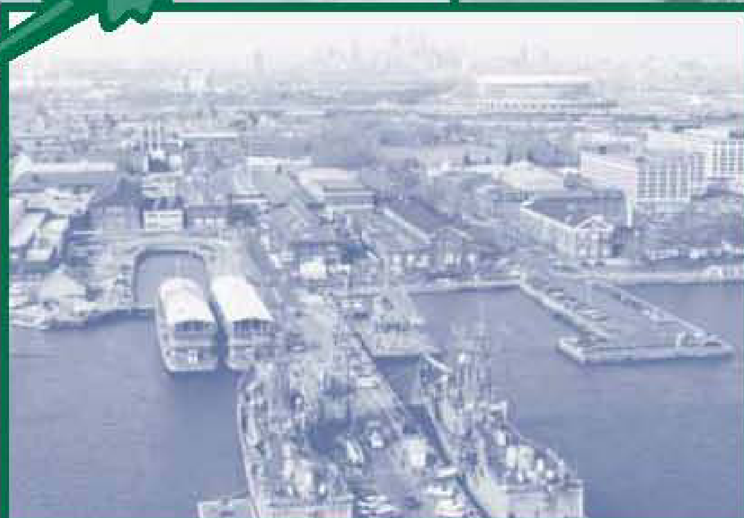
DELAWARE ESTUARY SCIENCE CONFERENCE 2005



COMPREHENSIVE PROGRAM

The State of Science in the Delaware Estuary
Cape May, New Jersey
January 10–12, 2005

Linking Science & Management for the Delaware Estuary
Newark, Delaware
May 10–11, 2005

PARTNERSHIP FOR THE DELAWARE ESTUARY INC.

PARTNERSHIP FOR THE DELAWARE ESTUARY, INC

Proceedings of the First Delaware Estuary Science Conference 2005

The State of Science in the Delaware Estuary
The Grand Hotel
Cape May, New Jersey
January 10 – 12, 2005

Linking Science and Management for the Delaware Estuary
Clayton Hall, University of Delaware
Newark, Delaware
May 10 - 11, 2005

A Publication of the
Partnership for the Delaware Estuary – A National Estuary Program
Report Number 05-01

Sponsors

Academy of Natural Sciences, Delaware Department of Natural Resources and Environmental Control, Delaware River Basin Commission, Delaware Sea Grant, DuPont, McCabe & Associates, National Fish and Wildlife Foundation, National Oceanic and Atmospheric Administration, New Jersey Coastal Zone Management Program, Pennsylvania Department of Environmental Protection, Coastal Zone Management Program, Pennsylvania Sea Grant, Philadelphia Water Department, PSEG, United States Environmental Protection Agency, United States Geological Survey

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Suggested Method for Referencing this Document:
Kreeger, Danielle A., editor. 2005. Proceedings of the First Delaware Estuary Science Conference. Partnership for the Delaware Estuary. Report #05-01. 110 pp.

Contents

Note: *This proceedings document contains information on more than 110 presentations from both the January and May 2005 meetings.*

Conceptual Framework

Prior to 2005, it had been nearly ten years since a science-oriented meeting was held to discuss the state of research and knowledge related to the Delaware Estuary. Recognizing this void, the Partnership for the Delaware Estuary: a National Estuary Program designed a two-part conference to bring researchers, resource managers, the public, and other interested parties together to summarize the **current state of science** in the system and to build consensus in defining and prioritizing **future science needs** for the Estuary.

Goals

Our goals were to bring together various groups who have a vested interest in the science of the Delaware Estuary and to assess the current state of knowledge about the system. We also wanted to foster development of a **new community spirit** by bringing scientists, resource managers and other parties interested in science together from both sides of the bay, the lower bay, the upper freshwater tidal reaches, and the watershed, to discuss current topics and future needs.

Looking to the future, we challenge this community to work together to share past knowledge, integrate present activities, and help build a **communication network** to coordinate and **chart science needs** for the Delaware Estuary. By strengthening science coordination, we intend to strengthen our capability to respond to current and emerging issues of special concern. The November 2004 oil spill provided a case study for how coordination of local scientists and scientific information could be improved. A special session addressing this unfortunate event was added to the program at the January meeting, and an update on this event was included as part of the May meeting. As part of our efforts to strengthen science coordination in the Estuary, we plan to develop a resource directory listing scientists and associated individuals throughout the basin. Web-based scientific resources hosted by the Partnership for the Delaware Estuary are also being considered to provide a common point of reference and contact for discussion of current topics by the scientific community.

Another important objective of the conference was to strategize ways to **strengthen energy and enthusiasm** for the science of the Delaware Estuary. One important message that was widely articulated was the need to raise awareness about the unique and important characteristics of our system and establish the basis to resolve the disparities in science funding between the Delaware and other mid-Atlantic/New England estuaries. Key messages and findings from the conference will be summarized and made available via the website of the Partnership for the Delaware Estuary.

Format

The conference consisted of eleven sessions and more than 100 presentations. The January meeting included Sessions 1-7 and was oriented toward research scientists who are most interested in how the system works and who are actively engaged in collecting or interpreting scientific information. Session 7 was included in the January program to address the Athos I oil spill that occurred in November, 2004.

The May portion of the conference was designed to be more issue-oriented and of special interest to those who rely on scientific information, such as resource managers, the public, and the various stakeholder user groups in the Estuary. In both events, all presenters, moderators and attendees were asked to assess the current state of science in the Estuary and to help prioritize science needs for guiding future science in the Estuary. The themes of the two meetings were:

***"The State of Science in the Delaware Estuary,"* Sessions 1-7**
January 10-12, 2005, Cape May, NJ

***"Linking Science and Management for the Delaware Estuary,"* Sessions 8-11**
May 10-11, 2005, Newark, DE

The four-month interval between the two events was used to compile interim summaries regarding the current state of our knowledge from the research scientists' perspective. These summaries were prepared by moderators from January for delivery as short recap talks to launch each of the sessions in May. Whereas most of the oral presentations given in January were contributed, the presenters at the May meeting were selected to ensure that science needs would be addressed from the perspective of resource managers and other stakeholders. The number of oral presentations for the May meeting was capped to limit the duration of the meeting and to minimize overlap of topic coverage. Contributed poster presentations represented an important component of both the January and May meetings.

Participants included scientists, resource managers, agency personnel, industry representatives, conservation groups, and the public. All presenters and attendees were asked to provide input on the most pressing scientific issues, data gaps, and recommendations for guiding future science funding within the system. This input was collected in presentations, workshops, question and answer sessions, and via written answers on the questionnaires in program packets. Following the conference, moderators are being asked to work with the Partnership to summarize presentations and other input. An integrated summary will be prepared, which will strengthen our conceptual framework for how the system works, help us prioritize future science, restoration and monitoring needs, supply information to guide science policy, and provide new tools to build national awareness for the special attributes of the Delaware Estuary Ecosystem.

Summary of January Program

MONDAY JANUARY 10, 2005

8:30	Registration, Poster Set-Up
10:30	Opening Remarks: The Partnership for the Delaware Estuary Kathy Klein, Executive Director Martha Maxwell-Doyle, Danielle Kreeger
10:45	Keynote Speaker: **Jonathan Sharp** *"The Delaware Estuary: 400 Years of Hostile Occupation and the Future of Science-Based Management"*
11:45	Lunch
1:15	**Session 1**. Hydrodynamics & Water Relations
2:15	Session change
2:30	**Session 2**. Biogeochemistry & Water Quality
3:15	Break
3:45	Session 2 continued
4:45	Dinner
7:00-11:00	Reception and Plenary Speaker: **John Teal** *"The State of Science in the Delaware Estuary"*

TUESDAY JANUARY 11, 2005

8:00	**Session 3**. Benthic Communities
10:00	Break
10:20	**Session 4**. Pelagic Communities
12:10	Lunch
1:20	**Session 5.** Edge Communities & Watershed Linkages
3:10	Break
3:30	**Session 6.** Data Gaps, Management & Interpretation
5:20	**Poster Session**
7:00-9:30	**Dinner Workshops** and Discussion

WEDNESDAY JANUARY 12, 2005

8:30	**Roundtable Workshops** and Discussion for Sessions 1-6
10:00	Break
10:20	**Session 7**. The Delaware Estuary Oil Spill
12:20	Closing Remarks

Summary of May Program

TUESDAY MAY 10, 2005

8:00	Registration, Poster Set-Up
9:00	Opening Remarks
9:15	Keynote Speaker
	Congressman **Mike Castle**
9:45	Meeting Intent and Format
9:55	**Session 8.** Water Resources
10:50	Break (stretch)
11:00	Session 8 Continued
12:00	Lunch
	Plenary Speaker: **Rebecca Hanmer**
	"Lessons from the Chesapeake Bay Program Experience"
1:15	Session 8 Continued
2:35	Break
2:55	**Session 9.** Living Resources
5:10	**Poster Session** & Reception
6:30	Buffet Dinner and Evening Presentations
6:45	Plenary Speaker: **Jonathan Sharp**
	"The Delaware Estuary: 400 Years of Hostile Occupation and the Future of Science-Based Management"
7:05	Plenary Speaker: **Eric Powell**
	"Challenges for the Successful Management of the Delaware Bay Oyster Beds of NJ: Is Stock Sustainability a Reachable Goal?"
7:30-9:00	Free Discussion

WEDNESDAY MAY 11, 2005

8:30	**Session 10**. Edges & Watershed Linkages
10:50	Break
11:00	**Special Panel:** Moderator: Mike McCabe
	Invitees: Kathleen Callahan, Bradley Campbell, John Hughes, Cathy Curran Myers, Merdith W.B. Temple, and Donald Welsh
	"Next Steps: What is Needed for a Sustainable Commitment to Improve the Health of the Delaware Estuary?"
12:20	Lunch & **Oil Spill Update**
1:35	**Session 11**. Management Goals & Needs, Data Coordination & Advocacy
3:00	Break
3:20	Session 11 Continued
4:40	Conference Closing Remarks

Featured Speakers *(listed alphabetically)*

Congressman Mike Castle

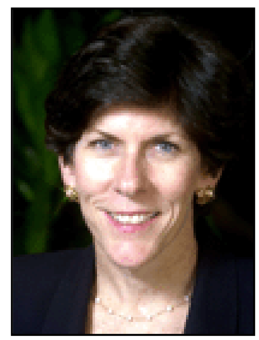
Keynote Speaker, Tuesday 10 May, 9:15

A former Deputy Attorney General, state legislator, Lieutenant Governor and two-term Governor of Delaware, Mike Castle is currently serving a record seventh term as Delaware's lone Member in the House of Representatives.

Mike Castle has played a key role in enacting many important laws that improve the lives of both Delawareans and Americans alike. Castle chairs the Education and Reform Subcommittee and remains dedicated to education reform to ensure students receive a quality, lasting education. Over the past year Castle saw his Child Nutrition Program and the Individuals with Disabilities Education Act (IDEA) signed into law.

Castle also serves on the House Financial Services Committee, which has jurisdiction over banking with the securities and insurance industries. Among Castle's other priorities are immigration reform, stem cell research, deficit reduction and implementing his vision to turn the Chesapeake & Delaware Canal into a recreational area for biking, hiking, fishing, and running.

Linda J. Fisher



VP & Chief Sustainability Officer, DuPont

Introduction of Congressman Castle, Tuesday 10 May, 9:05 am

Linda J. Fisher is vice president and chief sustainability officer. She has responsibility for advancing DuPont's progress in achieving sustainable growth; DuPont environmental and health programs; the company's product stewardship programs; and global regulatory affairs. She joined DuPont in June 2004. Prior to joining DuPont, Ms. Fisher has served in a number of key leadership positions in government and industry including: deputy administrator of EPA; EPA assistant administrator – Office of Prevention, Pesticides and Toxic Substances; EPA assistant administrator – Office of Policy, Planning and Evaluation; and chief of staff to the EPA Administrator. Fisher, an attorney, was also vice president of Government Affairs for Monsanto and counsel with the Washington, D.C., office of the law firm, Latham & Watkins.

Ms. Fisher received a law degree from Ohio State University, a master's of business administration from George Washington University and a B.A. from Miami University. She is a member of the DuPont Health Advisory Board, the DuPont Biotechnology Advisory Panel and serves as liaison to the Environmental Policy Committee of the DuPont Board of Directors. Ms. Fisher serves on the board of directors of the Environmental Law Institute and on the board of trustees of The National Parks Foundation.

Rebecca Hanmer

Director, Chesapeake Bay Program Office

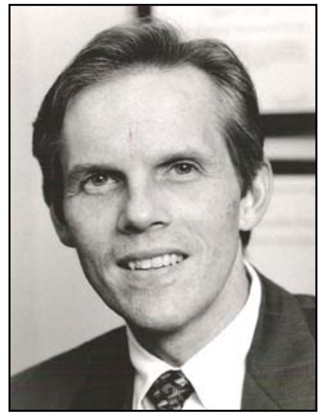
Plenary Speaker, Tuesday 10 May, 12:00 pm

Rebecca Hanmer was named Director of EPA's Chesapeake Bay Program Office, Region III, in April 2002, after serving as the Region's Water Protection Division Director. She has held a number of executive positions in USEPA in the past 25 years, including Acting Regional Administrator - Region VIII (Denver) during 2000, Acting Assistant Administrator for Water, Deputy Assistant Administrator for Water, Regional Administrator - Region IV (Atlanta), Deputy Regional Administrator - Region I (Boston), Director of Water Enforcement and Permits, and Director of Federal Activities. From 1990-96, she worked at the Organization for Economic Cooperation and Development in Paris, where she led the Pollution Prevention and Control Division and managed OECD's Technology and Environment Program. Ms. Hanmer began her government career in 1964. Her first jobs in environmental protection were with the Department of Interior. She has received the Meritorious and Distinguished Federal Executive awards, as well as USEPA's Silver and Gold Medals. Born in Virginia, she earned B.A. and M.A. degrees in Government from the College of William and Mary and the American University. Her presentation at the Delaware Estuary Science Conference is titled **"Lessons from the Chesapeake Bay Program Experience."**

Featured Speakers (continued)

W. Michael McCabe

President, McCabe & Associates
Special Panel Moderator, Wednesday 11 May, 11:00 am



W. Michael McCabe is President of McCabe & Associates, a private consulting firm committed to addressing high-stakes energy and environmental projects, and policies and programs at the state and federal level. Clients include non-profit, state government and private sector interests.

McCabe brings to the position 30 years of energy and environmental policy experience including a term as a deputy member of the President¹s Cabinet where McCabe served as Deputy Administrator for the U.S. Environmental Protection Agency from 1999-2001. Together with Administrator Carol Browner and key Administration officials he ensured completion of President Clinton¹s far-reaching environmental policy initiatives.

Prior to his post in the No.2 slot at EPA, McCabe was Regional Administrator of the EPA's Mid-Atlantic Region. As Regional Administrator, he led the implementation of Federal environmental programs in Delaware, Maryland, Pennsylvania, Virginia, West Virginia, and the District of Columbia, and was the longest serving Administrator in the history of the Mid-Atlantic Region. Since he began his career, McCabe has held senior positions on congressional committees and non-profit organizations, including organizing and directing the national commemoration of the tenth anniversary of Earth Day in 1980.

Before joining EPA, McCabe served as Delaware Senator Joe Biden's Director of Communications and Projects representing the Senator throughout the state and applying national programs and policies to meet

specific needs in Delaware. Prior to that, he directed the staff of the U.S. House of Representatives Energy Conservation and Power Subcommittee from 1981 - 1985, and was Staff Director of the bipartisan Congressional Environmental and Energy Study Conference from 1976 - 1979. McCabe started his career in public service in 1975 as legislative assistant to Senator Gary Hart, where he specialized in environmental and energy policy.

Mike McCabe is moderator of a special panel at the Delaware Estuary Science Conference, titled **"Next Steps: What is Needed for a Sustainable Commitment to Improving the Health of the Delaware Estuary?"**

Featured Speakers (continued)

Eric N. Powell

Haskin Shellfish Research Laboratory

Plenary Speaker, Tuesday 10 May, 7:10 pm

Eric Powell presently serves as the Director of the Haskin Shellfish Research Laboratory and Aquaculture Technology Transfer Center at Rutgers University/New Jersey Agricultural Experiment Station. He has been an oceanographer/marine biologist for the past 26 years at Texas A&M University and at Rutgers University. Over that time, Powell has published over 160 articles in refereed journals. Powell is the leader or co-leader of several national programs including SSETI (Shelf and Slope Experimental Taphonomy Initiative), the biological component of NS&T (National Status and Trends) Mussel Watch, and the Rutgers/ODU shellfish modeling program. The oyster population dynamics model developed by Powell (and co-workers at ODU) is the only peer-reviewed model of its type in the world and has been used in the USACE Houston Ship Channel Project, the USACE Delaware Bay Ship Channel Project, and the NOAA ODR program. In coordination with the National Fisheries Institute, Powell runs a number of multi-agency cooperative survey programs, including the dredge calibration program for ocean quahogs with NMFS, the multispecies finfish transect survey in the Mid-Atlantic Bight with NMFS, and the stock assessment program for oysters in Delaware Bay with NJDEP. He has played a leading role in implementing the NOAA Research Set-Aside Program, a program by which fishermen in the Mid-Atlantic donate fish allocation to pay for science. Recently, Powell has headed up a multi-agency consortium focused on revitalizing the Delaware Bay oyster fishery. The following are the title and abstract for Eric Powell's presentation at the Delaware Estuary Science Conference.

"Challenges for the Successful Management of the Delaware Bay Oyster Beds of NJ: Is Stock Sustainability a Reachable Goal?" A stratified random stock survey has been conducted yearly on the New Jersey oyster beds since 1953. This is one of the longest running surveys of its kind. In 2004, the 51-year survey time series was quantitated retrospectively to determine whether biological reference points can be defined for management that consistently permit fishing without jeopardizing the sustainability of the stock. A surprisingly strong broodstock-recruitment relationship exists for oysters in Delaware Bay. The relationship is clearly compensatory and this compensation defines a carrying capacity for the Delaware Bay oyster beds. The fraction dying each year averages about 9.6% for non-epizootic years. The epizootic trajectory, however, is a depensatory relationship potentially defining a point-of-no-return abundance below which the population will collapse. Carrying capacity is estimated at about 1×10^{10} animals. Abundance at maximum sustainable yield, Amsy, is approximately 4.86×10^{9} animals. The maximum allowable fishing rate, fmsy, is approximately 0.080 $year^{-1}$, or the removal of 7.7% of the population annually. This can occur only in a narrow abundance range near Amsy. These low fishing mortality rates are more similar to the longest lived bivalves, such as geoducks and ocean quahogs than other species with life spans of the same order as the oyster and emphasize the fact that oysters are much more akin in their population dynamics to long-lived k-selected species than to short lived r-selected ones. Of greater importance is a point-of-no-return abundance below which the population is unlikely to recover to fishable levels. This abundance, on the order of 1.6×10^{9}, represents the point at which natural mortality will consistently exceed recruitment. Management must minimize the likelihood that abundance will drop to this level. The single greatest challenge for managers may be the inherently low recruitment rate in oyster populations. A one-year replacement event in Delaware Bay, 1 spat per adult, has occurred only 17 times in 52 years. A two-year replacement, 0.5 spat per adult, occurs only half the time. Thus oysters inherently are poorly insulated from the increased mortality associated with Dermo and MSX disease. Whether population stability can be achieved over the long term under these conditions is not yet known.

Featured Speakers (continued)

Jonathan Sharp, Ph.D.

Keynote Speaker, Monday 10 January, 10:45 am
Also Tuesday 10 May, 6:50 pm

photo by Kevin Fleming

Jonathan Sharp received his BA and MS degrees (Biology/Biochemistry) from Lehigh University and Ph D (Oceanography) from Dalhousie University. After a post-doctoral research experience at Scripps Institution of Oceanography, he joined the faculty of the University of Delaware in 1973 and is now a Professor of Oceanography there in the Graduate College of Marine Studies.

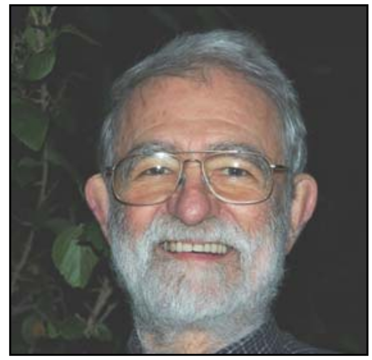
A major research direction throughout his career has been refinement of analytical chemical methodology and accuracy of the international marine community in routine biogeochemical measurements. Associated with this effort is his involvement with the Global Ocean Flux efforts related to climate change. He has had a 25-year research effort on the biogeochemistry of the Delaware Estuary. As an outgrowth, he has been involved with a number of activities related to the Delaware Estuary Program and other local cooperative resource management efforts for about 20 years. He is trying to return to an earlier research interest in tropical ecology with a new effort in coral reef carbon budget studies. His teaching has primarily been through courses in chemical oceanography and general oceanography. From his laboratory about 25 MS and Ph D students have been launched into a variety of academic, government, teaching, and industrial careers. The following are the title and abstract for Jonathan Sharp's presentation at the Delaware Estuary Science Conference.

"The Delaware Estuary: 400 Years of Hostile Occupation and the Future of Science-Based Management." It could be argued that the estuary of the Delaware River and Bay was the first and most extremely degraded estuary in the U.S. For almost 400 years, it suffered from careless use by the rapid growth in the greater Philadelphia area. It is a comparatively small estuary with a large human population and much stress from multiple demands on its resources. It serves as one of the major drinking water supplies and one of the largest port complexes in the U.S. From an environmental perspective, the impact of western civilization on the Delaware Estuary might be viewed as "hostile occupation". This presentation will review the rapid municipal and industrial growth in the area and impacts on water quality and environmental conditions. It will also discuss the remarkable improvements in water quality of the past few decades, but will recognize some of the current problems in environmental conditions. There is a need today to develop a more science-based management approach to the Delaware Estuary. Many good components for such an approach are available, such as some good beginnings of long-duration monitoring programs. However, the monitoring programs need revision and expansion. Also, there are significant gaps in basic information about the estuary that need more research. Perhaps, most critical is the need for a commitment among government agencies, non-government organizations, commercial interests, and the general public for development, ownership, and use of a cooperative research-monitoring-management approach for the estuary.

Featured Speakers (continued)

John Teal, Ph.D.

Plenary Speaker, Monday 10 January, 7:30 pm



John Teal is Senior Scientist Emeritus at Woods Hole Oceanographic Institution, and also a Partner of Teal Partners, USA. Dr. Teal's career and interest in aquatic systems began when his father gave him *The Pond Book* as a Christmas present when he was about seven years old. His professional career began in the early 1950s, with his Ph.D. thesis on the trophic relationships in a tiny cold spring in Massachusetts. After his degree, he joined the University of Georgia Marine Institute at Sapelo Island where he studied salt marshes. Four years later, Teal went to Dalhousie University in Halifax at the new oceanography establishment in eastern Canada. He joined Woods Hole Oceanographic Institution in 1961, and since 1995 he has been Scientist Emeritus there.

In addition to research on coastal wetlands, Teal has worked on the effects of hydrostatic pressure on deep-sea animals, physiology of large, warm-blooded fishes, bird migration over the oceans, oil pollution, wastewater treatment, and restoration ecology. He is now involved with the use of constructed wetlands for wastewater treatment and with marsh restoration in fresh, brackish, and salt wetlands. Teal has been active for 11years in a salt marsh restoration project in Delaware Bay and is on the National Science Committee for restoration of the salt ponds in South San Francisco Bay.

Teal has served on many National Academy committees, editorial boards of scientific journals, and has published in the scientific literature as well as written popular articles and books. He has a keen interest in the use of science for sound public policy. He has served on the board of the Conservation Law Foundation of New England since 1978, and been vice-chair since 1980. The following are the title and abstract for John Teal's presentation at the Delaware Estuary Science Conference.

"The State of Science in the Delaware Estuary." Delaware Bay, a drowned river valley like others on the east coast, is valuable to people and nature for many reasons. Delaware Bay is different from estuaries north and south of it - different in sediment loading and in the type of edge. In Delaware Bay, the silts and fines are abundant, resulting in less phytoplankton and little SAV compared to other estuaries, but there is more marsh and therefore more nursery habitat for commercial and recreational fishes. The distribution of sand within the system has changed over the centuries, in part because of human activities. Global warming and sea level rise change the Bay and the fringing marshes. Oil spills have readily observable short-term impacts but also long-term effects on the Bay ecosystem. Delaware Bay is muddy and marshy, but not static. It is an ideal estuary for marsh restoration.

Program Detail and Session Summaries
January, 2005 Meeting

(Each presentation was assigned a unique reference number, listed after each title)

Note Posters: All posters were aligned with a session theme, and they are therefore listed at the end of each session summary below. A comprehensive list of posters presented during both January and May meetings is also provided on pages 26-28. Posters were displayed throughout the meetings, and authors were asked to stand by their poster only during the poster session.

MONDAY JANUARY 10, 2005

10:45 Keynote Speaker: **Dr. Jonathan Sharp** ***"****The Delaware Estuary: 400 Years of Hostile Occupation and the Future of Science-Based Management"*

11:45-1:00 **LUNCH**

Session 1. ***Hydrodynamics & Water Relations***

Moderators: **Pierre LaCombe** (United States Geological Survey)
Jeff Fischer (United States Geological Survey)
Ralph Spagnolo (Environmental Protection Agency, Region 3)

1:15 Richard **Garvine**. "The present state of knowledge of the tidal and residual circulation in the Delaware Estuary and adjacent continental shelf." (#12)

1:30 Christopher **Sommerfield** and David Walsh. "Historical changes in the morphology of the subtidal Delaware Estuary." (#25)

1:45 Kuo-Chuin **Wong**. "On the Current Variability in the Upper Delaware Estuary." (#11)

2:00 Pierre **Lacombe**. "Saltwater intrusion into Cape May County aquifers from Delaware Bay." (#27)

Session 2. ***Biogeochemistry & Water Quality***

Moderators: **Jonathan Sharp** (University of Delaware)
Ed Santoro (Delaware River Basin Commission)

2:30 Jeffrey **Fischer,** Kristin Romanok, Robin Brightbill, Karen Riva-Murray, and Michael Bilger. "Organochlorine compounds and trace elements in fish tissue and streambed sediment in the Delaware River Basin, New Jersey, Pennsylvania, and New York, 1998-2000." (#36)

MONDAY JANUARY 10, 2005

Session 2 continued. ***Biogeochemistry & Water Quality***

2:45 R. Edward **Hickman**. "Pesticide compounds in streamwater of the Delaware River Basin, Pennsylvania, New Jersey, New York, and Delaware, December 1998 – August 2001." (#38)

3:00 Thomas **Church**, Christopher Sommerfield, David Velinsky, David Point, Christelle Benoit, David Amouroux, Daniel Plaa and Olivier Donard. "Marsh sediments as records of eutrophication and metal pollution in the urban Delaware Estuary." (#15)

3:15-3:45 **BREAK**

3:45 Ann **Faulds**, Nancy Connelly, Barbara Knuth, Jill Benowitz, Joe Matassino, Kevin Norton."Patterns of sport-fish consumption at six Pennsylvania sites along the tidal portion of the Delaware River with special emphasis on shore anglers." (#40)

4:00 Edward **Santoro**. "Water Quality in the Delaware Estuary." (#50)

4:15 Mary **Chepiga**, Susan Colarullo and Jeffrey Fischer. "Preliminary analysis of estimated total nitrogen and total phosphorus loads and factors affecting nutrient distribution within the Delaware River Basin." (#35)

4:30 David **Whitall**. "Quantitative modeling of nitrogen loading to Delaware Bay: sources, fluxes and management options." (#6)

Poster Jeffrey **Ashley**, David Velinsky, Matt Wilhelm, Joel Baker and Megan Toaspern. Polychlorinated biphenyl accumulation in Delaware River Estuary food webs." (#14)

Poster Rebecca **Hays** and William Ullman. "Attenuation of nitrogen fluxes during groundwater seepage across a beachface at Cape Henlopen, Delaware." (#34)

Poster David **Velinsky** and Jeffrey Ashley. "Water and sediment quality assessment of the tidal freshwater Schuylkill River, Philadelphia, PA: understanding sources and fate of nutrients and chemical contaminants." (#13)

4:45 – 7:00 **DINNER**

7:00 - 11:00 **RECEPTION**

7:30 – 8:00 Plenary Speaker: **Dr. John Teal** *"The State of Science in the Delaware Estuary"*

TUESDAY JANUARY 11, 2005

Session 3. ***Benthic Communities***

Moderator: **John Kraeuter** (Rutgers University)

8:15 Charles **Epifanio**. "Supply of blue crab postlarvae to juvenile habitat in Delaware Bay: a classic case of biophysical coupling." (#19)

8:30 Desmond **Kahn**. "Blue crab population dynamics in Delaware Bay: density dependent juvenile mortality and the relationship between spawning stock and recruitment." (#52)

8:45 Mark **Botton** and Robert Loveland. "Perspectives on the status of horseshoe crab research in Delaware Bay." (#20)

9:00 Susan **Ford** and David Bushek. "Oysters and oystering in Delaware Bay." (#54)

9:15 Frank **Steimle**. "The status and future of benthic macrofauna science in the Delaware Estuary." (#3)

9:30 Ian **Hartwell**, Larry Claflin and Jawed Hameedi. "Discerning impacts of sediment contamination on benthic communities in Delaware Bay." (#10)

9:45 Ryan **Dale** and Doug Miller. 3-D Thermal mapping shows the potential of intertidal groundwater seeps as a mechanism for structuring sandflat biodiversity." (#26)

Poster Russ **Babb**, Jason Hearon and David Bushek. "Use of surf clam shell to enhance oyster seed bed production in Delaware Bay." (#55)

Poster Sean **Boyd** and David Bushek. "Potential impact of the non-native marine *isopod Synidotea laevidorsalis* (Miers 1881) in the Delaware Bay." (#28)

Poster Stewart **Tweed** and James Tweed. "Restoration of the Cape May Salt Oyster." (#62)

Poster Stewart **Tweed**. "Utilizing native oyster seed to enhance oyster populations and aquaculture: the New Jersey experience." (#63)

10:00-10:30 **BREAK**

TUESDAY JANUARY 11, 2005

Session 4. ***Pelagic Communities***
Moderator: **Susan Kilham** (Drexel)

10:30 Lisa **Waidner**, Matthew Cottrell and David Kirchman. "Dynamics of photoheterotrophic bacteria in the Delaware Estuary." (#17)

10:45 David **Kirchman**."Bacterial production and respiration in the Delaware Estuary." (#18)

11:00 Kohei **Yoshiyama**. "High nutrient and low growth in the Delaware Estuary: evaluation of primary production using a long-term database." (#47)

11:15 Christopher **Ottinger** and Jed Brown. "Mycobacterial infections in striped bass (*Morone saxatilis*) from Delaware Bay." (#33)

Poster Edward **Santoro**. "Aquatic Resources of the Delaware Estuary." (#51)

11:20-12:50 **LUNCH**

Session 5. ***Edge Communities and Watershed Linkages***
Moderators: **Danielle Kreeger** (Delaware Estuary Program)
Daniel Soeder (United States Geological Survey)

12:50 Denise **Seliskar**, John Gallagher, Jiangbo Wang and Michael League. "Mitigating problems in the Delaware Estuary: selecting plants to hone the functions of the edges." (#30)

1:15 David **Smith**, Lorne Brousseau, Kevin Kalasz, Karen Bennett and Michael Millard. "Species interactions along edge communities of the Delaware Bay Estuary: using a baywide telemetry array to track horseshoe crabs and migrant shorebirds." (#43)

1:30 Nancy **Jackson**, David R. Smith and Karl Nordstrom. "Beach dynamics, shore protection and habitat restoration for horseshoe crabs in Delaware Bay, USA." (#37)

1:45 Eric **Stiles** and David Mizrahi. "Meta-analysis of horseshoe crab and shorebird research on the Delaware Bay - are there enough horseshoe crab eggs to sustain spring shorebird migration?" (#39)

TUESDAY JANUARY 11, 2005

Session 5 continued. ***Edge Communities and Watershed Linkages***

2:00 Barnett **Rattner**, Pamela Toschik and Peter McGowan. "Ospreys of Delaware River and Bay: contaminant exposure, reproduction and habitat suitability." (#1)

2:15 Harold **Avery**, Karen Klein, James Spotila and Walter Bien. "Ecology and population structure of a model community of vertebrates in wetland habitats in the Delaware Estuary ecosystem: a case study of the effects of habitat fragmentation, modification, and isolation on turtles." (#7)

2:30 Barbara **Bell**. "High incidence of deformity in aquatic turtles in the John Heinz National Wildlife Refuge." (#32)

2:45 Kenneth **Strait**. "Use of Alaska Steeppass fishways to promote herring passage at low-head dams on Delaware Estuary tributaries." (#41)

3:00 Danielle **Kreeger**. "A holistic view of the conservation and propagation of freshwater, brackish and estuarine bivalves for ecosystem services." (#2)

Poster Michael **League**, Denise Seliskar and John Gallagher. "Dr. Jekyll and Mr. Hyde: Comparing the rhizome growth dynamics of native and non-native populations of *Phragmites australis*." (#48)

Poster Daniel **Soeder** and Dixie Birch. "Deterioration of a mid-Atlantic coastal marsh." (#5)

Poster Jiangbo **Wang**, Denise Seliskar and John Gallagher. "Tissue culture generated native marsh plants: an alternative plant resource for wetland creation and restoration." (#49)

3:15-3:45 **BREAK**

Session 6. ***Data Gaps, Management & Interpretation***

Moderators: **Jawed Hameedi** (National Oceanic and Atmospheric Administration)
Ed Santoro (Delaware River Basin Commission)

3:45 Mohsen **Badiey** and Kuo Wong. "Delaware Bay Observing System (DBOS)." (#16)

4:00 Alfred **Pinkney** and John Harshbarger. "Using fish tumor surveys to evaluate habitat quality in the Delaware Estuary watershed." (#21)

TUESDAY JANUARY 11, 2005

Session 6 continued. ***Data Gaps, Management & Interpretation***

4:15 Shawn **Shotzberger**. "Visualizing fisheries data – the temporal integration of a comprehensive, multi-gear dataset in the Delaware Estuary." (#42)

4:30 Gunnar **Lauenstein** and Jawed Hameedi. "Status and temporal trends of toxic contaminants in Delaware Bay: evidence from bivalve tissues." (#22)

4:45 John **Kraeuter**, Stephen Fegley and Eric Powell. "Long-term data sets on the biology and ecology of the American oyster, *Crassostrea virginica*, in Delaware Bay." (#31)

5:00 David **Smith**, Benji Swan, Bill Hall, Stewart Michels, Sherry Bennett and Katy O'Connell. "Spatial and temporal distribution of horseshoe *crab (Limulus polyphemus*) spawning in Delaware Bay: insights from six years of standardized monitoring." (#44)

5:15 John **Young**, Ann Rafter, David Smith and Wayne Wright. "Use of LIDAR remote sensing to characterize beach morphology for a study of horseshoe crab habitat selection in the Delaware Bay." (#45)

Poster Craig **Bartlett**, Ralph Stahl and Christine Wallace. "Developing a GIS database for the Delaware River." (#53)

5:20-7:00 **POSTER SESSION**

7:00-9:30 **DINNER WORKSHOPS: SESSION SYNTHESES**

WEDNESDAY JANUARY 12, 2005

8:30-10:00 **ROUNDTABLE WORKSHOPS: FUTURE SCIENCE NEEDS**

10:00-10:20 **BREAK**

Session 7. ***The Athos I Oil Spill and Its Impact on the Delaware Estuary***
Moderator: **Thomas Fikslin** (Delaware River Basin Commission)

10:20 Lyle **Trumball**, O'Brien and Gere Consulting - Summary of the event.

