



A Joint Program of:

- State University of New York
- Cornell University
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Administrative offices at
Stony Brook University

New York Sea Grant

121 Discovery Hall
Stony Brook University
Stony Brook, NY 11794-5001

Telephone: 631.632.6905

Fax: 631.632.6917

Office email:

NYSeaGrant@stonybrook.edu

Website: www.nyseagrant.org

January 5, 2007

Ms. Kim Tripp
Jamaica Bay Institute, Gateway National Recreation Area
HQ Building 69
Floyd Bennett Field
Brooklyn, NY 11234

Hello Ms. Tripp,

Two recent New York Sea Grant projects dealing with estrogenicity have produced multiple publications that you might find interesting. The projects are:

- 1) McElroy & Elskus (R/CTP-25) "Estrogenicity of Municipal Sewage Treatment Plant Effluents: Vitellogenic and Estrogen Receptor Responses in Striped Bass"
- 2) McElroy & Schreiber (R/CTP-28) "Endocrine Disruption in Jamaica Bay: Are Winter Flounder Being Affected?"

I am sending copies of several recent publications stemming from these projects and a research impact statement I put together summarizing this work. These documents are for your information and files, and to share with anyone who might find this information valuable.

One of Sea Grant's objectives is to demonstrate how the New York Sea Grant research program has influenced or been useful to society (including industry, government, and the public), the economy and the environment. It is important to show the impacts of our program on the many issues it intended to address and to document cases where results from projects have been used for the benefit of interested Stakeholders. In these trying fiscal times, accountability for federal funding is even more important.

I will contact you in a few months to see what you thought of this work, to see if this information was useful to you or if you have passed some of this on to other who might find it useful.

Best Regards

Patrick Dooley
Research Program Coordinator
631-632-9123
patrick.dooley@stonybrook.edu

I have attached an impact statement for these projects for your information and files.

I have also enclosed the following publications:

- 1) Ferguson, P.L., R.F. Bopp, S.N. Chillrud, R.C. Aller, and B.J. Brownawell. 2003. Biogeochemistry of Nonylphenol Ethoxylates in Urban Estuarine Sediments, *Environ. Sci. Technol.*, 37:3499-3506.
- 2) Ferguson, P.L. 2002. Analysis and Fate of Sewage-Derived Polar Organic Contaminants in the Coastal Marine Environment. Thesis 255 pp. Abstract only.
- 3) Ferguson, P.L. and B.J. Brownawell. 2003. Degradation of Nonylphenol Ethoxylates in Estuarine Sediment Under Aerobic and Anaerobic Conditions. *Environ. Toxicol. Chem.* 22(6):1189-1199.
- 4) Ferguson, P.L., C.R. Iden and B.J. Brownawell. 2001. Analysis of Nonylphenol and Nonylphenol Ethoxylates in Environmental Samples by Mixed-Mode High-Performance Liquid Chromatography-Electrospray Mass Spectrometry. *J Chromatogr.* 938:79-91.
- 5) Ferguson, P.L. C.R. Iden, A.E. McElroy, and B.J. Brownawell. 2001. Determination of Steroid Estrogens in Wastewater by Immunoaffinity Extraction Coupled with HPLC-Electrospray-MS. *Anal. Chem.* 73:3890-3895.
- 6) Ferguson, P.L., C.R. Iden and B.J. Brownawell. 2001. Distribution and Fate of Neutral Alkylphenol Ethoxylate Metabolites in a Sewage-Impacted Urban Estuary. *Environ. Sci. Technol.* 35:2428-2435.
- 7) Mena, L. 2004. Endocrine Disruption in Winter Flounder (*Pleuronectes americanus*): in Jamaica Bay, NY. Thesis 42 pp. Abstract only.
- 8) Reddy, S., C.R. Iden and B.J. Brownawell. 2005. Analysis of Steroid Conjugates in Sewage influent and Effluent by Liquid Chromatography-Tandem Mass Spectrometry. *Anal. Chem.* 77:7032-7038.
- 9) Reddy, S. and B.J. Brownawell. 2005. Analysis of Estrogens in Sediment from a Sewage-Impacted Urban Estuary Using High-Performance Liquid Chromatography/Time-of-Flight Mass Spectrometry. *Environ. Toxicol. Chem.* 24(5):1040-1047.
- 10) Roy, L.A. 2002. Assessing Sediment Quality using Biomarkers in Various Flatfish Species off the Coast of Southern California. Thesis 100 pp. Abstract only.
- 11) Schlenk, D., Y. Sapozhnikova, M.A. Irwin, L. Xie, W. Hwang, S. Reddy, B.J. Brownawell, J. Armstrong, M. Kelly, D.E. Montagne, E.P. Kolodzie, D. Sedlak, and S. Snyder. 2005. In Vivo Bioassay-Guided Fractionation of Marine Sediment Extracts from the Southern California Bight, USA, for Estrogenic Activity. *Environ. Toxicol. Chem.* 24(11):2820-2826
- 12) Swartz, C.H., S. Reddy, M.J. Benotti, H. Yin, L.B. Barber, B.J. Brownawell, and R.A. Rudel. 2006. Steroid Estrogens, Nonylphenol Ethoxylate Metabolites, and other Wastewater Contaminants in Groundwater Affected by a Residential Septic System on Cape Cod, MA. *Environ. Sci. Technol.* 40:4894-4902.
- 13) Todorov, J.R. A.A. Elskus, D. Schlenk, P.L. Ferguson, B.J. Brownawell, and A.E. McElroy. 2002. Estrogenic Responses of Larval Sunshine Bass (*Morone saxatilis* X *M. chrysops*) Exposed to New York City Sewage Effluent. *Mar. Environ. Research.* 54:691-695.

