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In This Issue

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Recent Advisory News

New Fish Consumption Advisories Reflect Continuing Improvements in Water Quality for Delaware Waterways

On February 20, 2018, new fish consumption advisories issued by the Delaware Department of Natural Resources and Environmental Control (DNREC) and the Delaware Department of Health and Social Services' Division of Public Health (DHSS/DPH) showed that the concentration of chemical contaminants in fish caught from the state's waterways continues to decline. The new advisories indicate that water quality is improving throughout the state and fish caught in many Delaware waters can be eaten today with lowered concerns about risks to public health.

Fish consumption advisories are recommendations by DNREC and DHSS to limit or avoid eating certain species of fish caught in local waters due to potential health risks from contaminants. The latest advisories convey that anglers and the public can eat more fish caught locally, while keeping health risks low and enjoying the dietary health benefits that fish provide. The agencies' recommendations on the safe amount of fish that can be eaten are based on the testing of these fish by DNREC and an assessment of the health risks associated with their consumption.

The updated advisories show a continuing trend of the most significant declines in fish tissue contaminant concentrations since the state began assessing contaminants in fish in 1986.

"Seeing the positive results of regional efforts to restore water quality and the health of Delaware's aquatic resources is very exciting and encouraging," said DNREC Secretary Shawn M. Garvin. "I anticipate that, with continued cleanup efforts and cooperation between DNREC, DHSS, and our regional partners who include New Jersey Department of Environmental Protection and the Delaware River Basin Commission that we will continue to see a trend of improvement into the future."

"The improved water quality allowing people to eat more fish caught in local waterways is good news across the board," said DHSS Secretary Dr. Kara Odom Walker, a board-certified family physician. "Consuming fish is an essential part of a healthy diet because fish contain so many key nutrients, are low in saturated fat, and contain omega-3 fatty

acids. The updated advisories will help Delawareans make good decisions for themselves and their families about the right kinds of fish to eat from our state's waterways, as well as the right amount."

Many of the contaminants that prompt fish consumption advisories in Delaware are "legacy pollutants" – chemicals, such as polychlorinated biphenyls (PCBs), the banned insecticide dichloro-diphenyl-trichloroethane (DDT), and dioxins and furans that were released into waterways in significant quantities in the past. These legacy pollutants are slow to break down in the environment and can accumulate in fish as well as in bottom sediments of lakes, streams, and estuaries.

The improvements, evidenced through relaxed advisories, are largely the result of declining PCB concentrations in fish, as much as 50 to 60% less in some state waters. The reduction in PCB levels is attributable to several efforts, including state-of-the-science testing to identify, prioritize, and control remaining sources of contaminants. Innovative clean-up strategies, such as adding activated carbon and quicklime to sediments that bind contaminants and limit their transfer to the water and fish, have also contributed to the declining concentrations.

The latest updates to Delaware's fish consumption advisories include the tidal Delaware River, the lower Delaware River and Delaware Bay, Atlantic Coastal waters, Waples Pond, Prime Hook Creek, and Slaughter Creek. The table on the next page highlights the improvements by noting the differences between the previous advisories and the 2018 advisories. For all advisories, the amount of fish constituting a meal is 8 ounces for an adult, 3 ounces for children.

Prime Hook National Wildlife Refuge. *(Image courtesy of U.S. Fish and Wildlife Service)*

2018 Changes to Fish Consumption Advisories in Delaware Waters (Previous Advisories Noted in Orange)				
Waterbody Name	**Fish Species**	**Average adult/angler**	**Women of childbearing age Children less than 6 years old**	**Contaminant**
Tidal Delaware River (between DE/NJ/PA border and northeast extent of the Chesapeake and Delaware (C&D) Canal)	All fish	1 meal per year 3 meals per year	Do not eat Do not eat	PCBs, dioxins, furans, and Dieldrin
Lower Delaware River and Delaware Bay (from the northeast extent of the C&D Canal down to the mouth of the Delaware Bay, defined by a line between Cape Henlopen, DE and Cape May, NJ)	Striped Bass Channel Catfish White Catfish American Eel	2 meals per year 3 meals per year	Do not eat Do not eat	PCBs
	White Perch	2 meals per year 6 meals per year	Do not eat 6 meals per year*	PCBs
	Bluefish – greater than 20 inches	1 meal per year 3 meals per year	Do not eat Do not eat	PCBs, Mercury
	Weakfish (Sea Trout)	12 meals per year No limit	12 meals per year 12 meals per year	-
Atlantic Coastal Waters (beyond the mouth of Delaware Bay, extending out 3 miles into the Atlantic Ocean between Cape Henlopen and Fenwick Island)	Striped Bass	2 meals per year 3 meals per year	Do not eat Do not eat	PCBs
	Bluefish – greater than 20 inches	1 meal per year 3 meals per year	Do not eat Do not eat	PCBs, Mercury
Waples Pond and Prime Hook Creek (located in northeastern Sussex County; part of the Prime Hook Creek National Wildlife Refuge)	All fish	12 meals per year 1 meal per week	12 meals per year 12 meals per year	Mercury
Slaughter Creek (entire creek)	All fish	6 meals per year 12 meals per year	6 meals per year 6 meals per year	PCBs, dioxin, furans

Notes: Colored text notes Previous Advisory

* For children less than 6 years old only. For women of childbearing age, the previous advisory (do not eat) for this waterbody remains in effect.