10:40 Sherry **Krest**, United States Fish and Wildlife Service - Summary of Immediate Impacts and Plans to Assess Long-Term Impacts

WEDNESDAY JANUARY 12, 2005

Session 7 continued.

11:10 Questions and Answers Forum. A panel consisting of speakers and representatives from the states affected will address questions from the audience.

12:00 Tom **Fikslin**, DRBC. Recommendations for assessing the long-term impacts and for response to future spills.

Challenge Questions for Conference Attendees to consider in advance of Session 7:

- Were you satisfied with the way information was disseminated on the Oil Spill?
- Do you feel that local knowledge on the estuary was used effectively in planning the initial response and assessing immediate impacts?
- What are your specific recommendations for long-term monitoring and assessment?
- Do you feel that there is a need for a coordinated effort to provide local knowledge for future spills?

12:20 **CLOSING REMARKS – JANUARY MEETING**

Program Detail and Session Summaries
May, 2005 Meeting

(Each presentation was assigned a unique reference number, listed after each title)

Note About Posters: All posters were aligned with a session theme, and they are therefore listed at the end of each session summary below. A comprehensive list of posters presented during both January and May meetings is also provided on pages 26-28. Posters were displayed throughout the meetings, and authors were asked to stand by their poster only during the poster session.

TUESDAY MAY 10, 2005

9:00 Opening Remarks
Kathy Klein, Executive Director, Partnership for the Delaware Estuary

9:05 Welcome Comments
Linda Fisher, Senior Vice-President, DuPont

9:15 Keynote Speaker
Congressman Mike Castle

9:45 Meeting Intent and Format
Danielle Kreeger, Science Coordinator, Delaware Estuary Program

Session 8. *Water Resources*

Lead Moderator: **Bob Tudor (**Delaware River Basin Commission)
Co-Moderators: **Jeff Fischer** (United States Geological Survey)
Jonathan Sharp (University of Delaware)

9:55 Bob **Tudor**. Session 8 Introduction

10:00 Jeff **Fischer**. Summary of Session 1 (Hydrodynamics & Water Relations)

10:05 Jonathan **Sharp**. Summary of Session 2 (Biogeochemistry & Water Quality)

10:10 Rick **Fromuth** and Hernan Quinodoz. "Technical support needs for estuary inflow policy decision making." (#76)

10:30 Colin **Apse**, Jeffrey Hoffman and Susan Ford. "Freshwater inflow management and the Delaware Estuary: assessing ecological consequences and future approaches." (#82)

10:50 **BREAK** (stretch)

TUESDAY MAY 10, 2005

Session 8 continued. ***Water Resources***

11:00 Tom **Fikslin**. "Scientific issues in developing TMDLs: PCBs in the Delaware Estuary." (#75)

11:20 Chris **Crockett**. "Endocrine disruptors, bacteria source tracking, BMP monitoring: managing emerging issues in Delaware Estuary tributaries." (#70)

11:40 Ifeyinwa **Davis**. "Developing nutrient criteria for estuaries: an update on Delaware Estuary and USEPA's perspectives." (#71)

12:00 **LUNCH**

12:15 Plenary Speaker (during lunch): **Rebecca Hanmer** (Director, Chesapeake Bay Program, EPA) *"Lessons from the Chesapeake Bay Program Experience"* (#98)

Session 8 continued. ***Water Resources***

1:15 Jim **Titus**. "… And the good news is that the Delaware Estuary is less vulnerable to rising sea level than Chesapeake Bay." (#79)

1:35 Lt. Colonel Robert **Ruch**. "The Corps' role in the Delaware River." (#86)

1:55 Ronald **MacGillivray** and Tom Fikslin. "Biological indicators of water quality." (#67)

Poster Ronald **Baker** and Kathryn Hunchak-Kariouk. "Relations of water quality to land use in drainage basins of four tributaries to the Toms River, Ocean County, New Jersey." (#29)

Poster Jeffrey **Hoffman** and Steven Domber. "Water withdrawals and transfers in the Delaware River Basin in New Jersey." (#4)

2:15 Moderator-facilitated Q & A for Session 8

2:35 **BREAK**

TUESDAY MAY 10, 2005

Session 9. ***Living Resources***

Lead Moderator: **Dorina Frizzera (**NJ Department of Environmental Protection)
Co-Moderators: **John Kraeuter** (Rutgers University)
Sue Kilham (Drexel University)

2:55 Dorina **Frizzera**. Session 9 Introduction

3:00 John **Kraeuter**. Summary of Session 3 (Benthic Processes)

3:05 Sue **Kilham**. Summary of Session 4 (Pelagic Processes)

3:10 Kurt **Powers**. "Fisheries management issues in Delaware Estuary." (#72, no abstract)

3:30 Rich **Horwitz**, Paul Overbeck and Ann Faulds. "Catfish, snakehead and mosquitofish in the watershed of the Delaware Estuary." (#46)

3:50 Russ **Babb** and David Bushek. "Efforts to enhance oyster resources in Delaware Bay." (#87, no abstract)

4:10 Lawrence **Niles**, Amanda Dey and Kathleen Clark. "The decline of the Delaware shorebird stopover and new opportunities for recovery." (#61)

4:30 Marc **Matsil**. "Salt marsh trophic pyramids: being a monograph on marsh meals of monumental meaning." (#80)

Poster Jed **Brown**. "American shad restoration in the Delaware River Basin." (#101)

Poster Parvaneh **Hajeb**, A. Christianus, Sh. Shakiba, A. Arshad, and C.R. Saad. "Comparison between morphology of two horseshoe crab species, *Tachypleus gigas* and *Carcinoscorpius rotundicauda* in Malaysia." (#90)

Poster Karen **Klein**, Harold Avery, James Spotila and Walter Bien. "Freshwater turtle communities as indicators of the effects of anthropogenic perturbation and habitat fragmentation in the Delaware Estuary ecosystem: a model for linking environmental science and habitat management." (#8)

Poster Andrew T. **Manus** and Andrew Milliken. "The Delaware Bay Oil Spill 2004: utilizing the Migratory Bird Treaty Act and the North American Wetland Conservation Act to help make birds and their habitats whole." (#65)

TUESDAY MAY 10, 2005

Session 9 continued. ***Living Resources***

Poster Shahram **Shakibazadeh**. Sh., P. Hajeb, A. Christianus, M.S. Kamarudin and M. Nor Shamsudin. “Histology of blood cells of two species of horseshoe crab found in peninsular Malaysia, *Tachypleus gigas* and *Carcinoscorpius rotundicauda*.” (#91)

Poster Pamela **Toschik**, Barnett Rattner and Peter McGowan. “Ospreys of Delaware River and Bay: habitat suitability.” (#64)

Poster Stewart **Tweed** and Jenny McCormick. “Using intertidal oyster reefs to enhance oyster populations in Delaware Bay.” (#92)

Poster Stewart **Tweed** and Jenny McCormick. “The role of aquaculture in promoting the restoration of Delaware Bay oysters and other estuarine species.” (#93)

Poster Craig **Woolcott**. “Hydrologic barriers: community-based restoration options.” (#99)

4:50 Moderator-facilitated Q & A for Session 9

5:10 **POSTER SESSION & RECEPTION**

6:30 **DINNER**

6:45 Plenary Speaker: **Jonathan Sharp.** “*The Delaware Estuary: 400 Years of Hostile Occupation and the Future of Science-Based Management.”* (#77)

7:05 Plenary Speaker: **Eric Powell.** *“Challenges for the Successful Management of the Delaware Bay oyster Beds of New Jersey: Is Stock Sustainability a Reachable Goal?”* (#78)

7:30-9:00 Free Discussion

WEDNESDAY MAY 11, 2005

Session 10. ***Edges and Watershed Linkages***

Lead Moderator: **Carol Collier (**Delaware River Basin Commission)
Co-Moderators: **Danielle Kreeger** (Delaware Estuary Program)
Dan Soeder (United States Geological Survey)
John Balletto (PSEG Services Corporation)

8:30 Carol **Collier**. Session 10 Introduction

8:40 Dan **Soeder** and Danielle Kreeger. Summary of Session 5 (Edges & Watershed Linkages)

8:50 Dorina **Frizzera**. "The A...B...CZM's of coastal management programs coincident with the Delaware Estuary!" (#81, no abstract)

9:10 Jessica **Rittler Sanchez**. "Linking land & water resources: lost in translation?" (#74)

9:30 Kellie **Westervelt**. "The relevance of the National Vegetation Classification System to restoration practice." (#83)

9:50 Kenneth **Strait** and John Balletto. "Wetland conservation and restoration along Delaware Bay: the edge effect." (#69)

10:10 Joseph **DiBello**. "Connecting the people and places of the Delaware." (#84)

Poster Simeon **Hahn**, Diane Wehner, Joseph Steinbacher and Lawrence Klein. "Upper Delaware Estuary (urban corridor) regional clean-up and restoration planning initiative." (#100)

Poster Gerald Kauffman, Martha Corrozi and Kevin **Vonck**. "Imperviousness: a performance measure of a Delaware Water Resource Protection Area Ordinance." (#94)

Poster Igor **Linkov**, Greg Kiker and Todd Bridges. "Linking estuaries science and management using comparative risk assessment and multi-criteria decision analysis." (#97)

10:30 Moderator-facilitated Q & A for Session 10

10:50 **BREAK**

WEDNESDAY MAY 11, 2005

Special Panel. ***Next Steps: What is Needed for a Sustainable Commitment to Improving the Health of the Delaware Estuary?***
Moderator: **Mike McCabe**

11:00 Introductions by Convener
Kathy Klein, Executive Director, Partnership for the Delaware Estuary
11:05 Goals Statement by Moderator
Mike McCabe, President, McCabe and Associates
11:15 Presentations by Panel Participants (invited):
Kathleen Callahan, Acting Regional Administrator, U.S. Environmental Protection Agency, Region 2
Bradley Campbell, Commissioner, New Jersey Department of Environmental Protection
John Hughes, Secretary, Delaware Department of Natural Resources and Environmental Control
Cathy Curran Myers, Deputy Secretary for Water Management, Pennsylvania Department of Environmental Protection
Merdith W. B. Temple P.E., Br. General, U.S. Army Corps of Engineers, North Atlantic Division
Donald Welsh, Regional Administrator, U.S. Environmental Protection Agency, Region 3

Focal Points for Panel Participants:

The theme for the panel is: *"Next Steps: What is Needed for a Sustainable Commitment to Improving the Health of the Delaware Estuary?"* Panel participants will address this issue broadly and provide commentary on the following challenge questions:

1) How can existing programs (such as the National Estuary Program and other state programs) provide adequate resources and direction for maintaining and improving watershed health?
2) Are new programs, such as a Chesapeake Bay-type program needed to take the Estuary to the next stage?
3) Do existing environmental laws such as the Clean Water Act provide adequate incentives to promote further improvements? Should they be strengthened or better enforced?
4) Is more scientific study required to better inform policy choices?
5) Beyond compliance with existing federal and state environmental laws, what role can industry play in advancing watershed health?

WEDNESDAY MAY 11, 2005

12:20 **LUNCH**

Special Update from Session 7: ***The Athos I Oil Spill*** (during lunch)
Moderator**: Thomas Fikslin**

12:20 Update on the Response to the Athos I Spill
Jerry Conrad, United States Coast Guard

12:35 Update on the Natural Resource Damage Assessments
James Hoff, National Oceanic and Atmospheric Administration (invited)

12:50 Preparing for Future Oil Spills in the Delaware Estuary
Marty McHugh, NJ Division of Fish & Wildlife

1:05 Coordination for Future Spill Events in the Delaware Estuary -
Thomas Fikslin, Delaware River Basin Commission

1:15 Question and Answer Forum

1:25 Closing Remarks

Possible Challenge Questions for Panel:

1) Are you satisfied with the way information was disseminated on the immediate and potential long range impacts of the Athos I oil spill?

2) Do you feel that we are better prepared to respond to future spill events in the estuary?

3) Do you have any additional recommendations for improving the linkages between science issues and future responses to spill events?

Session 11. ***Management Goals and Needs, Data Coordination & Advocacy***
Lead Moderator: **Jawed Hameedi** (National Oceanic and Atmospheric Admin.)
Co-Moderator: **Ed Santoro** (Delaware River Basin Commission)

1:35 Jawed **Hameedi**. Session 11. Introduction

1:40 Jawed **Hameedi** and Ed Santoro. Summary of Session 6 (Data Gaps, Management & Interpretation)

WEDNESDAY MAY 11, 2005

Session 11 continued. ***Management Goals and Needs, Data Coordination & Advocacy***

1:50 Jawed **Hameedi**. "Environmental indicators as performance measures in coastal resource use management." (#23)

2:10 Dave **Chapman**. "Coastal Ocean Observing for the Delaware Estuary." (#88)

2:20 Ralph **Stahl**. "Restoration banking: a conceptual framework for increasing restoration nationally." (#85)

2:40 Michael **Reiter** and George Parsons. "Linking changes in valued ecosystem components to human use of coastal resources: an example from the St. Jones River Watershed, Delaware." (#73)

3:00 **BREAK**

3:20 Michael **Frisk**, Thomas Miller, Steven Martell and Robert Latour. "Building an ecosystem model of the Delaware Estuary: background, goals and project status." (#68)

3:40 Eric **Stiles** and David Mizrahi. "Lost in translation or how to bridge the gap between science and advocacy." (#66)

4:00 Ed **Johnson** and Jawed Hameedi. "On-line access and analysis of data from NOAA's National Status and Trends Program." (#24)

Poster Cara **Campbell**. "An information system for the Delaware River Basin." (#89)

Poster Robert **Freudenberg**. "Enhancing coastal public access within the Delaware Estuary. (#96)

Poster Gerald Kauffman, Martha **Corrozi** and Kevin Vonck. "State of the Basin Report Card for the Delaware River." (#95)

4:20 Moderator-facilitated Q & A for Session 11

4:40 **CLOSING REMARKS – 2005 SCIENCE CONFERENCE**

Poster Presentations

A comprehensive list of posters presented during the Delaware Estuary Science Conference follows below. Posters 1-12 were attended by presenters from 5:20 to 7:00 on Tuesday January 11. Posters 13-28 were attended by presenters from 5:20 to 6:30 on Tuesday May 10.

TUESDAY JANUARY 11, 2005

1. Jeffrey **Ashley**, David Velinsky, Matt Wilhelm, Joel Baker and Megan Toaspern. Polychlorinated biphenyl accumulation in Delaware River Estuary food webs. (#14)

2. Russ **Babb**, Jason Hearon and David Bushek. Use of surf clam shell to enhance oyster seed bed production in Delaware Bay. (#55)

3. Craig **Bartlett**, Ralph Stahl and Christine Wallace. Developing a GIS database for the Delaware River. (#53)

4. Sean **Boyd** and David Bushek. Potential impact of the non-native marine *isopod Synidotea laevidorsalis* (Miers 1881) in the Delaware Bay. (#28)

5. Rebecca **Hays** and William Ullman. Attenuation of nitrogen fluxes during groundwater seepage across a beachface at Cape Henlopen, Delaware. (#34)

6. Michael **League**, Denise Seliskar and John Gallagher. Dr. Jekyll and Mr. Hyde: Comparing the rhizome growth dynamics of native and non-native populations of *Phragmites australis*. (#48)

7. Edward **Santoro**. Aquatic Resources of the Delaware Estuary. (#51)

8. Daniel **Soeder** and Dixie Birch. Deterioration of a mid-Atlantic coastal marsh. (#5)

9. David **Velinsky** and Jeffrey Ashley. Water and sediment quality assessment of the tidal freshwater Schuylkill River, Philadelphia, PA: understanding sources and fate of nutrients and chemical contaminants." (#13)

10. Jiangbo **Wang**, Denise Seliskar and John Gallagher. Tissue culture generated native marsh plants: an alternative plant resource for wetland creation and restoration. (#49)

11. Stewart **Tweed** and James Tweed. "Restoration of the Cape May Salt Oyster." (#62)

12. Stewart **Tweed**. "Utilizing native oyster seed to enhance oyster populations and aquaculture: the New Jersey experience." (#63)

Poster Presentations (continued)

TUESDAY MAY 10, 2005

13. Ronald **Baker** and Kathryn Hunchak-Kariouk. "Relations of water quality to land use in drainage basins of four tributaries to the Toms River, Ocean County, New Jersey." (#29)

14. Jed **Brown**. "American shad restoration in the Delaware River Basin." (#101)

15. Cara **Campbell**. "An information system for the Delaware River Basin." (#89)

16. Robert **Freudenberg**. "Enhancing coastal public access within the Delaware Estuary. (#96)

17. Simeon **Hahn**, Diane Wehner, Joseph Steinbacher and Lawrence Klein. "Upper Delaware Estuary (urban corridor) regional clean-up and restoration planning initiative." (#100)

18. Parvaneh **Hajeb**, A. Christianus, Sh. Shakiba, A. Arshad, and C.R. Saad. "Comparison between morphology of two horseshoe crab species, *Tachypleus gigas* and *Carcinoscorpius rotundicauda* in Malaysia." (#90)

19. Jeffrey **Hoffman** and Steven Domber. "Water withdrawals and transfers in the Delaware River Basin in New Jersey." (#4)

20. Gerald Kauffman, Martha Corrozi and Kevin **Vonck**. "Imperviousness: a performance measure of a Delaware Water Resource Protection Area Ordinance." (#94)

21. Gerald Kauffman, Martha **Corrozi** and Kevin Vonck. "State of the Basin Report Card for the Delaware River." (#95)

22. Karen **Klein**, Harold Avery, James Spotila and Walter Bien. "Freshwater turtle communities as indicators of the effects of anthropogenic perturbation and habitat fragmentation in the Delaware Estuary ecosystem: a model for linking environmental science and habitat management." (#8)

23. Igor **Linkov**, Greg Kiker and Todd Bridges. "Linking estuaries science and management using comparative risk assessment and multi-criteria decision analysis." (#97)

Poster Presentations (continued)

TUESDAY MAY 10, 2005

24. Andrew T. **Manus** and Andrew Milliken. "The Delaware Bay Oil Spill 2004: utilizing the Migratory Bird Treaty Act and the North American Wetland Conservation Act to help make birds and their habitats whole." (#65)

25. Shahram **Shakibazadeh**. Sh., P. Hajeb, A. Christianus, M.S. Kamarudin and M. Nor Shamsudin. "Histology of blood cells of two species of horseshoe crab found in peninsular Malaysia, *Tachypleus gigas* and *Carcinoscorpius rotundicauda*." (#91)

26. Pamela **Toschik**, Barnett Rattner and Peter McGowan. "Ospreys of Delaware River and Bay: habitat suitability." (#64)

27. Stewart **Tweed** and Jenny McCormick. "Using intertidal oyster reefs to enhance oyster populations in Delaware Bay." (#92)

28. Stewart **Tweed** and Jenny McCormick. "The role of aquaculture in promoting the restoration of Delaware Bay oysters and other estuarine species." (#93)

29. Craig **Woolcott**. "Hydrologic barriers: community-based restoration options." (#99)

Abstracts

Abstracts are listed alphabetically by last name of first author. Each presentation was assigned a unique reference number and was aligned with one of the eleven session themes. The reference number, session affiliation, and presentation time and date are listed following the lead presenter's email address.

FRESHWATER INFLOW MANAGEMENT AND THE DELAWARE ESTUARY: ASSESSING ECOLOGICAL CONSEQUENCES AND FUTURE APPROACHES. **Colin D. Apse,** The Nature Conservancy, 108 Main Street, New Paltz, NY 12561; **Jeffrey L. Hoffman**, NJ Geological Survey, PO Box 427, Trenton, NJ 08625; and **Susan E. Ford**, Rutgers University, Haskin Shellfish Research Laboratory, 6959 Miller Avenue, Port Norris, NJ 08349. capse@tnc.org. **Session 8**, 10:30, 5/10/05 (presentation #82).

Flow management in the Delaware Basin has been an issue of significant contention since the 19th century, long before the U.S. Supreme Court defined the basic water management rules for the basin in 1954. Over a half-century later, a collaborative effort between New York City, state and federal government agencies, and the non-profit and academic sectors is seeking to facilitate sustainable management of Delaware Basin waters into the future. The primary step in this science and policy effort is to define ecological flow needs in the Delaware Basin. Studies are initially focused on the heavily regulated Upper Delaware using a blend of techniques in an attempt to address the needs of target species and the ecosystem as whole. Yet crucial to any flow management assessment is an understanding of how the pattern of freshwater inputs to the Delaware Estuary is related to its ecological health.

The pattern of freshwater inflow to the Estuary, measured as Delaware River flows at Trenton, shows apparent alteration with basin development, including completion of New York City's reservoir and diversion system in the late 1960s. This change in the pattern of inter- and intra-annual variability in freshwater inflow has implications for salinity distribution and the associated ecology of the Estuary. Data on Eastern oyster (*Crassostrea virginica*) spat survival provides one indicator of how freshwater inflows, interacting with other environmental factors, may be influencing the species and communities in Delaware Estuary.

Freshwater inflow management approaches that take estuarine ecology into account have been designed and implemented in a number of estuaries around the country. These approaches provide guidance on how, in the future, freshwater inflows could be managed in the Delaware Basin in a manner more closely linked to ecological goals. Clearly, additional research is needed to better understand the relationship between patterns of freshwater inflow, salinity distribution, and critical estuarine processes, species, and communities. For research efforts to constructively contribute to the Delaware Basin flow management process, both a short-term targeted effort and a long-term adaptive management design should be pursued.

POLYCHLORINATED BIPHENYL ACCUMULATION IN DELAWARE RIVER ESTUARY FOOD WEBS. **Jeffrey T.F. Ashley, David J. Velinsky, Matt Wilhelm**, Patrick Center for Environmental Research, Academy of Natural Sciences, Philadelphia, PA 19103; **Joel E. Baker** and **Megan Toaspern**, Chesapeake Biological Laboratory, University of Maryland, Solomons, MD. ashley@acnatsci.org. **Session 2**, poster, 1/11/05 (presentation #14).

Due to historical and current point and non-point source inputs of polychlorinated biphenyls (PCBs), the Delaware River Estuary has been classified as "impaired" under the Clean Water Act Section 303(d). These contaminants may enter the Delaware River Estuary through point and non-point sources (e.g., stormwater runoff, contaminated land sites) or atmospheric deposition. The transfer and fate of PCBs within the estuary is highly dependent on their sorptive behavior due to their varying but relatively high affinities for dissolved and particulate organic carbon. Aquatic organisms, especially those inhabiting benthic regions may bioaccumulate and biomagnify PCBs. The factors controlling this transfer from environment to biota are numerous (*e.g*., proximity to source, lipid content, diet, *etc*.) and are often dependent on a spectrum of physical, biological and chemical properties of both the system and organisms.

To begin to unravel the important factors in controlling PCB bioaccumlation, a spatially comprehensive evaluation of contaminant inventories in selected biota and sediment within the estuary was performed during two seasons (fall, 2001 and spring, 2002). White perch, channel catfish, invertebrates, small prey fish and sediment were collected from four segmented areas within estuary from Trenton southward to Hope Creek and analyzed for a suite of PCB congeners. Highest PCB concentrations within surficial sediments were found at sites adjacent to urbanized and industrialized areas (e.g., Philadelphia/Camden corridor). Whole organism body burdens (white perch, channel catfish, invertebrates, and small prey fish) reflected spatial distributions in sediment concentrations with those from mid-estuary sites harboring the highest biotic PCB concentrations (both on a wet weight and lipid normalized basis). There was considerable variation in t-PCB concentrations for individual catfish and perch fillets within a region of a zone. These differences were not significantly reduced upon lipid normalization of t-PCB concentrations suggesting that within a zone, there may be many factors driving accumulation such as dietary shifts, short-range shifts in habitat use (e.g., channel versus marshes), small-scale heterogeneity in sediment contamination, and non-equilibrium conditions in contaminant partitioning. Predator/prey ratios revealed greater bioaccumulation from select prey items (amphipods and prey fish) in spring-collected predators. However, these ratios should be used only as rough indicators of bioaccumulation because of the dietary shifts that occur spatially and temporally within and between zones. Interestingly, with down-estuary distances, all biota except for perch had enhanced concentrations of more chlorinated congeners, especially octa-, nona- and deca-chlorinated biphenyls. Specific congeners such as PCB 206 and 209 may act as indicators of specific and unique local sources of contamination within zones of the Delaware River estuary.

With the knowledge gained from this cursory study, a more accurate representation of PCB transfer and fate may be modeled. However, a more detailed investigation encompassing more trophic level breadth and depth is needed. Moreover, this research pointed to the need for more information regarding the role of shallow estuarine environments such as the tidal marshes in retaining and determining bioaccumulation.

ECOLOGY AND POPULATION STRUCTURE OF A MODEL COMMUNITY OF VERTEBRATES IN WETLAND HABITATS IN THE DELAWARE ESTUARY ECOSYSTEM: A CASE STUDY OF THE EFFECTS OF HABITAT FRAGMENTATION, MODIFICATION, AND ISOLATION ON TURTLES. **Harold W. Avery, Karen M. Klein, James R. Spotila** and **Walter F. Bien**, Department of Bioscience and Biotechnology, Drexel University, 3141 Chestnut Street, Philadelphia Pennsylvania, 19104. haltort@aol.com. **Session 5**, 2:15, 1/11/05 (presentation #7).

Habitat loss, degradation and fragmentation are major factors in the global decline of semi-aquatic organisms. Wetlands and surrounding upland habitats that provide opportunities for foraging, predator avoidance, nesting, dispersal, and other essential activities have declined precipitously in the United States over the last 200 years. This is especially true in the Delaware Estuary and most notably in the freshwater marshes in the Philadelphia area. The loss, fragmentation, and isolation of wetlands and surrounding upland habitat have impacted the Delaware Estuary ecosystem since colonial times. Using freshwater turtles as a model system, we determined the relative abundance, population size structure, and possible causes of decline in turtle populations inhabiting existing wetlands. We conducted a comparative study of five sympatric species inhabiting twelve aquatic wetlands on and adjacent to the Philadelphia International Airport (Philadelphia, Pennsylvania, USA). We assessed each wetland for severity of habitat modification, fragmentation, and isolation. We marked, measured, and recaptured >1,500 individual state-listed Threatened red-bellied turtles (*Pseudemys rubriventris*), painted turtles (*Chrysemys picta*), common snapping turtles (*Chelydra serpentina*), musk turtles (*Sternotherus odoratus*) and invasive red-eared slider turtles (*Trachemys scripta*) to determine how fragmentation, isolation, and wetland modifications affect turtle populations and communities.

Populations of red-bellied turtles inhabiting wetlands <0.5 km apart from adjacent wetlands had higher densities, and had more size classes represented, than populations occupying more isolated wetlands. Isolated wetlands (≥0.5 km apart) had either 1) populations of red-bellied turtles that were highly biased in favor of adult size classes, or 2) had no red-bellied turtles. In contrast, populations of painted turtles and snapping turtles were ubiquitous throughout the system of Airport wetlands, achieved relatively high densities, and generally had more size/age classes represented, compared to populations of red-bellied turtles. Populations of non-native red-eared slider turtles occurred predominantly outside of protected Airport grounds, where the surrounding human population had free access to wetlands. Populations of red-eared slider turtles were composed primarily of juvenile-sized individuals, suggesting that non-native turtles had relatively higher rates of nest success, or, more likely, high rates of introduction to the ecosystem from anthropogenic sources (i.e., captive releases). Musk turtles were relatively rare in all wetlands. Nest sites were generally extremely limited for all turtle species, and nest surveys indicated high rates of predation along landscape edges of surrounding upland habitat (e.g., along fencelines, roads, etc.). Our determination of the causes of decline of the state-threatened red-bellied turtle was confounded by observations that seemingly similar species apparently persist and thrive in the same ecosystems.

Our comparative study of sympatric turtle species at the Philadelphia International Airport within the Delaware Estuary ecosystem 1) provides a case study and model for understanding the complex effects of wetland fragmentation and isolation on semi-aquatic wildlife at the individual, population, and community levels, and 2) illustrates the importance of using freshwater turtles as models to represent the effects of habitat modification on numerous semi-aquatic organisms inhabiting the Delaware Estuary ecosystem.

USE OF SURF CLAM SHELL TO ENHANCING OYSTER SEED BED PRODUCTION IN DELAWARE BAY. **Russ Babb, Jason Hearon**, New Jersey Department of Environmental Protection, Bureau of Shellfisheries, Port Norris, NJ 08349; and **David Bushek**, Haskin Shellfish Research Laboratory, Rutgers University, Port Norris, NJ 08349. rbabb@gte3.com. **Session 3**, poster, 1/11/05 (presentation #55).

Oyster production in the Delaware Bay today is a fraction of historical levels due to the combined effects of over harvesting, habitat degradation, predation and disease. Economics and better management have reduced over harvesting and resistance to MSX disease is improving in wild stocks within the bay. Susceptibility to dermo disease remains high as does predation on the lower oyster grounds. In recent years, however, natural recruitment of oysters onto Delaware Bay seedbeds has been at or near record lows. Efforts to enhance recruitment on the seedbeds by planting shell to catch natural oyster sets have often failed due to inconsistent spat setting over the range of the seedbeds. High recruitment zones persist along the inshore areas of the lower beds, but predation and disease eliminate most of this potential production before oysters begin to reach marketable sizes. The purpose of this study was to demonstrate the utility of inshore portions of the lower Delaware Bay as a viable source of oyster seed for enhancing production on the seedbeds in Delaware Bay or even for direct planting onto leased grounds. Nearly 25,000 bushels of surf clam shell was planted on an inshore ground along the New Jersey portion of the lower Delaware Bay in June 2003 to collect spat. In September 2003, approximately 16,000 bushels of spatted clam shell were recovered and transplanted to Bennies Sand, a primary seedbed. The clam shell cultch contained a mean of 1800 spat per bushel compared to 25 spat per bushel on average across the seed beds. During summer 2004, oysters that had set on the clam shell and were subsequently transplanted grew from a mean shell height of 26 mm to nearly 50 mm. Dermo disease remained relatively low with prevalence peaking at 45% in August, then dropping 20% by October. Weighted prevalence (or infection intensities) never exceeded 0.7 on a scale of zero to five. Monthly mortalities declined to less than 5% after the initial transplanting mortality and fell to zero by October. Given the high survival rate, low prevalence and intensity of disease, we anticipate that many of these oysters could reach market size by fall 2005.

As mentioned above, the historic populations of oysters were many times greater than extant populations. In addition to supporting what was once a highly valuable fishery that helped to support the local and regional economy, these oysters undoubtedly performed a variety of ecosystem services that included nutrient cycling, filtering vast quantities of water, providing habitat and possibly even preventing shoreline erosion. Enhancing seedbed production will help maintain and restore the fishery and thereby improve local economies. Moreover, increasing oyster abundances should also increase the capacity of oysters to provide secondary benefits via one or more of these ecological functions.

DELAWARE BAY OBSERVING SYSTEM (DBOS). **Mohsen Badiey** and **Kuo C. Wong**, University of Delaware, College of Marine Studies, Robinson Hall, Newark, DE 19716. badiey@udel.edu. **Session 6**, 3:45, 1/11/05 (presentation #16).

This paper presents the preliminary results of a monitoring station established in the Delaware estuary for the purpose of providing real-time data to the community. These data can be used for a variety of different purposes such as managing the health of the ecosystem based on selected measurements and providing aid for mariners and shipping traffic. In addition, the feasibility of using broadband acoustic tomography to provide cost-effective acoustic-based monitoring of the physical processes in coastal and estuarine waters is demonstrated to showcase the versatility of this observing system. While broadband acoustic signals can be used to measure a wide range of physical parameters in coastal regions, the focus of the present study lies in the determination of current fluctuations in the lower Delaware Bay using such techniques. A combination of data derived from conventional oceanographic sampling platforms and broadband acoustic wave propagation measurements is reported.

RELATIONS OF WATER QUALITY TO LAND USE IN DRAINAGE BASINS OF FOUR TRIBUTARIES TO THE TOMS RIVER, OCEAN COUNTY, NEW JERSEY. **Ronald J. Baker** and **Kathryn Hunchak-Kariouk**, U.S. Geological Survey, 810 Bear Tavern Rd, W. Trenton, NJ, 08628. rbaker@usgs.gov. **Session 8**, poster, 5/10/05 (presentation #29).

