

# State of the River 2003



THE Elizabeth River Project



# Criteria for Grading the River

	<b>Sediment Contamination (PAHs)</b>	<b>Bottom Community Health (B-IBI<sup>1</sup>)</b>	<b>Cancer in Mummichog Fish</b>	<b>Dissolved Oxygen (DO)<sup>2</sup></b>	<b>Dissolved Metals</b>	<b>Tributyltin (TBT)</b>
<b>Not a Problem</b>	No constituent exceeding TEC <sup>3</sup> or ERL <sup>4</sup>	Average > 2.9	Background liver lesion prevalence (Pre-cancerous AHF <sup>5</sup> < 5%; neoplasms <sup>6</sup> 0%)	< 5% of all values failing to meet respective criteria; D.O. levels generally provide good conditions for aquatic life.	< 5% of all values failing to meet chronic WQC <sup>7</sup> for any metal	Concentrations not detected at 1 ppb in any of the samples
<b>Borderline Problem</b>	1 constituent exceeding TEC or ERL	Average 2.7-2.9	AHF 5-20%; neoplasms 0%	> 5% of all values failing to meet respective criteria; D.O. levels might impact aquatic life at certain times.	> 5% of all values failing to meet chronic WQC for any metal	Concentrations at or > 1 ppb in some samples but average concentrations < 1 ppb
<b>Problem</b>	1 constituent exceeding PEC <sup>8</sup> or ERM <sup>9</sup> but below 2 times the PEC or 2 times the ERM	Average 2.1-2.6	AHF at moderate prevalence (20-30%); neoplasms at low prevalence (< 5%)	> 10% of all values failing to meet respective criteria; D.O. levels impacting aquatic life.	> 10% of all values failing to meet chronic WQC for any metal.	Average concentrations > 1 ppb
<b>Severe Problem</b>	1 constituent exceeding 2 PEC or 2 ERM	Average < 2.1	AHF at high prevalence (30%); neoplasms at high prevalence (> 5%).	> 20% of all values failing to meet respective criteria; D.O. levels can have substantial impact on aquatic life.	> 20% of all values failing to meet chronic WQC for any metal	Concentrations > 10 ppb, or multiple observations > 20 ppb

# State of the Elizabeth River 2003

	Main Stem	Lafayette River	Western Branch	Eastern Branch	Southern Branch
<b>Sediment Contamination (PAHs)</b>	Borderline Problem	Borderline Problem	Borderline Problem	Problem	Severe Problem
<b>Bottom Community Health (B-IBI)</b>	Problem	Problem	Severe Problem	Problem	Severe Problem
<b>Cancer in Mummichog Fish</b>	<i>Insufficient Data</i>	Not a Problem	Not a Problem	Problem	Severe Problem
<b>Dissolved Oxygen (DO)</b>	Borderline Problem	Not a Problem	Not a Problem	Problem	Severe Problem
<b>Dissolved Metals</b>	Not a Problem	Not a Problem	Not a Problem	Not a Problem	Not A Problem
<b>Tributyltin (TBT)</b>	Problem	Problem	Problem	Severe Problem	Severe Problem

<sup>1</sup> B-IBI: Benthic Index of Biological Integrity; combines several metrics describing benthic communities including: species diversity, abundance, biomass, and balance between pollution tolerant and pollution sensitive species and balances of different feeding types. Criteria for assigning scores are numeric (1-5) and dependent on habitat type.

<sup>2</sup> Dissolved Oxygen: All segments were assessed against proposed Chesapeake Bay criteria for open water habitat, deep water and deep channel habitat. There were no violations for the deepwater and deep channel habitat. Violation percentages shown are for open water habitat criteria. DO levels can vary greatly throughout the segments. Small creeks and coves may experience very low DO levels during certain times of year. The assessment is based on data from the monitored stations which are located near the main channel of the segments.

<sup>3</sup> TEC (Total Effects Concentration): Screening concentration representing the concentration below which adverse effects are expected to occur only rarely.

<sup>4</sup> ERL (Effects Range Low): Screening concentration representing the value at which toxicity may begin to be observed in sensitive species.

<sup>5</sup> AHF: Altered hepatocellular foci - small precancerous liver lesions definitively diagnosed by histopathological analysis.

<sup>6</sup> Neoplasm: larger cancerous liver lesions that may be benign (adenoma) or malignant (carcinoma) diagnosed by histopathological analysis.

<sup>7</sup> WQC: Chronic Water Quality Criteria from VA DEQ's proposed Water Quality Standards.