Additionally, a special study conducted by DNREC in 2016 and 2017 indicates that the Red Clay Creek in New Castle County can be reinstated in 2018 as a stream suitable for trout stocking by DNREC's Division of Fish and Wildlife, more than 30 years after being taken off the state's trout-fishing list due to contaminant concerns. In the spring of 2018, DNREC was expected to stock trout in Red Clay Creek in the vicinity of Auburn Heights Preserve, in Yorklyn, Delaware. The study, *Feasibility of Stocking Red Clay Creek with Trout*, can be read here.

Fish consumption advisory data can be found on the DNREC website. Fish consumption advisory charts can be found on DNREC's Division of Fish & Wildlife website.

For more information, please contact John G. Cargill at 302-739-9939 or john.cargill@state.de.us.

Source: https://news.delaware.gov/2018/02/20/dnrec-dhss-issue-new-fish-consumption-advisories-reflect-continuing-improvement-water-quality-delaware-waterways/ and http://www.dnrec.delaware.gov/Admin/Documents/2018-Delaware-fish-consumption-advisory-data.pdf

EPA News

Guidelines for Measuring Changes in Seawater pH and Associated Carbonate Chemistry in Coastal Environments of the Eastern United States

Coastal monitoring of acidification has been a unique challenge due to greater variability of pH in the coastal environment. Although there is interest in monitoring ocean acidification in coastal waters, until now there has been little available guidance on how to best utilize or expand capabilities. The U.S. Environmental Protection Agency's (EPA) *Guidelines for Measuring Changes in Seawater pH and Associated Carbonate Chemistry in Coastal Environments of the Eastern United States* serves as a resource for learning about and performing measurements of the seawater carbonate system. These guidelines are intended to facilitate the development of compatible datasets for the large community of investigators interested in coastal acidification.

This report begins with descriptions of the differences between coastal and ocean acidification, factors contributing to acidification on the U.S. east coast, and basic characteristics of the seawater carbonate system and its parameters. A basic survey of available methods and challenges for collecting and analyzing samples is also included, often with multiple alternatives for each method, but specific recommendations are not provided due to the need to consider study objectives, which will vary among users, during the selection of specific methods.

The information in the report will assist citizen scientists, states, tribes, and existing water quality laboratories who wish to initiate or improve measurements of seawater carbonate chemistry.

Reference: Pimenta, A. and J. Grear. 2018. Guidelines for Measuring Changes in Seawater pH and Associated Carbonate Chemistry in Coastal Environments of the Eastern United States. U.S. EPA Office of Research and Development, Washington, DC, EPA/600/R-17/483.

For more information contact Adam Pimenta at pimenta.adam@epa.gov and Jason Grear at grear.jason@epa.gov.

Source: https://nepis.epa.gov/Exe/ZyPURL.cgi?Dockey=P100UDMR.txt

Other News

Weekly Fish Consumption Linked to Better Sleep, Higher IQ

Children who eat fish at least once a week sleep better and have IQ scores that are four points higher, on average, than those who consume fish less frequently or not at all, according to new findings from the University of Pennsylvania published December 21, 2107 in *Scientific Reports*, a Nature journal.

Previous studies showed a relationship between omega-3s, the fatty acids in many types of fish, and improved intelligence, as well as omega-3s and better sleep. But they've never all been connected before. This work, conducted by Jianghong Liu, Jennifer Pinto-Martin, and Alexandra Hanlon of the School of Nursing and Penn

Integrates Knowledge Professor Adrian Raine, reveals sleep as a possible mediating pathway, the potential missing link between fish and intelligence.

"This area of research is not well-developed. It's emerging," said Liu, lead author on the paper and an associate professor of nursing and public health. "Here we look at omega-3s coming from our food instead of from supplements."

For the work, a cohort of 541 9- to 11-year-olds in China, 54% boys and 46% girls, completed a questionnaire about how often they consumed fish in the past month, with options ranging from "never" to "at least once per week." They also took the Chinese version of an IQ test called the Wechsler Intelligence Scale for Children-Revised, which examines verbal and non-verbal skills such as vocabulary and coding.

Their parents then answered questions about sleep quality using the standardized Children Sleep Habits Questionnaire, which included topics such as sleep duration and frequency of night waking or daytime sleepiness. Finally, the researchers controlled for demographic information, including parental education, occupation and marital status, and number of children in the home.

Analyzing these data points, the Penn team found that children who reported eating fish weekly scored 4.8 points higher on the IQ exams than those who said they "seldom" or "never" consumed fish. Those whose meals sometimes included fish scored 3.3 points higher. In addition, increased fish consumption was associated with fewer disturbances of sleep, which the researchers say indicates better overall sleep quality.

"Lack of sleep is associated with antisocial behavior; poor cognition is associated with antisocial behavior," said Raine, who has appointments in the School of Arts and Sciences and Penn's Perelman School of Medicine. "We have found that omega-3 supplements reduce antisocial behavior, so it's not too surprising that fish is behind this."