The effects of nonpoint-source contamination on the quality of water in four tributaries to the Toms River in Ocean County, New Jersey, were investigated in a 6-year study by the U.S. Geological Survey, in cooperation with the New Jersey Department of Environmental Protection. The purpose of the study was to relate the extent of land development in the drainage basins to loads of nutrients and other contaminants to these streams and, ultimately, into Barnegat Bay. Volumetric streamflow (discharge) was measured at six monitoring sites during 19 stormflow and 18 base-flow sampling events over the 6-year period (1994-99). Concentrations and yields (area-normalized instantaneous load values) of nitrogen and phosphorus species, total suspended solids, and fecal coliform bacteria were quantified, and pH, dissolved-oxygen concentration, and stream stage were monitored during storms and base-flow conditions. The subbasins selected for this study are Long Swamp Creek, in a highly developed basin (64.2 percent); Wrangle Brook, in a moderately developed basin (34.5 percent); Davenport Branch, in a slightly developed basin (22.8 percent); and Jakes Branch, in an undeveloped basin (0 percent). No point sources are known to discharge to these streams.

Total-nitrogen concentrations were higher in Long Swamp Creek and Wrangle Brook (in the highly and moderately developed basins, respectively) than in Davenport Branch (in the slightly developed basin) during both stormflow and base flow. Concentrations of total nitrogen and nitrate were highest in Wrangle Brook. Nitrate concentrations in base-flow samples from Wrangle Brook were much higher than those in samples from any of the other streams, possibly as a result of the presence of an experimental wastewater (secondary effluent) disposal site that was in operation during the 1980's. Ammonia concentrations were higher in samples from Long Swamp Creek than in those from the other three streams under all conditions, and ammonia yields were higher during stormflow than during base flow at all monitoring sites. Concentrations and yields of fecal coliform bacteria and total suspended solids were higher during stormflow than during base flow at all monitoring sites, and were significantly higher in Long Swamp Creek and Wrangle Brook than in Davenport Branch. Concentrations and yields of phosphate species, which also are strongly related to stormflow, were higher in Long Swamp Creek than in the other streams. Loads of total nitrogen, organic nitrogen, nitrate, ammonia, fecal coliform bacteria, and orthophosphate were significantly correlated with the percentage of developed land in all four basins.

A follow-up study is underway to relate stormwater quality to land use in the lower Delaware River Basin. An understanding of the effects of land development on stormwater quality and nutrient loading in the Delaware River Basin can aid in the development of best management practices for protecting streams and wetlands from excessive nutrient loading.

DEVELOPING A GIS DATABASE FOR THE DELAWARE RIVER. Craig Bartlett, Ralph Stahl, DuPont Engineering, Corporate Remediation Group, Barley Mill Plaza, Route 141 & Lancaster Pike, Wilmington, DE 19805; and **Christine Wallace**, URS Corp., Barley Mill Plaza, Route 141 & Lancaster Pike, Wilmington, DE 19805. Craig.L.Bartlett@usa.dupont.com**. Session 6**, poster, 1/11/05 (presentation #53).

For a number of the large river and estuarine systems of the United States, there are often a significant number of chemical, physical and biological studies that have been conducted by diverse groups over a number of years. When individuals, regulators or the public attempt to access this diverse set of data, they are confronted with a significant challenge. The data may not be in an electronic form, they may not be searchable, nor are they easily visualized with relevant maps. To address this issue, DuPont has undertaken a project to construct a GIS database for the Delaware River. Electronic, hardcopy and web-based data sources were found and the relevant chemical, physical and biological information extracted. Data were imported or hand-entered into a searchable MS Access® database, and relevant sample location data collected and verified. To allow visual interpretations, the ArcView® program was used to link the relevant data with appropriate maps. The development of this database and its use for data interpretation and visual display will be discussed.

HIGH INCIDENCE OF DEFORMITY IN AQUATIC TURTLES IN THE JOHN HEINZ NATIONAL WILDLIFE REFUGE. Barbara A. Bell, Drexel University, Department of Bioscience and Biotechnology, 3141 Chestnut Street, Philadelphia, PA 19104. bab22@drexel.edu. **Session 5**, 2:30, 1/11/05 (presentation #32).

The John Heinz National Wildlife Refuge (JHNWR) is the only national wildlife refuge in a large metropolitan city. Its urban setting makes the refuge subject to pollution from many sources such as: 1) runoff from adjacent highways and railroads, 2) atmospheric deposition from the city and the neighboring airport, and 3) seepage from various industrial and municipal sites along the Lower Darby Creek watershed. The JHNWR includes a large, man-made reservoir fed by Darby Creek, a freshwater tidal creek. We studied the effects of this pollution on the development of snapping turtles (*Chelydra serpentina*) and painted turtles (*Chrysemys picta*) in the refuge from 2000-2003. We developed a system to rate severity of observed deformities as minor, moderate or lethal. Although they varied in percentage and severity of abnormality, both species exhibited high rates of embryonic deformity. Over the four year study, 89 to 100% of painted turtle clutches examined each year contained at least one deformed embryo, compared to 81 to 100% of all snapping turtle clutches examined. Mean percent deformity of painted turtle clutches over four years ranged from 45 to 63%, while that of snapping turtles ranged from 11 to 19%. The mean percent embryonic deformity of clutches was at least 25% higher every year for painted turtles than for snapping turtles. Minor deformities were dominant in snapping turtle embryos, while lethal deformities were dominant in painted turtle embryos. Adult painted turtles also showed a higher rate of deformity than adult snapping turtles, although the majority of abnormalities were rated as minor in both species. Although the refuge offers many advantages to the resident turtle populations, pollution places them at a developmental disadvantage.

Snapping turtles are emerging as excellent bioindicators of environmental pollution. Their prevalence in wetland habitats, size, long life span, reproductive habits and large clutch size make them excellent organisms for studies of environmental contamination. They feed at the top of the aquatic food chain and can live for decades, which affords them ample opportunity to accumulate biomagnified toxins. Turtles provide the additional benefit of non-destructive sampling because we can capture females during the nesting season and quantify contaminants in their eggs and blood to determine female contaminant load, as well as incubate eggs to determine egg fertility, mortality and deformity rates of the next generation. This allows us not only to take a snapshot of the array of toxins in their environment from a widely available animal, but to determine how those toxins are

accumulating in organisms at higher trophic levels. Knowledge of contaminant load in animals that humans consume, such as fish and turtles, can help managers determine if such activities are safe. Further research is needed to determine the physiological and mechanistic differences between species that lead to differences in susceptibility to the effects of contamination. Such understanding could lend insight into how contaminants accumulate in and affect humans as well.

PERSPECTIVES ON THE STATUS OF HORSESHOE CRAB RESEARCH IN DELAWARE BAY. **Mark L. Botton**, Department of Natural Sciences, Fordham University, 113 West 60th Street, New York, NY 10023; and **Robert E. Loveland**, Department of Ecology, Evolution & Natural Resources, Cook College, Rutgers University, New Brunswick, NJ 08901. Botton@fordham.edu. **Session 3**, 8:45, 1/11/05 (presentation #20).

When our research on horseshoe crabs began in the 1970's, the species was generally regarded as a zoological curiosity with little economic or ecological importance. Since then, a large commercial bait fishery has developed, and the significance of horseshoe crabs as both predators and prey in the Delaware Estuary food web has been elucidated. In particular, the linkage between horseshoe crab eggs and migratory shorebirds has elevated the profile of horseshoe crabs in the research community, and raised concerns within various State and Federal agencies and NGO's about the status and trends of the crab population in Delaware Bay. Several key questions about the biology of horseshoe crabs that emerged in the 1980's have been (at least partially) addressed in the past two decades. These areas include: (1) the size of the commercial fishery and the population of adult horseshoe crabs in the Delaware Estuary and adjacent coastal waters; (2) the extent to which the Spring shorebird migration through the estuary was linked to the abundance of crab eggs; (3) the reproductive biology of the species, particularly the roles of body size and condition in mating success; (4) the influences of beach quality on spawning success and the subsequent survival of eggs; (5) the effects of water quality in the Delaware Estuary on the survival of horseshoe crab embryos and larvae; and (6) the role of larvae and juveniles in recruitment and dispersal.

What are the main questions for future fisheries-related research? We still know little about the distribution and abundance of juvenile horseshoe crabs from the end of their first summer of life until the time they come back to the shoreline as spawning adults, approximately 10 years later. Is there such a thing as a "critical habitat" for juvenile horseshoe crabs? What are the ecological factors affecting the survivorship of particular year-classes? Lastly, although there is evidence for a declining spawning population of horseshoe crabs in Delaware Bay from the 1980's to the present, existing data are insufficient to enable us to unambiguously tease out the possible impacts of commercial fishing and the loss of prime spawning habitat from natural fluctuations in crab abundance.

POTENTIAL IMPACT OF THE NON-NATIVE MARINE ISOPOD *SYNIDOTEA LAEVIDORSALIS* (MIERS 1881) IN THE DELAWARE BAY. **Sean Boyd** and **David Bushek**, Haskin Shellfish Research Laboratory, Rutgers University, 6959 Miller Avenue, Port Norris, NJ 08349. boyd@hsrl.rutgers.edu. **Session 3**, poster, 1/11/05 (presentation #28).

The Delaware Bay is a likely conduit for the introduction of non-indigenous species given its abundant shipping and recreational maritime traffic. A recent immigrant is the marine isopod *Synidotea laevidorsalis* (Miers 1881). This isopod was first documented in the Maurice River, a tributary of the Delaware Bay, in 1999 at the Rutgers University Haskin Shellfish Research Laboratory (R. Barber, personal communication). *Synidotea laevidorsalis* has garnered scientific interest during the past two decades due to its occurrence outside of its native eastern Pacific range. Specifically, it has been used to demonstrate the global introduction of non-indigenous species, especially those that use international shipping as their intermediary. Documentation has shown range extension to include Australia, Europe and North America (Chapman and Carlton 1991, 1994).

Dockside monitoring for *S. laevidorsalis* at the Haskin Shellfish Research Laboratory began in May 2004. Isopods were removed and enumerated weekly from a 63 cm x 53 cm x 12 cm submerged plastic tray. During spring and summer (May through August) weekly abundance ranged from 373 to 3070 individuals. In fall (September to October) abundance increased substantially with numbers ranging from 4,795 to 28,371 individuals in the sampled tray. Field sampling and anecdotal evidence have documented large populations throughout the Delaware Bay in salinities between 5 and 21 ppt. The isopod has not been reported along the Atlantic Coast of New Jersey. Notably, these isopods aggregate along pilings, ropes, buoy lines, and other structures suspended in the water column. Curiously, it has been found in Charleston Harbor, SC (D. Knott, SERC, pers. communication), but not in the Chesapeake Bay (C. Dungan, MDDNR Oxford, AJ Erskine**,** VIMS, pers. communication and D. Bushek, pers. observation).

Ongoing research is continuing to document seasonal abundance and distribution of *S. laevidorsalis* in the Delaware Bay. Additional investigations have begun to examine the tropic interactions of *S. laevidorsalis* with native and previously introduced species. Preliminary observations have not yet identified their local diet. Predation on *S. laevidorsalis* in Delaware Bay appears to be minimal based upon their high abundance. Furthermore, at least four species of fish (*Fundulus heteroclitus*, *F. majalis*, *Paralichthyes dentatus* and *Trinectes maculates*) have rejected the isopod when offered it as food. Gut content studies are ongoing to generate more information on potential predators. As a recent recruit to both the Delaware Bay and Charleston Harbor, SC, further research should address the potential for additional range extension along the east coast of North America and the ecological impacts of this non-native species. The participation of the National Estuary Research Reserve System, with numerous sites distributed along the Atlantic coast, could provide a useful platform to monitor its spread and identify habitat characteristics.

AMERICAN SHAD RESTORATION IN THE DELAWARE RIVER BASIN. **J. Jed Brown**, U.S. Fish and Wildlife Service, 2610 Whitehall Neck Road, Smyrna, DE 19977. Jed_Brown@fws.gov. **Session 9**, poster, 5/10/05 (presentation #101).

Historically, the Delaware River supported the largest population of American shad. In the late 1890's and early 1900's the catch exceeded 10 million pounds annually. The population began to plummet after the 1920's, due to overfishing, poor water quality in the River and habitat destruction (damming of tributaries). The American shad population began to increase in the 1970's as the water quality in the River improved. Current restoration efforts are focused on the Schuylkill and Lehigh Rivers, principal tributaries of the Delaware River. Construction of dams on these rivers, which were historical shad spawning grounds, prevented upstream shad migration. Currently fish passage facilities are being installed on these dams, and the shad are beginning to return. In order to initiate the shad runs, hatchery-reared shad fry are being stocked above blockages in these two tributaries.

AN INFORMATION SYSTEM FOR THE DELAWARE RIVER BASIN. **Cara A. Campbell**, US Geological Survey, Leetown Science Center, Northern Appalachian Research Laboratory, 176 Straight Run Road, Wellsboro, PA 16901. ccampbell@usgs.gov. **Session 11**, poster, 5/10/05 (presentation #89).

Billions of dollars are spent every year on information generation through research, data collection through monitoring, and the analysis and storage of data. However, much of this data is never utilized because it is inaccessible, incompatible with other data, and standards for data exchange have not been widely adopted. Thus, there is a need to identify existing information and datasets, and incorporate them into a single framework accessible to a wide variety of users. The National Biological Information Infrastructure (NBII) was established to provide this framework by serving as an electronic information network that provides access to biodiversity, conservation, and biological information. The NBII is being implemented through the development of a series of nodes that serve as interconnected entry points to the NBII framework and the information held by partners. Each node focuses on developing, acquiring, and managing content on a defined subject area (thematic node) or geographic region (regional node). The thematic Fisheries and Aquatic Resources (FAR) node was established to bring together the people and information necessary to promote the successful conservation of these vital resources. The identification and integration of distributed datasets collected by a variety of partners will provide users one-stop shopping to fisheries information. This improved access to data will result in more widespread use of the information, thus facilitating further analyses by partners and others within the management and research communities. Development of the node is focused around four goals: 1) coordinate and provide access to information that permits multiple-scale analysis of the status and trends of aquatic resources (by species or watershed); 2) develop a clearinghouse for FAR-related information; 3) promote the development of FAR-related data standards; and 4) leverage existing programs and information systems to further develop fisheries applications. To address goal one, FAR has initiated the development of an information system for the Delaware River basin.

An information system for the Delaware River basin is inherently relevant to the larger scientific landscape for two reasons. First, this system will serve as a clearinghouse for information within the Delaware River and Estuary. The creation of this clearinghouse will entail identifying available information, integrating it into a single interface, and making the data easily accessible to mangers and researchers within the basin. This clearinghouse will then allow for the identification of data gaps that can be used to focus future science and funding. Secondly, the information system will be developed using a holistic approach, incorporating data from different themes (chemical, physical, biological, and landscape) as well as from different sections of the basin (riverine and estuarine). This will provide a platform for examining the basin from an ecosystem perspective, focusing on processes, interactions, and the connectivity of the system as a whole, rather than as individual parts. Ultimately, having the ability to analyze data within the context of the entire basin is necessary for evaluating the effects of both anthropogenic change and resource management decisions.

COASTAL OCEAN OBSERVING FOR THE DELAWARE ESTUARY. **David S. Chapman**, University of Delaware, 700 Pilottown Road, Lewes, DE 19958. dchapman@udel.edu. **Session 11**, 2:10, 5/11/05 (presentation #88).

The Mid-Atlantic Coastal Ocean Observing Regional Association (MACOORA) is one of eleven such Regional Associations around the country that make up the Integrated Coastal Ocean Observing System (ICOOS). MACOORA has a geographic span from Cape Cod to Cape Hatteras, covering five sub-regions (Massachusetts and Rhode Island Bays, Long Island Sound, New York Bight, Delaware Bay, and Chesapeake Bay) in nine states and the District of Columbia. MACOORA is a partnership or consortium of
data providers and users from both private and public sectors that use, depend on, study and manage coastal environments and their resources in a region. MACOORA has been formed to:

- ensure that all major stakeholders are involved in the design of the observing system and the periodic evaluation of the system's performance;
- oversee and manage the design and sustained operation of integrated observing systems that provide data and information required to improve
  - the efficiency and safety of marine operations,
  - national and homeland security,
  - predictions of natural hazards and their effects,
  - predictions of climate change,
  - public health,
  - protection and restoration of healthy ecosystems, and

◦ the sustainability of living resources.

MACOORA and its fellow Regional Associations will enable more effective coordination of federal, state and local observing activities within the regions. Improved availability, coverage and long-term sustainability of accurate coastal ocean observations will enhance coordinated decision-making.

The Delaware Estuary has numerous stakeholders in MACOORA. With over 3,000 ship arrivals each year, and last November's oil spill tragedy, coastal ocean observation presents significant benefits for marine transportation and protection and restoration of the ecosystem. Natural hazards such as the Delaware's early April flooding could be mitigated through timely water level, flow, and wind data to permit better modeling for flood potential and severity. Sustainment of fisheries and other estuarine resources is also a key objective, as is the prediction of harmful algal blooms and other environmental troubles. MACOORA will address the goals of protecting and restoring healthy ecosystems and marine resources by observing such parameters as:

◦ surface and interior fields of chlorophyll-a and macro zooplankton abundance;
◦ extent and condition of benthic habitats;
◦ distributions of spawning stocks of harvestable fish species; and
◦ land-sea freshwater flows and associated transports of sediments, nutrients and contaminants.

MACOORA offers the opportunity to facilitate the control and mitigation of the effects of land-based sources of pollution and to engage in ecosystem-based, adaptive management of the Delaware Estuary's natural resources and environmental protection.

PRELIMINARY ANALYSIS OF ESTIMATED TOTAL NITROGEN AND TOTAL PHOSPHORUS LOADS AND FACTORS AFFECTING NUTRIENT DISTRIBUTION WITHIN THE DELAWARE RIVER BASIN. **Mary M. Chepiga, Susan J. Colarullo** and **Jeffrey M. Fischer**, U.S. Geological Survey, 810 Bear Tavern Road, West Trenton, NJ 08648. mchepiga@usgs.gov. **Session 2**, 4:15, 1/10/05 (presentation #35).

To aid in the management of nutrients entering reservoirs, ponds, and lakes in the Delaware River Basin (DRB), an analysis of the total nitrogen (TN) and total phosphorus (TP) loads in the DRB is being done using the SPARROW regression program that is being developed by the U.S. Geological Survey (USGS). Information on nutrient sources and estimates of annual nutrient loads at selected monitoring stations are evaluated in conjunction with land and stream characteristics that affect the delivery of nutrients to streams and their transport within streams by the SPARROW model. Results of the model include estimates of TN and TP loads in 2000 for all stream reaches within the DRB, an estimate of the nutrient load delivered to the Delaware estuaries, and an estimate of the amount of nutrients from various sources.

Nutrient sources being evaluated include municipal and industrial point-source discharges, fertilizer use, animal-waste production, and atmospheric deposition. Factors that affect the delivery of nutrients to streams are being evaluated for their usefulness in predicting nutrient-load distributions; factors include slope, soil permeability, temperature, precipitation, elevation, population, nutrient gains and losses due to ground-water/surface-water interactions, stream flashiness, and land-use distance-weighting factors. The accuracy of the model results are limited by the degree to which the model input data are estimated. Development of improved and consistent methods of estimating model input data -- estimates of nutrient sources, delivery factors and annual load estimates at monitoring stations – will increase the usefulness of the model results in the management of nutrient loads.

Annual nutrient loads at selected monitoring stations were estimated for all sites with adequate data within the non-tidal parts of the DRB using the FLUXMASTER load estimation program, also being developed by the USGS. These loads, and subsequently yields, were calculated using discharge data collected by the USGS from 1940 through 2001 and water-quality measurements made by various Federal, State, and local agencies from 1974 through 2001. Although data are not available for all sites for the entire period of analysis, the available water-quality records indicate that nutrient loads in the basin have declined primarily because concentrations declined during this period. Yields of TN range from 24 to 4,430 kg/km^2/yr (kilograms per square kilometer per year) for 87 sites. Yields for about half the sites are less than 700 kg/km^2/yr, and yields for 10 sites exceed 1,600 kg/km^2/yr. Yields of TP range from 1.5 to 200 kg/km^2/yr for 100 sites. Yields for about half the sites are less than 25 kg/km^2/yr, and yields for 12 sites exceed 70 kg/km^2/yr. TN and TP yields generally are highest at sites in basins that are characterized by highly populated urban areas or agricultural land use in the Piedmont physiographic province of Pennsylvania and Delaware, and the inner Coastal Plain of New Jersey. TN and TP yields generally are lowest at sites in basins that are characterized by forested areas in the Appalachians of New York and the outer Coastal Plain of New Jersey.

MARSH SEDIMENTS AS RECORDS OF EUTROPHICATION AND METAL POLLUTION IN THE URBAN DELAWARE ESTUARY. **Thomas M. Church, Christopher K. Sommerfield**, College of Marine Studies, University of Delaware, Newark and Lewes, Delaware, 19716 and 19958; **David J. Velinsky**, Academy of Natural Sciences, 1900 Ben Franklin Parkway, Philadelphia, PA 19103; **David Point, Christelle Benoit, David Amouroux, Daniel Plaa** and **Olivier Donard**, LCABIE, UMR 5034 CNRS, Universite de Pau-et des Pays de l' Adour, Pau, FRANCE. tchurch@udel.edu. **Session 2**, 3:00, 1/10/05 (presentation #15).

The tidal freshwater portion of the Delaware Estuary near Philadelphia includes intense urban and industrial activities. Detailing the past pollution history of this area could reveal if various control strategies are working. It would also provide a time frame on how the estuary has responded to legislated controls in the use or discharge of pollutants. Two cores were collected in fringing marshes, and used to investigate such historical pollution records. They exhibit regular and congruent radionuclide geochronology (7-12 mm/yr) dating back over the past half century.

Recorded in the fresh marsh sediment is a dramatic increase in total phosphorus (TP) starting in 1950-60. As in the water, this traces the introduction of P detergent and increased fertilizer use, but only a substantial decrease after removal of the P detergent source. Carbon stable isotopes ($\delta^{13}C$) generally track P after 1955, with heavier carbon isotopes following higher levels of P. The return to lighter ^{12}C in recent times corresponds to decreased use or discharge of P from better wastewater controls with decreased growth/eutrophication. A dramatic increase in heavy $\delta^{15}N$ starting in the early 1960s track a substantial increase in the concentration of dissolved nitrate from population growth, fertilizer applications or changes in wastewater treatment.

The industrial metals correspond to two transient records. (1) The As, Ag, Cd, Cr, Co, Cu, Sb, V and Zn show 2-4 fold increases after 1950 with steady inventories over the past 20-30 years. Implicated is limited sewage control, relict sedimentary sources, or urban runoff from atmospheric deposition. (2) The Pb and Sn show similar, but much larger (ten-fold) increase after 1950, with notable return of Pb, but not Sn to lower values in recent times. This reflects first use and then legislated controls of tetra ethyl lead added to gasoline, and organo-tins, including tributyl tin (TBT) added to anti-fouling paints. Although both were banned over twenty years ago, TBT still has evident relict sources from urban runoff or shipping activities. Interestingly, the upwardly decreasing order of butyl-tins is mon-to di- to tri-butyl species that implicates degradation of sedimentary TBT as the unique source with continuing mobilization into the tidal Delaware Estuary.

The relevancy of these findings to science in the Delaware Estuary is the limited success in controlling the pollution of the Delaware urban estuary as recorded in marsh sediments. Although there is recorded substantial abatement in phosphate, there remain high levels of oxidized products of nitrogen from sewage discharge. Industrial metals also have remained high, in spite of efforts or legislation for specific pollutants such as TBT. The only abatement evident is for lead from national controls that eliminated its use in leaded gasoline. This suggests that industrial metals continue to be introduced to the urban Delaware estuary from non-point sources such as atmospheric deposition, urban run off, or uncontained relict sources, including tidal sediments.

ENDOCRINE DISRUPTORS, BACTERIAL SOURCE TRACKING, BMP MONITORING: MANAGING EMERGING ISSUES IN DELAWARE ESTUARY TRIBUTARIES. **Chris Crockett**, Philadelphia Water Department, 1101 Market Street, Philadelphia, PA 19107. Chris.Crockett@phila.gov. **Session 8**, 11:20, 5/10/05 (presentation #70).

The Philadelphia Water Department's Office of Watersheds (OOW) seeks to meet regulatory requirements for combined sewer overflow abatement, stormwater management, and source water protection, while achieving measurable improvements to the region's waterways through the implementation of comprehensive watershed management strategies. Several of the most pressing emerging challenges facing OOW include 1) the presence of endocrine disrupting compounds in our waterways; 2) the identification and trackdown of microbial sources; and 3) and a lack of realistic goals for environmental improvement.

1) When ingested by organisms, endocrine disrupting compounds (EDCs) interfere with the activities of natural hormones that help maintain homeostasis and regulate developmental processes. These compounds, found in prescription drugs, herbicides, fragrances, and other products, have been found during preliminary studies in small concentrations in Philadelphia's drinking water, which is derived from both the Schuylkill and Delaware Rivers. The sources of these compounds potentially include effluent of wastewater treatment plants upstream of the City's drinking water intakes, farming activities, and industrial discharges. Research is needed to investigate impacts of long-term exposure to low levels of the most common combinations of EDCs found in local drinking water. Other research needs include how these health effects compare to risks from other products (e.g., foods and beverages). One of the most challenging aspects to researching the impact of EDCs on human health is accounting for the sheer number of potential contaminants, and capturing the synergistic effects resulting from the potential combinations of contaminants present in drinking water.

2) In light of stricter drinking water regulations focusing on improved control of microbial pathogens, OOW seeks to better identify sources of pathogens found in Philadelphia's drinking water supply. One method includes the development of "libraries" of fecal samples from local wildlife. Specific bacterial cultures (e.g., E. coli) will be grown for each fecal sample, and the cultures will be assessed for their genetic characteristics. Grab samples will also be collected from river water. Fecal coliform bacteria will be removed from the water samples and their DNA analyzed. Bacterial from the fecal samples that share genetic characteristics with bacteria from the water samples will be considered primary sources of contamination. Science needs include the development of complete bacteria source libraries, as well as researching other effective microbial trackdown techniques and technologies.

3) As budgets for environmental projects tighten, much focus has been placed on demonstrating environmental improvement resulting from the implementation of watershed management strategies. Response to this focus has centered on efforts to improve water quality monitoring techniques and generate long-term performance data for best management practices. Equally important as measuring progress, however, is using the results to help define goals for environmental improvement. Given the current level of technology, and assuming urban land influences stay the same, what is the most we can expect from efforts to improve water quality aquatic habitat, and total natural resource recovery?

How much would it cost to achieve maximum environmental results? Answers to these questions are critical to watershed managers in defining long-term management plans and resource needs.

3-D THERMAL MAPPING SHOWS THE POTENTIAL OF INTERTIDAL GROUNDWATER SEEPS AS A MECHANISM FOR STRUCTURING SANDFLAT BIODIVERSITY. **Ryan K. Dale** and **Doug C. Miller**, University of Delaware, Lewes, DE, 19958. ryandale@udel.edu. **Session 3**, 9:45, 1/11/05 (presentation #26).

Intertidal groundwater seeps 1-10 m wide impose sharp gradients which encompass the temperature and salinity ranges of an entire 10-100 km long estuary. Compared to summer surface temperatures, groundwater seeps are noticeably cooler and appear as thermal anomalies in the sediment. Pore-water salinities correlate with temperature, ranging from as low as 2 ppt in an anomaly to 25 ppt or more in surrounding sediment. We have developed simple thermistor probes allowing us to rapidly assess intertidal sites for thermal anomalies associated with groundwater seepage. Several 3-D thermal maps have been generated during summer at Cape Henlopen, DE, showing consistent localized thermal anomalies of cool temperatures 4 degrees C lower than the surrounding sediment at the same sediment depth several meters away, while vertically in a single sediment column differences of over 12 degrees C have been observed between 30 cm and the surface. In addition, long-term temperature logs show that temperature stays more constant in an anomaly than it does in surrounding sediment throughout the seasons. Dominant benthic species change abruptly between thermal anomalies and surrounding sediment in apparent response to these sharp physical and chemical gradients.

In a larger scientific and management context, groundwater seeps are important to native and invasive benthic species distribution as well as to nutrient dynamics. Distribution of marine species is in a general sense determined by temperature and salinity. Groundwater seeps with their thermal stability and reduced salinity serve to extend favorable conditions into otherwise uninhabitable regions. For example, a mesohaline native or invasive species could take advantage of patches of reduced salinity in an otherwise polyhaline environment. In fact, this has already occurred with the red-gilled mudworm *Marenzelleria viridis* which has a salinity tolerance of 5-10 ppt but is found at Cape Henlopen, DE where the surface water salinity is 28-30 ppt. The relative thermal stability of a groundwater seep offers protection for thermally intolerant species from extreme summer and winter temperatures. For any given species, a favorably altered temperature regime such as that found in a groundwater seep would change biological and biogeochemical rates, growth and productivity. On a landscape scale, the presence of patchy groundwater seeps affects the biodiversity of the region by allowing a wider range of species to colonize a given area. In addition, the organisms inhabiting groundwater seeps act as trophic linkages between the nutrient-rich groundwater and overlying surface water. Thus, the geographical extent of seeps, the effects of seeps on the biota, and the effects of the biota on nutrient dynamics are all important in understanding species distribution patterns and nutrient dynamics of Delaware Bay.

DEVELOPING NUTRIENT CRITERIA FOR ESTUARIES: AN UPDATE ON DELAWARE ESTUARY AND USEPA'S PERSPECTIVES. **Ifeyinwa Davis,** US Environmental Protection Agency, Office of Science & Technology, US-EPA, Washington, DC 20460. davis.ifeyinwa@epa.gov. **Session 8**, 11:40, 5/10/05 (presentation #71).

Nutrients, generally implicated as important sources of impairments in aquatic ecosystems, have been on the 305(b) Reports to Congress. Nutrients have been cited as part of the problem in the Chesapeake Bay, the Everglades, the Gulf of Mexico Hypoxia, and may well be in the Delaware Estuary. The USEPA has encouraged and supported various work in the Delaware estuary, and presents the Agency's perspectives on how to deal with the nutrient issues. The Agency has a desire to work collaboratively with institutions and states to come up with criteria that will protect the designated uses of the estuary. Most desirable on the part of the states is that they establish numeric endpoints that will lead to a reduction of nutrient inputs and associated contaminants to prevent further impairments. EPA plans to assist states in developing such criteria that they can adopt into state water programs and water quality standards. The basis for these are set in the 1998 *National Nutrient Strategy* that provides the blueprint for EPA and states action.

CONNECTING THE PEOPLE AND PLACES OF THE DELAWARE. Joseph DiBello,
National Park Service, 200 Chestnut Street, Philadelphia, PA 19106. joe_dibello@nps.gov.
Session 10, 10:10, 5/11/05 (presentation #84).

Everyone knows that the network of rivers and streams of the watershed are our lifelines. They also tell an intricate and interesting story that intertwines our history and natural environments. The waterways frame our story and residents and visitors feel the richness as they learn about, explore and experience the region. The parks, greenways, waterfront projects, trails and historic preservation projects in watershed communities have improved the quality of life and have had positive economic impacts. A notable trend is the emergence of partnerships, heritage areas, and heritage conservation in the region.

The challenge is linking and connecting these activities in the watershed. A group of us assembled at the Flowing to the Future Conference and we mapped and identified a sample of these areas. We noted a number of opportunities and came up with some suggestions. The discussion group concluded that we should **INVENTORY AND MAP WATERSHED RESOURCES** so we can see a “work in progress” inventory of the park, preservation, recreation and heritage activities underway and then figure out the links. For example: the Delaware and Hudson Canal is developing heritage tourism/education program, the Delaware & Raritan Canal/Delaware & Lehigh Canals are conserving resources and telling the story of industry and transportation: Delaware County, Philadelphia, Delaware historic sites; Delaware River Bay Authority – link DE and NJ Coastal Heritage Trail activities. “Crossroads of the Revolution” – Morristown, NJ to Washington Crossing and Brandywine Battlefields; Schuylkill River (lower part) – Manayunk, south to Fort Mifflin and so on represent just a few of the many initiatives underway. Another suggestion was to **MARKET THE REGION** and develop a Watershed public information guide – include historic and recreation information – and create a “Pride Package” for the entire Watershed. **SHARE INFORMATION** and link ideas on “heritage” projects and convene an “antique road show” type event to bring in material and showcase watershed heritage under one roof. **LINK URBAN WATERFRONT ACTIVITIES particularly in** Camden, Chester, Philadelphia, Wilmington, Brandywine, and others to coordinate/collaborate on historic and environmental activities related to rivers (i.e., the Environmental Education Center at the Philadelphia Waterworks on the Schuylkill River).

SUPPLY OF BLUE CRAB POSTLARVAE TO JUVENILE HABITAT IN DELAWARE BAY: A CLASSIC CASE OF BIOPHYSICAL COUPLING. Charles E. Epifanio, Graduate College of Marine Studies, University of Delaware, Lewes, DE 19958. epi@udel.edu. **Session 3**, 8:15, 1/11/05 (presentation #19).

The blue crab *Callinectes sapidus* supports the largest fishery in the Delaware Estuary. The life history of the species includes mating in low-salinity areas, migration of inseminated females down the estuary, and release of larvae in high-salinity regions near the bay mouth. Unlike many estuarine species, blue crab larvae show no behavioral adaptation for retention within the estuary. Rather, they are exported to the adjacent coastal ocean where they pass through 7 zoeal stages before molting to the postlarval or megalopal stage. Larvae maintain a near-surface position in the water column throughout the 3-4 week period of zoeal development and are transported by a combination of buoyancy-driven and wind-driven circulation. Specific agents of larval transport include: (a) the buoyancy-driven Delaware Coastal Current, which carries larvae southward and away from the estuary; (b) a seasonal wind-driven counter-current that brings larvae back toward Delaware Bay; and

(c) a wind-driven upwelling/downwelling circulation that provides across-shelf transport of zoeae and megalopae. The biophysical coupling inherent in these processes ultimately controls the supply of megalopae to juvenile nursery areas within the bay. Major biological parameters include size of the spawning stock, location of hatching grounds, and timing of larval release. Important physical parameters center on variations in river flow and variation in coastal wind patterns. Our research group has been instrumental in developing a large data base relevant to these processes. Recent work has concentrated on the incorporation of these data into a numerical model that allows simulation of variations in larval supply as a function of changes in biological and physical parameters. Modelers within our group have developed a workable version of the *ECOM3d* numerical model coupled to a particle advection scheme and have used the coupled model to simulate larval trajectories within Delaware Bay and the adjacent coastal ocean. *ECOM3d* is a primitive equation numerical model that allows for realistic flow patterns due to the inclusion of small scale topographical features, realistically varying coastlines, and accurate boundary conditions. We have used the model with excellent success to hind-cast observed temporal patterns of megalopal settlement during a selected 5-year period in Delaware Bay.