Research Impact Statement

Endocrine Disrupting Compounds

Anne E. McElroy; R/CTP-25

Estrogenicity of Municipal Sewage Treatment Plant Effluents: Vitellogenic and Estrogen Receptor Responses in Striped Bass

Anne E. McElroy; R/CTP-28

Endocrine Disruption in Jamaica Bay: Are Winter Flounder Being Affected?

I. Background & Need

In the 1990s, the potential impact of contaminants altering hormonal status and reproductive success of wildlife species became a global environmental issue. Collectively these compounds are termed endocrine disruption compounds or EDCs. In some areas of Europe, widespread evidence of exposure to estrogenic EDCs was documented. In the following decade increased availability of more sensitive analytical techniques demonstrated the presence of biologically significant concentrations of two groups of compounds with estrogenic activity (natural and synthetic estrogens, and nonylphenol, a breakdown product belonging to a common class of surfactants the alkylphenol ethoxylates used in many products including industrial detergents) in inland and coastal waters. Regulatory agencies in the U.S. and Europe scrambled to develop procedures for evaluating endocrine disruptive capabilities for new compounds as well as those already licensed for use. A major source of EDCs to aquatic and estuarine environments comes from sewage treatment plants (STPs). Although EDCs are metabolized during secondary (biological) sewage treatment, the resulting products can be more toxic and persistent in the environment than their parent compounds. At the time this project started, little was known about the degree of EDCs contamination or their effects on native fish populations in the New York metropolitan region.

II. The Projects

The first project teamed Drs. Anne McElroy, Bruce Brownawell & Charles Iden of Stony Brook University with Dr. Adria Elskus from the University of Kentucky and Dr. Daniel Schlenk from the University of Mississippi. This team of researchers examined three New York City STPs looking at estrogenic effects on striped bass and the concentrations of compounds known to be estrogenic in sewage effluent providing for the first time chemical and toxicological data from NYC area STPs to managers and environmental groups.

The second project paired Dr. Anne McElroy from Stony Brook University with Dr. Martin Schreiber from Brooklyn College – CUNY and expanded on the previous projects to study the effects of chronic exposure to environmental estrogen mimics using a resident benthic fish, winter flounder, as a model species of exposure in the field. Specifically, they looked to see if winter flounder were being feminized, impaired reproductively and to see if the metabolite nonylphenol could be implicated in any adverse effects observed in winter flounder in Jamaica Bay, NY.

III. Results & Accomplishments

Application of newly developed state of the art, extremely sensitive, liquid chromatography-mass spectroscopy (LC-MS) methods indicated levels of the natural estrogens, estradiol and

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estrone to range from 5 to 18 parts per trillion (ng/L) in sewage from the three STPs. Levels of the estrogenic detergent break-down products, nonylphenol and its 1,2, and 3 ethoxylate metabolites (collectively termed NPEOs) were thousands to tens of thousand times higher, ranging from 100 to 600 parts per billion (µg/L). Effluent from the largest, oldest, and least effective STP, Newtown Creek, proved to be highly estrogenic to juvenile striped bass increasing levels of the egg yolk precursor protein vitellogenin, normally elevated only in ripe female fish, by up to 200 times over levels observed in fish not exposed to effluent.

Young flounder throughout Jamaica Bay showed biochemical signs of exposure to estrogenic compounds in their environment. The Jamaica Bay winter flounder had high levels of an egg yolk precursor protein (vitellogenin). Young winter flounder also showed signs of female reproductive tissues within the testes of male fish, a condition known as ovo/testes. Altered sex ratios were also observed in Jamaica Bay winter flounder with many more females caught than males as compared to the reference site Shinnecock Bay, NY. Preliminary evidence also indicated that healthy winter flounder embryos exposed to sediment from Jamaica Bay showed delayed development and reduced hatching success. Winter flounder exposed to sediments dosed with nonylphenol showed some of the same responses seen in fish collected from Jamaica Bay, indicating that this estrogenic contaminant could be responsible for the effects observed.