Pinto-Martin, who is executive director of Penn's Center for Public Health Initiatives, as well as the Viola MacInnes/Independence Professor of Nursing and a professor of epidemiology in Penn Medicine, sees strong potential for the implications of this research.

"It adds to the growing body of evidence showing that fish consumption has really positive health benefits and should be something more heavily advertised and promoted," she said. "Children should be introduced to it early on." That could be as young as 10 months, as long as the fish has no bones and has been finely chopped, but should start by around age 2.

"Introducing the taste early makes it more palatable," Pinto-Martin said. "It really has to be a concerted effort, especially in a culture where fish is not as commonly served or smelled. Children are sensitive to smell. If they're not used to it, they may shy away from it."

Given the young age of this study group, Liu and colleagues chose not to analyze the details participants reported about the types of fish consumed, though they plan to do so for work on an older cohort in the future. The researchers also want to add to this current observational study to establish, through randomized controlled trials, that eating fish can lead to better sleep, better school performance, and other real-life, practical outcomes.

For the moment, the researchers recommend incrementally incorporating additional fish into a diet; consumption even once a week moves a family into the "high" fish-eating group as defined in the study.

"Doing that could be a lot easier than nudging children about going to bed," Raine said. "If the fish improves sleep, great. If it also improves cognitive performance, like we've seen here, even better. It's a double hit."

For more information, the lead author, Jianghong Liu, can be contacted through the following web-form: https://www.nature.com/articles/s41598-017-17520-w/email/correspondent/c1/new.

Reference: Jianghong L., Y. Cui, L. Li, L. Wu, A. Hanlon, J. Pinto-Martin, A. Raine, and J. R. Hibbeln. 2017. The mediating role of sleep in the fish consumption – cognitive functioning relationship: a cohort study. *Scientific Reports* 7 (1) DOI: 10.1038/s41598-017-17520-w.

Source: https://www.sciencedaily.com/releases/2017/12/171221101341.htm

Vaccines to Benefit Both Fish and Human Health

In its Spring 2018 issue of *Northwest Treaty Tribes*, the Northwest Indian Fisheries Commission (NWIFC) reported that a little home cooking is helping tribal hatcheries keep chinook and coho disease-free and eliminating the need for antibiotics that could lead to drug resistance in people.

For the past three decades, staff from the NWIFC's tribal fish health program have been producing vaccines to treat vibriosis and enteric redmouth disease that can be lethal to young salmon in hatcheries. Treaty tribes in western Washington produce about 40 million salmon annually.

Both of the vaccines produced in NWIFC's lab eliminate or sharply reduce the need for antibiotics to treat infected fish in hatcheries. It is thought that the overuse of antibiotics in animals used for food reduces the effectiveness of antibiotics in humans.

Betsy Hall, NWIFC microbiologist, checks the status of vaccines being produced in the NWIFC fish health lab in Olympia. *(Image courtesy of T. Meyer of NWIFC)*

"The vaccines we produce are highly effective and can be made at a fraction of the cost that companies charge," said Bruce Stewart, the lab's director. "We made 750 gallons of vaccine for use this year that we can use to inoculate about five million fish, saving the tribes tens of thousands of dollars a year, and protecting salmon that are harvested by Indian and non-Indian fishermen."

Enteric redmouth disease is a bacterial infection of freshwater and marine fish that mainly affects steelhead and chinook early in their life cycle, sometimes before their immune system is developed.

The *vibrio* virus occurs naturally and is widespread in western Washington marine waters. Outbreaks are influenced largely by water temperatures that exceed 55 degrees. If unchecked, the disease can lead to huge losses of young salmon in hatcheries.

Coho and chinook are especially susceptible to vibriosis, but their treatment varies because of the difference in size and how much the young fish are handled before release.

To further gauge the effectiveness of inoculating young chinook in fresh water, tribal and fish health lab staff will use a coded-wire program to track survival rates of the treated fish over the next three years.

For more information contact Tony Meyer at the NWIFC at tmeyer@nwifc.org.

Source: https://nwtreatytribes.org/download/14101/, page 7

In WSU Stormwater Runoff Research, Coho Salmon Die Quickly, Chum Survive

On April 20, 2018, the *Columbia Basin Fish and Wildlife News Bulletin* reported that Washington State University (WSU) scientists discovered that different species of salmon have varying reactions to polluted stormwater runoff.

In a recent paper published in the journal *Environmental Pollution*, scientists found that coho salmon became mortally ill within just a few hours of exposure to polluted stormwater. But chum salmon showed no signs of ill-effects after prolonged exposure to the same water.

The study can be found at https://www.sciencedirect.com/science/article/pii/S026974911734527X?via%3Dihub.

"It really surprised us," said Jen McIntyre, an assistant professor in WSU's School of the Environment. "Not that the coho were affected so quickly, but how resistant the chum were. We saw no impact at all in the chum's post-exposure blood work."

Stormwater is toxic to fish because it can include carcinogenic hydrocarbons, metals, and other organic compounds, most of which have yet to be identified.