The importance of this approach is best considered in the context of the management of fishery stocks within the estuary and in the adjacent coastal ocean. An iterative program of biological and physical observation, followed by closely integrated mathematical modeling will allow researchers to focus on areas of biophysical coupling critical to population dynamics of species comprising these fisheries. In the case of blue crabs, the modeling approach under development by our group will eventually provide a tool for reliable prediction of temporal variation in supply of postlarvae to juvenile nursery areas. Further use of modeling techniques to predict the magnitude of these events will depend on characterization of fine-scale temporal and spatial variation in larval release.

PATTERNS OF SPORT-FISH CONSUMPTION AT SIX PENNSYLVANIA SITES ALONG THE TIDAL PORTION OF THE DELAWARE RIVER WITH SPECIAL EMPHASIS ON SHORE ANGLERS. **Ann Faulds**, Pennsylvania Sea Grant, Penn State University, 1450 Edgmont Avenue Suite 150, Chester, PA 19013; **Nancy Connelly**, Human Dimensions Research Unit, 117 Fernow Hall, Cornell University, Ithaca, NY 14853; **Barbara A. Knuth**, Human Dimensions Research Unit, 117 Fernow Hall, Cornell University, Ithaca, NY 14853; **Jill Benowitz**, Pennsylvania Sea Grant, Penn State University, 1450 Edgmont Avenue Suite 150, Chester, PA 19013; **Joe Matassino**, Partnership for the Delaware Estuary, 400 West 9th Street, Suite 100, Wilmington, DE 19801; **Kevin P. Norton**, Geoscience Department, Penn State University, Penn State Erie Behrend College, Erie, PA 16563. afaulds@psu.edu. **Session 2**, 3:45, 1/10/05 (presentation #40).

Polychlorinated biphenyl (PCB) and mercury contamination in the Pennsylvania portion of the Delaware Estuary has made it necessary for the Commonwealth of Pennsylvania to issues health advisories to inform the public about safe limits for consuming wild-caught fish. In 2003, we surveyed over a thousand anglers fishing at six popular locations along the Delaware River between Neshaminy State Park and Barry Bridge Park to find the answer to questions such as: How many and what proportion of anglers eat the fish they catch? What ethnicities are anglers? Where do they live? Are anglers aware of fish advisories? How frequently and what kind of fish is being eaten? Who cooks the fish and how is it prepared?

While a total of 22 anglers nationalities were identified in our survey, 94% of the shore anglers reported belonging to the following nationalities: Caucasian American (n = 527), Afro American (n = 175), Puerto Rican (n = 44), Vietnamese (n = 57), and Cambodian (n = 39). We estimate that 19% of the shore and 7% of boat anglers eat the fish they catch with weighted mean estimate higher for Afro American (43%), Cambodian (38%), Vietnamese (29%) and Puerto Rican (19%) shore anglers than White Americans (8%). Seven percent of boat anglers reported eating the fish they catch. We identified a substantial number of anglers who were not aware of the Pennsylvania fish consumption advisory and were not following the advisory's recommendations. Advisory awareness was generally low with 41% of shore and 63% of boat interviewees reporting that they were aware of the Commonwealth's advisory. Many who were familiar with the advisory were unaware of advice for specific fish.

The is the first consumption survey of its kind conducted in the Pennsylvania portion of the Delaware Estuary and a first effort at identifying and characterizing the major nationalities of anglers in the greater Philadelphia area. As such, these data will be valuable in crafting a safe fish consumption campaign. While the intent of the survey was to help enhance current fish risk communication, these findings also have important implications for the monitoring and management of sources of fish contaminants to protect human health. A complete technical report is available for download at: www.pserie.psu.edu/seagrant.

SCIENTIFIC ISSUES IN DEVELOPING TMDLS: PCBS IN THE DELAWARE ESTUARY. **Thomas J. Fikslin,** Delaware River Basin Commission, 25 State Police Drive, P.O. Box 7360, West Trenton, NJ 08628-0360. Thomas.Fikslin@drbc.state.nj.us. **Session 8**, 11:00, 5/10/05 (presentation #75).

The Delaware River Estuary (Trenton, NJ to the head of Delaware Bay) was listed as impaired under Section 303(d) of the Clean Water Act by three bordering states (DE, NJ, and PA) due to the levels of PCBs in the tissues of resident and anadromous fish species. Court mandates and administrative agreements between the U.S. EPA and state agencies required development of the TMDLs by December 2003. The development of TMDLs for complex estuarine ecosystems like the Delaware Estuary for classes of hydrophobic contaminants such as PCBs from multiple source categories presents a number of policy and procedural issues that require scientific input. Three areas where scientific studies were conducted during the development of the TMDLs that provided essential information on the sources and processes controlling PCBs were: 1) sediment studies, 2) airshed monitoring, and 3) source identification.

Studies of the sediment were essential to provided information on the erosional/depositional nature of the estuary, and to provide data for incorporation into the water quality model for PCBs that was being established by the Commission. Studies of this type are particularly important for hydrophobic contaminants such as PCBs and for sediment-associated contaminants such as metals. Furthermore, the sediments will act as a reservoir of contaminants, mediating the water column concentrations and extending the time required to attain the water quality criteria.

Airshed monitoring was also extended from sites on the New Jersey side of the estuary to additional sites in Pennsylvania and Delaware. This was deemed necessary due to the finding of high concentrations of PCBs in samples collected in Camden, NJ under the New Jersey Atmospheric Deposition Network. A major finding of this study was that the estuary was acting as a source of PCBs to the atmosphere at the current time, but would become a source of PCBs to the estuary if the air concentrations were not reduced. Data from this study was also used to parameterize the water quality model for the significant flux of PCBs between the gaseous phase in the atmosphere and the dissolved phase in the estuary.

Source identification was also a critical issue not only for the development of the water quality model, but also to partition the TMDLs into their respective wasteload allocation and load allocation portions, and elucidate sources for implementation of reduction strategies. These studies identified contaminated sites, point sources, non-point sources and the two major tributaries to the estuary as significant sources of PCBs. The studies also indicated that the contribution of PCBs from the coastal waters was minor relative to other source categories.

ORGANOCHLORINE COMPOUNDS AND TRACE ELEMENTS IN FISH TISSUE AND STREAMBED SEDIMENT IN THE DELAWARE RIVER BASIN, NEW JERSEY, PENNSYLVANIA, AND NEW YORK, 1998-2000. **Jeffrey M. Fischer, Kristin M. Romanok, Robin A. Brightbill, Karen Riva-Murray** and **Michael D. Bilger**, U.S. Geological Survey, 810 Bear Tavern Road, West Trenton, NJ, 08628. Fischer@USGS.gov. **Session 2**, 2:30, 1/10/05 (presentation #36).

From 1998 to 2000 the U.S. Geological Survey conducted a study to determine the occurrence and distribution of organic compounds and trace elements in fish tissue and streambed sediment in streams of the Delaware River Basin. Fish-tissue samples were collected from 25 sites, and streambed sediment samples were collected from 35 sites, in forested, agricultural, and urban settings.

At least one organochlorine compound was detected in all streambed sediment and fish tissue from every site sampled. The most frequently detected compound was DDT, which was found in fish and (or) sediment from more than 80 percent of the sampled sites. Polychlorinated biphenyls (PCBs) were widely detected in fish from streams in all land-use settings, but were detected only in sediment from streams in urban settings. Chlordanes and dieldrin were detected in fish collected from every stream in urban watersheds and from more than half the streams in agricultural watersheds.

Guidelines developed for the protection of fish-eating wildlife and sediment-dwelling organisms were exceeded frequently, especially in urban areas. Concentrations of PCBs in whole fish exceeded the fish-eating wildlife guideline at 52 percent of the sites. Concentrations of dieldrin and DDT also exceeded this guideline (at 16 and 12 percent of sites, respectively). Furthermore, concentrations of PCBs in streambed sediment exceeded the Probable Effect Concentration (PEC) at 55 percent of urban sites, and chlordanes exceeded the PEC at 18 percent of urban sites, indicating concentrations of these compounds are likely to be harmful to sediment-dwelling organisms.

Concentrations of trace-element contaminants (such as arsenic, cadmium, chromium, copper, lead, mercury, nickel, and zinc) in sediment generally were highest in streams draining watersheds that are associated with either historical or current industrial activities. Concentrations of some trace elements (particularly cadmium and zinc) were elevated above background concentrations in regions with historical coal mining, including the headwaters of the Lehigh and Schuylkill Rivers. Concentrations of chromium, lead, nickel, and zinc each exceeded a PEC at about 20 percent of the sites.

Concentrations of mercury found in fish fillets exceeded the human health criterion at 22 percent of the sites sampled, and exceeded the guideline for protecting fish-eating wildlife at 87 percent of the sites sampled. These levels were exceeded at sites in both urban and forested settings. Concentrations of total mercury in water and streambed sediments were lowest in forested settings and highest in urban settings; however, concentrations of mercury in fish from both forested and urban settings were similar because the percentage as methylmercury was generally higher in forested settings. A relatively high rate of production of the more bioavailable methylmercury due to geochemical conditions in forested settings could explain the elevated mercury concentrations in fish from some forested streams.

Organic compounds and trace elements often are found at levels of concern in Delaware River tributaries. These results indicate that tributaries could be a significant source of these contaminants to the estuary. The persistence of many of these compounds years after their use was discontinued indicates that these compounds continue to present a risk to human and ecosystem health. Also, geochemical conditions in the estuary that can make contaminants bioavailable must be considered, especially for compounds like mercury.

OYSTERS AND OYSTERING IN DELAWARE BAY. Susan E. Ford and **David Bushek**, Haskin Shellfish Research Laboratory, Rutgers University, Port Norris, NJ 08345. susan@hsrl.rutgers.edu. **Session 3**, 9:00, 1/11/05 (presentation #54).

The eastern oyster, *Crassostrea virginica*, grows in Delaware Bay from the Atlantic Ocean to Bombay Hook, DE and just below Artificial Island, NJ. This 80 km span covers a salinity range of 30 to 5 ppt. Although early records indicate large oyster reefs in the lower bay, most extant beds lie along the eastern portion of the upper half of the bay. Large-scale harvesting probably did not begin until the early 19th century when the oyster dredge was introduced. The states of Delaware and New Jersey managed the public beds by limiting harvest to several weeks each year and mandating that shell be returned to provide substrate for settling larvae. Nevertheless, records dating to the 1840s indicate that the three dimensional aspect of the reefs was already being destroyed. By mid-century, natural beds in the lower bay were largely extinct and had been replaced by privately leased grounds. Large oysters from the remaining public upper bay beds were marketed directly, while smaller "seed" oysters were planted on leased grounds where growth and fattening was better. As the larger oysters disappeared, planting seed oysters on the lower bay leases became the standard mode of operation. Combined landings from Delaware and New Jersey were between one and three million bushels annually from 1880 to 1930 and then about 750,000 bushels annually until 1956. Maintaining these harvests required supplementing native seed with imports from outside the estuary. Harvests plummeted following the late 1950's epizootic of MSX disease. Today, the combined effects of over harvesting, disease, and poor setting have reduced landings to below 100,000 bushels in most years.

Heavy setting of oysters still occurs regularly along the inshore areas of the lower bay, but heavy parasitism and disease minimize survival. Before MSX, the oyster drill *Urosalpinx cinerea*, and various species of mud crabs were the principal causes of mortality. Two bay-wide MSX epizootics (late 1950s and mid 1980s) significantly reduced Delaware Bay oyster populations. Selective breeding programs have produced lines that are highly resistant to MSX and recent data indicate that the wild populations are becoming substantially more resistant. Unfortunately, dermo disease became established in 1989. It tolerates low salinity better than MSX, and resistance to dermo disease has been slow to develop.

Following the Dermo epizootic, direct marketing from the seedbeds was re-initiated and helps sustain the New Jersey oyster fishery today. Management programs in both states involve annual, quantitative stock assessment surveys of the beds. Decisions on harvest limits involve both industry and state regulators, and in New Jersey, Rutgers University, which provides stock assessments. Although dermo disease has recently been on the decline, the current harvest outlook is bleak following five years of poor recruitment. Fledgling oyster aquaculture operations are producing limited quantities of oysters in New Jersey, but face numerous legislative obstacles and perceived conflicts with horseshoe crabs and migrating shorebirds. Oyster restoration for ecological value such as habitat, biological filtration or prevention of shoreline erosion has received relatively little consideration.

ENHANCING COASTAL PUBLIC ACCESS WITHIN THE DELAWARE ESTUARY. Robert W. Freudenberg, New Jersey Department of Environmental Protection, Coastal Management Office, 401 E. State Street, Trenton, NJ 08625-0418. Robert.Freudenberg@dep.state.nj.us. **Session 11**, poster, 5/10/05 (presentation #96).

The ability of the public to access coastal lands, water and their resources is a right that predates the founding of this country and has been woven into the fabric of our basic rights and principles. With its numerous tidal rivers and bays, in addition to the Atlantic shoreline, New Jersey boasts over 1,000 miles of coastline that today is used for residential, commercial and recreational purposes. An important feature of this shoreline is the Delaware Estuary, the shores of which are subject to the Public Trust Doctrine and thus are held in trust by the State for the benefit of the public.

An important natural resource, the Delaware Estuary faces pressures from the numerous uses along its shores. Increasingly, residential and commercial development tend to isolate the public from access to large portions of the estuary. In addition, knowledge of the Public Trust Doctrine is being lost or ignored at local government levels and with it, the rights of the public to access these areas diminished. As a result, much of the public has lost appreciation for the Delaware Estuary as a natural resource and lack a sense of stewardship for its protection, adding to the threats facing the Estuary.

In response to these challenges, the Coastal Management Office (CMO) of New Jersey's Department of Environmental Protection (DEP) has taken on a NOAA Coastal Management Fellow to help address some key issues with the goal of enhancing public access to the shorelines of the state. Working with representatives from various offices, the 2-year project will focus on three issue areas to enhance coastal access:

1. Developing materials on the Public Trust Doctrine to help municipalities become aware of it and how it should influence their actions.
2. Preparing a public access policy guide, drawing upon knowledge of the Public Trust Doctrine, onsite evaluations of existing sites and literature review.
3. Drafting rule changes regarding public access to the coast in order to revise the current enforceable policies on public access.

These objectives will be met through the development of CMO-sponsored public access workshops that will reach out and provide information and a written handbook to county and local municipal officials as well as advocacy groups and real estate agents. In addition, a series of coastal site visits will help to produce an inventory of public access locations as well as a matrix of waterfront public access design guidelines. These same guidelines will be useful in drafting a public access rule that appropriately addresses the variety of coastal access sites throughout the state and clearly defines the State's policies.

Overall, it is anticipated that the work of this project will help to increase public and governmental awareness of the Delaware Estuary as a natural resource and help to ensure that it will be protected through sound management and science. The more that those who live, work and play along the Delaware Estuary appreciate what it has to offer, the more that its many scientific and management needs can be addressed.

BUILDING AN ECOSYSTEM MODEL OF THE DELAWARE ESTUARY: BACKGROUND, GOALS AND PROJECT STATUS. **Michael G. Frisk, Thomas.J. Miller**, University of Maryland Center for Environmental Science, Chesapeake Biological Laboratory, P.O. Box 38, Solomons, MD 20688-0038; **Steven J. D. Martell**, Fisheries Centre, University of British Columbia, Vancouver, Canada; and **Robert J. Latour**, Department of Fisheries Sciences, Virginia Institute of Marine Science, College of William & Mary, Gloucester Point, VA 23062-1346. frisk@cbl.umces.edu. **Session 11,** 3:20, 5/11/05 (presentation #68).

UMCES, in conjunction with the UBC Fisheries Centre, is developing a ecosystem model of the Delaware Estuary. The outcome will be a model open to the general scientific community that can be used to: address ecological questions, evaluate ecosystem effects of fishing, explore management policy options, and evaluate effect of environmental change. Building on data accumulated from historical monitoring programs and results from previous analytical studies, a simplified food web model of the Delaware Estuary ecosystem is being constructed using the modeling software package Ecopath with Ecosim.

Within the Ecopath modeling framework, trophically-linked biomass pools have been identified in order to create a mass-balanced snapshot of the resources and interactions in the Delaware Estuary ecosystem. This mass-balance model also forms a leading parameter frame-work for initializing a dynamic model (Ecosim). The biomass pools generally consist of either a single species or a group of species representing an ecological guild. Biomass pools were created for all major components of the ecosystem, including those at lower trophic levels such as plankton, invertebrates, and detritus.

At the ecosystem level, we define production as the net change in biomass with respect to time. Our model accounts for all losses associated with natural predator-prey interactions as well as other known removals associated with fisheries. The dynamic ecosystem model (Ecosim) will be tuned to historical data on abundance using maximum likelihood methods in order to estimate compensation rate parameters and changes in ecosystem production associated with varying input parameters.

The success of this project involves intensive input, both in terms of advice and data, from state government agencies in New Jersey and Delaware, academic institutions and PSEG, a regional electric utility. A model development workshop with invited participants was conducted in October 2004 and a second workshop is being planned for Spring 2005. (http://hjort.cbl.umces.edu/defem/defem.html) We plan to finalize the model by the end of summer (2005) and appreciate any feedback from the scientific and management community. The model will initially be applied to evaluate ecosystem effects of the increased production associated with PSEG's wetland restoration efforts, but it is hoped that the general scientific community will utilize the model to address a wide range of ecological and management-oriented questions.

TECHNICAL SUPPORT NEEDS FOR ESTUARY INFLOW POLICY DECISION MAKING. **Richard K. Fromuth** and **Hernan A.M. Quinodoz,** Delaware River Basin Commission, 25 State Police Drive, P.O. Box 7360, Richard.Fromuth@drbc.state.nj.us. **Session 8,** 10:10, 5/10/05 (presentation #76).

Maintaining freshwater inflow to the Delaware Estuary has been a major component of Delaware River Basin flow management decisions since the 1954 Supreme Court Decree. The Decree apportioned the Basin's water between the City of New York and the Basin States, establishing a requirement for releases from the City's reservoirs to meet a flow target at Montague, NJ. Limiting ocean salinity intrusion for the purpose of protecting public water supplies has driven the establishment of a flow target for the Delaware River at Trenton, NJ. This target is included in the Delaware River Basin Commission (DRBC) drought operating plan. The flow target varies both with drought severity and the extent of salinity intrusion during drought. The present DRBC water quality standard for estuary chlorides is 180 mg/l as a 30-day average at River Mile 98, and is based on a 1980's evaluation of the chloride limit needed to protect municipal supply wells in the Camden, NJ vicinity. The DRBC water quality regulations also include the provision that Zone 3 of the estuary (RM 95.0 to RM 108.4) be suitable for public water supply after reasonable treatment. Salinity intrusion is a concern because the secondary maximum contaminant level for chlorides in public water supplies is 250 mg/l. The present set of Trenton targets is aimed at maintaining estuary chlorides within DRBC standards during a repeat of the 1960's drought of record. Factors affecting chloride intrusion include estuary inflow, projected sea level rise, consumptive water use, and changes in the estuary channel.

Since the development of the present set of Trenton flow targets, the U.S. Geological Survey performed particle track modeling of chloride intrusion into ground water and found that an annual one-month intrusion event of approximately 1800 mg/l would be required to threaten the potability of the most vulnerable Camden area wells. This is much higher than any observed intrusion, or any intrusion expected with a repeat of the drought of record. Although this finding challenges the existing chloride standard for protection of the Camden ground water supplies, the protection of surface supplies in Water Quality Zone 3, waste load allocations and their relationship to inflow, and ecological concerns such as the impact of inflow policy on shellfish or wetlands, expand rather than eliminate the technical support needs for the evaluation of inflow policy. Support needs include improved linkage of chloride and daily flow modeling for the estuary, incorporation of relationships between estuary ecology and inflow, evaluating impacts of low inflow in estuary quality based on waste and nutrient loading, projections of consumptive use and sea level rise, and updated evaluation of the relationship between inflow and municipal and industrial user costs.

THE PRESENT STATE OF KNOWLEDGE OF THE TIDAL AND RESIDUAL CIRCULATION IN THE DELAWARE ESTUARY AND ADJACENT CONTINENTAL SHELF. **Richard W. Garvine**, College of Marine Studies, University of Delaware, Newark, DE 19716. rgarvine@udel.edu. **Session 1**, 1:15, 1/10/05 (presentation #12).

Water circulation is the most fundamental and consequential process in any estuary. The life cycle of the blue crab *Callinectes sapidus* neatly illustrates this point. Larvae are hatched in the estuary mouth synchronously with nocturnal ebb tide. The timing serves to assure their export to the adjacent shelf. There they drift in the near surface propelled with the current, most often with the lighter, fresher water of the estuary into the Delaware Coastal Current which carries them to the south alongshore. Upwelling (positive toward the north) winds excite surface Ekman transport (an outcome of the earth's rotation and the resulting Coriolis force) which is directed 90^{o} to the right of the surface wind or offshore here. Many larvae are thus able to escape the southward moving waters of the Delaware Coastal Current and slowly move back to the north where some may re-enter the estuary of origin in the form of megalopae. The timing and magnitude of these current reversals are critical for the recruitment of crab larvae.

For better comprehension we separate the circulation into tidal and residual components;the total current is then given by the sum of these. Residual current includes slowly time varying elements. Numerical models are quite successful at reproducing observed tidal currents and tidal heights. These currents are vigorous in the Delaware and contribute to strong tidal mixing of salt and fresh water. The resulting axial distribution of salinity is nearly linear with distance from the mouth and changes remarkably little with change in freshwater discharge. The tidal forcing also contributes to the residual circulation through nonlinearities in the tidal motion. These currents contribute a substantial fraction of the residual circulation in the estuary and just beyond the mouth.

The circulation within the estuary is strongly coupled with that on the adjacent continental shelf. The effect of wind over the shelf imposes water level changes on the estuary that alter water levels within the estuary. The estuary contains fresher, less dense water than the adjacent shelf. This supplies the Delaware Coastal Current with buoyant water on the shelf. This structure is sometimes plainly observable as far south alongshore as the Capes of the Chesapeake. In its progress south the waters of the coastal current impact the beaches and near shore waters of the Delmarva peninsula. A companion landward flow of saltier, heavier shelf water is drawn into the estuary below and to the right (viewed looking landward into the estuary) of the exiting light waters of the coastal current. This shelf water is drawn from near bottom water at least 40 km from the mouth.

The numerical model of Whitney and Garvine (*Journal of Physical Oceanography*, in press) simulates well the tidal and residual circulation in the estuary and on the shelf, including the coastal current. To improve modeling and ultimately forecasting capability we will need better representations of the turbulent processes that govern mixing between shelf and estuarine water.

UPPER DELAWARE ESTUARY (URBAN CORRIDOR) REGIONAL CLEAN-UP AND RESTORATION PLANNING INITIATIVE. Simeon Hahn, National Oceanic and Atmospheric Administration (NOAA), Coastal Protection and Restoration Division, 1650 Arch Street, c/o EPA Region III, 3HS41, Philadelphia, PA 19103; **Diane Wehner,** RIDOLFI, Inc, Seattle, WA; **Joseph Steinbacher,** NOAA Damage Assessment Center, Silver Spring, MD; and **Lawrence Klein,** NOAA Coastal Protection and Restoration Division, Seattle, WA. Simeon.Hahn@noaa.gov. **Session 10**, poster, 5/10/05 (presentation #100).

There are numerous Superfund sites, Resource Conservation and Recovery Act (RCRA) corrective action facilities, state hazardous waste sites, and potential Brownfield areas located along the main stem Delaware River in the upper Delaware Estuary (Delaware River Zone 2 through portion of Zone 5). This stretch of the Delaware River includes portions of the states of Pennsylvania, New Jersey, and Delaware and the cities of Trenton, Philadelphia, and Wilmington. It is the most impacted area of the entire estuary from a contaminant and natural resource loss perspective. Habitat loss has impacted many species such as migratory fish including the endangered short-nosed sturgeon. Contamination from the various sites located along the Delaware River has contributed to fishing restrictions and advisories. A significant oil spill recently occurred in this reach (November, 2004). Contamination and habitat concerns have been raised regarding a major dredging project and a recently proposed liquified natural gas terminal.

Efforts to characterize the sources, nature and extent, and environmental fate of , contamination in the upper estuary are underway, but currently the ability to make scientific, risk-based decisions for management of contaminated sediments is limited. Historically, many restoration projects to compensate for impacts to natural resources from releases of contaminants from waste sites have been targeted in the lower Delaware Estuary due to lack of regional restoration planning and concerns regarding regional contamination issues. This has resulted in decreased benefit to or net loss of the impacted natural resources in the upper estuary.

Improved coordination among compliance, clean-up, and restoration efforts is necessary to holistically address contamination and impacts from habitat loss in the upper Estuary. The ability to share and access data from multiple sources in a central database is needed. Building upon previous efforts, NOAA is developing a regional database and mapping project that incorporates contaminant data, existing habitat and natural resource information, and land use and restoration opportunities in the upper Delaware Estuary. This will be a valuable tool to plan and coordinate future contaminant investigations, conduct effective remedial and restoration projects, and to monitor improvements in the upper estuary. The poster will present the current status of the project and identify additional data needs.

COMPARISON BETWEEN MORPHOLOGY OF TWO HORSESHOE CRAB SPECIES, *TACHYPLEUS GIGAS* AND *CARCINOSCORPIUS ROTUNDICAUDA* IN MALAYSIA. Parvaneh Hajeb, A. Christianus, Sh. Shakiba, A. Arshad, and C. R. Saad, Dept. of Agricultural Technology, Faculty of Agriculture, University Putra Malaysia 43400 UPM, Serdang, Selangor, Darul Ehsan, Malaysia. Parvanehha@yahoo.com. **Session 9**, poster, 5/10/05 (presentation #90).

There are only four living species of horseshoe crabs that is *Lymulus polyphemus*, *Tachypleus gigas*, *T. tridentatus* and *Carcinoscorpius rotundicauda*. Between these four species, three of them are distributed throughout South East Asia, which is *T. gigas*, *T. tridentatus* and *C. rotundicauda*. Two of three Asian species, *T. gigas* and *C. rotundicauda*, have identified throughout Peninsular Malaysia.

These two species show evident morphological differences. Comparison was made between morphology of adult individuals of these two species. External anatomy as well as species description and keys to adult stages were covered for two species. Morphological characteristics and measurements employed to identify the two species and the sexes were presented. A total of 108 horseshoe crabs, 56 *C. rotundicauda* and 52 *T.gigas*, were used.

There are obvious differences between these species in terms of body size, weight, color, telson and carapace shape. *C. rotundicauda* is the smaller species which can be distinguished from the other species by its different body coloring (dark green), while *T. gigas* has larger body size and lighter color (olive green). The most distinctive feature used to identify *C. rotundicauda* from *T. gigas* is its telson with smooth surface and spherical cross-section. In *T. gigas,* telson has a row of sharply pointed spinnerets on every edge and its cross-section is triangular which is similar to the observation by Sekiguchi (1988). Females are larger than males in these two species of horseshoe crab. The difference between configurations of male and female is almost the same in both species. *C. rotundicuda* and *T. gigas* both showed no significant differences in terms of ratios of prosomal width/carapace length, telson length/ total length and telson length/ carapace lenght. Significant differences between male and female of *C. rotundicauda* in terms of Ow/OL ratios, indicating wider opisthosomal width relating to opisthosomal length in females. Comparison between the ratio of the first and last marginal opisthosomal spines in the two sexes of *T. gigas* showed significant differences, indicating longer S6 in relations to S1 in the females, whereby in *C. rotundicauda,* no significant difference in term of this ratio between the males and females. Almost all Morphological body ratio of male is completely different between the two species, except for the ratios of Ow/ Cl and Tl/Cl. In females, no significant difference in terms of Ow/ Ol and Tl/ T ratios rather than Pw/ Cl and Tl/ Cl ratio. It shows that the difference between the two species is more obvious in males compared to females.

ENVIRONMENTAL INDICATORS AS PERFORMANCE MEASURES IN COASTAL RESOURCE USE MANAGEMENT. **Jawed Hameedi**, National Oceanic and Atmospheric Administration (NOAA), 1305 East-West Highway, Silver Spring, MD 20910. Jawed.Hameedi@noaa.gov. **Session 11**, 1:50, 5/11/05 (presentation #23).

The rationale for developing indicators is to offer simplified descriptors of environmental complexity and the environment’s response to stressors, and to communicate that information widely to assure prudent and informed decisions about resource use activities or options. Indicators or indices to describe to condition of the aquatic environment have existed for over one hundred years. However, focused and systematic efforts to develop such indices in the United States followed recommendations of the Environmental Pollution Panel of the President’s Science Advisory Committee in 1965 that included “assigning a numerical index of chemical pollution to water samples.” Since then numerous efforts, some of them mandated by law or a court order, have been undertaken to quantify and communicate information about the environment in order to gauge progress, develop solutions and make sound decisions about resource use in the U.S. coastal waters and estuaries. Although various criteria have been proposed for selecting indicators in environmental management, it is surmised that they should at least be SMART: specific (with clearly stated objective), measurable (both in time and quantity), achievable (within available resources and intellectual capital), relevant (to elucidate the issues at hand), and trackable (amenable to evaluation and determining progress).

Indicators are viewed as an example of “usable science:” science that can influence environmental policy and resource management decisions and meet the criteria of being adequate, effective, valuable and legitimate. A broad societal framework is important in this regard. The drivers-pressure-state-impact-response framework is proposed as a strategy to incorporate the socio-economic aspects of environmental decision-making that is both scientifically sound and transparent in approach. This presentation will also include a summary of NOAA’s efforts during the late 1990s to assist the Environmental Indicators Technical Advisory Committee in developing and charactering a suite of indicators to link with four goals for effective use of the Delaware Coastal Zone: improving air quality; improving water quality; protecting the mosaic of habitats and land cover; and maintaining or restoring healthy native plant and animal populations, and preserving biodiversity.

DISCERNING IMPACTS OF SEDIMENT CONTAMINATION ON BENTHIC COMMUNITIES IN DELAWARE BAY.
S. Ian Hartwell, Larry. W. Claflin and **M. Jawed Hameedi**, National Oceanic and Atmospheric Administration, Silver Spring, MD 20910. Ian.Hartwell@noaa.gov. **Session 2**, poster, 1/11/05 (presentation #10).

Characterizing and delineating areas of sediment contamination and toxicity are viewed as important scientific goals for coastal resource management. Sediment contamination in coastal areas is a major environmental issue because of potential toxic effects on biological resources and often, indirectly, on human health. Distributions of benthic organisms are predictable along estuarine gradients and are characterized by similar groups of species over broad latitudinal ranges. The physical setting of a habitat has a profound effect on our ability to subdivide the habitat into statistically repeatable units and establish reference and test sites. Basic biological measurements such as species richness or abundance, while informative, may be too simplistic. More complex indices (e.g., diversity, evenness) are more robust, but are inherently flawed for use as predictive tools because distinctly different communities may be equivalent mathematically.

Various Index of Biotic Integrity (IBI) schemes for estuarine benthic communities have been developed. While contaminant gradients allow the original application to work well in streams, the highly variable nature of the estuarine environment has rendered strict application of the approach difficult. A fundamental issue with any of these approaches is whether or not the methods can be used to distinguish between contaminated habitats and naturally occurring poor habitats due to salinity stress, poor food availability, strong currents, etc. If it is possible to eliminate or normalize for those parameters, would a purely chemical response signal become apparent?

This study used results from NOAA's sediment toxicity assessment of Delaware Bay, which was based on the sediment quality triad approach and utilized a stratified-random sampling design. Samples were collected for analyses of a suite of toxic chemicals, bioassays, and benthic community assessment. Toxicity and contaminant levels were correlated when aggregated into indices, but were only marginally correlated with benthic communities. Species diversity and abundance were generally lowest in the fresh/salt mixing zone. Various statistical techniques, including cluster analysis, identified factors which bias interpretation of the data and the dependence of species distributions on physical parameters. Sites and species were clustered with a variety of techniques. The best results were obtained using unweighted pair-group method of clustering with the Jaccard distance coefficient – an index based on overlap between two sets of data. The most informative analysis, termed nodal analysis, was the intersection of species cluster analysis with site cluster analysis. This technique produced a visual representation of species association patterns among site clusters. Salinity and grain size appeared to be the primary factors determining species distributions. This suggests that sediment quality triad needs to include physical parameters as a distinct leg from chemical concentrations to improve sediment quality assessments in large water bodies.

ATTENUATION OF NITROGEN FLUXES DURING GROUNDWATER SEEPAGE ACROSS A BEACHFACE AT CAPE HENLOPEN, DELAWARE.
Rebecca L. Hays and **William J. Ullman**, College of Marine Studies, 700 Pilottown Road, Lewes DE, 19958. rhays@udel.edu. **Session 2**, poster, 1/11/05 (presentation #34).