<sup>8</sup> PEC (Probable Effects Concentration): Screening concentration representing the level above which adverse effects are expected to occur frequently.

<sup>9</sup> ERM (Effects Range Median Concentration): Screening concentration representing the median concentration of the compilation of only samples labeled as toxic by the original investigators.

# Summary

## Milestone Study Confirms Cleaning Lizzy's Bottom

**S**tate of the River 2003, the most exhaustive study yet of Elizabeth River conditions, confirms long-term goals endorsed by community leaders: Focus priority action on cleaning the river bottom and improving the Southern Branch. Track the health of the "mummichog" minnow to judge progress.

- ♦ *The Southern Branch exhibited a severe problem* for five of six parameters studied for this report by the Virginia Department of Environmental Quality's Elizabeth River Monitoring Program.
- ♦ *An extremely high prevalence of cancer* was found in the mummichog fish at several locations along the Southern Branch.
- ♦ *The fish cancer is linked to contamination* of river mud with polycyclic aromatic hydrocarbons, or PAHs. Of 21 samples of Elizabeth River bottom sediments examined for this study, 81 percent showed "borderline" to "severe" problems with PAH contamination.

Public and private community leaders from virtually every river interest have endorsed the Elizabeth River Project goal, "Clean the river's most toxic sediments -- make the mummichog well again by 2020." A \$13 million project to achieve the first cleanup of Elizabeth River sediments, along with restoration of eight wetlands, enters final engineering and design by the US Army Corps of Engineers in 2003, co-sponsored by four cities, the state and federal government.

State of the River 2003 represents a milestone in the restoration of the Elizabeth River. The report achieves the most comprehensive baseline ever of data on water quality, sediment quality and living resources for our home river, gathered since 1997 by an Elizabeth River Monitoring Program of the Virginia Department of Environmental Quality. Technical advisors from across the community, sitting on The Elizabeth River Project's Monitoring Advisory Committee, provide guidance for the program, including summarizing monitoring findings for the public. The committee's initial report, State of the River 2000, announced the first findings. Since then, scientists have filled important gaps. The intent has been to set a sound foundation for tracking long-term river trends, a critical complement to the multi-million dollar river restoration currently underway by River Star industries and many other public and private partners.

**I**t also must be noted that a state budget crisis has jeopardized the goal of tracking long-term river trends, and the goal of cleaning the Elizabeth River bottom. At this writing, Virginia Governor Mark Warner has proposed cutting all state funding for the Elizabeth River Monitoring Program, as well as eliminating the state's share of the cost for the Corps of Engineers bottom clean up. The Elizabeth River Project is seeking relief from the General Assembly and assistance from other partners. This region has launched one of the great river restorations of our time. The momentum must continue.

## **N**ew data sets acquired since the 2000 report:

- ◆ The state added monitoring for tributyltin, or TBT, an extremely toxic antifoulant in marine paint. The study by the Virginia Institute of Marine Science found *TBT to be the most serious problem in the water column* of the Elizabeth River. All stations monitored throughout the river show TBT contamination. The Elizabeth River Project supports progress being made toward enforcement of an international ban on TBT in hull paints.
- ◆ The state also commissioned new studies to determine the impact of sediment contamination on life at the bottom of the river. The bottom life, or "benthos," is the foundation of the river ecosystem. Some 16 percent of all life on earth is found at the bottom of water bodies, and the Elizabeth River bottom must flourish for the rest of the river to recover. A study by Old Dominion University found the *highest levels of bottom life degradation in the Southern Branch, and the healthiest river bottom along the Mainstem.*

Other sampling allowed scientists to fill gaps and confirm early findings for additional parameters, including:

- ◆ *Dissolved oxygen, a leading indicator of a water body's ability to support healthy aquatic life, continued an improving trend* but nonetheless registered at "severe problem" levels in the Southern Branch.



**Cleaning Lizzy's Bottom Starts Here** - US Army Corps of Engineers is completing final engineering to remove toxic sediments from Scuffletown Creek, just south of the Jordan Bridge.

- ◆ *Dissolved metals in the water column did not exceed Virginia's proposed water quality standards anywhere in the river, an encouraging sign.*

**M**any thanks to the Virginia Department of Environmental Quality, participating scientists and technical advisors for making this report possible, and many thanks to thousands of other partners throughout the community who are also doing their part for a cleaner Elizabeth. Let's make 2003 truly a banner New Year for our home river.