Chum salmon. *(Image courtesy of the U.S. Fish and Wildlife Service)*

McIntyre and her team collected stormwater runoff in large tanks from a highway in western Washington. Then they placed salmon in that water for four hours or until the fish showed signs of illness. Blood samples were then taken from all of the fish.

Only a few coho lasted four hours before having to be removed. In blood tests, the team found a significant increase in lactic acid concentrations and their blood was much thicker. Their blood pH was thrown off and the amount of salt in their plasma decreased significantly.

The chum test results showed none of those changes, all these fish lasting the full four hours without showing any signs of distress or sickness.

"These fish are very closely related," said McIntyre, who works at WSU's Puyallup Research and Extension Center. "They're the same genus, but obviously something is significantly different physiologically. We just don't know what that difference is yet."

The study was done at the Suquamish Tribe Grovers Creek Salmon Hatchery, with fish donated by the Suquamish Tribe.

McIntyre worked on the project with fellow WSU scientists, along with colleagues from the National Oceanic and Atmospheric Administration (NOAA) National Marine Fisheries Service and the U.S. Fish and Wildlife Service.

McIntyre and her team noticed a few clues for where to start their next round of investigations: studying what makes the chum nearly impervious to toxic runoff. One is that the coho appeared hypoxic, meaning they weren't getting enough oxygen. But the water had plenty of oxygen, so they'll look at blood circulation issues, how the fish metabolize oxygen in their muscles, and a few other areas.

"We don't know if the thicker blood is a symptom of the problem, or if that's the initiating event that then causes the oxygen deprivation," McIntyre said. "There's a lot of work still to come, but this really narrows down where we need to look."

They're also hoping that looking further into chum will turn up clues about how they resist the effects of toxic runoff.

In a later study, not included in this paper, McIntyre and her team conducted a prolonged exposure test on chum. Those fish swam in the stormwater runoff for four days and none of them got sick.

"We're still trying to understand how they're unaffected," she said. "It's actually really impressive."

Another problem for the coho is that scientists don't know what particular contaminants in the runoff are causing the problems.

"There's a whole variety of heavy metals and hydrocarbons in that water," McIntyre said. "And a whole bunch of chemicals we are working with scientists at the University of Washington in Tacoma to identify so that we can protect more delicate species like coho salmon from the effects of human pollution."

McIntyre's research is part of a grant from EPA.

For more information, Jen McIntyre can be reached at jen.mcintyre@wsu.edu.

Source: http://www.cbbulletin.com/440562.aspx

New Study: Climate Change to Shift Many Fish Species North

Reported on May 17, 2018, a new NOAA Fisheries-funded study published in the journal *PLOS ONE* presents the first major projections of where U.S. fish species populations may shift under future climate scenarios. The research was led by James Morley and Malin Pinsky of Rutgers University-New Brunswick.

According to Rutgers: "Climate change will force hundreds of ocean fish and invertebrate species, including some of the most economically important to the United States, to move northward, disrupting fisheries in the United States and Canada.

Fish are sensitive to the temperature of the water where they live, and as it becomes too warm, populations often shift to where the water temperature is right for them. This process has already begun, though at different rates in different places. As climate change continues and the oceans warm up, the study shows, more species of fish will move north to where the temperature range is habitable for them."

Sixteen different climate models were used by researchers for this study, as was NOAA Fisheries stock assessment data for many species including finfish, sharks, rays, crustaceans, and squid.

Cisco Werner, Chief Science Advisor for NOAA Fisheries, stated, “This kind of science helps fishermen, fishery managers, and fishing communities track ocean change, assess resources at risk, and safeguard the nation's valuable marine fish stocks and the many businesses and people that depend on them.”

More information on NOAA Fisheries and changing oceans is here. Also view the NOAA Fisheries Climate Science Strategy.

Source: https://www.fisheries.noaa.gov/feature-story/new-study-climate-change-shift-many-fish-species-north?utm_medium=email&utm_source=govdelivery

Evaluating Fish Community Changes to Stream Flow Alterations

In March 2018, the Organization of Fish and Wildlife Information Managers (OFWIM) published an article by Emily Tracy-Smith, recipient of an OFWIM 2017 Travel Grant Award. The article covered a five-year study that is underway to improve understanding of fish community responses to stream flow alterations. The study is being conducted through a collaborative effort between the University of Missouri and the Missouri Department of Conservation (MDC). A spatial framework was established using existing data for Missouri streams and flow alteration metrics were developed to understand how flow alterations affect riverine systems and their biota. Alteration metrics include basic attributes of impoundments (reservoir area, maximum storage) and metrics for the hydrologic effect of withdrawals, using their natural surrogate, losing streams. Working downstream from each headwater segment, the study team used RivEX software to accumulate values of these metrics for every stream segment within the Missouri stream network. Accumulated values of impoundment and withdrawal metrics were applied for every fish community-sampling site of the MDC Resource Assessment and Monitoring Program and for every stream gauge site.

A key to ecologically informed water management is to understand the dynamic ecological responses to changes in river flow regimes. A limitation to developing these quantitative relationships is the lack of stream flow data. MDC has developed a preliminary method using available data and reference (least disturbed) flow duration curve percentiles to estimate mean annual flow for stream segments. Flow estimates for individual stream segments are derived from drainage-area based regression equations for the group and adjusted for the effects of springflow, and losing streams (a stream or reach of stream in which water flows from the streambed into the ground-water system).