Estuaries and coastal systems are extremely vulnerable to the effects of cultural eutrophication due to land-use practices in their watersheds. While current watershed management practices are already leading to a reduction of nutrient inputs to land surfaces, there are still substantial quantities of nutrients stored in aquifers that will, as a consequence of long residence times, continue to discharge to coastal and estuarine waters and associated marshes for many years. Direct groundwater discharge, associated nitrogen loads, and the extent to which biogeochemical processes moderate nitrogen loads to the Delaware Estuary were determined at a sandy beachface site at Cape Henlopen, Delaware. The rates of fresh groundwater discharge and associated nitrogen loads were determined approximately monthly, by measuring the discharge, salinity, and nitrogen concentrations of brackish water discharging from tidal pools formed at the base of the beachface during low tide. The water in the tidal pool represents a mixture of recycled estuarine water and "new" fresh groundwater enriched in nitrogen from upland sources. Nitrogen concentrations and speciation were also determined in offshore estuarine waters and fresh groundwater high on the beachface to determine the deviation in nitrogen concentrations and speciation in the tidal pool discharge waters from ideal mixing lines. Freshwater discharges were found to range between 0.53 and 4.01 L/min/m of beachface with lowest values during the summer, consistent with hydrological balance. The flux of nitrogen from the upland to the beachface was determined from the measured freshwater discharge and the concentration of dissolved nitrogen in fresh groundwater. This flux was compared to the total flux of nitrogen discharged from the tidal pool. Significant nitrogen transformations and removal from the groundwater were noted as the freshwater entered the tidal system. During the majority of the year, there is net DIN loss (6-77%) during discharge, presumably due to denitrification. However, during the coldest winter months, the addition of DIN (52-110%) by nitrification is observed. Nitrification is probably supported by organic matter entrapped in beach sand by wave swash. The changes in nitrogen concentrations and speciation in the beachface indicate that beach sands and associated micro-organisms are an effective natural bioreactor for nitrogen attenuation, at least during summer months, and could be further managed to mitigate estuarine eutrophication.

There is significant fresh groundwater discharge and associated nutrient loading to the Delaware Estuary. Sandy beachfaces, however, are sites of active nitrogen cycling and attenuation during most of the year. This suggests that nitrogen loads determined from hydrological balance and average upland concentrations or from land use export factors may overestimate the impact of direct submarine or marginal marine discharge to estuarine nutrient cycling. Lastly, this research indicates that sandy beachfaces can serve an important biogeochemical function to the adjacent coastal and estuarine waters and therefore beach preservation may serve more than a recreational need. The management of beaches for nutrient attenuation may mitigate some of the impacts to estuaries of nutrient overenrichment.

PESTICIDE COMPOUNDS IN STREAMWATER OF THE DELAWARE RIVER BASIN, PENNSYLVANIA, NEW JERSEY, NEW YORK, AND DELAWARE, DECEMBER 1998 – AUGUST 2001. **R. Edward Hickman,** U.S. Geological Survey, 810 Bear Tavern Road, Suite 206 West Trenton, New Jersey 08628. whickman@usgs.gov. **Session 2**, 2:45, 1/10/05 (presentation #38).

During 1998-2001, 531 samples of streamwater were collected at 94 sites in the Delaware River Basin in Pennsylvania, New Jersey, New York, and Delaware as part of the U.S. Geological Survey National Water-Quality Assessment Program. These samples were analyzed for dissolved concentrations of 47 pesticide compounds (43 pesticides and 4 pesticide degradation products). Most samples were collected at least monthly during storms and base flow (nonstorms). Additional samples were collected under base-flow conditions at 84 sites during May-June and August-September. The objectives of this program were to document spatial and temporal patterns of the detections and concentrations of these compounds, and to determine how these patterns were related to other factors such as land use.

Of the 47 pesticide compounds analyzed for, 30 were detected in samples from throughout the Delaware River Basin. At least one compound was detected in samples from 91 of the 94 sites (95 percent of all samples from all sites). More than 1 compound was detected in samples from 84 of the sites (90 percent of all samples from all sites).

Concentrations of pesticide compounds varied with land use. Concentrations of atrazine, metolachlor, and pendimethalin increased with an increase in the percentage of drainage basin composed of agricultural land. Concentrations of prometon, diazinon, and carbaryl increased with an increase in the percentage of drainage basin composed of urban land.

Concentrations measured during the growing season, April-October, generally were greater than those measured during the nongrowing season. This probably reflects the greater use of pesticides during the growing season than during the rest of the year. Concentrations of atrazine, metolachlor, and acetochlor appeared to be greatest during May-July, possibly reflecting their application to agricultural fields in the spring.

Concentrations of pesticide compounds rarely exceeded either drinking-water standards or guidelines or guidelines designed to protect aquatic life. Drinking-water standards or guidelines were exceeded by one or more compounds in samples from five sites. Guidelines designed to protect aquatic life were exceeded in samples from 11 sites. Not all of the 30 identified compounds have such standards or guidelines; 9 do not have standards or guidelines for drinking water, and 13 do not have standards or guidelines to protect aquatic biota.

Because all the streams sampled are tributaries of the Delaware Estuary, results of this study provide information on pesticide compounds that could be transported into the estuary in streamflow and adversely affect the estuary's biota. Results also indicate that any sampling of the estuary for pesticide compounds should include samples collected during spring and summer, the periods of greatest concentrations of pesticide compounds in the tributaries.

WATER WITHDRAWALS AND TRANSFERS IN THE DELAWARE RIVER WATERSHED IN NEW JERSEY. **Jeffrey L. Hoffman** and **Steven E. Domber**, N.J. Geological Survey, NJDEP, Box 427, Trenton, NJ 08625. Jeffrey.L.Hoffman@dep.state.nj.us.
Session 8, poster, 5/10/05 (presentation #4).

During the period 1990-1999 withdrawals of ground and surface freshwater in the Delaware River watershed in New Jersey averaged 493 billion gallons a year (bgy). This is a very misleading statistic. Much of this water was returned to the ecosystem, albeit with either a changed quality (as by discharge from a treatment plant) or with a thermal load (after being used for cooling purposes). It may be better to analyze net consumptive (evaporative) losses and net depletive (export) losses.

Net consumptive loss by all users in the New Jersey portion of the Delaware River watershed was about 33.6 bgy or 7% of total use. Also during this period a net of 29.7 bgy of freshwater was exported from the New Jersey portion. This was somewhat counterbalanced by an average net import of 3.8 bgy of sewage. Overall reduction of water in the Delaware River watershed due to New Jersey's water exports and evaporative losses averaged 59.5 bgy over the period 1990-1999. This does not account for consumptive and depletive water use outside of New Jersey (such as water exported to New York City).

These results are from the New Jersey Water Transfer Data System (NJWaTr). This is an Access data base designed to track withdrawals and transfers of fresh water, transfers of sewage, and discharges of reclaimed waste water on a HUC14 (subwatershed) basis. It currently holds data for New Jersey for the period 1990-1999. Withdrawal and discharge locations are generally very accurately located. The location of potable water service areas and sewage service areas are less precise. For this reason transfers of water and sewage to and from service areas are considered accurate to the HUC11 (watershed) scale. NJWaTr is being used by the NJ Department of Environmental Protection as one tool during the development of a new statewide water supply plan.

These data are currently available over the Internet via an Excel workbook that summarizes withdrawals and transfers on a watershed management area (WMA) basis. New Jersey is divided into 20 WMAs for management purposes. The Delaware River Basin in New Jersey covers six WMA. From north to south they are: Upper Delaware; Central Delaware; Assiscunk, Crosswicks, and Doctors; Rancocas; Lower Delaware; and Maurice, Salem, and Cohansey.

This research is necessary because defining the water needs of all components of the water system (humans as well as ecological) is a critical step in investigating how to manage water demands. The need to supply water to the human population of the Delaware River watershed (and some significant population centers outside of the watershed) sets practical criteria that any water management plan for ecological needs must acknowledge. Better definition of these water demands allows for a greater chance of successfully implementing a plan to share the water resources of the watershed.

CATFISH, NORTHERN SNAKEHEAD AND MOSQUITOFISH IN THE WATERSHED OF THE DELAWARE ESTUARY. **Richard J. Horwitz, Paul Overbeck**, Academy of Natural Sciences of Philadelphia, 1900 Benjamin Franklin Parkway, Philadelphia, PA 19103; and **Ann Faulds**, Pennsylvania Sea Grant, 1450 Edgmont Avenue Suite 150, Chester, PA 19013. horwitz@acnatsci.org. **Session 9**, 3:30, 5/10/05 (presentation #46).

Local occurrence of three species of introduced fishes may have significant effects on native fish populations. The flathead catfish (*Pylodictes olivaris*) is native to the Mississippi River drainage and has been introduced widely in the Southeastern US. It was first recorded in the Delaware River drainage in 1997 from Blue Marsh Reservoir. From 1999 through 2004, it has been documented at several sites between rkm 6 and 72 in the Schuylkill River. The range of sizes indicates that the species is reproducing. It has been found commonly in the fish ladder at the Art Museum Dam in Philadelphia, at the head of tide. There are a few documented occurrences in and near the main stem Delaware River. Based on impacts elsewhere in its introduced range, flathead catfish may have significant effects on prey species, including bullheads (*Ameiurus*), sunfishes, crayfish and anadromous clupeids. A number of small adult Northern snakehead (*Channa argus*) were caught in Meadow Lake, Philadelphia, in the summer of 2004. At least one brood of fry was also noted. The limited range of sizes collected suggests a recent introduction. The pond is connected to the tidal Schuylkill River, but there are no documented records of the snakehead outside of the pond. The Eastern mosquitofish (*Gambusia holbrooki*) is native north to Delaware and southern New Jersey. An introduced population (species uncertain) was recorded in southeastern Pennsylvania in the early 20^{th} Century. Recently, the Eastern mosquitofish (*G. affinis*) has been recorded from a number of streams in the Delaware drainage. Possible effects include hybridization with Western mosquitofish.

While all three species may have important effects on Delaware Estuary resources, there is incomplete information on the status of all three species. Monitoring is impeded by potentially large range (all three species), difficulty of capture (flathead catfish), limited access to important habitats (snakehead), difficulty of separation from congeners (Eastern mosquitofish) and the number of undocumented reports (flathead catfish and snakehead). All three species are capable of rapid spread, and control will be difficult.

BEACH DYNAMICS, SHORE PROTECTION AND HABITAT RESTORATION FOR HORSESHOE CRABS IN DELAWARE BAY, USA.

Nancy L. Jackson, Department of Chemistry and Environmental Science, New Jersey Institute of Technology, Newark, NJ, 07102; **David R. Smith**, U. S. Geological Survey, Leetown Science Center, Kearneysville, WV; and **Karl F. Nordstrom**, Institute of Marine and Coastal Sciences, Rutgers University, New Brunswick, NJ. jacksonn@njit.edu. **Session 5**, 1:30, 1/11/05 (presentation #37).

There is a growing interest in the status of beaches in estuaries where biota are being threatened by beach loss or alteration. Interest in Delaware Bay beaches focuses on horseshoe crab egg production, the nutritional dependence of migratory shorebird populations on these eggs, and the value of intertidal beaches as feeding areas for the prey of commercially valuable fish. Bulkheads and beach nourishment are the leading options for shore protection in many estuaries, including Delaware Bay, but the effects of these options on the suitability of the foreshore as habitat are not known. For horseshoe crabs, changing the sedimentary characteristics and geometry of the beach can influence both spawning and subsequent viability of eggs that are deposited in the beach matrix. Beach nourishment provides the opportunity for restoring horseshoe crab habitat on eroding or armored shorelines, but knowledge of the type of fill sediment and the dimensions of the operations is critical to success. This presentation will report on a series of investigations that assess the interactions between beach dynamics and horseshoe crabs. Areas explored include: the contribution of waves and bioturbation to sediment activation and egg exhumation, the difference in sedimentary characteristics of nourished and unnourished beaches in Delaware Bay, and the effects of beach nourishment on horseshoe crab egg viability and development.

ON-LINE ACCESS AND ANALYSIS OF DATA FROM NOAA'S NATIONAL STATUS AND TRENDS PROGRAM.

W. Edward Johnson and **M. Jawed Hameedi.** National Oceanic and Atmospheric Administration, Silver Spring, MD 20910. ed.johnson@noaa.gov. **Session 11**, 4:00, 5/11/05 (presentation #24).

NOAA initiated its National Status and Trends (NS&T) Program in 1984 in response to Federal legislation to establish a comprehensive national program for consistent monitoring and assessment of the Nation's coastal ecosystems. Since its inception in 1986, the program's Mussel Watch Project has remained the backbone of contaminant monitoring in U.S. coastal waters and established a benchmark by which to gauge the spatial distribution and temporal trends of chemical contamination. Currently, the project has over 250 sampling sites nationwide, including sites in the Great Lakes. Samples are analyzed for a variety of toxic contaminants, including pesticides, industrial chemicals, petroleum-related compounds, and metals as well as ancillary biological parameters, e.g., gonadal index. The program's "Bioeffects Studies," intensive region-specific investigations, provide a comprehensive assessment of environmental toxicity in water bodies ranging from small embayments, such as Newark Bay, to large estuaries such as Puget Sound. The study results help coastal managers in identifying areas that require priority clean-up, restoration or mitigation efforts. The program has also provided data, based on analyses of sediment cores, to reconstruct contamination and sedimentation history over decadal scales. The program's data and results are distributed worldwide as research papers, data sets, sampling and quality assurance protocols, and information brochures in paper and electronic formats.

The program has also been instrumental in developing quality assurance protocols, applying new measurement techniques, and providing interpreted data and information products to users. A significant new effort is underway to compile and organize the program's data on chemical contamination and sediment toxicity (nearly one million records) into a relational database. Users will be able to access the database (and associated metadata) via Internet from a NOAA website and also have the capability to develop information products on-line through web-based data analysis and visualization tools. This will greatly facilitate sharing of coastal environmental data among

researchers, resource managers and the public at large, thereby promoting more informed and transparent decisions.

BLUE CRAB POPULATION DYNAMICS IN DELAWARE BAY: DENSITY DEPENDENT JUVENILE MORTALITY AND THE RELATIONSHIP BETWEEN SPAWNING STOCK AND RECRUITMENT. **Desmond M. Kahn**, Delaware Division of Fish and Wildlife, 89 Kings Highway, Dover Delaware, 19901. Desmond.Kahn@state.de.us. **Session 3**, 8:30, 1/11/05 (presentation #52).

Blue crabs, *Callinectes sapidus*, (Portunidae) are abundant, large-bodied predaceous benthic invertebrates. They range from Uruguay through Massachusetts, so the Delaware Bay population is one of the northernmost, and has occasionally declined dramatically due to severe winterkill. Less severe winterkill has occurred in 1994, 1996 and 2003 during the last decade. An intensive commercial fishery harvests crabs during the winter, spring summer and fall, using dredges in winter and pots in the rest of the year. Using data continuous since 1978 from the Delaware Division of Fish and Wildlife's research trawl survey, I have estimated trends in abundance of several life-stages, including early juveniles, late juveniles, adults and spawning females. An overcompensatory Ricker stock-recruitment model provides a significant fit to the relation between indices of recruits and of female spawning biomass, indicating that while environmental factors have a large effect on recruitment, the level of spawning stock biomass can play a significant role as well. The effect of spawning biomass became particularly evident after a severe winterkill in 1977 reduced the population to a relatively low level, where it remained for approximately eight years. Spawning biomass was very low and recruitment was also very low during this period. The inference is that recruitment was limited by low spawning biomass. Survival analysis of the indices indicates that the early juvenile stage manifests density-dependent mortality. Combining survey indices of relative abundance with estimates of catch via a catch-survey model produced estimates of absolute abundance, survival and fishing mortality. Maximum harvest of 48.5 million blue crabs occurred in 1995. Estimated abundance of recruits from 1979 through 2002 ranged from a low of 34 million o a peak of 631 million in 1995, with an average of 284 million. Adult abundance estimates ranged from a low of 19.6 million in 1979 to a peak of 146 million in 1993, with an average of 72 million. Total annual survival ranged from a low of 12% in 1990 to a high of 58% in 1991, and average survival was 27%. Average upper and lower bounds of fishery exploitation rate were 8% an 23%, with an increasing trend over the period. Exploitation rates appear to be sustainable, however. Model results should be validated by a second approach, however, because they are dependent on the relative weighting in the model of measurement and process error.

IMPERVIOUSNESS: A PERFORMANCE MEASURE OF A DELAWARE WATER RESOURCE PROTECTION AREA ORDINANCE. **Gerald J. Kauffman, Martha B. Corrozi** and **Kevin J. Vonck*,** Water Resources Agency, Institute for Public Administration, University of Delaware, DGS Annex, Newark, Delaware 19716. mcorrozi@udel.edu. **Session 10**, poster, 5/10/05 (presentation #94).

The New Castle County Resource Protection Area Technical Advisory Committee (RPATAC) requested that the Water Resources Agency of the University of Delaware (WRA) utilize impervious cover estimates to evaluate the performance of the Water Resource Protection Area (WRPA) ordinance. This 1991 ordinance was the first in Delaware to protect the quantity and quality of drinking water supplies by limiting new development in WRPAs such as recharge, wellhead, reservoir watershed, and limestone aquifers to a maximum 20 percent impervious cover. The research used geographic information system (GIS) techniques to evaluate the effectiveness of the ordinance in limiting development to less than 20 percent impervious cover. The analysis indicated 138 new developments were proposed in WRPAs since the ordinance was approved in 1991. The composite impervious cover of the 89 square miles of WRPAs in New Castle County is 15 percent, less than the 20 percent code requirement, ranging from 7 percent in recharge areas to 41 percent in several wellhead protection areas. To further protect drinking water supplies, the researchers recommend that the RPATAC discourage code variances for new development in WRPAs that already exceed 20 percent impervious cover. The county should acquire parks and open space to protect the healthier WRPAs where impervious cover is currently less than 20 percent.

There are a variety of zoning techniques designed to protect the ground and surface water supplies implemented throughout the states, counties, and localities in the Delaware River Basin. The relevancy of these findings to science in the Delaware Estuary is best considered in the context of protecting ground and surface water supplies by limiting impervious cover to 20 percent for new development within recharge, wellhead, reservoir watershed, and limestone aquifer areas through local ordinances. The *September 2004 Water Resources Plan for the Delaware River Basin* specifically states in Objective 3.3.D. that states, "Adopt and implement plans and ordinances that incorporate scientifically sound and legally implementable provisions for the protection and enhancement of water resources (States to support and encourage; local and county government to implement; private and non-governmental organizations to partner)." This analysis provides scientifically sound conclusions that the New Castle County Water Resource Protection Area Ordinance is an effective tool for the protection and enhancement of water resources and can serve as a useful water resource management tool for the governments throughout the Delaware River Basin.

STATE OF THE BASIN REPORT CARD FOR THE DELAWARE RIVER. **Gerald J. Kauffman, Martha B. Corrozi*** and **Kevin J. Vonck,** Water Resources Agency, Institute for Public Administration, University of Delaware, DGS Annex, Newark, Delaware 19716. mcorrozi@udel.edu. **Session 11**, poster, 5/10/05 (presentation #95).

The September 2004 Water Resources Plan for the Delaware River Basin recommends developing a set of indicators to assess baseline conditions and measure progress toward objectives that can be published in a State of the Basin Report. The Delaware Estuary Program is required by its 1996 Comprehensive Conservation and Management Plan to regularly update the State of the Estuary Report, last published in 2002. The water resources institutes for the four land grant universities for the states in the basin – Cornell, University of Delaware, Rutgers, and Penn State - will collaborate to collect available watershed data and will work with the DRBC and the DELEP to prepare the State of the Basin Report Card grades. The Water Resources Agency of the University of Delaware (WRA) will serve as the coordinator for this yearlong project.

Watershed units will be segmented based on physiographic province, land use, stream order, and hydrologic network. The Delaware River Basin is 13,539 square miles in area and approximately 50 watershed units will be delineated, each approximately 250 square miles in area. The September 2004 Water Resources Plan organizes the Delaware River Basin into the Upper Region (NYS), Central Region, Lower Region, and Bay Region watershed regions and these will be further delineated using DRBC and WRA geographic information systems (GIS).

Grades will be assigned to each of the watersheds in the Delaware River Basin as well as the basin on the whole. There are several existing report card approaches that are being considered for this project, including the Christina Basin Report Card (a graded scale, A-F), Chesapeake Bay (a numerical scale, 0 – 100), Lehigh River (a scale of poor, marginal, sub optimal, and optimal), Delaware Estuary Report (measurable indicators based on trends over time), and Relative Rating Assessment (rates indicators as better, same, or worse tied to a baseline year). Each of the four land grant universities will collect existing watershed, water quality, and habitat data (since 1990) for the determined indicators in their respective state in the Delaware River Basin. Sources of data could include state Section 303d Clean Water Act Reports, USGS/EPA STORET monitoring data, Source

Water Protection area reports, existing reports issued by existing organizations such as the Stroud laboratory (for the New York City Catskill reservoir watersheds), Philadelphia Water Department, and State of the Lehigh Report. Once the collaborators have chosen the most appropriate grading system the corresponding grades or scale will be assigned to each watershed and the basin on a whole based on the determined indicators.

The coordinating team will prepare a report card over the course of 2005 and will publish a Delaware River Basin Report card with color graphics, maps, and figures in January 2006. The Report Card will report on the state of the Basin incorporating features that will be reader friendly to the public, elected officials, and stakeholders in the Delaware River Basin. The report card will be published in paper and digital format for widespread dissemination throughout the four states in the basin.

BACTERIAL PRODUCTION AND RESPIRATION IN THE DELAWARE ESTUARY.
David L. Kirchman, College of Marine Studies, University of Delaware, Lewes, DE, 19958. kirchman@udel.edu. **Session 4**, cancelled, 1/11/05 (presentation #18).

Heterotrophic and autotrophic microbes have large impacts on oxygen, carbon and nitrogen budgets in all aquatic ecosystems, including the Delaware Estuary. Although many microbial parameters have been measured in the Delaware, respiration has not been examined extensively. The paucity of the data on respiration has hampered efforts to understand the relationships between respiration and microbial biomass production and the impact of respiration on oxygen concentrations and net community production. The goal of this study was to estimate total and bacterial respiration in the water column of the Delaware Estuary where primary and bacterial production has been examined extensively in the past. We found that respiration often exceeded in situ primary production at several sites in the estuary and in different seasons, and that net oxygen production consequently was negative especially at an upstream station in the Delaware River where oxygen concentrations are often below saturation. Respiration by heterotrophic bacteria accounted for about 50% of total respiration and correlated significantly with ^{14}C-primary production, but there was no significant correlation between bacterial production (thymidine and leucine incorporation) and primary production. A simple budget was used to explore relationships among production, respiration, and input of terrestrial carbon. These calculations revealed that some values, e.g. high bacterial production relative to primary production along with low bacterial respiration relative to total respiration, were not consistent with common estimates of bacterial growth efficiency, although non-steady-state conditions should not be ignored. But other values of bacterial respiration (50% of total) and production (bacterial production to primary production ratio equal to about 0.8) in the Delaware River were consistent with high growth efficiencies (30%) of bacteria using a large input of terrestrial organic material. This input may explain why heterotrophic bacteria appear to have a larger impact than primary production on net oxygen saturation in the Delaware Estuary. Further work is needed to compare rates of oxygen utilization by heterotrophic microbes and by nitrification and to integrate these rates with inputs of organic carbon by in situ primary production and from terrestrial sources into a unified biogeochemical model.

FRESHWATER TURTLE COMMUNITIES AS INDICATORS OF THE EFFECTS OF ANTHROPOGENIC PERTURBATION AND HABITAT FRAGMENTATION IN THE DELAWARE ESTUARY ECOSYSTEM: A MODEL FOR LINKING ENVIRONMENTAL SCIENCE AND HABITAT MANAGEMENT. **Karen M. Klein, Harold W. Avery, James R. Spotila** and **Walter F. Bien,** Department of Bioscience and Biotechnology, Drexel University, 3141 Chestnut Street, Philadelphia Pennsylvania, 19104. haltort@aol.com. **Session 9**, poster, 5/11/05 (presentation #8).

Wetlands and the surrounding upland habitats within the Delaware Estuary provide essential resources necessary for semi-aquatic animals to complete their life cycles. Resources include 1) food

necessary for growth and reproduction; 2) shelter sites necessary for protection from predation and climatic factors such as temperature extremes, desiccation, etc.; 3) terrestrial nesting areas necessary for successful reproduction, and 4) interconnecting habitat (both aquatic and terrestrial) necessary for immigration and emigration of individuals. Since colonial times, freshwater wetlands and surrounding uplands have been lost in the Delaware Estuary. Remaining wetlands continue to be further fragmented and isolated from one another. Using freshwater turtles as models, we examine how fragmentation and perturbation of freshwater wetlands have affected semi-aquatic vertebrates in the Delaware Estuary. We measured the relative abundances, size distribution of individuals, sex ratios, and other measures of turtle populations inhabiting twelve wetlands in and adjacent to the Philadelphia International Airport. For each wetland we characterized the type of habitat modification that has occurred, and the extent of isolation and fragmentation. We individually marked, measured, and recaptured >1,500 individual state-listed Threatened red-bellied turtles (*Pseudemys rubriventris*), painted turtles (*Chrysemys picta*), common snapping turtles (*Chelydra serpentina*), musk turtles (*Sternotherus odoratus*) and invasive red-eared slider turtles (*Trachemys scripta*) from each wetland to determine how anthropogenic perturbations have affected turtle populations and turtle communities.

Intensive live-trapping of turtles from aquatic areas revealed distinct patterns and differences in population densities and size classes of individuals making up turtle populations of wetlands varying in fragmentation and isolation. State-Threatened red-bellied turtle populations inhabiting interconnecting wetlands achieved greater densities and had more size classes of individuals represented than populations occupying more isolated wetlands. Painted turtles and snapping turtles were ubiquitous throughout the Airport wetlands. Their populations were denser and had more represented size classes than other turtle species. Non-native red-eared slider turtles were mostly found outside the ground of the Airport, where the surrounding human population had free access to wetlands, compared to wetlands within the patrolled Airport grounds. Populations of red-eared slider turtles were composed primarily of juvenile-sized individuals, suggesting that non-native turtles had relatively higher rates of nest success, or, more likely, high rates of introduction to the ecosystem from anthropogenic sources (i.e., captive releases). Musk turtles were relatively rare in all wetlands. Nesting areas were generally extremely limited in available area for all turtle species. Surveys of nesting areas revealed high rates of predation along fencelines, roads, and other landscape edges.

Our comparative study of sympatric turtle species inhabiting freshwater wetlands of the Delaware Estuary ecosystem provides a case study and model for understanding how fragmentation and isolation affect semi-aquatic animals at the individual, population and community levels. We show how studies of freshwater turtle communities can provide new insights to understanding how fragmentation and isolation affect wildlife in the Delaware Estuary. Based on the findings of our study, and discussions with other scientists from the Delaware Estuary Conference Research Scientist Meeting (January 2005), we will delineate recommendations for managers to improve the viability of wildlife populations in the Delaware Estuary.

LONG-TERM DATA SETS ON THE BIOLOGY AND ECOLOGY OF THE AMERICAN OYSTER, *CRASSOSTREA VIRGINICA*, IN DELAWARE BAY. **John N. Kraeuter**, Haskin Shellfish Research Laboratory, Institute of Marine and Coastal Science, Rutgers University, 6959 Miller Avenue, Port Norris, NJ 08349; **Stephen R. Fegley**, Corning, School of Ocean Studies, Maine Maritime Academy, Castine, Maine 04420; and **Eric N. Powell**, Haskin Shellfish Research Laboratory, Institute of Marine and Coastal Science, Rutgers University, 6959 Miller Avenue, Port Norris, NJ 08349. kraeuter@hsrl.rtgers.edu. **Session 6**, 4:45, 1/11/05 (presentation #31).

Haskin Shellfish Research Laboratory, and its predecessor, the Department of Oyster Culture, has been involved in work on oysters and the ecology of Delaware Bay since the late 1800's. Data collections were modest until the 1950's when the laboratory began a systematic annual survey of the condition of the oyster resource. There are now over 50 years of data from these surveys and various amounts of data from ancillary investigations – many of which have 10 or more years of continuous collection. Examples of these data sets are: Oyster Seed Bed Survey (1953 to 2004) – numbers of live and dead oysters including spat counts. Ancillary information collected in the above survey – Condition index 1990 to 2004, Size of live oysters 1990 to 2004, Size of dead oysters 1999 to 2004; Oyster Disease Levels (1959 to 2004) – oysters from selected grids on the seed bed survey analyzed for *Perkinsis marinus*, MSX (1959-2004) and *Haplosporidium nelsoni*, dermo, (1990 to 2004); Seed Bed Oyster Harvest (1956 to 1989 with additional data collected by NJDEP after this period) –daily estimate of volume on deck of all harvesting vessels for the entire season; Oyster Spat Survey (1953 –1991) counts of settled oysters spat throughout the bay; Oyster Larval Survey (1956-1988) – counts of plankton samples for oyster larvae throughout the bay; Temperature and Salinity (1927-1988) bottom water data taken in conjunction with surveys and other investigations. These latter data were analyzed and comparisons were made for data from 1927 to 1952 vs 1953 to 1969 at 5 stations on the Delaware Bay oyster beds (Haskin Report to Delaware River Basin Commission dated May 15, 1970). These data indicate that under increasing river flows the oyster seed beds experienced higher salinity in more recent times. In addition to illustrations of the salinity information, the type of data available, methods of collection, and its status in terms of electronic availability will be outlined for each data set. Some examples of trends, the challenges presented by data representing an estuarine gradient and transferring data through time will be highlighted. The lack of long-term data on other biological systems of the Delaware Estuary, and fractured nature of the science efforts within the system are serious long term issues that should be addressed by the citizens, and the scientific and management communities.

A HOLISTIC VIEW OF THE CONSERVATION AND PROPAGATION OF FRESHWATER, BRACKISH AND ESTUARINE BIVALVES FOR ECOSYSTEM SERVICES. **Danielle A. Kreeger,** Delaware Estuary Program, Delaware River Basin Commission, 25 State Police Drive, West Trenton, NJ 08628. DKreeger@acnatsci.org. **Session 5**, 3:00, 1/11/05 (presentation #2).

Native freshwater mussels (Mollusca: Unionacea) are the most imperiled fauna in the United States, and resources are being increasingly mobilized to protect and restore their biodiversity. Comparatively less effort has been directed at documenting and remedying declines in their population biomass, and the ecological consequences of losing these animals are unknown. The goal of this preliminary study was to assess whether mussels (*Elliptio complanata*) remain sufficiently abundant in the lower Brandywine River in southeast Pennsylvania to affect key functional processes. My approach was to quantify physiological rate functions (e.g., allometric rates of consumption, excretion, biodeposition) of adult mussels under simulated natural conditions. These processing rates were then related to both the population biomass of mussels in a six mile stretch of river and to the volume and flow of water. Within this reach, mussel density averaged only 1.7 m^{-2}, which was low compared to other streams where healthy mussel beds still exist. Nevertheless, the combined population of more than 500,000 *E. complanata* in the study area was estimated to remove more than 25 metric tons of suspended particulates per year during base flow conditions, which represented more than 7% of upstream inputs. I also observed that particle concentrations in bottom waters became depleted by up to 80% as water passed small pocket beds of mussels. Sediment organic content within and below mussel groups was also enriched by up to 50% compared to areas immediately upstream where no mussels were found.

The relevancy of these findings to science in the Delaware Estuary is best considered in the context of water quality. These data suggest that the population biomass of native freshwater mussels in the lower Brandywine River, while vestigial compared to historic reports, is still sufficient to have a substantial impact on biogeochemical and energetic cycling in the river. Hence, the presence and health of these freshwater mussel populations could have important consequences for watershed inputs to the estuary. The benefits of protecting and restoring native mussel populations therefore extend beyond preserving biodiversity, which is the current focus of conservation biologists. For the same reasons that oyster reef restoration is being considered for providing ecosystem services in Chesapeake Bay, where abundant, native mussels can provide important ecosystem services and a powerful management tool for maintaining and reclaiming water quality. Future efforts to protect or restore water quality within the Delaware Estuary may therefore benefit by applied restoration programs targeting the integrated "biofiltration services" contributed by bivalves throughout the basin, including estuarine oysters, brackish mussels, and freshwater mussels.

SALTWATER INTRUSION INTO CAPE MAY COUNTY AQUIFERS FROM DELAWARE BAY. **Pierre Lacombe**, U.S. Geological Survey, 810 Bear Tavern Road, West Trenton, NJ 08628; placombe@usgs.gov. **Session 1**, 2:00, 1/10/05 (presentation #27).

Saltwater intrusion into the freshwater aquifers of southern Cape May County, New Jersey has resulted in the abandonment of more that 20 pubic- and industrial-supply wells and more than 100 domestic-supply wells. Saltwater intrusion forced Cape May City Water Department to abandon its five public-supply wells. Since 1998, Cape May City, West Cape May, and Cape May Point are the only communities in New Jersey to rely on desalinated ground water for their water supply.

Saltwater intrusion rates from Delaware Bay into the Cape May City Water Department well field ranged from 95 ft per year during the 1950's to 350 ft per year during the 1990's. Cape May City Water Department abandoned relying on the well field as the only water source in 1998. Saltwater intrusion rates in Cape May Point's well field were 120 ft per year during 1950-70. The Water Department abandoned their second of two wells about 1972. Saltwater intrusion was 40 ft per year at a former magnesite manufacturing plant on Delaware Bay shore in Lower Township.

The USGS and NJDEP have monitored chloride concentrations in 14 wells tapping five aquifers along the Delaware Bay shoreline of Cape May County since the 1950's. The aquifers are Holly Beach water-bearing zone, estuarine sand aquifer, Cohansey aquifer, Rio Grande water-bearing zone, and Atlantic City 800-foot sand. In most wells the chloride concentration has remained relatively static. However, water samples from the Cohansey aquifer collected from a monitor well at the mouth of Fishing Creek has chloride concentrations that have increased 100 milligrams per liter per year since 1995. Chloride concentrations are in excess of 800 milligrams per liter.

Intrusion of saltwater from Delaware Bay into the fresh-water aquifers of Cape May County is responsible for the New Jersey Legislature to enact a Bill in 2002 to investigate the saltwater intrusion of Cape May Peninsula and determine the sustainable potable water supply of the County. The USGS in cooperation with the NJDEP is investigating and developing plans for an alternative sustainable potable water supply to address the saltwater intrusion problems. The investigation is designed to insure that the ecological water-supply demand also is sustainable and that any sustainable ground water withdrawal plan for potable water supply does not deplete streams, freshwater wetlands, or other ecological water supplies.