- Marjorie Mayfield  
Executive Director, Elizabeth River Project  
January 2003

## Sediment Contamination (PAH) in the Elizabeth

**M**any polycyclic aromatic hydrocarbons, or PAHs, are considered potent carcinogens and harmful to aquatic life. PAHs can be introduced into the river as byproducts of incomplete combustion of wood or other organic compounds, creosote from wood treatment facilities, heat and power generation, refuse burning and industrial activities involving coke ovens and coal refuse piles. These scores are based on analysis of sediment samples collected at 21 stations for PAHs in the spring of 2000 for the Virginia Department of Environmental Quality's Elizabeth River Monitoring Program.

Analysis for PAH were prepared by Geochemical and Environmental Research Group at Texas A & M. These data were released after the State of the River 2000 report. For the State of the River 2000 report, the evaluation of PAH was based on data provided by Dr. Rebecca Dickhut, Virginia Institute of Marine Science, from an independent study funded by the NOAA CBEEC through the Virginia Sea Grant College Program. Station locations in Dickhut's study did not correspond precisely to those of the state program. Nonetheless, the general conclusions presented in the 2000 report are consistent with scores presented here.

### *Key Points*

- ◆ Of the 21 sediment samples collected in the Elizabeth River, 81 percent received a grade of "Borderline Problem" to "Severe Problem" based on PAHs.
- ◆ PAH concentrations at four of six stations in the Southern Branch ranked a "Severe Problem." These four stations are north of I-64 and south of the junction where the Southern and Eastern branches form the Mainstem.
- ◆ PAH concentrations at stations located at the confluence of the Eastern and Southern Branches and the Mainstem result from a variety of sources, in particular historical releases from creosote plants as well as on-going automobile emissions.

### *Qualifications*

- ◆ All substituted PAHs [compounds with 1-4 carbon chains attached] and all internal standards were excluded in the calculation of total PAH and evaluation of sediment PAHs.
- ◆ Two sets of guidelines were used in the evaluation of sediment PAHs. The guidelines used most often are those published by NOAA. These guidelines are concentrations of particular PAHs that produce defined biological effects at an assumed probability of occurrence and are available for a relatively limited number of PAHs. If no guideline exists for the PAHs dominant in sediment from a particular station, the sediment would receive a "good" grade even though the total concentration of PAH equals or exceeds that of a station receiving a failing grade. Therefore a secondary guideline based on total PAH was used in some cases to arrive at the scores.

# Bottom Community Health of the Elizabeth

**The biological integrity of a water body can be judged by the health of life along the bottom.**

Communities of organisms living on the bottom of aquatic ecosystems are referred to as “benthic communities.” Benthic communities, from microbes to fish, are used extensively as indicators of environmental health because numerous studies have demonstrated that benthic organisms not only form the foundation of the ecosystem, but respond predictably to stressors.

Benthic organisms generally have limited mobility and cannot avoid adverse conditions. This immobility is advantageous in environmental assessments because, unlike most animals in the water column, benthic communities reflect local environmental conditions. *Healthy benthic communities are characterized by high species diversity, dominance of species intolerant to pollution and intermediate levels of abundance and biomass.*

The health of the benthic communities of the Elizabeth River watershed was characterized by combining previously developed benthic restoration goals, the Benthic Index of Biotic Integrity (B-IBI) for the Chesapeake Bay of the Chesapeake Bay Program, and probability-based sampling, taken from random locations throughout a designated area.



## *Key Points*

- ◆ In general for the Elizabeth River watershed, species diversity and biomass were below reference condition levels while abundance values were within reference condition levels. The benthic community species composition was unbalanced as levels of pollution indicative species (fast-growing, short-lived, “weedy” species) were above, and pollution sensitive species below, the designated reference conditions.
- ◆ The Southern Branch had the highest level of degradation. Species diversity and the amount of pollution indicative species were the farthest from meeting the benthic restoration goals when comparing river segments, but abundance met the goals, indicating a degraded community.
- ◆ The Mainstem appears to be the healthiest segment of the Elizabeth River, meeting benthic restoration goals for abundance, biomass, and the amount of pollution sensitive species. It was also the segment closest to, but not meeting, the designated reference conditions for species diversity and the amount of pollution indicative species.