The resulting datasets will help to evaluate differences in fish communities as a function of flow alteration and assist MDC in determination of the flows needed in water management decisions and development of flow recommendations.

For more information or data sources contact Tracy Smithe at tracysmithe@missouri.edu.

Source: http://www.ofwim.org/wp-content/uploads/2018/04/OFWIM-Newsletter-2018-03.pdf, page 7

Stormwater Mimics Oil Spill's Effect on Pacific Herring

On May 21, 2018, the following was published in the *Encyclopedia of Puget Sound* of the Puget Sound Institute at the University of Washington by Katie Keil.

After the 1989 Exxon Valdez oil spill, studies found that Pacific herring (*Clupea pallasi*) are particularly sensitive to crude oil exposure, compounding serious population declines in Prince William Sound that continue into the present. Low exposure to oil can harm juvenile herring, and new research presented last month at the Salish Sea Ecosystem Conference in Seattle shows that stormwater can partially mimic some of the problems seen in large tanker disasters.

“We like to say the fish are telling us that every time it rains, there’s a little oil spill,” notes Louisa Harding, a research associate at Washington State University. She explains that urban stormwater runoff can contain high levels of carcinogenic polycyclic aromatic hydrocarbons (PAHs), similar to some of the “bad actors” found in crude oil.

Harding’s research on Pacific herring aims to quantify the effects of stormwater runoff on embryonic development by exposing them to varying levels (12.5%, 25%, and 50%) of stormwater collected from a nearby highway. Harding says the amounts of contaminants found in the fish in her experimental treatments were similar to those measured in local, wild fish by the Washington Department of Fish and Wildlife. When comparing PAHs in the stormwater to Harding’s experimental herring embryos, the stormwater and embryos had almost identical contaminant profiles. The herring embryos, Harding notes, are “acting as perfect little sponges."

In all of the stormwater treatments, herring experienced partially enlarged hearts, mirroring what is found in studies of oil-exposed herring. As a result, the herring struggled to pump a sufficient amount of blood through their systems. With increasing doses of stormwater, there was also a dramatic increase in the fluid around the heart. “In humans, this is a sign of heart disease,” Harding says.

Herring also showed developmental problems such as shorter body length and smaller eyes. In the more extreme 50% stormwater treatment, the embryonic yolk sac in herring larvae was not absorbed. Harding says this may point to the larvae's inability to use the yolk sac's nutrients necessary for development, which can have serious implications for overall fitness.

Juvenile Pacific herring. *(Image courtesy of NOAA Fisheries)*

Harding says more research is needed to quantify the long-term effects these injuries have on Pacific herring survival, but preliminary results appear concerning for this keystone species. The State of Washington is working to reduce the release of PAHs in the environment, but with over 28,000 stormwater outfalls in Puget Sound alone, Harding says her research illuminates the need for increased efforts to protect nearshore species from potentially chronic sources of cardiotoxic PAHs in urban stormwater runoff.

For more information, contact the *Encyclopedia of Puget Sound* at the following link: https://www.eopugetsound.org/contact.

Source: https://www.eopugetsound.org/articles/stormwater-mimics-oil-spills-effect-pacific-herring, story licensed under Creative Commons, CC BY-NC-ND 4.0

Research Brief 281: AHR is Required for Normal Organ Development and Behavioral Responses in Zebrafish

On May 2, 2018, the National Institute of Environmental Health Sciences released Research Brief 281, which discusses new research that demonstrates the important function of the aryl hydrocarbon receptor (AHR) in normal organ development, reproduction, fertility, and behavior. The results of the study, out of the Oregon State University Superfund Research Program Center (OSU SRP Center), may help researchers understand the target organs and molecular mechanisms involved in toxicity to environmental contaminants that require AHR, a protein required for organisms to develop properly.

Because AHR is a highly conserved receptor in humans and zebrafish, zebrafish can be used to rapidly study key biological functions of the AHR with and without exposure to environmental contaminants. Led by Robert Tanguay, Ph.D., the OSU SRP Center research team generated AHR2-null zebrafish, meaning that they lack AHR, using CRISPR Cas9 genome editing. These fish were compared to normal, or wild-type, fish early in development, during adulthood, and during reproductive maturity.

AHR in TCDD Toxicity and Cartilage Development

AHR is known to be disrupted by many different environmental contaminants, including dioxins, biphenyls, and polycyclic aromatic hydrocarbons. Even at low levels, these exposures can inappropriately activate AHR and disrupt neurological and cognitive development. The researchers further investigated this by comparing the response of AHR2-null and wild-type zebrafish to 2,3,7,8-tetrachlorodibenzo-p-dioxin (TCDD) exposure.

As expected, TCDD exposure led to permanent cartilage abnormalities in wild-type fish early in development. These included changes in the eye, jaw, snout, trunk, and fins. Wild-type fish also had alterations in the yolk sac. AHR2-null zebrafish had normal cartilage even though they were exposed to TCDD. According to the authors, these findings suggest that TCDD requires functional AHRs to produce toxicity in zebrafish.

