7 unpaired comparisons with all reported detections near the RL, and OCPs included 41 paired and 15 unpaired comparisons. The median RPDs for the field replicates for PCBs, PBDEs, and OCPs were 16%, 39%, and 19%, respectively, with greater than 90% of the replicates from all compound classes having differences less than 80%.

Concentrations of semi-volatile organic compounds in SRM 1946 analyzed with the six bluefish batches are reported in table 19. The percent recoveries, based on NIST certified values for PCBs and OCPs in SRM 1946, ranged from 68 to

121 % with a median of 95% and from 45 to 121% with a median of 95%, respectively. All reported PCB and OCP concentrations at greater than the RLs were acceptable on the basis of the 95% confidence intervals of the true value. In SRM 1946, seven compounds (6 PCBs and 1 OCP) had NIST certified values that were at or less than the laboratory RLs (less than 1.5 µg/kg) and were either not detected or were detected at extremely low concentrations. An additional 9 PCBs and 3 OCPs with NIST-certified values at greater than the RLs, ranging from 2 to 11.4 µg/kg, were not detected in 3 or more of the 6 SRM laboratory batches. Most of these compounds in the environmental samples were already estimated on the basis of the RLs. The standard reference material used for the tissue analysis did not include PBDE congeners. Values were considered estimates and coded "E" if they were less than the RLs or were qualified owing to blank contamination. All other environmental data were considered of acceptable quality on the basis of the QA/QC results.

Young of Year Bluefish Health Assessments

A fish health assessment was conducted on 20 individual YOY bluefish from each bay. The sex ratio varied from site to site (table 20). Mean total length varied by bay; however, only bluefish from Sandy Hook Bay were significantly shorter than those from the other bays. The most common abnormality observed visually was the presence of an ectoparasitic gill isopod (*Livoneca redmanii*). These parasites attach to the gills under the operculum (fig. 4), causing localized erosion of gill lamellae.

The prevalence of the gill isopod infestation ranged from a low of 20% in Great South Bay to a high of 35% in Jamaica Bay (table 20). This parasite has previously been identified on juvenile bluefish and fish infected with a single parasite (Landau and others, 1995; Marks and others, 1996), which was also the case in the study area, but bluefish were not considered seriously affected. Previous studies have reported a prevalence of 7–16% in Great South Bay and 10% in Sandy Hook Bay (Marks and others, 1996), considerably less than those observed in this study (20% in Great South Bay and 30% in Sandy Hook Bay).

Microscopic examination of the gills demonstrated localized areas of erosion and fusion of secondary lamellae owing to the presence of the isopod. Otherwise, gill lesions were minor. The presence of the protozoan parasite *Trichodina* sp. (fig.5*A*) was common and appeared to be commensal with no gill damage. Epitheliocystis, a rickettsial-like organism (fig. 5*B*), was also noted but did not appear to cause any significant adverse effects.