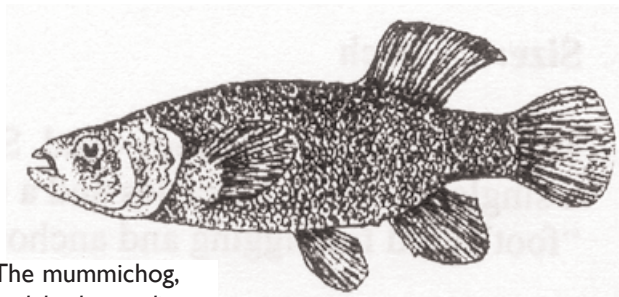
## *Qualifications*

- ◆ The B-IBI provides a means for comparing relative condition of benthic invertebrate communities across habitat types.
- ◆ The approach presented here is consistent with the use of the B-IBI in the Chesapeake Bay Benthic Monitoring Program.
- ◆ Application of the index is limited to a summer index period from July 15th through September 30th.

# Cancer in Mummichog Fish, Elizabeth River

**T**he mummichog (*Fundulus heteroclitus*) is a small, abundant, non-migratory fish known to reflect the quality of its local environment. Because of high cancer rates in the mummichog, the Elizabeth River Project has adopted this fish as a key indicator species, for tracking success in reducing toxics in the river bottom. Many more visible species, such as wading birds and sport fisheries, depend on the mummichog for food.

For this report, mummichog populations were sampled at 12 near-shore stations in fall 1998. Fish tissue was analyzed by the Virginia Institute of Marine Science (VIMS). Scientists studied the occurrence of liver proliferative lesions (precancerous and cancerous changes) in this fish that may be directly related to levels of certain pollutants in its environment. Adverse health effects attributable to pollutant exposure measured locally in mummichogs are thought to be a reflection of the quality of the immediate environment.



The mummichog,  
*Fundulus heteroclitus*

## ***Key Points:***

- ◆ Mummichog proliferative liver lesion prevalence (pre-cancers and cancers) varied greatly throughout the River, with lowest lesion prevalences occurring in fish inhabiting the more residential portions of the system (e.g., Western Branch) and highest prevalences occurring in fish from heavily industrialized portions of the system (Southern Branch).
- ◆ Extremely high prevalences of cancer occur in fish from several sites along the Southern Branch alongside former facilities which treated timbers with creosote and other wood preservatives. Previous VIMS studies have shown these sites to be grossly contaminated by PAHs of creosote origin. Experimental exposures of mummichogs to PAHs of creosote origin have resulted in development of pre-cancerous and cancerous liver lesions.
- ◆ High prevalences of liver proliferative lesions also occurred in the heavily industrialized proximal portions of the Eastern Branch. However, this is a much more restricted area, with the upper reaches of that branch largely characterized by residential development.

## ***Qualifications:***

- ◆ Only the fish *Fundulus heteroclitus* was examined in this study.
- ◆ Problem rating is based on lesion prevalence data obtained from 60 large adult fish collected at each of the 12 stations. The rating assigned to each of the main portions of the river system are based on as few as one or two study sites within that section of river. There is a need to expand this data base in the future to make the scores more closely represent the overall condition of the various river segments.

# Dissolved Oxygen in the Elizabeth River

**L**ike animals on land, fish and other aquatic animals need oxygen to live. Dissolved oxygen, or DO, is considered one of the most important and commonly employed indicators of a water body's ability to support healthy aquatic life. Adequate concentrations of dissolved oxygen are necessary for fish and other aquatic life.

For this report, DO levels were measured at 14 stations in the summers of 2000-2001 and were evaluated using the Chesapeake Bay Program's draft DO criteria for open water, deep water, and deep channel habitat.

DO conditions in the Elizabeth River are a function of physical and chemical factors unique to the river, such as depth and tidal flushing rates. During a span of over 100 years, the mean channel depth in the Elizabeth increased by approximately 5 - 8 m. Even small changes in depth (1-1.5 m) have been found to significantly reduce tidal currents and exchange rates and increase vertical stratification, which often leads to reduced DO levels at the bottom of the river. The Elizabeth River is a poorly flushed estuary, with a reduced rate of exchange with the lower James River and the Chesapeake. Although further improvements in DO levels may be possible, permanent physical alterations to the system may prevent the river from consistently meeting criteria.