To understand the role of AHR in normal physical development without environmental insult, the team compared cartilage around the skull and face early in development and in adult fish with and without AHR. Early in life, no differences were observed between AHR2-null and wild-type fish. These findings suggest that AHR2 is not required for early development of cartilage around the skull and face, but the absence of AHR2 protects the fish from TCDD-induced malformations, according to the authors.

In adults, AHR2-null fish had more visible jaw malformations than wild-type fish. They also had more fin defects, as well as significant skeletal defects. Interestingly, these malformations appeared to be more pronounced in females than in males. The authors stated that these results confirmed their earlier research findings that AHR2 is required for proper skeletal development in adult zebrafish.

AHR in Reproduction and Fertility

To explore the biological role of AHR in reproductive health, the team measured the fertility of sexually mature AHR2-null and wild-type fish during six spawning attempts over 10 weeks. They found that AHR2-null fish produced significantly fewer eggs than fish with normal AHR2. In fact, AHR2-null fish produced viable embryos only in the second spawning attempt.

The researchers further investigated these findings by examining fish ovary tissue. Compared to wild-type fish, female AHR2-null fish had more immature and degenerative follicles and fewer mature follicles. According to the authors, these findings suggest that AHR2 plays an important role in normal female reproduction by promoting proper follicle development.

AHR in Behavioral Response

The researchers also investigated the functional role of AHR2 on movement and behavior early in development by using a light-dark photomotor response assay and in adults by using startle-response, predator avoidance, and social cohesion assays.

They found that AHR2-null larvae had significantly hyperactive responses to light stimulus compared to wild-type fish. In adults, anxiety-related behaviors were reduced in AHR2-null fish compared to wild-type fish. They were less reactive to a startle stimulus and to a predator stimulus. Interestingly, adult AHR2-null fish also spent more time near a video projection of a school of free-swimming zebrafish in the social cohesion assay. These findings suggest that AHR2 is involved in proper neuromuscular or sensory system development, which can be observed into adulthood, according to the authors.

For more information, contact Robert L. Tanguay at robert.tanguay@oregonstate.edu or 541-737-6514.

Source: https://tools.niehs.nih.gov/srp/researchbriefs/view.cfm?Brief_ID=281

Duke University Superfund Research Center

Community Engagement Core

The Duke Superfund Community Engagement Core (CEC) hosted a health educator training with Cape Fear River Watch in Wilmington, North Carolina, to kick off its campaign on safe fish consumption from the Northeast Cape Fear River. The campaign is part of a study funded with an EPA Environmental Justice Grant and the CEC is an academic partner and project coordinator. The study will explore subsistence fish consumption in three neighborhoods in the Cape Fear River Basin. Other partners in the project include the Wake Forest School of Medicine, the New Hanover County Department of Public Health, and the Duke Environmental Law and Policy Clinic. More about the study can be found at the Cape Fear River Watch website.

After the training, local health educators will identify and communicate with subsistence fisherman, especially women and children who are likely to consume fish from the river containing unsafe levels of mercury and other industrial pollutants. Health educators will share information on selecting and preparing fish that are lower in mercury and other contaminants through community outreach and events in the summer and fall of 2018.

The CEC also participated in the "Fish Forum 2.0" at the Boston University Superfund Research Program on May 22, 2018. CEC Program Coordinator Catherine Kastleman presented on the Northeast Cape Fear River study and networked with groups across the country attempting similar outreach and education efforts around subsistence fish consumption and fish consumption advisories.

For more information about the Cape Fear River Watch visit http://www.capefearriverwatch.org/.

More information about the Duke CEC can be found here: http://sites.nicholas.duke.edu/superfund/community-engagement-core/.

Conference Update: Triangle Zebrafish Symposium

The Triangle Zebrafish Symposium was held at the Trent Semans Center on Duke University's medical center campus on May 14, 2018. Tara Raftery Catron, former Superfund postdoctoral associate in the Di Giulio Laboratory, gave a talk at the event titled, "Differential effects of exposure to bisphenol analogues and estradiol on zebrafish host-associated microbiota and behavior." Current and former members of the Di Giulio Laboratory Rafael Trevisan, Jordan Pitt, Andrey Massarsky, Jordan Kozal, and Nishad Jayasundara had a poster at the Symposium on the "Toxicity of nanopolystyrene plastics and their interactions with polycyclic aromatic hydrocarbons on early life stages of zebrafish."

Source: Duke Superfund Research Center “Duke Superfund Summer 2018 Newsletter” and http://www.capefearriverwatch.org/advocacy/epa-fish-consumption-study

Recently Awarded Research

EPA Provides $980,000 to Michigan to Restore Fish And Wildlife Habitat in Saginaw Bay, Lake Huron

On April 12, 2018, EPA Region 5 awarded $980,000 to the state of Michigan to restore rock reef in Saginaw Bay and improve fish and wildlife habitat in the Lake Huron watershed. Saginaw Bay is located within Lake Huron on the eastern side of the state of Michigan. Its recreational fishery is currently valued at more than $33 million per year.