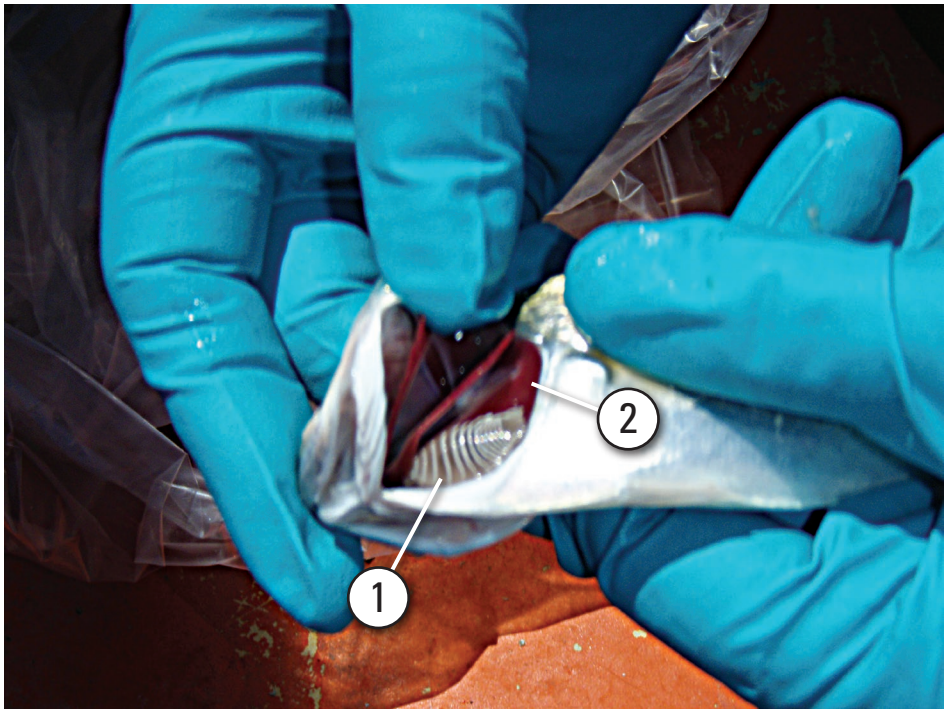


Figure 4. Parasitic isopod, *Livoneca redmanii,* (1) observed attached to the gill filaments (2) of a bluefish when the operculum is lifted.