This work demonstrates the importance of treatment level in the ability of sewage treatment plants to remove polar compounds such as the nonylphenol exthoxylates (NPEOs) from effluent. It also provides some of the first direct evidence of endocrine disruption in wild fish (striped bass and winter flounder) exposed to sewage-derived endocrine disruptors, particularly nonylphenol, in New York waters. This information could support legislation to limit use and release of these potent chemicals into the coastal environment.

Aspects of this work have been picked up by the popular scientific press, appearing in the *Amicus* journal Rivlin, M.A. 2000, "The Next Big, Bad Thing". McElroy was invited to speak on the subject at a special session on emerging issues at the Society of Environmental Journalists. Additionally, multiple publications have resulted from applying methods developed as part of this project.

The results of this work have led to several additional major funded research projects, totally over \$1.2 million, in McElroy and Brownawell's laboratory. These leveraged funds led to the development of an environmental mass spectrometry facility housed at the Marine Science Research Center, Stony Brook University that brings in between \$70,000 – 100,000 per year. Orange County California has used these methods to test out new treatment technologies for removing estrogen from sewage effluent.

IV. Students

Three students successfully completed their degree programs from this suite of projects. Dr. Patrick Ferguson received his PhD from Stony Brook University in 2002 for his dissertation entitled: Analysis and Fate of Sewage-Derived Polar Organic Contaminants in the Marine Environment. For his efforts, he received the President's Award for Distinguished Doctoral Student in 2002 from Stony Brook University. He is currently an assistant professor in the Department of Chemistry and Biochemistry at the University of South Carolina.

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Luck Roy received his Master's degree in 2002 from Stony Brook University for his thesis entitled: Assessing Sediment Quality Using Biomarkers in Various Flatfish Species Off the Coast of Southern California. He has since entered the doctoral program at Auburn University in Alabama.

Lourdes Mena received her Master in 2004 from Stony Brook University for her thesis entitled: Endocrine Disruption in Winter Flounder (*Pseudopleuronectes americanus*): In Jamaica Bay, NY. She is currently working on her doctorate on a continuation of this project at Stony Brook University.

V. Publications

- 1) Ferguson, P.L., R.F. Bopp, S.N. Chillrud, R.C. Aller, and B.J. Brownawell. 2003. Biogeochemistry of Nonylphenol Ethoxylates in Urban Estuarine Sediments, *Environ. Sci. Technol.* 37:3499-3506.
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- 4) Ferguson, P.L., C.R. Iden and B.J. Brownawell. 2001. Analysis of Nonylphenol and Nonylphenol Ethoxylates in Environmental Samples by Mixed-Mode High-Performance Liquid Chromatography-Electrospray Mass Spectrometry. *J Chromatogr.* 938:79-91.
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- 6) Ferguson, P.L., C.R. Iden and B.J. Brownawell. 2001. Distribution and Fate of Neutral Alkylphenol Ethoxylate Metabolites in a Sewage-Impacted Urban Estuary. *Environ. Sci. Technol.* 35:2428-2435.
- 7) Mena, L. 2004. Endocrine Disruption in Winter Flounder (*Pleuronectes americanus*): in Jamaica Bay, NY. Thesis 42 pp.
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- 9) Reddy, S. and B.J. Brownawell. 2005. Analysis of Estrogens in Sediment from a Sewage-Impacted Urban Estuary Using High-Performance Liquid Chromatography/Time-of-Flight Mass Spectrometry. *Environ. Toxicol. Chem.* 24(5):1040-1047.
- 10) Roy, L.A. 2002. Assessing Sediment Quality using Biomarkers in Various Flatfish Species off the Coast of Southern California. Thesis 100 pp.
- 11) Schlenk, D., Y. Sapozhnikova, M.A. Irwin, L. Xie, W. Hwang, S. Reddy, B.J. Brownawell, J. Armstrong, M. Kelly, D.E. Montagne, E.P. Kolodzie, D. Sedlak, and S. Snyder. 2005. In Vivo Bioassay-Guided Fractionation of Marine Sediment Extracts from the Southern California Bight, USA, for Estrogenic Activity. *Environ. Toxicol. Chem.* 24(11):2820-2826
- 12) Swartz, C.H., S. Reddy, M.J. Benotti, H. Yin, L.B. Barber, B.J. Brownawell, and R.A. Rudel. 2006. Steroid Estrogens, Nonylphenol Ethoxylate Metabolites, and other Wastewater Contaminants in Groundwater Affected by a Residential Septic System on Cape Cod, MA. *Environ. Sci. Technol.* 40:4894-4902.
- 13) Todorov, J.R. A.A. Elskus, D. Schlenk, P.L. Ferguson, B.J. Brownawell, and A.E. McElroy. 2002. Estrogenic Responses of Larval Sunshine Bass (*Morone saxatilis* X *M. chrysops*) Exposed to New York City Sewage Effluent. *Mar. Environ. Research.* 54:691-695.