"This project would not be possible without the cooperation of federal, state, and local partners," said Bretton Joldersma, Lake Huron Coordinator for Michigan's Office of the Great Lakes. "Restoring reef habitat in Saginaw Bay has been a long-term management goal; the restoration will help support native fish species including important commercial and recreational species."

Michigan Department of Environmental Quality will manage the restoration of rock reef in Saginaw Bay, recreating fish spawning and nursery habitat for key species like walleye and whitefish. The project, which was identified in the recently released Lake Huron Lakewide Action Management Plan, may also facilitate the restoration of other native species like cisco and lake trout. Multiple groups in the Lake Huron basin have identified the project as a priority and the work will help guide future reef restoration efforts throughout the Great Lakes.

This funding was made available through the Great Lakes Restoration Initiative (GLRI). The GLRI was launched in 2010 to accelerate efforts to protect and restore the Great Lakes. EPA has funded more than 900 projects to address GLRI's highest priorities: cleaning up highly-contaminated "areas of concern," reducing nutrient runoff, combating invasive species, and restoring habitat. For more information, visit https://www.glri.us/.

For more information contact Allison Lippert at lippert.allison@epa.gov.

Source: https://www.epa.gov/newsreleases/epa-provides-980000-michigan-restore-fish-and-wildlife-habitat-saginaw-bay-lake-huron

Tech and Tools

New Interactive Map to Provide Fish Consumption Advisories

In the spring of 2018, the Maryland Department of the Environment developed an interactive map that provides modernized, user-friendly information on fish consumption advisories. A consumption advisory is a recommendation to limit or avoid eating certain species of fish caught from specific water bodies due to environmental factors.

Screenshot of the app. *(Image courtesy of Maryland Department of the Environment)*

The map, which can be opened on web browsers, allows anglers to see what advisories are in effect in specific waterways. Users can search by species or waterbody. The map is optimized for mobile devices, with a widget that allows users to zoom to their exact location on the map with the press of a button. It is one of the only "clickable" maps for fish consumption advisories in the nation. Click here to access the map.

For more information, contact Amy Laliberte at 410-537-3614 or Amy.Laliberte@maryland.gov.

Source: http://mde.maryland.gov/programs/Marylander/fishandshellfish/Pages/fishconsumptionadvisory.aspx

Recent Publications

Journal Articles

The list below provides a selection of recent research articles:

- Discrete longitudinal variation in freshwater mussel assemblages within two rivers of central Michigan, USA
  Chambers, A.J., and D.A. Woolnough. 2018. Discrete longitudinal variation in freshwater mussel assemblages within two rivers of central Michigan, USA. *Hydrobiologia* 810(1):351-366.

- Simulated juvenile salmon growth and phenology respond to altered thermal regimes and stream network shape
  Fullerton, A. H., B. J. Burke, J. J. Lawler, C. E. Torgersen, J. L. Ebersole, and S. G. Leibowitz. 2017. Simulated juvenile salmon growth and phenology respond to altered thermal regimes and stream network shape. *Ecosphere* 8(12):e02052. 10.1002/ecs2.2052.

- An overview of the ongoing insights in selenium research and its role in fish nutrition and fish health
  Khan, K.U., A. Zuberi, J.B.K. Fernandes, I. Ullah, and H. Sarwar. 2017. An overview of the ongoing insights in selenium research and its role in fish nutrition and fish health. *Fish Physiology and Biochemistry* 43(6):1689-1705.

- The affinity of brominated phenolic compounds for human and zebrafish thyroid receptor β: Influence of chemical structure
  Kollitz, E.M., L. De Carbonnel, H.M. Stapleton, and P.L. Ferguson. 2018. The affinity of brominated phenolic compounds for human and zebrafish thyroid receptor β: Influence of Chemical Structure. *Toxicological Sciences* 163(1):226-239.

- Occurrence of β-*N*-methylamino-l-alanine (BMAA) and isomers in aquatic environments and aquatic food sources for humans
  Lance, E., N. Arnich, T. Maignien, and R. Biré. 2018. Occurrence of β-*N*-methylamino-l-alanine (BMAA) and isomers in aquatic environments and aquatic food sources for humans. *Toxins* 10(2):83.

- Genotoxic and cytotoxic effects on the immune cells of the freshwater bivalve *Dreissena polymorpha* exposed to the environmental neurotoxin BMAA
  Lepoutre, A., N. Milliote, M. Bonnard, M. Palos-Ladeiro, D. Rioult, I. Bonnard, F. Bastien, E. Faassen, A. Geffard, and E. Lance. 2018. Genotoxic and cytotoxic effects on the immune cells of freshwater bivalve *Dressena polymorpha* exposed to the environmental neurotoxin BMAA. *Toxins* 10(3): 106.

- Immunotoxicity in green mussels under perfluoroalkyl substance (PFAS) exposure: Reversible response and response model development
  Liu, C. and K. Yew-Hoong Gin. 2018. Immunotoxicity in green mussels under perfluoroalkyl substance (PFAS) exposure: Reversible response and response model development. *Environmental Toxicology and Chemistry* 37:1138-1145.