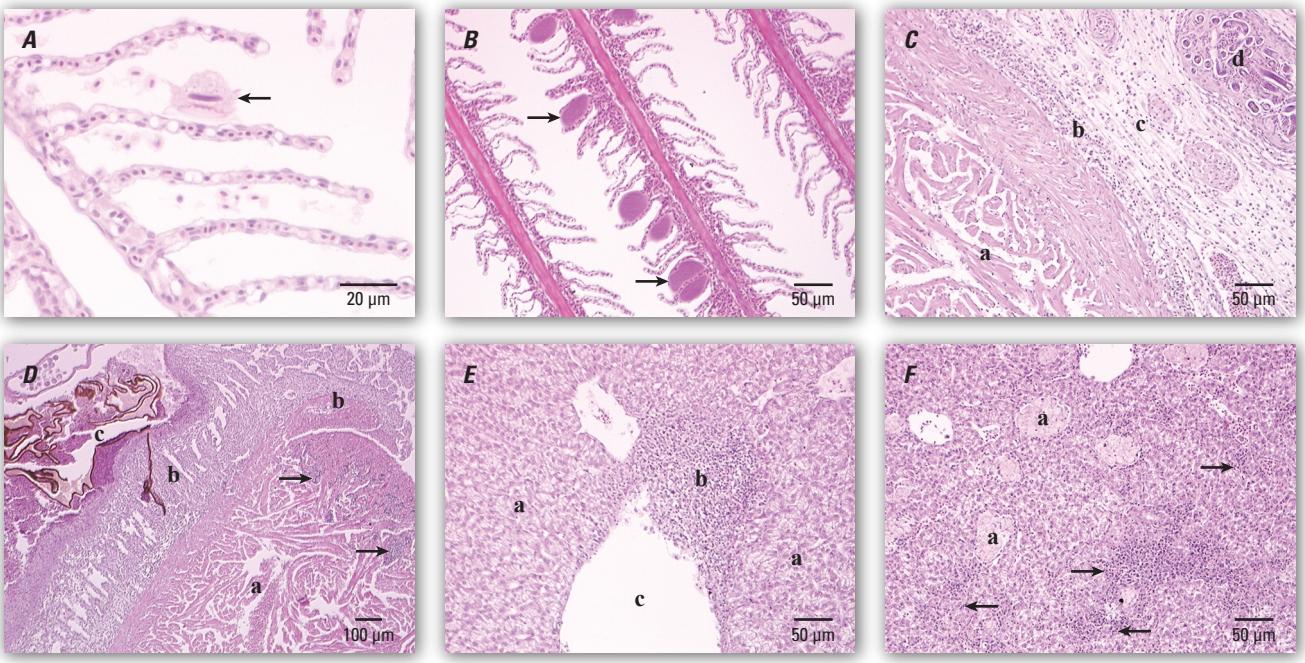


Figure 5. Microscopic pathology observed in young of year bluefish. *A*, Section of a gill filament illustrating a protozoan parasite, *Trichodina* sp. (arrow), on the lamellae. *B*, Hyperplasia of individual epithelial cells (arrows) containing a rickettsial-like organism *Epitheliocystis* sp. *C*, Section of the heart ventricle (a) with extensive inflammation of the epicardium (b) and within the pericardial sac (c) caused by the presence of immature nematodes (d). *D*, Section of heart ventricle (a) with chronic inflammation and fibrosis (b) of the endocardium and pericardium associated with the presence of adult nematodes (c). Inflammation was also noted within the heart muscle (arrows). *E*, Section of liver tissue (a) with inflammation (b) associated with blood vessels (c). *F*, Section of liver with diffuse areas of inflammation (arrows) and focal accumulations of lipofuscin/ceroid (a). (µm, micrometer)

Other visible lesions, including parasites and discolored areas, were observed in the heart (figure 5*C* and 5*D*). Most of these lesions were related to the presence of a nematode parasite, although in many cases endocardial inflammation was noted with no parasites present in the section. Previous studies have identified *Philometra saltatrix* as a parasite that infects ovaries of adult bluefish and the pericardial cavity of juveniles (Clarke and others, 2006; Koske and Juanes 2012). The presence of the nematode caused significant damage to the pericardial sac, and in some cases, lesions were noted in the heart itself. Fibrosis, focal granulomatous inflammation, around parasites and diffuse inflammation were observed in the pericardial sac, sometimes leading to adhesions between the heart surface (epicardium) and pericardium (fig. 5*C*). In a few instances, inflammation was noted in the myocardium (fig. 5*D*). Koske and Juanes (2012) speculate that heart infections of young bluefish by *P. saltatrix* are an important source of juvenile mortality in the Hudson River estuary, N.Y.

Although *P. saltatrix* has recently been redescribed and appears to be specific to bluefish (Moravec and others, 2008), the life cycle has not been definitively demonstrated. Clarke and others (2006) speculate that nematode larvae within the ovaries are released into the water during spawning. They pass through a copepod intermediate host and perhaps a second intermediate host and then infect YOY bluefish. The worms reside in non-ovarian sites, such as the heart, until the fish reach sexual maturity, at which time they migrate to the ovary to complete the life cycle. However, a number of young bluefish in the current study had severe inflammation within the immature ovaries, and parasites were observed within the ovarian tissue.

Microscopic lesions were also noted in the liver. In some fish, focal areas of inflammation were observed, most commonly around or adjacent to blood vessels (fig. 5*E*). A few fish had severe diffuse inflammation together with accumulations of lipofusin/ceroid (fig. 5*F*). No parasites or infectious agents were observed within liver tissues.

Mussel Shell Chronology

Mytilus edulis (blue mussel) and *Geukensia demissa* (ribbed mussel) shells were thin-sectioned (fig. 6) and aged. Mussel size and age varied by species and collection site (table 21). Blue mussels were generally smaller (range 23.2 to 63.0 mm) than ribbed mussels (range 28.9 to 86.3 mm). Age ranges were similar with blue mussels, ranging from 4 to 13 years and ribbed mussels from 3 to 12 years, indicating that ribbed mussels have higher growth rates than blue mussels. No relation was observed between latitude and blue mussel length (r^2=0.25, p=0.10) or age (r^2=0.32, p=0.07), likely because of the narrow spatial scale of this study. Relations could not be assessed for ribbed mussels because of low sample size (3 sampling sites).

Summary

This study was designed to provide information on the potential environmental health impacts associated with human and ecological exposures to storm-derived contaminants in areas affected by Hurricane Sandy throughout coastal New Jersey and New York. Young of year *Pomatomus saltatrix* (bluefish) were collected from Barnegat Bay, N.J., Sandy Hook Bay, N.J., Jamaica Bay, N.Y., and Great South Bay, N.Y. and analyzed for indicators of health and chemical contamination. These species were selected because they are residents of the impacted bays during their critical high-growth early developmental phase, have associated historical chemical data, and are valuable aquatic resources. At each bluefish sampling site, bed sediment was also collected as a habitat indicator and analyzed for a suite of contaminants.