STATUS AND TEMPORAL TRENDS OF TOXIC CONTAMINANTS IN DELAWARE BAY: EVIDENCE FROM BIVALVE TISSUES. **Gunnar G. Lauenstein** and **M. Jawed Hameedi**, National Oceanic and Atmospheric Administration, Silver Spring, MD 20910. Gunnar.Lauenstein@noaa.gov. **Session 6**, 4:30, 1/11/05 (presentation #22).

As part of its nationwide monitoring of toxic contaminants in coastal bays and estuaries, NOAA's National Status and Trends (NS&T) Mussel Watch Project has established eight sites in Delaware Bay. Sampling of the sites began in 1986; since 1992 the sites have been sampled biennially. Oysters are collected at most of the sites in the bay, except mussels are collected at Cape May and Cape Henlopen. Using the Spearman Rank Correlation Coefficient, temporal trends have been documented for a variety of toxic chemicals such as silver, arsenic, cadmium, copper, mercury, nickel, lead, tin, zinc, hexachlorbenzene, lindane, Mirex, total-DDT, total-PAHs, total-chlordane, total-dieldrin, total-butyltin, and total-PCBs.

For six sites in the mainstem of the bay, the mean concentration of silver, cadmium, copper, nickel, zinc, total-DDT and lindane in oyster tissues (1984-2003 data) is higher than the nationwide median values for these analytes; in some of these cases, the mean concentrations exceeded the 85th percentile, indicative of a "high" value, of the nationwide database. Temporal trends of contaminant concentration are generally consistent with National findings: no trends are discernible for most organic compounds and trace elements at most sites. When trends exist, decreasing trends are much more prevalent than increasing trends. For example, all six sites for which trends could be determined had decreasing lindane concentrations and all but one site (Cape May) exhibited decreasing total-chlordane concentrations. Three sites had decreasing concentrations of total-DDT. The remaining analytes showed decreasing trends at two or fewer sites. The only multi-site increasing trend was found for silver, at three sites, two of which are the cape sites. The site at Arnolds Point Shoal exhibited a nearly monotonic increase in inorganic tin.

DR. JEKYLL AND MR. HYDE: COMPARING THE RHIZOME GROWTH DYNAMICS OF NATIVE AND NON-NATIVE POPULATIONS OF *PHRAGMITES AUSTRALIS.*

Michael T. League, Denise M. Seliskar and **John L. Gallagher**, College of Marine Studies, University of Delaware, Lewes, DE, 19958. mleague@udel.edu. **Session 5**, poster, 1/11/05 (presentation #48).

In the last century, *Phragmites australis* has expanded from a minor component of the mid-Atlantic wetlands to a dominant species. For example, in Delaware, *Phragmites* has been estimated to occupy approximately one-third of the tidal marshes. Recent genetic analysis of historic and modern populations of *Phragmites* suggests that the expansion of a particular genetic haplotype may be responsible for the observed invasion. While the non-native haplotype is dominating the landscape, there still exist small populations of native haplotypes along the Delaware Estuary. Knowledge of growth differences between different haplotypes is necessary to facilitate management of the invasive haplotype and preservation of native populations. The dynamics of rhizome growth are particularly important because of their role in invasion. For this reason, a bioassay protocol to quantify rhizome growth dynamics was developed and tested. While the original purpose of this assay was to examine effects of control treatments, the method provides a mechanism to compare the growth dynamics of native and non-native haplotypes.

In March 2004, rhizomes were collected from adjacent native and non-native populations in a brackish salt marsh along the Appoquinimink River, near Odessa, Delaware. Rhizomes were classified by depth (0-25 cm and 25-75 cm) and appearance (white or brown), and grown in sand under greenhouse conditions for 65 days without nutrient supplements. Shoots from rhizomes exhibiting growth were harvested to remove apical dominance and the rhizomes replanted for 30 days. Significant differences were noted in number of shoots, average shoot height, and in belowground growth dynamics. Concurrently, a five-month salinity and nutrient enrichment experiment was conducted comparing the effects of three salinity levels (0, 10, and 20 ppt) and three nutrient levels (0, 35, and 70 g/m^2) on rhizome segments of the two haplotypes. Aboveground growth dynamics were measured throughout the study and belowground growth dynamics were assessed upon harvesting. Significant differences between the two haplotypes were noted in the number of shoots and average shoot height. Significant differences were also noted in a variety of belowground growth dynamics including new rhizome length, number of nodes, number of buds, rhizome fresh weight, and root fresh weight.

LINKING ESTUARIES SCIENCE AND MANAGEMENT USING COMPARATIVE RISK ASSESSMENT AND MULTI-CRITERIA DECISION ANALYSIS. **Igor Linkov,** Cambridge Environmental Inc., Cambridge, MA 02141; **Greg Kiker**, University of Florida; and **Todd Bridges**, U.S. Army Corps of Engineers. Linkov@CambridgeEnvironmental.com. **Session 10**, poster, 5/10/05 (presentation #97).

With attention in many areas of the world focused on perceived and real security issues, people in many professional disciplines are developing policies and actions that integrate risk assessment and functional decision-making into environmental resource planning. Estuaries attract people and are subject to increased industrial activities and overpopulation. At the same time, these areas have a need to balance anthropogenic needs such as navigation, industrial development with ecological factors such as restoration or invasive species. During the 21st century environmental challenges in balancing human and ecological needs are likely to increase and may lead to significant conflicts if functional approaches to addressing these environmental problems are not recognized and discussed. In response to these challenges, integrative decision-making policies and plans should be launched jointly in the framework of co-operative strategies and conflict avoidance. Addressing the environmental threats and their resulting mitigation actions necessitates not only an understanding of the basic risk assessment paradigm along with a familiarity with the tools of risk analysis to assess, interpret and communicate risks, but also requires a modification of the risk paradigm to incorporate unique political and ecological challenges of different countries and their level of development.

This presentation will summarize results of the NATO/Army Corps of Engineers April 2005 workshop on "Environmental Security in Harbors and Coastal Areas: Management using Comparative Risk Assessment and Multi-Criteria Decision Analysis." (www.risktrace.com/nato) The workshop took place in Greece and was attended by about 50 experts from 20 countries. The workshop discussed applications of comparative risk analysis (CRA) and multi criteria decision analysis (MCDA) to environmental security in coastal regions including sub-topics such as navigation issues, restoration and invasive species.

BIOLOGICAL INDICATORS OF WATER QUALITY. **A. Ronald MacGillivray** and **Thomas J. Fikslin,** Delaware River Basin Commission, 25 State Police Drive, West Trenton, NJ 08628. ronald.macgillivray@drbc.nj.state.us. **Session 8**, 1:55, 5/10/05 (presentation #67).

Biological indicators of water quality for aquatic life and wildlife recommended by the EPA for assessment according to Section 305(b) of the Clean Water Act include the condition of biological communities, the health of resident organisms, and toxicity bioassays. These biological indicators integrate environmental exposures and reflect the effects of multiple stressors on living resources. Among other things, integrated measures of water quality can assess point sources and non-point sources, they can assess mixtures (additive and cumulative interactions) and they can assess toxicants with no chemical specific water quality standard and/or toxicants that are not being monitored by chemical analysis. Biological indicators can be used to assess if "safe" or "no effects" conditions are present in the ambient river water or sediment which would permit the normal propagation of fish and other aquatic life.

When linking indicators of water quality and ecological health with environmental management, a weight of evidence approach should be used. For example, the National Coastal Assessment evaluation of sediment condition in the Delaware Estuary includes measurements of chemical concentrations in sediment, sediment toxicity bioassays, and information on the condition of benthic communities.

When selecting biological indicators of water quality, a consensus should be developed among stakeholders. The DRBC has established a workgroup of stakeholders to study and characterize the nature and extent of cumulative chronic toxicity in the Delaware Estuary. The workgroup is developing scientifically sound sampling and analysis plans to determine if ambient chronic toxicity occurs in the estuary. In consultation with EPA-ORD, the workgroup is developing data for test species and test methods that are appropriate for low salinity levels present in the estuary.

Since a single organism or test can not provide a definitive assessment, data should be collected in a tiered manner that provides increasing information in support of environmental effects. A set of biological parameters should be added to the existing suite of chemical parameters in a comprehensive monitoring strategy for the Delaware Estuary that includes a gradient of monitoring from screening level evaluations to conclusive surveys for regulatory compliance.

THE DELAWARE BAY OIL SPILL 2004: UTILIZING THE MIGRATORY BIRD TREATY ACT AND THE NORTH AMERICAN WETLAND CONSERVATION ACT TO HELP MAKE BIRDS AND THEIR HABITATS WHOLE. **Andrew T. Manus**, The Nature Conservancy - Delaware Chapter, 210 Union Street, Milton, DE 19968; and **Andrew Milliken**, Atlantic Coast Joint Venture Coordinator, U.S. Fish and Wildlife Service U.S. Fish and Wildlife Service, 300 Westgate Center Drive, Hadley, MA 01035-9589. amanus@tnc.org. **Session 7**, poster, 5/10/05 (presentation #65).

Dr. John Teal in his recent plenary remarks at the Delaware Estuary Science Conference in Cape May, New Jersey suggested that the recent oil spill settlement in Buzzards Bay, Massachusetts that directed funds to the North American Wetlands Conservation Council might be a model to look to with respect to the oil spill now being clean-up in the Delaware Bay. To that point, recent oil spills, the North Cape Oil Spill in Rhode Island Sound, Rhode Island (1996) and Buzzards Bay, Massachusetts (2003) caused considerable natural resource damages to the respective estuaries. In addition to the estuarine resources that were affected, migratory bird damages were equally egregious. Both migratory bird habitat and a number of species were damaged as a result of these two spills. In both of these spills the question of liability was determined early on during the response phase of the spills. These determinations were critical to federal charges being filed by the USFWS under the Migratory Bird Treaty Act (MBTA).

As the MBTA provided the basis upon which criminal charges were filed and fines collected, the North American Wetlands Conservation Act (NAWCA) provided the structure and process under which the funds were committed to specific habitat projects. This process ensured that funds were expended in a systematic way via a technical scoring program that ranked and recommended only those meritorious projects with the highest habitat values for those birds affected by the respective oil spills.

How the MBTA and NAWCA might be applied in the case of the Delaware Bay oil spill is a question that is currently being asked. The lessons learned from the two previous oil spills on the East Coast will be discussed. The efficacy of applying this approach in the Delaware Estuary depends on a fuller understanding of the MBTA and NAWCA. This paper/presentation will present the opportunities that this approach may hold for making migratory birds and their habitats whole in the Delaware Bay. A key underpinning to this approach is a strong commitment and track record of seeking solutions that link the best available science to the management and habitat protection actions taken. Both the compensation approach available under these two acts and the way the best available science is linked to the action taken have relevancy to Partnership for the Delaware Estuary Conference schedule for May 2005.

SALT MARSH TROPHIC PYRAMIDS: BEING A MONOGRAPH ON MARSH MEALS OF MONUMENTAL MEANING.

Marc A. Matsil, New Jersey Department of Environmental Protection, Commissioner's Office, PO Box 418, Trenton, NJ 08625-4608. Marc.Matsil@dep.state.nj.us. **Session 9**, 4:30, 5/10/05 (presentation #80).

A series of oil spills in local waters clustered around 1990 drew our attention to the difficulties of characterizing damages to estuarine ecosystems. Damages were sometimes considered by tallying numbers of dead taxa and ascribing dollar values. Such assessments ignored the complex, systemic, trophic relationships between organisms in estuarine ecosystems. When one component of a system is perturbed, a ripple affect permeates the entire system. Some ecosystem components carry a larger burden in maintaining ecosystem function. Some, like *Spartina alterniflora* – often referred to as keystone species – are essential. When they are effected, the entire system is perturbed. Others are relatively insignificant. Their function may be a redundant one, performed by several other taxa.

This paper is an attempt to identify and compile some of the more critical pathways through which individual taxa are linked according to who eats what and whom in our local waters. Information here is distilled from diverse and far flung sources. There remain several important players in the estuarine drama for which published information was assimilated here. This remains a work in progress.

THE DECLINE OF THE DELAWARE SHOREBIRD STOPOVER AND NEW OPPORTUNITIES FOR RECOVERY.

Lawrence J. Niles, Amanda Dey and **Kathleen Clark,** New Jersey Division of Fish and Wildlife, New Jersey Department of Environmental Protection, P.O. Box 400, Trenton, NJ 08625-0400. larry.niles@dep.state.nj.us. **Session 9**, 4:10, 5/10/05 (presentation #61).

The Delaware Bay ranks among the most important shorebird stopovers in the world because a significant portion of six shorebird species depend on the bay's resources to complete their journeys to Arctic breeding sites. They come because of the dependable super abundance of horseshoe crab eggs that allow them to double their body weight in just two weeks. Over the last ten years the supply of eggs has diminished so that only a small portion of the stopover population reaches suitable weight, causing declines in species populations; we suggest many shorebirds are now bypassing the bay. The fight to protect the stopover was hampered by inadequate information on both the horseshoe crab population and the resource requirements of the shorebirds on the bay, as well as the condition of wintering areas in South America and breeding areas in the Arctic. In response, a team of scientists led by the Endangered and Nongame Species Program has studied the shorebird population in New Jersey since 1997, and in key South American wintering areas and in the Arctic breeding areas since 1999. With these data we have been able to persuasively argue for decreasing the harvest horseshoe crabs, increasing protection of shorebirds from disturbance, and improving habitat conditions while continuing extensive research and monitoring. But the protection of shorebirds is not unlike the protection of waterfowl, which has been the subject of a 50 year old system of flyway-wide management involving all states and countries along the Atlantic flyway. Recovery of the Delaware Bay stopover must include a flyway-wide system of protection. Consequently, the Division of Fish and Wildlife is now part of a national effort to expand the existing waterfowl flyway system to shorebirds.

MYCOBACTERIAL INFECTIONS IN STRIPED BASS (*MORONE SAXATILIS*) FROM DELAWARE BAY.

Christopher A. Ottinger, U. S. Geologic Survey, Leetown Science Center, National Fish Health Research Laboratory, 11649 Leetown Road, Kearneysville, WV 25430; and **J. Jed Brown,** U.S. Fish and Wildlife Service, 2610 Whitehall Neck Road, Smyrna, DE 19977. chris_ottinger@usgs.gov. **Session 4**, 11:15, 1/11/05 (presentation #33).

Mycobacteriosis is a bacterial disease in which striped bass (*Morone saxatilis*) may be disfigured as a result of skin ulcers and internal lesions. The bass may also be emaciated due to the chronic nature of this wasting disease. Recent evidence of polymicrobial infections in some striped bass suggests that the observed condition of infected fish may be the result of a relatively complex disease progression. While the extent of mortality associated with mycobacteriosis in wild striped bass is not known, laboratory studies indicate that the bacteria can cause lethal infections when administered in biologically relevant doses. The impact of this disease on striped bass population levels is not known. In the Delaware Bay, as well as many other regions of the United States, striped bass are a highly prized target species for both recreational anglers and commercial fishermen. The economic impact of striped bass devalued as a result of mycobacterial infection could be significant. Unpublished Data collected from 1998 to 2003 suggest that infection rates is some locations within Chesapeake Bay approach 70% and that the disease has persisted in these populations for at least six years. Given that a substantial percentage of the striped bass found along the eastern seaboard originate from the Chesapeake Bay, the impact of mycobacteriosis on striped bass found outside this region may be significant. The incidence and severity of this disease in striped bass in Delaware Bay as well as other regions along the eastern seaboard is a relative unknown.

A preliminary study was initiated in 2003 to determine if mycobacteriosis is occurring in Delaware Bay striped bass. Eighty-one striped bass were obtained from commercial gill-nets off Woodland (n = 71) and Bowers (n = 10) Beach over an eight day period in December of 2003. Tissues were examined for the presence of mycobacteria and associated pathology. Preliminary data from this study indicated an overall infection rate of approximately 19% in the fish sampled. Infection rates on individual sample days varied from 7 to 58% suggesting that there may be substantial variation in different striped bass schools. The fish were in good condition overall with only one sampled fish exhibiting a heavy infection. Although the data from this preliminary study suggests that the incidence and severity of mycobacteriosis in Delaware Bay striped bass sampled is low relative to that observed in Chesapeake Bay, the study involves a small number of fish thus generalizations about the relative condition of the striped bass in the two bays should not be made. The data does indicate that striped bass infected with mycobacteria are present in Delaware Bay and that the infection incidence and intensity should be monitored.

USING FISH TUMOR SURVEYS TO EVALUATE HABITAT QUALITY IN THE DELAWARE ESTUARY WATERSHED. **Alfred E. Pinkney**, U.S. Fish and Wildlife Service, Chesapeake Bay Field Office, 177 Admiral Cochrane Drive, Annapolis, MD 21401; and **John C. Harshbarger**, George Washington University Medical Center, 2300 I Street, NW, Washington, DC 20037. Fred_Pinkney@fws.gov. **Session 6**, 4:00, 1/11/05 (presentation #21).

Tumor surveys in bottom-dwelling fish have been used widely as an indicator of contamination and for monitoring the success of cleanup actions. In freshwater ecosystems, the brown bullhead, *Ameiurus nebulosus*, develops skin and liver tumors in response to contaminant exposure, with the most persuasive linkage to polynuclear aromatic hydrocarbon (PAH)-contaminated sediments. In East Coast North American estuaries, a similar linkage between liver tumors and PAH contamination has been demonstrated with the mummichog, *Fundulus heteroclitus*. Both species have relatively small home ranges and interact with sediments. Here, we briefly review the history of tumor surveys in the Delaware Estuary and focus on two recently completed studies. In 2003, we collected 31 brown bullheads (>260 mm total length) from a 1.6 km reach of Lower Darby Creek, a tributary of the Delaware River in Philadelphia, PA. This area is within the John Heinz National Wildlife Refuge at Tinicum and was listed by the U.S. Environmental Protection Agency as a Superfund site in 2001. We found a 26% prevalence of liver tumors, significantly higher than our long-term reference location, the Tuckahoe River (MD) which had a 4% prevalence (chi-square, $p<0.001$). Total skin tumor prevalence was 6% in Darby Creek and 1% in the Tuckahoe ($p=0.21$). Total PAHs in sediments from this reach of Darby Creek averaged 48.9 ppm. In 2002 and 2003, we collected mummichogs ($\geq$ 70 mm in total length) from Hershey Run, a tributary of White Clay Creek, adjacent to the Koppers Superfund Site, Newport, DE. One sediment sample in Hershey Run had a total PAH concentration of 13,300 ppm due to creosote releases from the site. Liver tumor prevalence in Hershey Run mummichogs was 7 of 21 (33%) in 2002 and 3 of 30 (10%) in 2003. In 2003-04, mummichogs were collected from the St. Jones River, Blackbird Creek, Newport Marsh (along the Christina River), and an unnamed Delaware River side channel near the Motiva Refinery, Delaware City, DE. Liver tumor prevalence was 0% to 3% at these locations. No skin tumors were found in any mummichogs.

An increased prevalence of tumors or other deformities is used as an indicator of Beneficial Use Impairment in the designation and monitoring of Great Lakes Areas of Concern. In the Chesapeake Bay, tumor surveys have been used to highlight contaminant impacts in two Regions of Concern, the Elizabeth River and the Anacostia River, and target areas for remediation. In the Delaware Estuary, we recommend developing a data base so that tumors and deformities can be used in a similar manner as in the Great Lakes. This would involve surveys with brown bullheads and/or mummichogs, depending on the salinity of the habitat. For each species, there is a need to develop a data base containing age-specific and sex-specific tumor prevalence at reference and contaminated sites. Studies that include tumor prevalence, biomarker analyses such as DNA adducts and bile metabolites, and sediment chemistry can be used to provide a weight-of-evidence for specific chemical classes.

OSPREYS OF DELAWARE RIVER AND BAY: CONTAMINANT EXPOSURE, REPRODUCTION AND HABITAT SUITABILITY. **Barnett A. Rattner**; USGS-Patuxent Wildlife Research Center, Laurel, MD 20705; **Pamela C. Toschik,** Marine, Estuarine, and Environmental Sciences Program, University of Maryland, College Park, MD; and **Peter C. McGowan**; Chesapeake Bay Field Office, U.S. Fish and Wildlife Service, Annapolis, MD. Barnett-Rattner@usgs.gov. **Session 5**, 2:00, 1/11/05 (presentation #1).

Despite serious water quality problems and pollutant loading, Delaware River and Bay provide important wildlife habitat. In 2002, we conducted a comprehensive evaluation of contaminant exposure, reproduction and habitat suitability for ospreys (*Pandion haliaetus*) breeding in the Delaware River and Bay. To assess contaminant exposure and reproduction, sample eggs were collected from 39 nests and analyzed for organochlorine pesticides, polychlorinated biphenyls (PCBs), and mercury; a subset of 15 eggs was analyzed for perfluorinated compounds and polybrominated diphenyl ethers (PBDEs). The fate of each nest was monitored weekly. Concentrations of 10 organochlorine pesticides or metabolites, total PCBs, and several toxic PCB congeners were greater ($p < 0.05$) in eggs collected between the Chesapeake and Delaware Canal (C & D Canal) and Trenton (Delaware River and northern Bay) compared to other sites. Concentrations of *p,p'*-dichloro diphenyl dichloroethylene (*p,p'*-DDE; 0.785-3.84 µg/g wet weight and total PCBs (5.50-14.5 µg/g wet weight) in eggs collected between the C & D Canal and Trenton were similar to levels recently found in some Chesapeake Bay regions of concern. In all study segments, at least one young fledged from 66 to 75% of nests. Productivity for Delaware Inland Bays (reference area) and south Delaware Bay was 1.17 and 1.42 fledglings/active nest, respectively; north of the C & D Canal productivity was 1.00 fledgling/active nest, which is marginally adequate to maintain the population. Several perfluorinated compounds and PBDEs were detected in eggs at concentrations approaching 1 µg/g ww. Osprey breeding habitat was characterized in the coastal zone of Delaware and the area around the river in Pennsylvania using data we collected as well as extant information provided by state and federal sources. Habitat was characterized based on locations of active osprey nests in Delaware and Pennsylvania. Fish biomass, water clarity, water depth, land use and land cover, nest availability, air pollution, and contaminants in osprey eggs and sediment were evaluated for use as parameters in nest activity and productivity models. The nest activity model developed in this study performed markedly better than existing habitat models for ospreys. Results demonstrated that the presence of active nests was associated with water depth, water clarity, distance to an active osprey nest, and presence of urban land use, while hatching success was associated with principal components derived from organochlorine contaminant concentrations (total PCBs, *p,p'*-DDE, chlordane and metabolites, and heptachlor epoxide) in eggs. Our findings provide evidence that contaminants continue to be a significant stressor on osprey productivity in the northern Delaware River and Bay. Based on this research we provide some guidelines for resource managers and local conservation organizations in management of ospreys and in development of habitat models that are appropriate for other piscivorous and marsh nesting birds.

LINKING CHANGES IN VALUED ECOSYSTEM COMPONENTS TO HUMAN USE OF COASTAL RESOURCES: AN EXAMPLE FROM THE ST. JONES RIVER WATERSHED, DELAWARE. **Michael A. Reiter**, Department of Agriculture and Natural Resources, Delaware State University, Dover, DE 19901-2277; and **George R. Parsons,** College of Marine Studies, University of Delaware, Newark, DE 19716. mreiter@desu.edu. **Session 11**, 2:40, 5/11/05 (presentation #73).

VEC (Valued Ecosystem Component) modeling is a conceptual modeling framework for linking Drivers and their associated Stressors to changes in ecosystem components of ecological, social, and/or economic value (VECs). To better integrate human activities and uses into this modeling framework, we have expanded the "two-component" VEC modeling structure to include a third (VEC-Services) and fourth (Services-Drivers) component. The four-component modeling structure has the potential to more clearly link human activities not only to significant ecological impacts within a habitat, but to possible social and economic impacts on human services including feedbacks upon the initiating drivers. The four-component model retains the "ranked matrix" assembly methodology utilized for the two-component model, but introduces steps in later components to limit the potential number of links to a manageable level. The resulting models can be further narrowed using fuzzy logic methods, potentially useful in support of management decisions. Simple link and fuzzy logic analysis of a four-component model for the St. Jones River watershed in central Delaware suggests that habitat disturbance, hydrology, and nutrient loading are likely to be important stressors in the watershed, and that the drivers with a high potential to be affected by feedbacks varied by habitat.

This approach will better allow for the incorporation of human activities and effects into modeling efforts commonly used as the starting point for integrated environmental assessment and adaptive management strategies for coastal environments in Delaware and beyond. The approach allows for a more explicit view of humans as a part of coastal ecosystems, and provides a framework for moving from conceptual to numerical predictive models that would directly link changes in ecosystem components and processes to impacts on social, economic, and political structures along with the more commonly tracked impacts on ecological concerns. With the increased interest in integrated assessment strategies for coastal resource management shown by state and national resource management agencies, this methodology can provide a solid starting point for the development of integrated management strategies directly relevant for policy along the Delaware estuary and beyond.

LINKING LAND & WATER RESOURCES: LOST IN TRANSLATION? **Jessica Rittler Sanchez**, Delaware River Basin Commission, 25 State Police Drive, West Trenton, NJ 08628. jessica.sanchez@drbc.state.nj.us. **Session 10**, 9:10, 5/11/05 (presentation #74).

Activities and development on our landscapes can have an impact on the quality and availability of water resources and natural communities. In order to know how land-side resources – from forests to residential development - should be managed, we need an improved working knowledge of a wide range of issues. For example:

- What is the range of "normal" seasonal fluctuations in hydrology, its effect on aquatic and terrestrial species of plants and animals, and the tolerable stress limits for various communities?
- What services do natural landscapes, assemblages and organisms - such as wetlands, or mussels - provide & through what processes?
- How does the scale of application – local or regional - affect selection of management alternatives?

  Ensuring a sound scientific base for decision-making is only part of the solution. Resource managers and decision-makers operate in a system that, in addition to natural resources, must account for financial and human resources. Once we have the answer to the questions posed above, we need then to translate those answers into the socio-economic language of decision-makers, who want to know:
- Can human development share the landscape without impairing its water resource or habitat function: Is there an optimal density for development on differing landscape types that is protective of critical functions?
- What are the local and regional costs of alternative development patterns? What are the benefits in terms of foregone water or wastewater processing, for example, when wetland systems are left intact?
- Are there equitable alternatives for sharing the costs and benefits among sectors of the community?

This is a call for more attention to the economic and social implications of potential management scenarios and decision guidance. To be most effective, collaborative efforts that link the chemical, physical, and biological sciences as well as the social sciences of planning, economics, and behavior are necessary. The link to the local land use decision-making process is especially critical. At the local level, concerns – such as a community's cultural past, future vision, current politics and economics – tend to drive decisions, frequently on a project-by-project basis. Injecting scientific understanding – through a local plan that incorporates the best scientific understanding of local conditions in a regional context - can form a solid foundation for improved local decisions. To accomplish this requires that scientific knowledge be *translated* into the language of local decision-making. Scientists and resource managers must explain the "so what" of the issues and help with the task of finding the nexus - the "hook" into local relevancy.

THE CORPS' ROLE IN THE DELAWARE RIVER. **Lt. Col. Robert J. Ruch**, District Commander, U.S. Army Corps of Engineers, Wanamaker Building, 100 Penn Square East, Philadelphia, PA 19107-3390. robert.j.ruch.ltc@usace.army.mil. **Session 8**, 1:35, 5/10/05 (presentation #86).

The U.S. Army Corps of Engineers, through its Philadelphia District, represents the federal interest in managing the water resources of the Delaware River Watershed, as authorized and funded by Congress and as directed by the Secretary of the Army. The Corps' main role among the Delaware Estuary's scientific community is to investigate, plan, design, build, operate and maintain projects. They range from comprehensive, watershed-based studies that evolve into multiple projects to small projects that address a specific problem at a specific location. We also regulate construction-related activities in waters and wetlands under Section 10 of the River and Harbor Act of 1899 and Section 404 of the Clean Water Act of 1972.

Unique among federal agencies, the Corps' funding is based not on grants but on projects. Operation and maintenance of existing projects, such as dams and navigation channels, is funded entirely by the federal government, as are initial one-year, $100,000 "reconnaissance studies" to identify federal interest. But since the Water Resources Development Act of 1986, all new projects require a non-federal, cost-sharing sponsor. In terms of realistic alternatives, the cost-sharing requirement is best viewed not as a burden on state and local governments, but as a means of leveraging federal resources to fund the majority (usually about two-thirds) of a project that would otherwise never come to fruition.

The Corps' history as the world's largest public engineering organization is well known. Less known is that over the past generation, our expertise is being applied more and more to environmental challenges, many of which confront the Delaware Estuary today. In addition to our regulatory role, we also conduct thorough environmental assessments of all our own projects. Moreover, the Corps' fastest growing category of projects is ecosystem restoration, where we seek to enhance aquatic and coastal habitat through engineered solutions. Accordingly, much of our technical expertise applies to environmental and water resources, including such specialties as groundwater modeling, flood plain mapping, flood warning systems, tidal wave dynamics, subsurface exploration, water quality testing and wetlands delineation and mitigation.

Part of understanding the Corps' role in the Delaware Estuary is in knowing our relationship to others in the region. We are the federal representative on the Delaware River Basin Commission, the one agency with oversight of the entire basin from the Catskills to the Atlantic. We coordinate with the EPA, Fish and Wildlife Service, National Marine Fisheries Service and four state environmental agencies on both regulatory actions and project environmental assessments. We maintain and regulate navigable waterways while the Coast Guard regulates traffic on those waterways. We are the primary supporting agency to FEMA in declared disasters, including floods and coastal storms.

Addressing the Estuary's most pressing needs will require not a new set of programs, but an increased level of partnership that helps our existing programs succeed—by bringing together our best technical resources to design solutions and pooling our financial resources to build them.

WATER QUALITY IN THE DELAWARE ESTUARY. **Edward D. Santoro**, Delaware River Basin Commission, 25 State Police Drive, West Trenton, NJ 08628. Edward.Santoro@drbc.state.nj.us. **Session 2**, 4:00, 1/10/05 (presentation #50).

There are three major ecological zones in the Estuary, distinguished by differences in salinity, turbidity, and biological productivity. The upper zone is characterized by freshwater under tidal influence and extends from Trenton downstream to Marcus Hook. The transition zone lies between Marcus Hook and Artificial Island; it has a wide range of salinity (from 0-15 parts per thousand) and is characterized by high turbidity and low primary biological productivity. The lower zone is open bay, extending to the Atlantic Ocean, and has higher salinity, large areas that are fairly shallow, and show high levels of primary biological productivity.

Improvements in dissolved oxygen levels in the Camden-Philadelphia area have been substantial since the late 1970's. Over the last 10 years dissolved oxygen data has continued to show dramatic improvements over the period at the Philadelphia area sampling stations, RM84 through RM111. The mean value at almost every sampling station remained above the average value of 4.5 mg/l at theses stations. No significant sag occurred from the summer of 1998 through 2003. Dissolved oxygen levels during the monitoring period reversed a three-to-four-year decline that had slightly eroded prior gains. During the summer months, the seasonal decline in dissolved oxygen was minor, where two decades earlier it had been dramatic. Bacteria and nutrients showed generally positive trends being below criteria. Main channel bacteria counts remained within federal and DRBC standards for the length of the estuary for the fifteenth consecutive year. The 1998-2003 main channel (boat run) data for bacteria showed mean annual (March through November) levels below the federal primary contact recreation standards. In contrast with bacteria trends in the main channel, shoreline and tributary data for the years 1998-2003 show persistent exceedence of the federal criteria in the tributaries over the period in the tidal portions of the Delaware River where recreational contact may be frequent.

Nutrient loadings to the estuary in 1998-2003 continued to be elevated, but with a continued absence of eutrophic effects. Chlorophyll levels and nutrients were consistent with NJDEP monitoring results for this time period. However, it is important to note that measurements taken at the channel are not necessarily representative of the entire estuary. Differences exist between the levels of parameters such as dissolved oxygen and nutrients between the channel locations where DRBC monitors and other portions of the bay. For example, based on NJDEP monitoring data, chlorophyll *a* levels at the channel average around 6 μg/L whereas non-channel stations average around 9 μg/L. Also, nitrate levels tend to be higher at channel stations than at non-channel stations. Overall variability of the data at the channel tends to be much less that at more inshore locations. This is especially true in the lower portion of Delaware Bay.

AQUATIC RESOURCES OF THE DELAWARE ESTUARY. **Edward D. Santoro**, Delaware River Basin Commission, 25 State Police Drive, West Trenton, NJ 08628. Edward.Santoro@drbc.state.nj.us. **Session 4**, poster, 1/11/05 (presentation #51).

In Delaware Bay, areas considered safe for shellfishing decreased slightly. At the end of 2003, the State of New Jersey classified 235 acres within the Maurice River Cove from Approved to Seasonally Approved. There are a few areas in the bay where water quality restrictions limit shellfish harvesting. Prohibited areas cover approximately 15.6 percent of the bay, or slightly fewer than 70,000 acres. They primarily occur north of the Smyrna River on the Delaware side and north of Artificial Island on the New Jersey side. Approved areas cover 377,579 acres.

There continues to be widespread fish advisories in the Delaware Estuary, predominantly from PCB contamination. The best available information currently indicates that point sources are the second-largest PCB loading source to the estuary. However, there are many significant sources not regulated by the NPDES program. It is evident that point source controls alone would not result in sufficient reductions to eliminate fish consumption advisories based on PCB contamination. Implementation of a broad-based effort to achieve PCB reductions from point and non-point sources will be necessary.

Delaware oyster abundance ranged from 350 oysters per bushel to slightly less than 100, and recently these resources have shown a substantial drop to the low end of the range. Historically, in the Delaware Estuary, oysters were removed from the seed beds and planted on leased grounds farther down bay. The four year period of very low spat abundance from 2000 to 2003 has caused a significant loss of oyster resources in the higher salinity parts of the seed beds. If this trend continues it will yield a continued reduction in oyster abundance throughout the Delaware Estuary.

Regarding the horseshoe crab, researchers conclude that spawning activity in the Delaware Bay over the past 5 years has been either stable or declining at a rate of less than 8% per year. Spawning activity appears to be more stable in New Jersey than in Delaware. The restrictive measures introduced in the Delaware Bay region on harvesting, the implementation of the Carl N. Shuster Jr. Horseshoe Crab Reserve (CNSJrHSCR), and the utilization of bait bags seem to be benefiting the horseshoe crab population. However, the increase is not substantial enough to warrant any less restrictive measures in the management of the species.