- Total particulate matter from cigarette smoke disrupts angiogenesis in zebrafish brain (*Danio rerio*)
  Massarsky. A., G.L. Prasad, and R.T. Di Giulio. 2018. Total particulate matter from cigarette smoke disrupts angiogenesis in zebrafish brain (*Danio rerio*). *Toxicology and Applied Pharmacology* 339:85-96.

- Bioactive peptides from fish by-products with anticarcinogenic potential
  Nurdiani, R., T. Vasiljevic, T.K. Singh, and O.N. Donkor. 2017. Bioactive peptides from fish by-products with anticarcinogenic potential. *International Food Research Journal* 24(5): 1840-1849.

- Microbial colonization is required for normal neurobehavioral development in zebrafish
  Phelps, D., N.E. Brinkman, S.P. Keely, E.M. Anneken, T.R. Catron, D. Betancourt, C.E. Wood, S.T. Espenschied, J.F. Rawls, and T. Tal. 2017. Microbial colonization is required for normal neurobehavorial development in zebrafish. *Scientific Reports* 7, Article number 11244.

- Uptake, tissue distribution, and toxicity of polystyrene nanoparticles in developing zebrafish (*Danio rerio*)
  Pitt, J.A., J.S. Kozai, N. Jayasundara, A. Massarsky, R. Trevisan, N. Geitner, M. Wiesner, E.D. Levin, and R.T. Di Giulio. 2018. Uptake, tissue distribution, and toxicity of polystyrene nanoparticles in developing zebrafish (*Danio rerio*). *Aquatic Toxicology* 194:185-194.

- Increased sediment load during a large-scale dam removal changes nearshore subtidal communities
  Rubin, S.P., I.M. Miller, M.M. Foley, H.D. Berry, J.J. Duda, B. Hudson, N.E. Elder, M.M. Beirne, J.A. Warrick, M.L. McHenry, A.W. Stevens, E.F. Eidam, A.S. Ogston, G. Gelfenbaum, and R. Pedersen. 2017. Increased sediment load during a large-scale dam removal changes nearshore subtidal communities. *PLoS One* 12(12): e0187742.

- Spatial and temporal variability in the effects of wildfire and drought on thermal habitat for a desert trout
  Shultz, L.D., M.P. Heck, D. Hockman-Wert, T. Allai, S. Wenger, N.A. Cook, and J.B. Dunham. 2017. Spatial and temporal variability in the effects of wildfire and drought on thermal habitat for a desert trout. *Journal of Arid Environments* 145:60-68.

- Nearshore fish community responses to large scale dam removal: Implications for watershed restoration and fish management
  Shaffer, J.A., F. Juanes, T.P. Quinn, D. Parks, T. McBride, J. Michel, C. Naumann, M. Hocking, and C. Byrnes. 2017. Nearshore fish community responses to larger scale dam removal: Implications for watershed restoration and fish management. *Aquatic Sciences* 79(3): 643-660.

- Differential toxin profiles of ciguatoxins in marine organisms: Chemistry, fate and global distribution
  Solino, L., and P.R. Costa. 2018. Differential toxin profiles of ciguatoxins in marine organisms: Chemistry, fate and global distribution. *Toxicon* 150:124-143.

- Health risk/benefit information for consumers of fish and shellfish: FishChoice, a new online tool
  Vilavert, L., et al. 2017. Health risk/benefit information for consumers of fish and shellfish: FishChoice, a new online tool. *Food and Chemical Toxicology* 104:79-84.

- Skagit River coho salmon life history model - Users' guide
  Woodward, A., G. Kirby, and S. Morris. 2017. Skagit River coho salmon life history model—Users' guide: U.S. Geological Survey Open-File Report 2017–1125, 57 p.

Upcoming Meetings and Conferences

International Conference on Food Safety and Health: Accentuating Current and Emerging Food Safety Issues
August 30-31, 2018
Dubai, UAE

9th International Conference on Fisheries and Aquaculture
September 17-18, 2018
Vancouver, British Columbia, Canada

12th World Congress on Aquaculture and Fisheries
September 19-20, 2018
Hong Kong

18th International Conference on Harmful Algae
October 21-26, 2018
Nantes, France

13th World Congress on Aquaculture and Fisheries
November 12-13, 2018
Melbourne, Australia

National Shellfisheries Association 111th Annual Meeting
March 7-11, 2019
New Orleans, Louisiana

8th International Symposium on Aquatic Animal Health
September 2-6, 2018
Prince Edward Island, Canada

72nd Annual Pacific Coast Shellfish Growers Association Shellfish Conference and Tradeshow
September 18-20, 2018
Blaine, Washington

European Aqua Congress
October 18-19, 2018
Paris, France

Organization of Fish and Wildlife Information Managers 26th Annual Conference and Business Meeting
November 4-8, 2018
Hood River, Oregon

Fish Passage 2018 - International Conference on River Connectivity
December 10-14, 2018
Albury, New South Wales, Australia

Additional Information

This monthly newsletter highlights current information about fish and shellfish.

For more information about specific advisories within the state, territory, or tribe, contact the appropriate state agency listed on EPA's National Listing of Fish Advisories website at https://fishadvisoryonline.epa.gov/Contacts.aspx.

For more information about this newsletter, contact Sharon Frey (Frey.Sharon@epa.gov, 202-566-1480).