In bed-sediment samples, 28 polychlorinated biphenyl (PCB) congeners, 5 polybrominated diphenyl ether (PBDE) congeners and hexabromocyclododecane (HBCD), 16 organochlorine pesticides (OCPs), 33 polycyclic aromatic hydrocarbons (PAHs), 33 aliphatic hydrocarbons (AHs), and 10 petroleum biomarkers (steranes and hopanes) were detected. Sediment collected from the Navesink River (Sandy Hook, N.J.), Metedeconk River (Barnegat Bay, N.J.), and Toms River (Barnegat Bay, N.J.) had the highest concentrations of measured contaminants compared to the other sites.

All 33 PCB congeners were detected in at least one of the 131 individual bluefish samples analyzed, and the highest median concentrations of total PCBs were present in bluefish from Jamaica Bay, N.Y. Twenty-one PBDE congeners and

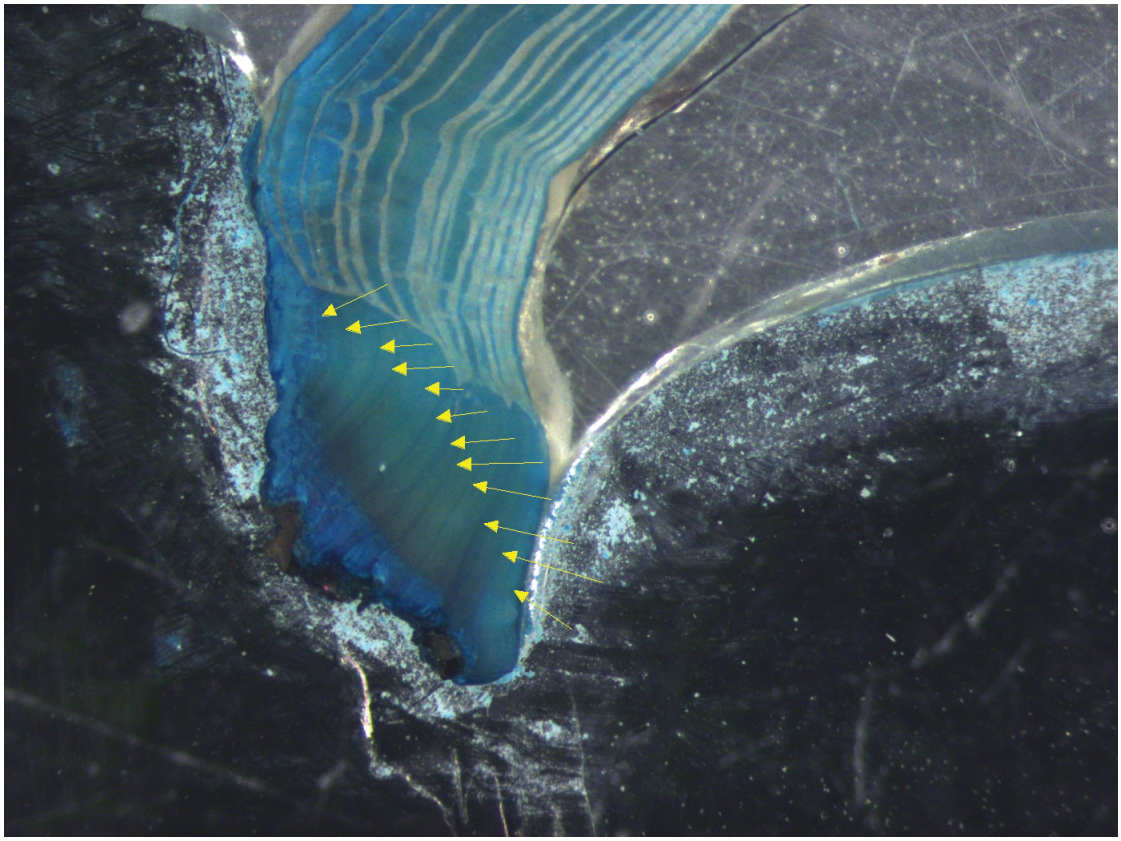


Figure 6. Annotated photograph showing the annuli in the umbo of a *Geukensia demissa* (ribbed mussel) from site HRJB in Jamaica Bay, New York. Each annuli indicates one year of age (this mussel is 12 years old).