## *Key Points*

- ◆ Dissolved oxygen concentrations show an improving trend in the Elizabeth River over the last decade.
- ◆ The Southern Branch is classified as “Severe Problem” because 31 percent of the DO values were lower than the Chesapeake Bay Program’s draft 30-day average criterion in the upper part of the water column. The daily minimum criterion for this part of the water column was consistently met both in the Southern Branch and the rest of the river. Nonetheless, aquatic life may be affected by low DO levels due to observed values in a number of stations well below (often 1 mg/l or more below) proposed criteria.
- ◆ Low DO occurs seasonally in several small coves and creeks in the Lafayette River, and may be related to natural effects, climactic conditions and/or storm events.
- ◆ DO values are influenced by weather conditions. The data set used in the analysis (2000-2001) represented a period of dry weather and generally good DO conditions, while in other years under different weather conditions lower minimum DO values were observed.
- ◆ The Elizabeth River consistently met the draft DO criteria for deep water and channel habitat. This result is significant because the deep water category provides the largest habitat by volume. Exceedences are based on the proposed open water habitat criteria.

## *Qualifications*

- ◆ Analysis was limited to summer critical period (June 1 to September 30th)
- ◆ The Chesapeake Bay Program's draft criteria for DO are:  
Open Water: 5.0 mg/l 30 day average, 3.0 mg/l minimum  
Deep Water: 3.0 mg/l 30 day average, 1.7 mg/l minimum  
Deep Channel: 1.0 mg/l minimum  
Deep Water depth: 30 feet and below.

# Water Column Metals in the Elizabeth River

**A**ll living things require trace amounts of metals to survive. However, when excessive levels of dissolved metals are biologically available, they can interfere with oxygen uptake, impacting the ability of aquatic life to grow, reproduce and survive. Metals exist naturally in the environment in trace amounts, but metal concentrations in water bodies may be increased due to discharges of industrial wastewater, municipal wastewater, urban runoff and atmospheric deposition.

Ratings for this report are based on monitoring at 14 stations during eight sampling events during 2000 - 2001. Dissolved metals samples were collected using clean techniques by state staff and analyzed by the state's Division of Consolidated Laboratory Services.



Photo: Bill Tiernan

## *Key Points*

- ◆ There were no exceedences of the proposed VA DEQ water quality standards for any of the nine metals evaluated (Arsenic, Cadmium, Copper, Lead, Mercury, Nickel, Selenium, Silver, and Zinc).
- ◆ Copper showed elevated levels in the Southern Branch, but does not exceed any proposed VA DEQ water quality standards.
- ◆ The Western Branch had elevated zinc values with respect to the other branches; however these were well below the chronic standard.

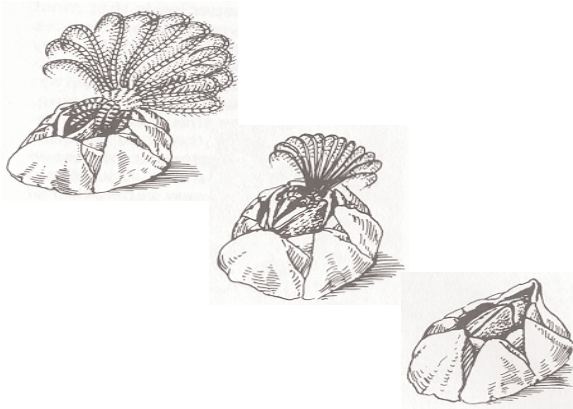
## *Qualifications*

- ◆ A site specific chronic criteria for copper of 10.5 ug/l) as well as a revised statewide chronic copper criteria of 6.0 ug/l are in the water quality standards regulation amendments recently proposed by DEQ. These criteria are based on recent scientific data. There were no exceedences of either of these proposed chronic copper criteria.

# Tributyltin, or TBT, in the Elizabeth River

**T**ributyltin, or TBT, is a biocide which has been popular in marine paints for its effectiveness in deterring the growth of barnacles, algae and other organisms on the hulls of boats and ships. TBT can be extremely toxic to fish and other aquatic life at very low concentrations, however, and proves to be the No. 1 problem in the water column of the Elizabeth River. The Elizabeth River Project supports enforcement of an international ban on use of TBT in hull paints.

Conclusions in this report are based on three years of monitoring TBT by VIMS in the water column at 18 river stations. Stations were sampled six times a year and average concentrations were calculated for each location over the twelve-month period.



## *Key Points*

- ◆ All monitoring stations had average yearly TBT concentrations that exceeded the Virginia Water Quality Criteria for TBT (1.0 ng/L) which placed them at least in the “Problem” category.
- ◆ Near the confluence of the Eastern and Southern branches, average concentrations at multiple stations were greater than 10 ng/L. This placed these branches into the “Severe Problem” category. Typically, TBT concentrations in the Elizabeth River showed a gradient with the highest levels near the confluence of the Eastern and Southern Branches.
- ◆ The highest measured concentrations, to date, occurred on September 20, 2001 with several stations near the confluence of the Eastern and Southern Branches exceeding 20 ng/L and the highest measured concentration was greater than 70 ng/L at a station in the Southern Branch.