The population of striped bass in the Delaware River has experienced a remarkable recovery within the last decade, largely attributable to improved water quality and strict fishery management measures. Over the past 5 years the striped bass harvest has stayed at approximately 2,500,000 to 3,500,000 fish. Recent estimates indicate the juvenile striped bass index for 2003 will be a record high value.

Based upon hydroacoustic methods, an estimated 300,000 American shad returned to the Delaware River to spawn in 2003 indicating a decline of approximately 40 percent from the 2002 population. The fluctuation in population over the report period likely reflects natural variation.

Over the period 1998 -2003 the abundance level of weakfish has ranged from approximately 220 weakfish per nautical mile in 2001 to 100 in 2002 (the last year reported). Some of the fluctuation in abundance may be due to changes in fishing pressure.

MITIGATING PROBLEMS IN THE DELAWARE ESTUARY: SELECTING PLANTS TO HONE THE FUNCTIONS OF THE EDGES. **Denise M. Seliskar, John L. Gallagher, Jiangbo Wang** and **Michael League.** College of Marine Studies, University of Delaware, 700 Pilottown Road, Lewes, DE 19958. seliskar@udel.edu. **Session 5**, 12:50, 1/11/05 (presentation #30).

The Delaware Estuary contends with the problems facing many estuaries in the U.S., those of reduced water quality due to contaminants and nutrient runoff, erosion due to sea level rise and wave action, and the spread of invasive plants and animals, such as *Phragmites australis* and the Asian shore crab. Because tidal marshes are the interface between upland and open water along much of the estuary, their role as a buffer for mitigating the detrimental events happening on both sides of the interface is increasingly important. After hydrology, the dominant vascular plant is the primary regulator of marsh functions, so it is here that we target our research. Not only is the species important, e.g. *Spartina vs. Phragmites*, but the genotype is critical as well. We have shown with *Spartina alterniflora* that genotypic variation in this species regulates not only biomass production above and belowground, but also the activity of decomposers, the soil community, benthic algae, and young fish. Plants can be selected and developed for performing functions that mitigate problems in the estuary. Maintaining elevation with rising sea level can be achieved in part by increasing the belowground deposition of organic material. We have found significant intraspecific differences in the resources that plants direct to root and rhizome formation. Likewise, nutrient or contaminant sequestration belowground or to long-lived organs can remove unwanted materials from estuarine water. Our current research investigates plant intraspecific variation in the sequestration of nutrients and carbon. In order to counter the spread of the invasive species *Phragmites*, we have also been selecting lines of local native plants to form multi-layered physical barriers to the invading stolons and rhizomes of *Phragmites.* Such plantings are placed at routes where *Phragmites* invades the marsh plain from the upland edge. Our findings indicate that such a technique can significantly reduce *Phragmites* invasion into restored wetlands. Plants regenerated from tissue culture are also a source of intraspecific variants. We have identified such genotypes that offer the ability to provide enhanced functions to the estuary's edge. Intraspecific variation also plays a role in the invasiveness of *Phragmites.* Our findings indicate differences in nutrient and salinity response between the native and invasive genotypes of this species at the whole plant level. Differences are seen as well between *Phragmites* genotypes at the cellular level. Understanding and exploiting the genetic diversity within the native plants of the estuary's edge will lead to developing plants that can mitigate some of our most challenging coastal problems.

HISTOLOGY OF BLOOD CELLS OF TWO SPECIES OF HORSESHOE CRAB FOUND IN PENINSULAR MALAYSIA, *TACHYPLEUS GIGAS* AND *CARCINOSCORPIUS ROYUNDICAUDA.* **Shahram Shakibazadeh, P. Hajeb, A. Christianus, M. S. Kamarudin,** and **M. Nor Shamsudin.** Dept. of Agricultural Technology, Faculty of Agriculture, University Putra Malaysia 43400 UPM, Serdang, Selangor, Darul Ehsan, Malaysia. Sh_Shakiba@yahoo.com. **Session 9**, poster, 5/10/05 (presentation #91).

Horseshoe crab is well known as living fossil, because it has been existed 100 million years before dinosaurs. This long life is not only because of its hard chitinous horseshoe shaped carapace, that has protected it for such a long time, but also owing to its unique innate immune system, which is accomplished by several proteins and peptides such as, coagulation factors, protease inhibitors, anti–microbial compounds, lectins and other substances.

Horseshoe crab immune system is carried by hemolymph, which contains hemocyte or amoebocyte. Cytoplasm of these cells is packed with granules, which contain all the factors required for blood coagulation, including the clottable protein. Amoebocytes are highly sensitive to trace amount of lipopolysaccharides (LPS), a major outer membrane component of G-negative bacteria, which responded by degranulation of these granules after stimulation by LPS. Degranulation of granules resulted in the: Releasing all coagulation factors, Releasing anti – bacterial substances that kill engulfed invaders.

Only four species of horseshoe crabs are extant. *Tachypleus gigas* and *Carcinoscorpius rotundicauda* are the species which are found in Peninsular Malaysia. The blood cells were studies histologically in both species. The number of blood cells was also compared between two available species. 75 specimens consists of *Tachypleus gigas* (21 males and 18 females) and *Carcinoscorpius rotundicauda* (21 males and 15 females), were bled by cardiac puncture. Blood cells were counted and compared possible differences between the two species and sexes of each species. The comparison was shown no differences between blood cell numbers in two species ($P > 0.05$), and there was not any significant differences between sexes of *T. gigas* in terms of blood cells counted ($P > 0.05$). But the differences of blood cell numbers were significant between male and female individuals of *C. rotundicauda* ($P < 0.05$). There was not any correlation between body weight and cell blood count in none of the sexes of both species.

VISUALIZING FISHERIES DATA – THE TEMPORAL INTEGRATION OF A COMPREHENSIVE, MULTI-GEAR DATASET IN THE DELAWARE ESTUARY.

Shawn Shotzberger; PSEG Estuary Enhancement Program, 130 Money Island Road, Salem, NJ 08079. shawn.shotzberger@pseg.com. **Session 6**, 4:15, 1/11/05 (presentation #42).

Data on fisheries abundance typically are presented either numerically in tabular form or graphically to describe the temporal and spatial distribution of fish. While useful, these traditional presentation methods usually abstract, or even obscure, holistic patterns that may emerge from the data. An alternative presentation of these data is a summary of catches for each gear and month superimposed visually on a base map that is then “animated” as a time series.

As part of its NJPDES Permit for the Salem Generating Station, PSEG conducts routine daytime beach seine and bottom trawl sampling of the region south of the Chesapeake and Delaware Canal. In 2002 through 2004, nighttime pelagic trawl and ichthyoplankton surveys were added to the monitoring program, and the study area was expanded to include tidal portions of the estuary from its mouth to near the fall line at Trenton, New Jersey. For each effort, the catches were identified to species and enumerated. Sub-samples of the following species were measured to the nearest millimeter: weakfish (*Cynoscion regalis*), bay anchovy (*Anchoa mitchilli*), white perch (*Morone americana*), striped bass (*M. saxatilis*), spot (*Leiostomus xanthurus*), Atlantic croaker (*Micropogonias undulatus*), American shad *(Alosa sapidissima*), blueback herring (*A. aestivalis*), alewife (*A. pseudoharengus*), Atlantic silverside (*Menidia menidia*), Atlantic menhaden (*Brevoortia tyrannus*), and bluefish (*Pomatomis saltatrix*).

Using ArcGIS software (ArcGIS 8.1), NOAA navigational charts and the PSEG sampling grids were digitized and geo-referenced to the Delaware Estuary’s shoreline. Catch data from the fisheries monitoring program were then superimposed on the ArcGIS base maps and exported as image files for subsequent use. All relevant catch summary information (e.g. density or CPUE, life stage, etc.) is preserved, but the presentation format allows for the immediate recognition of spatial and temporal patterns that are not always apparent in tabular form. Furthermore, by ordering the presentations quasi-ontologically, salient life-history information can be derived efficiently and intuitively.

In this presentation, data visualizations are presented for bay anchovy and white perch from PSEG's 2003 sampling efforts in the Delaware estuary. These examples immediately highlight expected spatial and temporal patterns for these species. Bay anchovy exhibit protracted spawning through summer months, and are observed to exploit upriver reaches as water temperatures increase. White perch spawning activity is apparent in the upriver regions in the spring, and recruitment to successive life stages through the summer is illustrated. In the fall, the down-bay movement of white perch becomes evident.

The visual integration of fisheries data provides a valuable management tool for understanding dynamic processes in the Delaware Estuary. The approach concisely distills large datasets into meaningful summaries. Furthermore, additional data layers can be added to address specific management questions or issues, and disparate datasets can be integrated into a single, comprehensive summary. Lastly, such presentations increase accessibility of large datasets to lay audiences otherwise not conversant with estuarine dynamics. Future efforts should consider similar approaches as an additional way of summarizing fisheries data.

SPECIES INTERACTIONS ALONG EDGE COMMUNITIES OF THE DELAWARE BAY ESTUARY: USING A BAYWIDE TELEMETRY ARRAY TO TRACK HORSESHOE CRABS AND MIGRANT SHOREBIRDS. **David Smith**, U.S. Geological Survey, Leetown Science Center, Kearneysville, WV 25430; **Lorne Brousseau**, Cornell Cooperative Extension, Vanderbilt Museum, 180 Little Neck Road, Centerport, NY 11721**;** **Kevin Kalasz, Karen Bennett**, Delaware Natural Heritage Program, Delaware Division of Fish and Wildlife, Delaware Natural Resources and Environmental Control, 4876 Hay Point Landing Road, Smyrna, DE 19977; and **Michael Millard**; U.S. Fish and Wildlife Service, PO Box 75, Lamar, PA 16848. drsmith@usgs.gov. **Session 5**, 1:15, 1/11/05 (presentation #43).

Low energy, sandy beaches and intertidal areas of Delaware Bay provide vital habitat for a wide variety of interrelated organisms. Over the last decade, two interrelated inhabitants of the Delaware Bay beaches have emerged prominently into public view. Concern for horseshoe crabs (*Limulus polyphemus*) and migrant shorebirds (especially red knots, *Calidris canutus*) has increased as population indicators have decreased. During their brief stopover in Delaware Bay, shorebirds consume large amounts of horseshoe crab eggs to fuel subsequent migration and reproduction. However, the continued reliance by shorebirds on horseshoe crab eggs as a source of energy depends on temporal and spatial overlap of the species distributions. Studying the distributions of multiple species throughout Delaware Bay over weeks and months is a daunting task that recently has been made tractable by advances in telemetry technology. We set up a large-scale radio telemetry array to track the horseshoe crabs and shorebirds (red knots and ruddy turnstones) throughout Delaware Bay continuously from early May to early July 2004. Initial results from the tracking effort have generated insights into age and sex related spawning patterns of horseshoe crabs, timing of migrations, and cross-bay movements of shorebirds and horseshoe crabs. Simultaneous tracking has indicated patterns of activity that might not have been apparent from surveys that rely on snapshots of visual observations. The telemetry system will be maintained to track species' distributions over multiple year and could be used to study temporal and spatial distributions of other species that inhabit Delaware Bay beaches.

SPATIAL AND TEMPORAL DISTRIBUTION OF HORSESHOE CRAB (*LIMULUS POLYPHEMUS*) SPAWNING IN DELAWARE BAY: INSIGHTS FROM SIX YEARS OF STANDARDIZED MONITORING. **David Smith**, U.S. Geological Survey, Leetown Science Center, Kearneysville, WV 25430; **Benji Swan**, Limuli Labs, 7 Bay Avenue, Cape May Court House, NJ 08210; **Bill Hall**, College of Marine Studies,700 Pilottown Road, Lewes, DE 19958; **Stewart Michels**, Delaware Division of Fish and Wildlife, PO Box 330, Little Creek, DE 19961; **Sherry Bennett,** New Jersey Division of Fish, Game, and Wildlife, PO Box 418, Port Republic, NJ 08241; and **Katy O'Connell**, Delaware National Estuarine Research Reserve, 818 Kitts Hummock Road, Dover, DE 19901. drsmith@usgs.gov. **Session 6**, 5:00, 1/11/05 (presentation #44).

Over the past six years hundreds of volunteers and coordinators have worked very hard to implement the Delaware Bay Horseshoe Crab Spawning Survey in a standardized manner throughout Delaware Bay during the main spawning period (May and June). The Delaware Bay Horseshoe Crab Spawning Survey was designed to accomplish several important objectives: (1) provide a reliable index of spawning activity to monitor the temporal and spatial distribution of horseshoe crab spawning activity for comparing baywide spawning among years, beach-level spawning within Delaware Bay, and distributions of spawning horseshoe crabs and shorebirds; (2) increase our understanding of the relationship between environmental factors and spawning activity; and (3) promote public awareness of the central role of horseshoe crabs in shorebird population dynamics, Atlantic coast fisheries, and human health through production of *Limulus* amoebocyte lysate (LAL). Estimates of spawning activity from this survey have been precise; coefficient of variation on baywide estimates of spawning activity have been below 14% over the past six years and below 10% in recent years. Survey results have shown shifts in timing and spatial distribution of spawning, which would not have been apparent if the survey had not been designed to encompass the Delaware Bay and the majority of the spawning season. Although spawning has tended to peak in late-May, there has been considerable year-to-year variation in the timing of spawning activity. The survey has shown that areas of high density spawning can shift within the bay. These spatial and temporal patterns have implications for determining trends in horseshoe crab spawning and on understanding the dependence of migrant shorebirds on horseshoe crab eggs. Survey results are providing insights into the multi-scale environmental variables that effect spawning. Public access to the results of the survey has been a program goal, and survey data are available through internet. Recently, software has been developed to aid in tabulating and graphing results and to increase the utility of the survey. The survey is a unique partnership of private and public efforts to monitor a vital indicator species of the Delaware Bay estuary.

DETERIORATION OF A MID-ATLANTIC COASTAL MARSH. **Daniel J. Soeder**, U.S. Geological Survey, 8987 Yellow Brick Road, Baltimore, MD 21237; and **Dixie L. Birch,** U.S. Fish & Wildlife Service, 2145 Key Wallace Drive, Cambridge, MD 21613. dsoeder@usgs.gov. **Session 5**, poster, 1/11/05 (presentation #5).

Blackwater National Wildlife Refuge was established in 1933 as a way-station for migratory birds along nearly the entire reach of the Blackwater River in Dorchester County, on Maryland's Eastern Shore. The 26,000-acre refuge is composed mainly of Chesapeake Bay tidal marsh, characterized by fluctuating water levels and salinity gradients. Deterioration and loss of marshland and forested wetlands at the refuge is significant. Aerial photographs from 1938 show a relatively intact marsh along the Blackwater River with only a few small ponds. By 1985, however, the marsh had degraded into large tracts of open water, and current wetland losses are estimated at 7,000 to 8,000 acres. Contributing factors may include rising sea level, invasive species such as nutria (*Myocastor coypus*), degraded water quality, and human activities, although the relative impacts of these are poorly understood. Observations show that erosion of the marsh is occurring at a rapid rate, and vertical accretion is not keeping pace with sea-level rise. Research indicates that restricted tidal exchange

within the marsh may be a critical factor, with impounded water causing deterioration of the largely organic, peat-rich substrate through the action of trapped sulfides, low dissolved oxygen, build-up of nutrients, or some combination of factors.

Saltwater intrusion into formerly freshwater areas due to marsh deterioration at a watershed divide, and plans for the construction of several large housing developments within a tributary watershed are but two of several issues of concern to the refuge management. Better hydrologic characterization of the marsh is needed to help understand the impacts of these and other problems at the refuge. Precise tidal-stage data, salinity measurements, streamflow, ground-water and water-quality analyses have all been proposed, along with laser interferometer distance and ranging (LIDAR) elevation studies, sediment accretion measurements, and substrate coring to achieve a better understanding of the physical, geological, geochemical, and hydrologic processes operating in the marsh. The effectiveness of any planned restoration may be dependent upon the knowledge of marsh hydrology and the underlying causes of wetland loss, neither of which are well understood. The time frame for such studies may be short, however; one proposal under consideration will re-build the marsh by adding dredge spoils from Baltimore Harbor at the rate of 30 million tons per year over 10 years.

The problems of Blackwater are relevant to wetland science in the neighboring Delaware Estuary, because the fringe marshes there are facing similar threats. Land-use changes, pressure from real estate development, habitat loss, degraded water quality, invasive species, and rising sea levels are as much of a problem in the Delaware Estuary as in the Chesapeake Bay. The pressure to dredge and to use the dredge spoils in a constructive manner has also been a concern in the Delaware Estuary. The applicable issue from Blackwater is that the performance of a wetland "restored" without a prior understanding of how the natural system works may be both unknowable and unpredictable.

HISTORICAL CHANGES IN THE MORPHOLOGY OF THE SUBTIDAL DELAWARE ESTUARY. **Christopher K. Sommerfield**, University of Delaware, College of Marine Studies, 700 Pilottown Rd., Lewes, DE 19958; and **David R. Walsh**, Woods Hole Group, 81 Technology Park Dr., East Falmouth, MA 02536. cs@udel.edu. **Session 1**, 1:30, 1/10/05 (presentation #25).

A range of natural and human factors have modified the native morphology of the Delaware Estuary and, by relation, its hydrodynamics, material fluxes and sedimentation patterns. Since the late 1800's dredging throughout the estuary has deepened the channel, shoreline development in the urbanized sector has reduced its width, while sea-level rise and shoreline erosion has increased its width in seaward areas. For the first time, we have quantified the extent geometric changes in the subtidal estuary by analysis of synoptic bathymetric datasets for the period 1878–1987. Hydrographic survey data for 1878–88, 1945–60, and 1985–87 was complied and datum-normalized to create digital terrain models of the seafloor from which changes in hydraulic geometry parameters (depth, width and cross-sectional area) were determined. For the 117-km segment between Philadelphia seaward to Port Mahon, bathymetric change data were used to 1) delineate spatial and temporal patterns in sediment accumulation and erosion, and 2) develop a sediment budget representative for the past several decades.

From 1878–88 to 1945–60 (Period 1), the overall mean depth of the estuary increased by 1.35 m, mean width decreased by 148 m, together increasing the mean cross-sectional area by 1,211 m^2. Changes during this period were largely due to systematic dredging of the 40 ft. shipping channel and localized shoreline development. From 1945–60 to 1980–87 (Period 2), the mean depth increased by 0.25 m, mean width increased by 216 m, and mean cross-sectional area increased by 1,764 m^2. We interpret Period 2 changes to reflect mostly natural accretion and erosion following the major disturbances of Period 1. From 1877 to 1987, the subtidal volume of the estuary increased by a total of 3.3 $x10^8$ cubic meters (17%), but the rate of change was two times greater during Period 1 than during Period 2. From continuity, the increased cross-sectional area of the channel implies that tidal discharge is now substantially larger that of the native estuary, a contention supported by historical increases in tidal range.

Spatial patterns of bathymetric change from 1877 to 1987 reveal that sediment accretion predominated on subtidal shoals and flats (<6 m water depths), whereas erosion took place throughout the deeper estuary, in particular, adjacent to the shipping channel. Widespread erosion within non-dredged areas removed an estimated 1.4×10^{11} kg of sediment from the seafloor during Period 2, an average erosion rate of 3.4×10^9 kg/yr. Significantly, this previously unappreciated sediment source is quantitatively more important than the mean annual influx from rivers (i.e., 1.3×10^9 kg/yr) and has major implications to the estuarine sediment budget and the fate of particle-borne contaminants. To understand the long-term consequences of morphologic change in the estuary, additional research is needed to 1) model the hydrodynamic response to variations in hydraulic geometry, and 2) identify sediment-transport pathways and fluxes among subtidal, intertidal and supratidal environments.

RESTORATION BANKING: A CONCEPTUAL FRAMEWORK FOR INCREASING RESTORATION NATIONALLY. **Ralph G. Stahl, Jr**., DuPont Company, Barley Mill Plaza, Bldg 19, Route 141 & Lancaster Pike, Wilmington, DE 19805. Ralph.g.stahl-jr@usa.dupont.com. **Session 11**, 2:20, 5/11/05 (presentation #85).

The concept of restoration banking has been discussed among industry and natural resource trustee groups for several years. Simply put it is the ability of an entity to place a number of "restoration credits" pre-assigned by the state and federal natural resource trustees, into a virtual "bank". Under this concept, a parcel of property is evaluated for natural resource service levels and those levels are given a set number of credits. At some later date, the entity owning the credits can use them to offset a natural resource damage claim to the extent allowed under the applicable state and federal regulations, or these credits can be sold to another entity facing similar claims. The use of credits is not limited to natural resource damage claims, but may be applicable to mitigation issues or the need for conservation credits where property development has encroached on natural habitats. The ability of companies to utilize undeveloped parcels of their own properties for this purpose may be a springboard for an increase in restoration or conservation in areas where such restoration or conservation is highly desirable. The presentation will discuss the framework for this concept, the business and environmental cases for its application, and potential areas where it might be applied in the next few years.

THE STATUS AND FUTURE OF BENTHIC MACROFAUNA SCIENCE IN THE DELAWARE ESTUARY. **Frank Steimle**, NOAA's Fisheries, JJ Howard Marine Sciences (Sandy Hook) Laboratory, Highlands, NJ 07732. frank.steimle@moa.gov. **Session 3**, 9:15, 1/11/05 (presentation #3).

The Delaware Estuary is an important or essential habitat for many species of interest to man, many of which rely upon the estuary's benthic macrofauna for food or other functions. The Estuary's benthos has been studied for at least 50 yrs and some of its characteristics and functions are known. But many research issues that were defined decades ago are still of concern to scientists and natural resource managers, but a few, such as radioactivity issues, have been quiet. The turbid, exposed Delaware Estuary is not an easy place to get answers, but as a highly productive major east coast estuary, it needs the research necessary know what benthic resources, besides shellfish, we have and their significance. This talk will briefly discuss what benthic science has been done in this estuary and will mention some of the information needs that a diverse group of stakeholders or regulators might want to know. Since the interests of the various stakeholders vary, their information needs and priorities will vary, too. Some of the old issues, such as the effect of a high silt load and sediment contamination on the stability and functions of benthic communities still warrant consideration. But benthic science in the Delaware Estuary should also begin to characterize the spatial and temporal variability in dominant species or communities and develop a better understanding of the functionality of at least the major benthic community types in all salinity zones of the estuary.

META-ANALYSIS OF HORSESHOE CRAB AND SHOREBIRD RESEARCH ON THE DELAWARE BAY - ARE THERE ENOUGH HORSESHOE CRAB EGGS TO SUSTAIN SPRING SHOREBIRD MIGRATION? **Eric Stiles** and **David Mizrahi**, New Jersey Audubon Society, PO Box 693, Bernardsville, New Jersey 07924. eric.stiles@njaudubon.org. **Session 5**, 1:45, 1/11/05 (presentation #39).

The Delaware Estuary hosts the second largest abundance of shorebirds in North America and the highest concentration of spawning Horseshoe Crabs (*Limulus polyphemus*) in the world. This phenomenon is no coincidence; nearly one million individuals of 9 shorebird species stopover on the Delaware Bay to gorge themselves on fat-rich horseshoe crab eggs during spring migration. An international team of scientists is working in collaboration to examine temporal trends in Horseshoe Crabs and their eggs, migrating shorebirds and their interactions. Long-term data sets indicate a decline in the number of Horseshoe Crabs and eggs on the Delaware Bay. This decline may have stabilized during the last several years. Similarly, abundance of several species shown to be heavily dependent (obligate) on Horseshoe Crab eggs during their stopover have exhibited declines. Scientists have concluded that weight gain rates have declined precipitously for obligate shorebird species while species such as the Least Sandpiper, which rely less heavily on horseshoe crab eggs, have remained relatively stable.

Much recent work has focused on the Red Knot (*Caladris canutus rufa*) which has shown significant declines in abundance and weight gain rates. Studies on their breeding, wintering and stopover locations support the hypothesis that these declines are linked with a decrease in Horseshoe Crab eggs available for foraging. Demographic models of the Red Knot *rufa* subspecies based on survivorship data indicate the population faces an imminent risk of extinction. Also, several other species including Semipalmated Sandpipers (*Caldris pusila*) and Ruddy Turnstone (*Arenaria interpres*) are exhibiting similar trends as the Red Knot population.

In response to initial scientific findings regarding shorebirds and Horseshoe Crab interactions on the Delaware Bay, the Atlantic States Marine Fisheries Commission (ASMFC) adopted a management plan in 1998. This plan established adult Horseshoe Crab harvest quotas. Despite these measurements, shorebirds and Horseshoe Crabs continued to exhibit declines prompting further ASMFC quota reductions and establishment of the Carl Schuster Marine Sanctuary. However, these policies have failed to meet the goal of restoring shorebirds, Horseshoe Crabs and their eggs to historic levels. Immediate, additional policy reforms including the following are needed to achieve this goal:

1. lowering or eliminating horseshoe crab harvest of the Delaware Bay spawning population;
2. federal listing of the Red Knot *rufa* subspecies;
3. lowering mortality associated with biomedical use of Horseshoe Crabs;
4. beach restoration to improve spawning sites; and
5. reducing harassment of foraging shorebirds in New Jersey and Delaware.

LOST IN TRANSLATION OR HOW TO BRIDGE THE GAP BETWEEN SCIENCE AND ADVOCACY. **Eric Stiles** and **Dr. David Mizrahi**, New Jersey Audubon Society, PO Box 693, Bernardsville, New Jersey 07924. eric.stiles@njaudubon.org. **Session 11**, 3:40, 5/11/05 (presentation #66).

Ask any academic – public policy should be based upon science. Research and monitoring should form the foundation for legislation, regulations, incentives and plans affecting conservation of our natural heritage and health and public safety. Policy writers should read peer-review and gray literature and simply adopt policies to protect the whole and parts of the Delaware Estuary. Findings of heavy metals in the estuary should immediately result in better water regulations. A drastic fall in Red Knots numbers should automatically trigger federal listing.

Ask any policy maven – ecologists, toxicologists, etc. should be conducting targeted research critical at answering public policy questions. Hydrologists should be collecting information to regulate groundwater withdrawal to protect vernal pools. Climatologists should be providing clear answers for regulations on carbon capping. Fisheries experts should provide clear guidance on regulations guiding non-source point pollution.

They are both right.

Policy advocates and academics travel in different planes. In the immortal words of Mark Twain, “East is east and west is west, and never the twain shall meet” or to badly damage another saying “policy and science must be two eyes onto one sight”. Conservation victories are only achieved through a marriage of the two.

We will present five principles to bridge the gap between policy and science:
1) Identify targets in both realms (e.g. clean and potable water/target compounds for contaminant analysis).
2) Focus on common ground (e.g. wildlife conservationists and shorebird researchers).
3) Craft complementary initiatives/projects (e.g. renewable energy advocates/science on sea level rise).
4) Communicate results early and often (e.g. Delaware Estuary Conference).
5) Speak with one or complementary voices to the public, media, elected officials, etc.(e.g. need for federal funding of fisheries research or for land use protection of critical nurseries)

USE OF ALASKA STEEPPASS FISHWAYS TO PROMOTE HERRING PASSAGE AT LOW-HEAD DAMS ON DELAWARE ESTUARY TRIBUTARIES. **Kenneth A. Strait**, PSEG Estuary Enhancement Program, 130 Money Island Road, Salem, NJ 08079. kenneth.strait@pseg.com. **Session 5**, 2:45, 1/11/05 (presentation #41).

As recognized by the Delaware River Basin Fish and Wildlife Management Cooperative, river herring, alewife (*Alosa pseudoharengus*) and blueback herring (*Alosa aestivalis*), play an important ecological role in the Delaware Estuary. Emigrating juvenile river herring provide an important source of forage for other predatory species. Adult river herring also contribute to significant recreational and commercial fisheries. As a result, the Comprehensive Conservation and Management Plan for the Delaware Estuary has recommended the construction of fish passageways to mitigate blockage to historic spawning grounds for these anadromous species. Suitable spawning and nursery habitat for river herring can be found on many of the smaller tributaries within the Estuary and Alaska Steeppass Fishways can be used to restore spawning populations of river herring to this habitat.

Public Service Enterprise Group has constructed fish ladders at twelve low-head dams on Delaware Estuary tributaries for spawning run restoration of alewife and blueback herring. Alaska Steeppass fish ladders have been constructed at: Sunset Lake, Cooper River Lake, Stewart Lake and Newton Lake in New Jersey, and in Delaware at Silver Lake (Dover), McGinnis Pond, Coursey Pond, McColley Pond, Garrison Lake, Moores Lake, Silver Lake (Milford), and Noxontown Pond. From 1996 through 2004, monitoring of these sites has entailed monitoring the adult usage of the fish ladders during the spring spawning run; egg and larval herring sampling during the late spring/early summer; and sampling during fall to assess the presence of juvenile herring in the impoundments. Beginning in 1998, the adult spawning run was augmented with stocked river herring for sites not passing a minimum of five adult herring per acre of impoundment. All fish ladder sites have exhibited either successful adult migration or presence of larval and juvenile herring. The highest total annual passages occurred in Coursey Pond (1399 in 2001, 1360 in 2002) and McColley Pond (1269 in 2000). All ladders successfully passed adult fish within one year of ladder installation, with variable, but generally increasing trends in passage each year. Juvenile river herring production has been documented by fall electrofishing in all sites except Garrison Lake. Juveniles collected in the impoundments are generally larger than emigrating juveniles collected in the mainstem Delaware River.

Additional fishways should be constructed within the Estuary as funds become available and as dam remediation permits come up for review; however, only limited information and data concerning the general suitability of habitat areas above and below these dams is presently available. Future efforts to promote the installation of additional fishways within the Estuary would benefit from a comprehensive review of the available data on river herring habitat suitability and from a coordinated effort to evaluate the current suitability of habitat in previously undocumented tributaries.

WETLAND CONSERVATION AND RESTORATION ALONG DELAWARE BAY: THE EDGE EFFECT. **Kenneth A. Strait,** PSEG Services Corporation, Estuary Enhancement Program, 130 Money Island Road, Salem, NJ 08079; and **John H. Balletto**. PSEG Services Corporation, Environment, Health and Safety, 80 Park Plaza, Newark, NJ 07101. kenneth.strait@pseg.com. **Session 11**, 9:50, 5/11/05 (presentation #69).

Wetlands are important contributors to the high productivity of temperate zone estuaries and, on an equivalent area basis; estuarine wetlands are among the most productive ecosystems on earth. Approximately three-quarters of the commercial fish landings in the United States consist of species that depend on estuaries and their wetlands. Ecologists estimate that more than half of the region's wetlands have been lost because of human activities dating from pre-colonial times. Southern NJ has lost approximately 25% of its coastal wetlands since 1953 and about 21% of Delaware's inland wetlands have been lost since the 1950's.

Healthy, intact, broad, upland buffers are integral components of healthy wetland landscapes. Buffers serve as physical and biological ecotones, providing habitat diversity and assuring the functional integrity of the ecosystem at the landscape scale. Permanent protection of upland buffer and estuarine wetlands ensures that these valuable ecological services will continue to be provided. The New Jersey Delaware Bayshore has an established "Greenway", but it is not continuous. Conservation and protection of the remaining parcels is critical to ensuring the long-term integrity of the bayshore ecosystem.

Restoration of degraded wetlands is necessary to return full ecosystem function to the Delaware Bayshore. The practice of diking tidal marshes for hay production began in the 1600s and continued at an accelerating pace through the 1700s and 1800s in Salem, Cumberland and Gloucester Counties, New Jersey. These diked wetlands are isolated from the estuary, contributing little productivity and few other benefits to the ecosystem. Much of the remaining coastal wetlands have been severely degraded by human activities and other disturbances. Among other stresses impacting coastal wetlands of the Delaware Estuary is the aggressive and highly persistent colonization by stands of common reed (*Phragmites australis*). Common reed was historically a relatively minor component of healthy, diverse coastal wetlands; however, earlier this century, *Phragmites* stands expanded, out competing other wetland species and monopolizing large areas. The spread of common reed has been particularly aggressive in the Mid-Atlantic region.

The health of the entire estuarine and coastal ecosystem complex is related to the health of the wetlands that provide critical habitat and trophic support ("the Edge Effect"). Available tracts of coastal wetland and their adjacent upland buffer should be permanently protected and preserved through Deeds of Conservation Restriction or other mechanisms. Protection of the local community tax base has been an impediment to further preservation in New Jersey and must be addressed.

The New Jersey Department of Environmental Protection, the Delaware Department of Natural Resources and Environmental Control, and PSEG's Estuary Enhancement Program have been working in conjunction to preserve and restore coastal wetlands along the Delaware Bayshore. Together, this partnership has protected and/or preserved more than 21,500 acres of additional coastal marsh and adjacent uplands since 1994. Approximately 10,500 acres have been newly preserved, and another 11,000 acres of coastal marsh have been preserved and restored.

By applying the principles of ecological engineering, 4500 acres of formerly diked wetlands have been/are being restored to fully functioning tidal marsh. Another 6500 acres of formerly *Phragmites*-dominated marsh have been returned to productive *Spartina* and mixed marsh.

Conservation and restoration of the Delaware Estuary's coastal wetlands will provide enormously valuable environmental services to the estuary and the ocean.

…AND THE GOOD NEWS IS THAT THE DELAWARE ESTUARY IS LESS VULNERABLE TO RISING SEA LEVEL THAN CHESAPEAKE BAY. **James G. Titus,** U.S. Environmental Protection Agency, Climate Change Division, Room 816, 1310 L Street, NW. Washington, DC 20460. titus.jim@epa.gov. **Session 8**, 1:15, 5/10/05 (presentation #79).

Rising sea level has gradually converted the nontidal Delaware River to a tidal freshwater system, and then an estuary. The salt front continues to gradually migrate upstream, inundation converts low lying dry land to wet land, and erosion converts the seaward edges of wetlands and beaches to open water. Greenhouse gases may accelerate that evolution by a factor of two or three. Sea level rise generally causes systems to migrate inland and upstream.