HBCD were detected, and congeners 47 and 100 were present most frequently. The highest median concentrations of total PBDEs, by bay, were present in bluefish from Sandy Hook Bay, followed by Jamaica Bay, Great South Bay, and Barnegat Bay. Twenty-five OCPs were detected in the bluefish, and *p,p'*-DDE was detected in 99 percent (%) of the samples and at the highest median concentrations compared to the other OCPs. The highest median concentrations of total OCPs, by bay, were observed in Sandy Hook Bay, N.J., followed by Barnegat Bay, N.J., Jamaica Bay, N.Y., and Great South Bay, N.Y.

Fish health assessments were conducted on 20 fish from the 4 bays. Results indicate that the sex ratio and the mean total length varied by site. The most common abnormality observed visually was the presence of *Lironeca ovalis* (an ectoparasitic gill isopod) that can cause localized gill erosion. The prevalence of the gill isopod infestation ranged from 20% in Great South Bay, N.Y., to 35% in Jamaica Bay, N.Y. Other visible lesions were observed in the heart (parasites and discolored areas). Microscopically, these lesions were related to the presence of a nematode parasite. Microscopic lesions were also noted in the liver and ovaries.

Resident *Mytilus edulis* (blue mussel) and (or) *Geukensia demissa* (ribbed mussel) were collected from historic NOAA Mussel Watch Program sites along the New Jersey and New York coastlines in the winter/spring of 2014 and analyzed for contaminants. Individual age of a subset of the mussels sampled was determined for each site. Mussels were chosen as representative species for this study because more than 20 years of historical data are available, contaminant levels in their tissues respond to changes in ambient environmental levels, and contaminant accumulation occurs with very little metabolic transformation.

In the composite mussel samples, 23 PCB congeners were detected in at least one of the samples, and the co-eluting congeners PCB 153 and 132 were detected at all 11 sites. Mussels from Raritan Bay, N.Y. (HRRB), and Fire Island, N.Y. (LIFI), had the greatest number of congeners detected at some of the highest concentrations, whereas mussels from Atlantic City, N.J. (AIAC), and Barnegat Light, N.J. (BIBL), had the fewest number of congeners detected at some of the lowest concentrations. Nine PBDE congeners were detected in at least one of the composite mussel samples, and PBDE congeners 47, 99, and 100 were detected in mussel samples from all sites. The highest median concentrations were observed in mussels collected from Raritan Bay, N.Y. (HRRB), and Fire Island Inlet, N.Y. (LIFI). Twenty OCPs were detected in at least one of the composite mussel samples, and similar to the bluefish, *p,p'*-DDE was detected in mussels from all sites. The highest median concentrations of OCPs were observed in mussels collected from Fire Island Inlet, N.Y. (LIFI), and Shark River, N.J. (NYSR). *Mytilus edulis* (blue mussels) and *Geukensia demissa* (ribbed mussels) were thin-sectioned and aged. The age range of the blue mussels was 4 to 13 years, with average age ranging from 5 to 8 years. The age range of the ribbed mussels was similar, 3 to 12 years, with an average age of 4–7 years.

References Cited

Able, K.W., Rowe, P., Burlas, M., and Byrne, D., 2003, Use of ocean and estuarine habitats by young-of year bluefish (*Pomatomus saltatrix*) in the New York Bight: Fisheries Bulletin (US), v. 101, no. 2, p. 201–214.