## *Qualifications*

- ◆ TBT concentrations are reported as the cation and are for whole water samples.
- ◆ Scores were assigned by the following definitions and are based on the concern for biological effects from TBT exposure as described in the literature.

## Citizen Monitoring - New Opportunity

**F**or the first time, the Elizabeth River Project is enlisting volunteers to add to what's known about the state of the river. A Citizen Monitoring Program began on a pilot level in 2002-03.

Starting with Scott's Creek and Paradise Creek in Portsmouth, volunteers will have a chance to learn directly about river conditions, while obtaining water quality data to supplement Elizabeth River Project, state and federal sampling efforts. The program is being launched in cooperation with the Virginia Department of Environmental Quality, Alliance for the Chesapeake Bay and VISTA/EASI.

A limited number of initial volunteers will receive training and equipment to collect weekly water samples and perform tests for dissolved oxygen, pH, salinity, Secchi and water depth, and air and water temperature. Some may also record daily precipitation and weather observations. These parameters indicate overall water quality.

Data will be posted on the web through the Alliance for the Chesapeake Bay, which maintains citizen monitoring data for the entire bay, and also will be posted at the Elizabeth River Project's new River Information Center, opening in downtown Portsmouth in spring 2003.

The Elizabeth River Project hopes lessons learned this year will result in a citizen monitoring program which can be expanded into tributaries throughout the watershed.

*“Never doubt that a small group of thoughtful, committed citizens can change the world. Indeed, it's the only thing that ever has.”*

*Margaret Mead*



Photo by John Peiper (VISTA/EASI program coordinator)

VISTA/EASI crew samples Scott's Creek water quality.  
Seated, L to R: Jennifer King, Laura Titulear and Robbie Marshall.  
Standing, L to R: Ed Giles and Dianne Predmore.

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Special thanks for analysis and recommendations regarding the data provided by the Monitoring Advisory Committee of the Elizabeth River Project and other contributors, including Will Hunley, HRSD, who analyzed the DO data. Stephanie Stegmeier, Monitoring Liaison, Elizabeth River Project, coordinated review efforts and prepared this report for publication.

### ***Map and Other Illustrations***

URS Corp., Carol Amorosi, graciously donated generation of the centerfold map. Special thanks for additional art work courtesy of Jim Walker, cover photograph, which appeared in The Living River art exhibition 2002; also Bill Tiernan, John Pieper, Alice Jane Lippson and the US Army Corps of Engineers.

# Meet the Mummichog, “Canary of the River”

**Y**ou can't normally see Elizabeth's toxic bottom, laced with contamination that makes our river one of the most toxic hotspots on the Chesapeake Bay. So how will the public know that “Lizzy's bottom” is recovering -- that millions being invested in an historic Corps of Engineers sediment cleanup at Scuffletown Creek, for instance, are successful?

*Watch the health of a silvery little fish, the mummichog.*

The Elizabeth River Project has selected this bottom-dwelling, non-migratory species as the key indicator, or “canary of the river,” for judging restoration progress. The mummichog lives in schools within a small area and burrows in mud during winter. Currently the mummichog exhibits an extremely high prevalence of liver cancer in some parts of the Southern Branch of the Elizabeth.

The No. 1 goal of the Elizabeth River Project, endorsed in 2001 by 70 diverse community leaders, is to reduce contamination in hotspots of the river mud to non-toxic levels by 2020 -- and test success by whether we make the mummichog well again. You are invited to the first Mummichog Tog in 2003, a community ball to celebrate the progress being made by federal, state and local partners. See page 9 for latest results on the health of the mummichog.



Photo: Bill Tiernan - Virginian Pilot

## **The mummichog - cancerous now, but watch for his recovery**

The mummichog, *Fundulus heteroclitus*, is a 4-6 inch minnow inhabiting the bottom of salt marshes and other shallow estuarine habitats of the Atlantic coastline. Females are silvery gray while males are dark olive with pearly white and blue spots. Mummichogs are largely non-migratory, often living in schools within a 2500 square-yard area their entire lives. The mummichog's abundance and non-migratory lifestyle make it an ideal indicator of the environmental quality of the Elizabeth River.

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## **Monitoring Activities Funded by**



## **Report Prepared by**

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