As long as the lands around the estuary remain undeveloped, the impacts tend to be fairly benign. An accelerated rise in sea level, however, could cause a large-scale net loss of coastal wetlands, which appear to be able to keep pace with the current rate of sea level rise-but have their limits. In developed areas, rising sea level gradually eliminates tidal wetlands and beaches as their seaward boundaries retreat and landowners block the landward migration that would take place under natural circumstances.

A draft EPA study (which has been reviewed by county planners) creates 1:100,000 scale maps depicting the areas where ecosystems are likely to migrate inland, and those areas where development will necessitate shore protection. Wetlands will be allowed to migrate inland along a much larger portion of the shore along Delaware Bay than along Chesapeake Bay. Leaving aside the question on landward migration, the lower tidal range of Chesapeake Bay implies that existing wetlands could be more rapidly eliminated by accelerated sea level rise.

A complacent interpretation is that managers in Delaware Bay can simply watch the situation in Chesapeake Bay, and maybe pay attention to sea level rise if the situation there deteriorates further. Another interpretation is

- Managers must follow wetland loss in Chesapeake Bay, because you will eventually have similar problems
- Delaware Bay is less vulnerable because of some land-use decisions downstream of the Delaware Memorial Bridge, but sea level rise may imperil tidal systems upstream of the Bridge unless means are developed soon to enable those systems to survive accelerated sea level rise.
- Your ability to plan a gradual abandonment of low lying areas upstream of the Bridge is doubtful and hence you have a very great interest in the development and implementation of erosion-control measures that minimize adverse impacts on habitat.

Meanwhile, back in Washington, D.C., high-level officials have asked the staff from several agencies to prepare a report on coastal elevations and vulnerability to sea level rise, with a focus on the mid-Atlantic. That effort—which will focus on existing GIS data sets—needs input from local scientists to ensure that we properly characterize the implications of a net loss of intertidal lands. Moreover, the National Research Council is seeking nominees for a panel assessment that will develop a handbook on how to minimize environmental impacts will protecting property from estuarine shore erosion.

OSPREYS OF DELAWARE RIVER AND BAY: HABITAT SUITABILITY. **Pamela C. Toschik,** USGS-Patuxent Wildlife Research Center, Laurel, MD; **Barnett A. Rattner,** Marine, Estuarine, and Environmental Sciences Program, University of Maryland, College Park, MD; and **Peter C. McGowan,** Chesapeake Bay Field Office, U.S. Fish and Wildlife Service, Annapolis, MD. ptoschik@nsf.gov. **Session 9**, poster, 5/10/05 (presentation #64)

Despite serious water quality problems and pollutant loading, Delaware River and Bay provide important wildlife habitat. In 2002, we conducted a comprehensive evaluation of contaminant exposure, reproduction and habitat suitability for ospreys (*Pandion haliaetus*) breeding in the Delaware River and Bay. Osprey breeding habitat was characterized in the coastal zone of Delaware and the area around the river in Pennsylvania using data we collected as well as extant information provided by state and federal sources. Habitat was characterized based on locations of active osprey nests in Delaware and Pennsylvania. Water clarity, water depth, land use and land cover, nest availability, and contaminants in osprey eggs and sediment were evaluated for use as parameters in nest activity and productivity models. The nest activity model developed in this study performed better than existing habitat models for ospreys. Results demonstrated that the presence of active nests was associated with water depth, water clarity, distance to an active osprey nest, and presence of urban land use, while hatching success was associated with principal components derived from organochlorine contaminant concentrations (total PCBs, *p,p'*-DDE, chlordane and metabolites, and heptachlor epoxide) in eggs. Our findings provide evidence that contaminants continue to be a significant stressor on osprey productivity in the northern Delaware River and Bay. Based on this research we provide some guidelines for resource managers and local conservation organizations in management of ospreys and in development of habitat models that are appropriate for other piscivorous and marsh nesting birds.

UTILIZING NATIVE OYSTER SEED TO ENHANCE OYSTER POPULATIONS AND AQUACULTURE: THE NEW JERSEY EXPERIENCE. **Stewart M. Tweed**, NJ Sea Grant Extension Program, 80 Millman Lane, Villas, NJ 08251. sgtweed@verizon.net. **Session 3**, poster, 1/11/05 (presentation #63)

Harvesting and transplanting oyster seed from state owned seed beds to private leased grounds has long been the tradition of the New Jersey oyster industry. MSX and DERMO diseases have caused the industry to modify or abandon these traditional planting activities.

NJ Sea Grant Extension Program is working to develop new methods to utilize the native oyster set in order to provide inexpensive oyster seed for restoring oyster populations in Delaware Bay and for demonstrating modern aquaculture techniques. Shell bags and "Chinese Hat" spat collectors were used to collect seed for oyster reef construction and for intertidal rack and bag aquaculture.

Careful selection of spat collection locations is key to production of native oyster seed. Spat collectors were placed on the Delaware Bay Cape Shore of NJ tide flats because this area historically produces large, consistent oyster sets that are not utilized by the oyster industry. Sea Grant Extension developed methods to collect and to promote utilization of this underutilized seed oyster resource.

Small oyster reefs, constructed with shell bags in 1990, have continued to recruit oyster seed and have five or six generations growing on them. From 1999 to 2003 each "Chinese Hat" array has produced 5,000 or more half-inch culchless oysters for aquaculture grow out. Five growers are using these seed collecting methods to increase their market production.

USING INTERTIDAL OYSTER REEFS TO ENHANCE OYSTER POPULATIONS IN DELAWARE BAY. **Stewart M. Tweed** and **Jenny McCormick**, NJ Sea Grant Extension Program, NJ Sea Grant College Program, Bldg. 22, Fort Hancock, NJ 07732. sgtweed@verizon.net. **Session 9**, poster, 5/10/05 (presentation #92).

Like salt marshes, oyster reefs are defining physical and ecological features of Mid Atlantic Estuaries. As a Keystone estuarine species, oysters and the reefs they form have advanced and retreated within the estuary with the rise and fall of sea level and the creation of Delaware Bay. Human exploitation of the Delaware Bay oyster resources began with native American populations, increased with European colonization of its shores, and eventually became the driving economic component of the region's maritime industries. Historical records indicate a complex pattern of utilization of the bay's oyster resources. Harvest areas included up bay seedbeds, mid bay Maurice River cove planting leases, and down bay Cape May salt oyster beds. Over exploitation of these oyster resources resulted in the mining of both the living oysters for food and the shell substrate which was the basis for the oyster communities. We now know that reefs of filter feeding oysters perform a vital estuarine function of controlling algal blooms and facilitating nutrient cycling. They also influence currents and reduce erosion. They provide critical habitat for numerous associated invertebrate species and important commercial and recreational finfish species. Declining oyster stocks resulted in the economic decline of the maritime oyster industry and loss of a vital ecological component of a health estuary. Recent studies in other estuaries have documented and quantified oyster reef benefits and have formed the basis for extensive reef restoration programs. Oyster reefs created by the NJSGEP on the cape shore tide flats have demonstrated the viability of reef creation in Delaware Bay and provide a model for reef building and scientific study. These small reefs were created with shellbags in the 1990's and now support populations of 400 adult oyster and 390 ribbed mussels per square meter.

Healthy oyster reefs in Delaware Bay are critical to the continued improvement in water quality and to the maintenance of populations of associated species that depend on oyster reefs for food and habitat. Intertidal oyster reefs can provide a model for scientists studying the ecological role of oyster reefs and for developing reef building methodology. Scientists should determine appropriate methods for reef building in Delaware Bay and identify the controlling processes and species interactions that will support a sustainable fishery and oyster populations. Small intertidal reefs can help resource managers identify areas with potential for rebuilding the Delaware Bay oyster resources. Successful reefs will also contribute spawn and substrate that is critical to the recovery of oyster populations.

THE ROLE OF AQUACULTURE IN PROMOTING THE RESTORATION OF DELAWARE BAY OYSTERS AND OTHER ESTUARINE SPECIES. **Stewart M. Tweed** and **Jenny McCormick**, NJ Sea Grant Extension Program, NJ Sea Grant College Program, Bldg. 22, Fort Hancock, NJ 07732. sgtweed@verizon.net. **Session 9**, poster, 5/10/05 (presentation #93).

Restoration of America's estuarine resources is a critical goal of all the federal and state agencies responsible for coastal resources. Scientific research has indicated that this goal is vital to the healthy ecological functioning of the estuary. Scientists and funding agencies agree that rebuilding and maintaining exploited estuarine resources will require substantial funding and a long-term commitment of personnel and funding for restoration programs. A recent paper suggested that restoration of Chesapeake Bay oyster resources will cost over $300 million. National Estuary Programs must recognize that sufficient funding will not be available to attain all their goals and they must develop alternative strategies to reach their stated goals. One alternative is to expect limited success and funding support. A second alternative is to look for innovative and economically efficient ways to achieve greater successes. Partnering with volunteer groups is one way to achieve this. These partnerships can increase the effectiveness of the Estuary programs but are still limited by available funding. In the Chesapeake Bay it is estimated that with volunteers and university support it can cost $50,000 to restore one acre of oyster reef. Partnering with commercial aquaculture can be a cost effective alternative to current restoration efforts and can help volunteer groups reduce their project costs. As an example, a NJSGEP demonstration farm in the lower Delaware Bay has generated economic data that shows viable aquaculture techniques can be effective in supplying the ecological benefits of oyster reefs without the large costs to the public. Successful aquaculturists will invest private money in developing oyster farms because they can expect to produce a profit while maintaining over one million oysters in the bay. Besides saving taxpayers dollars and while accomplishing the Estuary Program goals, aquaculture will also generate economic benefits for the region. Aquaculturists can also provide seed and technical assistance to volunteer programs. Successful industry recovery and expanded support for volunteer programs may help the Estuary Programs demonstrate to funding agencies that their successful programs should be better funded.

Successful shellfish aquaculture can provide the ecological benefits of water filtration and substrate creation while contributing to oyster spawning success in the bay. Successful culture will depend on the development of sound scientific practices to address the needs of the aquaculture industry. Scientists should study industry problems inorder to improve the profitability of oyster farming and to promote sustainability of the Delaware Bay oyster resources. Resources managers should develop the regulatory guidelines that will promote successful culture techniques and encourage programs to develop volunteer restoration efforts. Their goal should be to increase and protect the resources and to support the industry that depends on these resources.

RESTORATION OF THE CAPE MAY SALT OYSTER. **Stewart Tweed**, New Jersey Sea Grant Extension Program, 80 Millman Lane, Villas, NJ 08251; and **James Tweed**. sgtweed@verizon.net. **Session 3**, poster, 1/11/05 (presentation #62).

From the late 1880's to the early 1950's the oysters harvested in the higher salinity waters of Cape May County were called Cape May Salts and were highly prized for their flavor and quality. Like much of the East Coast oyster resources, Cape May Salts succumbed to over harvesting and oyster diseases and disappeared from local markets.

NJ Sea Grant, in order to contribute to the restoration of Delaware Bay oyster resources and to provide economic recovery for coastal communities, has worked with local oystermen to develop economically viable aquaculture for "Cape May Salt" oysters. Both hatchery reared and natural oyster seed was grown in rack and bag culture systems on the Cape Shore tide flats of Cape May County. Practical methods were developed to control fouling, predation, and over winter loses. These methods produced market size oysters in 2to3 years.

In 2002 the first significant production of Cape May Salt oysters in almost a quarter century occurred on these oyster farms. Five growers produced about $125,000 of market oysters and planted over 5 million oyster seed. These oysters were marketed to restaurants locally and in New York and Philadelphia. Successful restoration of these Cape May Salts was demonstrated by the favorable restaurant reviews in regional papers and their adoption as a preferred product by the International Slow Food Movement.

WATER AND SEDIMENT QUALITY ASSESSMENT OF THE TIDAL FRESHWATER SCHUYLKILL RIVER, PHILADELPHIA, PA: UNDERSTANDING SOURCES AND FATE OF NUTRIENTS AND CHEMICAL CONTAMINANTS. **David J. Velinsky** and **Jeffrey T.F. Ashley**, Patrick Center for Environmental Research, The Academy of Natural Sciences, 1900 Ben Franklin Parkway, Philadelphia, PA 19103. velinsky@acnatsci.org. **Session 2**, poster, 1/11/05 (presentation #13).

The tidal portion of the Schuylkill River (approximately 15 km), the second largest input of freshwater into the Delaware River, drains a heavily urbanized and industrialized segment of greater Philadelphia. Despite its location in the heart of a major urban area, there has been little monitoring of the chemical and biological status in the tidal freshwater area. To begin understanding the sources and fate of water column nutrients and trace metals in the tidal river, a two year monitoring effort was undertaken. Sub-surface water samples were collected monthly, beginning in April 1999, using trace metal clean techniques. Dissolved (0.45 µm) and particulate matter were analyzed for various forms of N, C, P and selected trace metals. In addition, surface sediment samples were collected throughout the tidal river and in the adjacent Delaware River.

The distribution of nutrients and trace metals within the tidal Schuylkill River appear to be closely related to both biological and hydrologic changes. The hydrology is very dynamic, with flows as low as 450 cfs in July and as high as 5500 cfs in September of 1999 (Tropical Storm Floyd). Biological production was high during the late spring and early summer as apparent by the elevated levels of Chlor *a* and lower nutrient concentrations. Spatially, concentrations of dissolved NO_3+NO_2 were highest in the upper portion of the tidal river (ca. 250 µM N) decreasing to approximately 140 µM N at the confluence with the tidal Delaware River. In addition to dilution, algal consumption and denitrification may account for a portion of the decrease in dissolved NO_3+NO_2 concentrations. Dissolved inorganic phosphorus concentrations exhibited substantial changes related to both algal uptake and release of sediment-bound P during time periods with low dissolved oxygen. Trace metal concentrations were low and more uniform throughout the tidal river. The concentration of dissolved lead generally decreased towards the Delaware River (i.e., 1.5 µg/L to 0.5µg/L. Particle-bound lead concentrations were highest at all stations (ca. 7 to 8 µg/L) in February and March 2000. Particle-bound copper and zinc, which are the dominant forms, were highest in July 1999 (11 and 18 µg/L) and February 2000 (10 and 28 µg/L) just below the Fairmount Dam. Regression analysis suggests nonpoint sources are dominant for metals and phosphorus and point sources important for nitrogen.

Sediment concentrations of trace metals and organic contaminants indicate a moderate to high degree of contamination in the tidal river. Concentrations of tPAHs were some of the highest in the mid-Atlantic region and the distribution of individual PAHs indicate direct petrogenic inputs in the lower

portion as well as a combustion source (i.e, urban sources). The distribution of trace metals and tPCBs indicate elevated concentration but no specific source (i.e., hot spot) in the tidal area
The monitoring of the tidal Schuylkill River has revealed substantial biogeochemical reactions are modifying the flux of material to the mainstem tidal Delaware River from the Schuylkill watershed. Non-point sources appear to be dominant for most constituents. These results provide a baseline for future comparison after potential source reduction strategies are implemented.

DYNAMICS OF PHOTOHETEROTROPHIC BACTERIA IN THE DELAWARE ESTUARY. **Lisa A. Waidner, Matthew T. Cottrell** and **David L. Kirchman**, University of Delaware, College of Marine Studies, 700 Pilottown Road, Lewes, DE 19958. lwaidner@udel.edu. **Session 4**, 10:30, 1/11/05 (presentation #17).

The primary goal of this study was to gain an understanding of the distribution and abundances of aerobic anoxygenic photosynthetic (AAP) bacteria in the Delaware Estuary. AAP bacteria are obligate aerobes that photosynthesize with the use of bacteriochlorophyll *a* (bchl *a*), but do not evolve oxygen. Light and organic matter are energy sources for these bacteria, and dissolved organic matter (DOM) may be used for reducing power in addition to being a carbon source. The abundance of AAP bacteria was estimated in transects of the Delaware Estuary.

AAP bacterial abundances as determined by microscopic counts of near-infrared autofluorescence of bchl *a*-containing cells were highest (10 to 20% of total prokaryotes) at the turbidity maximum of the estuary. The lowest abundances of AAP bacteria (2 to 5%) were found at both ends of the estuary, where light attenuation is lowest, and there was a significant correlation between attenuation and bchl *a*-containing cells. In addition, we examined the abundance of a gene marker for AAP photoheterotrophy (*puf*M) in DNA extracted from surface waters of the Delaware Estuary. The abundance of *puf*M was highest where light attenuation was greatest, and generally covaried with the microscopic counts of bchl *a*-containing cells.

To examine whether AAP genes in the estuary were from aerobic bacteria, we isolated genomic DNA from the Delaware River and sequenced two large segments (33 and 35 kb) of DNA containing anoxygenic photosynthesis genes, including *puf*M genes. Most of the photosynthesis genes in each genomic fragment (91% and 80%) were most closely related to those of aerobic bacteria, and both segments of genomic DNA contained the *acs*F gene, which encodes a protein required for aerobic bacteriochlorophyll *a* synthesis. In addition, two *puf*M PCR libraries were constructed with DNA isolated from the Delaware River in December 2001 and August 2002. In both samples, 98 to 100% of the *puf*M clones were most closely related to aerobic anoxygenic photosynthesizers. Finally, most (90%) of expressed *puf*M genes (RNA) in the summer sample were related to aerobic AAP bacteria. These data indicate that the AAP bacteria in the Delaware Estuary are aerobic members of the pelagic bacterial community.

The aerobic but anoxygenic photosynthetic bacteria may have a large impact on organic matter degradation throughout the Delaware Estuary, but especially at the turbidity maximum. The upper estuary, including the turbidity maximum, is net heterotrophic, most likely because of terrestrial organic matter inputs. While phytoplankton growth is light-limited at the turbidity maximum, these AAP bacteria were especially successful in this region of the Delaware Estuary. These bacteria may harness light energy via electron transport mechanisms for the production of ATP, obviating some of the need for DOM oxidation. Since current estimates of bacterial growth efficiencies are based on dark incubations, AAP bacteria may affect growth estimates of the heterotrophic bacterial communities in the Delaware and elsewhere. Where AAP bacteria are abundant, our understanding of bacterial degradation and processing of organic matter will be affected, having an impact on current biogeochemical models.

TISSUE CULTURE GENERATED NATIVE MARSH PLANTS: AN ALTERNATIVE PLANT RESOURCE FOR WETLAND CREATION AND RESTORATION. **Jiangbo Wang, Denise M. Seliskar** and **John L. Gallagher**, Halophyte Biotechnology Center, College of Marine Studies, University of Delaware, 700 Pilottown Road, Lewes, DE 19958. wangjb@udel.edu. **Session 5**, poster, 1/11/05 (presentation #49).

Tissue culture and plant regeneration protocols for five salt marsh monocots, *Spartina patens*, *Spartina alterniflora*, *Juncus gerardi*, *Juncus roemerianus*, and *Scirpus robustus*, were developed. Selected regenerants of each of the species were planted in a simulated marsh field plot. Plant growth was evaluated after one growing season. Phenotypic variation among regenerants was found in *S. patens* and *J. gerardi*, indicating the occurrence of somaclonal variation. In the case of *S. patens*, two of the nine regenerants were found to spread vegetatively over a larger area than the other seven regenerants and exhibit higher biomass and stem density. By using the random amplified polymorphic DNA (RAPD) technique, genome DNA variation in *S. patens* regenerants was detected. Genetic diversities not only occurred among phenotypically different regenerants, but also among phenotypically similar ones. This study suggested that tissue culture could develop plants with specific characteristics valuable for wetland creation and restoration. For example, plants with a dense root system and thick canopy may form a barrier that withstands or blocks *Phragmites australis* invasion into the marsh. In addition, tissue culture regenerated plants may have desirable genetic diversity and adaptability because of somaclonal variation and may therefore be able to thrive in the non-pristine created or restored wetland environment.

THE RELEVANCE OF THE NATIONAL VEGETATION CLASSIFICATION SYSTEM TO RESTORATION PRACTICE. **Kellie A. Westervelt**, Partnership for the Delaware Estuary, 1 Riverwalk Plaza, Suite 202, 111 S. Poplar Street, Wilmington, DE 19801. kwestervelt@DelawareEstuary.org. **Session 10**, 9:30, 5/10/05 (presentation 83).

Use of the National Vegetation Classification System (NVCS) can improve the quality of habitat projects being performed throughout the Delaware Estuary region. Ecological classification systems are scientific constructs that attempt to define, categorize, and describe the natural environment. There are many classification systems in use today, from Rosgen's classification of stream types to Anderson's classification of land coverage types. For the purpose of ecological restoration in terrestrial systems, the NVCS can provide a good reference for project planning.

The NVCS is a hierarchical physiognomic-floristic classification system that was developed by The Nature Conservancy and is now used by all state natural heritage programs and overseen nationally by NatureServe. Because it is a hierarchical system, it is useful on multiple scales, from the landscape to the site-specific. At the plant association level, the NVCS provides descriptions for ecological communities. Community descriptions include information on species composition, community structure, physical attributes, environmental conditions, management concerns, and geographic range. Additionally, each ecological community described has a corresponding conservation status, a ranking that indicates relative abundance or rarity of the community type. Since the NVCS is a standardized system, it is valid across local, regional, and state boundaries

The NVCS can be an incredibly useful tool for planning restoration projects. The information contained in ecological community descriptions can help guide projects. The identification of a natural community and corresponding reference system is one of the very first steps in restoration planning. Identifying restoration targets based on a natural community classified under the NVCS in the planning phases can result in better projects. The species appropriate to plant and planting densities can be determined. Similar restoration projects can be compared and their results evaluated. Restoration projects can be prioritized according to conservation status. Combining all the descriptive features used in the NVCS, it becomes a powerful reference tool for site-specific restoration planning and implementation, as an evaluation tool in restoration project assessments, and as a planning tool in developing regional habitat restoration strategies that crosses political and watershed boundaries. It allows for integration, comparison, evaluation, and overall better management.

The Partnership for the Delaware Estuary is currently working with NatureServe and the Natural Heritage Programs in New Jersey, Pennsylvania, and Delaware to update the Estuary's community descriptions based on the NVCS. As a result, restoration practitioners will have an additional resource to help guide their efforts and conservation planners will have important information about the status of natural communities in the region.

QUANTITATIVE MODELING OF NITROGEN LOADING TO DELAWARE BAY: SOURCES, FLUXES AND MANAGEMENT OPTIONS. **David Whitall**, NOAA, National Ocean Service, National Centers for Coastal Ocean Science, Center for Coastal Monitoring and Assessment, 1305 East West Hwy, Silver Spring, MD 20910. dave.whitall@noaa.gov. **Session 2**, 4:30, 1/10/05 (presentation #6).

Nitrogen (N) pollution originates from multiple sources and is transported through several media (air, soil, water); a major challenge of the development of N management strategies will be the control of multiple sources to effectively reduce N loads to estuaries. Nitrogen input to estuaries is of concern because primary production is frequently N-limited in a diverse range of estuarine and coastal waters. Nitrogen enrichment has been linked to eutrophication in N-sensitive systems. Anthropogenically enhanced eutrophication includes symptoms such as loss of seagrass beds, changes in algal community composition, increased algal (phytoplankton) blooms, hypoxic or anoxic events and fish kills. Quantitative models can be useful for predicting the delivery of watershed N loading to estuaries and for evaluating management strategies for reducing N load. The WATERSN model has been used to quantify N loading to Delaware Bay and to compare the relative contributions of various N sources to those of other east coast estuaries. Nitrogen loads to Delaware Bay are dominated by human waste (47%), followed by agricultural runoff (34%) and atmospheric deposition (17%). This source distribution falls between more highly populated watersheds such as Long Island Sound (70% human waste, 6% agricultural runoff 19% atmospheric deposition) and more agricultural watersheds such as Chesapeake Bay (21% human waste, 55% agricultural runoff, 22% atmospheric deposition) and Pamlico Sound (12% human waste, 79% agricultural runoff, 8% atmospheric deposition). The model was also used to evaluate a variety of management strategies for reducing N loads to the estuary. These management strategies encompass reductions in atmospheric emissions and deposition of N from sources including, fossil fuel burning utility emissions and mobile NO_x emissions, N treatment in wastewater and controls on agricultural N inputs. In Delaware Bay and Long Island Sound biological removal of N in wastewater treatment produces the greatest reduction in N loading (32-57% reductions), while in Chesapeake Bay and Pamlico Sound reductions in agricultural runoff are more effective (5-56% reductions) in decreasing N loads to coastal ecosystems. Because anthropogenic N inputs are derived from a variety of sources, an integrated scenario targeting all major N sources resulted in 35-58% reductions in N loading for the four watersheds.

These results from the WATERSN model have implications for the management of eutrophication in Delaware Bay. Models such as this may be very useful to watershed managers in evaluating a variety of management strategies for reducing N loading. Future research might be directed to improving the model parameters that deal with how nitrogen is retained by the landscape, specifically by improving land use data to differentiate between similar land uses (e.g. urban and suburban) which may have very different nitrogen retention capacities.

ON THE CURRENT VARIABILITY IN THE UPPER DELAWARE ESTUARY. Kuo-Chuin Wong, College of Marine Studies, University of Delaware, Newark, DE 19716. kcwong@udel.edu. **Session 1**, 1:45, 1/10/05 (presentation #11).

The spatial and temporal variabilities of the currents in the upper Delaware estuary are examined based on an 80-day field survey conducted between mid-March and early June 2003. Two bottom-mounted ADCP were deployed during the survey, one located at roughly 130 km upstream of the bay entrance at Tinicum Island, Pennsylvania and the other at about 95 km from the bay mouth at New Castle, Delaware. The measurements show that the currents exhibit temporal variability at tidal and subtidal frequencies. At tidal frequencies the M2 is the dominant constituent, with amplitude of about 80 cm/s near the surface. The amplitude of the M2 current decreases with increasing depth, consistent with the effect of bottom friction. There is only a slight variation of the M2 current phase with depth. In addition to M2, there are other weaker but still significant semidiurnal currents (N2 and S2) with amplitude roughly ¼ of that of M2. The amplitude of the M4 current is only about 1/10 of that of M2, indicating that the Delaware estuary is a weakly nonlinear system.

At several-day time scales the currents exhibit significant subtidal variability with a standard deviation of about 10 cm/s. The subtidal currents show coherent fluctuations throughout the water column. These barotropic subtidal current fluctuations appear to be driven primarily by the remote wind effect acting on the continental shelf adjacent to the Delaware estuary. A downwelling favorable wind over the shelf produces a coastal set-up at the entrance of the estuary, and this set-up in turn drives a rise in subtidal sea level and an up-estuary flow in the upper part of the estuary. An upwelling favorable wind on the continental shelf has the opposite effect in producing a drop in sea level and an outflow in the upper estuary.

The mean currents at the 2 sites show down-estuary mean flow throughout the water column. While the outflow is stronger at the surface (15 cm/s) than at depth (10 cm/s), there is no evidence of a two-layer gravitational circulation pattern. This is due to the fact that the 2 observational sites are upstream of the salt intrusion limit during this spring freshet period, so the mean flow is driven by the river discharge but not the density effect.

HYDROLOGIC BARRIERS: COMMUNITY-BASED RESTORATION OPTIONS. Craig A. Woolcott, U.S. Department of Commerce, NOAA Fisheries Service, Restoration Center, 74 Magruder Road, Highlands, NJ, 07732. Craig.Woolcott@noaa.gov. **Session 9**, poster, 5/10/05 (presentation 99).

The NOAA Restoration Center enhances living marine resources to benefit the nation's fisheries by restoring their habitats. The NOAA Restoration Center is the leader of marine and estuarine habitat restoration within NOAA. The Restoration Center (a division within in the National Marine Fisheries Service, Office of Habitat Conservation) performs restoration pursuant to federal legislation and improves the state of restoration ecology and habitat management.

Working with others, the Restoration Center achieves its mission by:

- Restoring degraded habitats
- Advancing the science of coastal habitat restoration
- Transferring restoration technology to the private sector, the public and other government agencies
- Fostering habitat stewardship and a conservation ethic

The Restoration Center achieves its goals and objectives through two primary programs:

- Under the *Damage Assessment and Restoration Program* (DARP), restoration scientists and managers ensure that injured marine resources are restored after oil spills, toxic releases or ship groundings.
- The NOAA *Community-based Restoration Program* (CRP) applies a grass-roots approach to restoration by actively engaging communities in on-the-ground restoration of fishery habitats around the nation. CRP emphasizes partnerships and collaborative strategies built around restoring NOAA trust resources and improving the environmental quality of local communities.

To complement these programs, the Restoration Center advances emerging restoration technology, science, and cost-effective practices through its Restoration Research Program (RRP). Together, these programs benefit countless acres of fragile and threatened coastal and marine habitats throughout the country.

The NOAA Restoration Center has funded approximately 200 diadromous fish passage and diadromous fish habitat projects to date throughout the coastal United States. Funding for fish passage projects is accomplished through both CRP and DARP. Restoration techniques are diverse and include fish ladder installation and modification, bypass channel creation and enhancement, fish lifts and elevators, eelway installations, dam removals and modifications, pool and weir structure installations, culvert modifications and removals, and nature-like fishway installations (e.g. rock ramps).

Successful fish passage and fish habitat projects are accomplished in partnership with federal, state, and local governmental organizations as well as with various non-profit and local community agencies, schools, and public organizations (see example figure 2). Many of the projects funded by the NOAA Restoration Center have also been accomplished through active volunteer participation, providing hands-on labor and other in-kind volunteer services.

HIGH NUTRIENT AND LOW GROWTH IN THE DELAWARE ESTUARY: EVALUATION OF PRIMARY PRODUCTION USING A LONG-TERM DATABASE.

Kohei Yoshiyama, Graduate College of Marine Studies, University of Delaware, 700 Pilottown RD, Lewes, DE 19958. kyoshi@udel.edu. **Session 4**, 11:00, 1/11/05 (presentation #47).

Using a 26-year database based on a number of cruises in the Delaware Estuary, we have examined phytoplankton response to estuarine eutrophication. Primary survey of the database revealed that biomass-normalized primary production did not increase linearly with increasing nutrient concentrations, and instead showed saturation at comparatively low nutrient concentrations and decreased at high concentrations, indicating that high nutrients do not support primary production in the estuary as in lakes. An empirical model of areal primary production accounted for 67% of the variability overall, indicating that the primary production was mainly controlled by light availability and temperature. In contrast, a similar model applied to a Chesapeake Bay database had shown a poorer fit, indicating consistent light limitation in the Delaware Estuary and varying strengths of light and nutrient limitation in the Chesapeake Bay. The model was applied to five estuarine regions and showed significant overestimation in the most urbanized part of the estuary. This result indicates that some factors limit and/or suppress primary production in the urbanized part. The residual variation from the model estimate was considered to represent the effect of other environmental variables on primary production and expressed as correction factors. The relationships between nutrients and correction factors for the Delaware Estuary showed that the model underestimates primary production at low/mid nutrient concentrations and overestimates it at high concentrations. This indicates that high nutrient concentrations themselves, especially nitrate and ammonium, and/or something that correlates with high nutrient concentrations inhibit primary production.

Our results indicate a HNLG (High Nutrient and Low Growth) situation in the urbanized part of the Delaware Estuary due to varying influences of light limitation, proportions of nutrients, and probably toxic contaminants in areas with large anthropogenic inputs including high nutrients. These findings indicate that high nutrient concentrations do not stimulate primary production; in contrast, high nutrients apparently inhibit primary production. Toxic contaminants that accompany with high nutrient concentrations are suspected to have a negative influence on primary production in the urbanized part. The HNLG phenomenon should be considered further in relation to estuarine eutrophication.

USE OF LIDAR REMOTE SENSING TO CHARACTERIZE BEACH MORPHOLOGY FOR A STUDY OF HORSESHOE CRAB HABITAT SELECTION IN THE DELAWARE BAY. **John Young, Ann Rafter, David Smith**, US Geological Survey, Leetown Science Center, Aquatic Ecology Branch, 11649 Leetown Road, Kearneysville, WV 25430; and **Wayne Wright**, NASA Observational Sciences Branch, Wallops Island, VA 23337. jyoung@usgs.gov. **Session 6**, 5:15, 1/11/05 (presentation #45).

We used data collected from the Experimental Advanced Airborne Research Lidar (EAARL) to map beach morphology in the Delaware Bay for a study of horseshoe crab (*Limulus polyphemus*) habitat selection. The EAARL system uses laser pulses from an airborne platform to detect surface heights at 2.5 meter intervals along and across the flight path. The unique properties of the EAARL system as opposed to other laser mapping systems are the use of a green-light laser less sensitive to attenuation by water and full waveform digitizing capabilities. Lidar data were collected over Delaware Bay beaches in July and November 2003. We processed the lidar data postings in a geographic information system and interpolated surfaces of beach elevation and beach slope for 61 beach segments on the Delaware and New Jersey portions of the bay. Additionally we processed laser return intensity data for an experimental assessment of surface substrate. Results of the lidar mapping are being used in a hierarchical model of habitat factors associated with horseshoe crab spawning activity. Lidar mapping allowed for detailed examination of beach morphology over a large area in a manner that would have been difficult, if not impossible using other methods. Lidar mapping should prove to be equally as useful for mapping and assessment of other characteristics of the near shore environment of the Delaware Bay estuary.

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Note: *Contact information was obtained from registration forms and correspondence, and so it may be incomplete or inaccurate. Some participants declined to be listed.*

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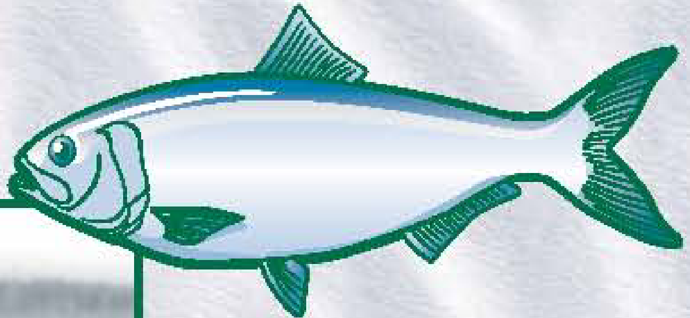

Aerial photos and horseshoe crab photo (above) by Bill Buchanan

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