Buxton, H.T., Andersen, M.E., Focazio, M.J., Haines, J.W., Hainly, R.A., Hippe, D.J., and Sugarbaker, L.J., 2013, Meeting the science needs of the Nation in the wake of Hurricane Sandy—A U.S. Geological Survey science plan for support of restoration and recovery: U.S. Geological Survey Circular 1390, 26 p. [Also available at http://pubs.usgs.gov/circ/1390/]

Clarke, L.M., Dove, A.D.M., and Conover, D.O., 2006, Prevalence, intensity, and effect of a nematode (*Philometra saltratrix*) in the ovaries of bluefish (*Pomatomus saltratrix*): Fisheries Bulletin, v. 104, p. 118–124.

Deshpande, A.D., Draxler, A.F.J., Zdanowicz, V.S., Schrock, M.E., Paulson, A.J., Finneran, T.W., Sharack, B.L., Corbo, K., Arlen, L., Leimburg, E., Dockum, B.W., Pikanowski, R.A., May, B., and Rosman, L., 2000, Contaminant levels in muscle of four species of recreational fish from the New York Bight apex: National Oceanic and Atmospheric Administration Technical Memo NMFS-NE-157, 99 p.

Deshpande, A.D., and Dockum, B.W, 2013, Polybrominated diphenyl ether congeners in the young-of-the-year bluefish, *Pomatomus saltatrix*, from several nursery habitats along the US Atlantic coastline: Marine Pollution Bulletin, v. 77, p. 237–250.

Fischer, J.M., Phillips, P.J., Reilly, T.J., Focazio, M.J., Loftin, K.A., Benzel, W.M., Jones, D.K., Smalling, K.L., Fisher, S.C., Fisher, I.J., Iwanowicz, L.R., Romanok, K.M., Jenkins, D., Bowers, L., Boehlke, A., Foreman, W.T., Deetz, A.C., Carper, L.G., Imbrigiotta, T.E., and Birdwell, J., 2015, Estuarine bed-sediment-quality data collected in New Jersey and New York after Hurricane Sandy, 2013: U.S. Geological Survey Data Series 905, 42 p., plus CD-ROM. [Also available at http://dx.doi.org/10.3133/ds905]

Hladik, M.L., Orlando J.L., and Kuivila, K.M., 2009, Collection of pyrethroids in water and sediment matrices: development and validation of a standard operating procedure: U.S. Geological Survey Scientific Investigations Report 2009–5012, 22 p., accessed September 3, 2013 at http://pubs.usgs.gov/sir/2009/5012/.

Kimbrough, K.L., Johnson, W.E., Lauenstein, G.G., Christensen, J.D., and Apeti, D.A., 2008, An assessment of two decades of contaminant monitoring in the Nation's Coastal Zone: Silver Spring, Md., National Oceanic and Atmospheric Administration Technical Memorandum NOS NCCOS 74. 105 p.

Kimbrough, K.L., Johnson, W.E., Lauenstein, G.G., Christensen, J.D., and Apeti, D.A., 2009, An assessment of polybrominated diphenyl ethers (PBDEs) in sediments and bivalves of the U.S. Coastal Zone: Silver Spring, Md., National Oceanic and Atmospheric Administration Technical Memorandum NOS NCCOS 94, 87 p.

Koske, S.E., and Juanes, F., 2012, Prevalence and characterization of cardiac pathology induced by the parasitic nematode *Philometra saltatrix* in juvenile bluefish of the Hudson River estuary, New York, Section IV, *in* Yozzo, D.J., Fernald, S.H., Andreyko, H., eds., Final Reports of the 2011 Tibor T. Polgar Fellowship Program, Hudson River Foundation, p. 1–45.

Landau, M., Danko, M.J., and Slocum, C., 1995, The effect of the parasitic cymothoid isopod (*Lironeca ovalis*) (Say) on growth of young-of-year bluefish (*Pomatomus saltatrix*): Crustaceana, v. 68, p. 397–400.

Lauenstein, G.G., Harmon, M.M., and Gottholm, B., 1993, National Status and Trends Program: Monitoring site descriptions (1984–1990) for the National Mussel Watch and Benthic Surveillance Projects: Silver Spring, Md., National Oceanic and Atmospheric Administration Technical Memorandum NOS ORCA 70, 358 p.

Luna, L.G., 1992, Histopathologic methods and color atlas of special stains and tissue artifacts: Gaithersburg, Md., American HistoLabs.

Marks, R.E., Juanes, F., Hare, J.A., and Conover, D.O., 1996, Occurrence and effect of the parasitic isopod, *Lironeca ovalis* (Isopoda: Cymothoidae), on young-of-the-year bluefish, *Pomatomus saltatrix* (Pisces: Pomatomidae): Canadian Journal of Fisheries and Aquatic Sciences, v. 53, p. 2052–2057.

Mills, M.A., McDonald, T.J., Bonner, J.S., Simon, M.A., and R.L. Autenrieth, R.L., 1999, Method for quantifying the fate of petroleum in the environment: Chemosphere, v. 39, no. 14, p. 2563–2582.

Moravec, F., Magi, M., and Macchioni, F., 2008, Redescription of the gonad-infecting nematode *Philometra saltatrix* Ramachandran, 1973 (Philometridae) based on specimens from the type host *Pomatomus saltatrix* (L.) (Osteichthyes) from the Tuscan Sea, Italy: Folia Parasitologica, v. 55, p. 219–223.

Packer, D.B, ed., 2001, Assessment and characterization of salt marshes in the Arthur Kill (New York and New Jersey) replanted after a severe oil spill: National Oceanic and Atmospheric Administration Technical Memorandum NMFS-NE-167, 232 p.

Radtke, D.B., revised June 2005, Bottom-material samples: U.S. Geological Survey Techniques of Water-Resources Investigations, book 9, chapter A8: Bottom sample materials, accessed September 3, 2013, at http://pubs.water.usgs.gov/twri9A.

U.S. Environmental Protection Agency (EPA), 1998, Method 8270C, Semi-volatile organic compounds by gas chromatograph/mass spectrometry (GS/MS): U.S. Environmental Protection Agency, Washington, D.C., accessed June 13, 2014, at http://www.caslab.com/EPA-Methods/PDF/8270c.pdf.

U.S. Environmental Protection Agency (EPA), 2001, Methods for collection, storage and manipulation of sediments for chemical and toxicological analyses: Technical Manual, EPA 823-B-01-002, U.S. Environmental Protection Agency, Office of Water, Washington, D.C. [Also available at http://water.epa.gov/polwaste/sediments/cs/upload/collection-manual.pdf]

U.S. Environmental Protection Agency (EPA), 2008, National functional guidelines for Superfund organic methods data review: Washington, D.C., U.S. Environmental Protection Agency. Office of Superfund Remediation Technology Innovation, USEPA-540-R-08-01.

Sloan, C.A., Adams, N.G., Pearce, R.W., Brown, D.W., and Chan, S.L., 1993, Northwest Fisheries Science Center organic analytical procedures, *in* Lauenstein, G.G., Cantillo, A.Y., eds., Sampling and analytical methods of the National Status and Trends Program, National Benthic Surveillance and Mussel Watch Projects, 1984–1992, v. 4., Comprehensive descriptions of trace organic analytical methods: National Oceanic and Atmospheric Administration Technical Memorandum NOS ORCA 71, 182 p.

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., 2004, Extraction, cleanup and gas chromatographic/mass spectrometry analysis of sediments and tissues for organic contaminants: National Oceanic and Atmospheric Administration Technical Memorandum NMFS-NWFSC-59, 61 p.

Williams, S.D., 2006, Bioaccumulation patterns of organochlorines in young-of-the year bluefish (*Pomatomus saltatrix*) in the Hudson River Estuary: Tallahassee, Fla., Florida Agricultural and Mechanical University, Ph.D. Dissertation.

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Document prepared by the West Trenton Publishing Service Center

ISSN 2327-638X (online)
ISSN 2327-0271 (print)
http://dx.doi.org/10.3133/ds956.