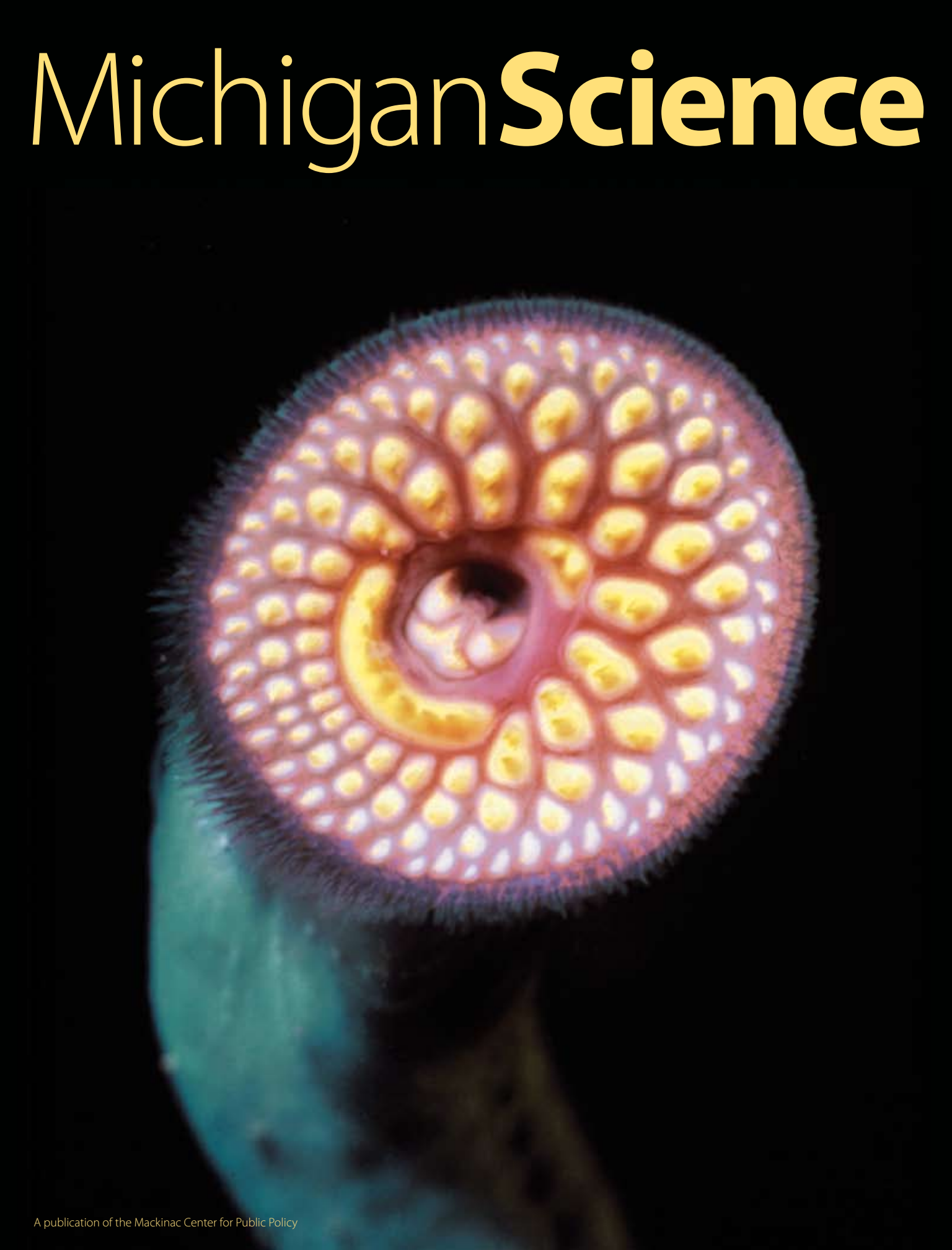
Michigan**Science**



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Henry Payne is the editorial cartoonist for The Detroit News. His work is syndicated to an additional 60 newspapers nationwide via United Feature Syndicate. Mr. Payne has been a runner-up for the Pulitzer Prize. A writer as well as an artist, his articles have appeared in The Wall Street Journal, The Weekly Standard magazine, National Review and Reason magazine.

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ON THE COVER
The sea lamprey (Petromyzon marinus), one of many invasive species in the Great Lakes. The lamprey is a parasite that attaches to a host fish with its suction disc, which it uses to penetrate the host's scales and suck out the fish's fluids — a creature capable of killing up to 40 pounds of fish in less than two years.
Source: SGNIS, www.sgnis.org

By The Numbers

Beyond propaganda and rhetoric, numbers tell the real story

FLATULENT COWS and other livestock far outrank sport utility vehicles as the largest single source of the gas emissions said to cause global warming, according to "Livestock's Long Shadow," a new report from the United Nations Food and Agriculture Organization. The report found that the gas and manure produced in barnyards worldwide contribute 35 percent to 40 percent of the methane emitted into the atmosphere. Overall, livestock emissions total 18 percent of so-called greenhouse gases when measured as equivalents of carbon dioxide. For more information go to http://www.virtualcentre.org/en/library/key_pub/longshad/A0701E00.htm.

INTERIOR SECRETARY Dirk Kempthorne has recommended designating the polar bear as a "threatened" species because of warmer temperatures in their arctic habitat. However, data published in the Wall Street Journal indicate that the polar bear population is larger now than 50 years ago. The number of polar bears in the 1950s was estimated at 5,000. The population increased to an estimated 8,000-10,000 from 1965 to 1970, and rose to 25,000 by 1984. Current estimates range between 20,000 and 25,000, according to the data collected by the Wall Street Journal from the International Bear Association, International Wildlife, the Polar Bear Study Group, the World Conservation Union, CoveBear and the New York Times. For more information go to http://online.wsj.com/article/SB116778985966865527-search.html?KEYWORDS=polar+bear&COLLECTION=wsjie/6month.

BETWEEN 1980 AND 2005, the number of vehicle miles driven annually roughly doubled, and the amount of coal burned for electricity production increased 61 percent. During the same period, sulfur dioxide levels in the air fell 63 percent; carbon monoxide concentrations dropped 74 percent; nitrogen dioxide levels decreased 37 percent; and fine particulate matter declined 40 percent, according to research by scientist Joel Schwartz, an American Enterprise Institute visiting scholar who analyzed air quality data collected by the U.S. Environmental Protection Agency. For more information go to http://www.aei.org/docLib/20061212_st294.pdf.

AN ANALYSIS OF CYCLONE DATA from 1970 through 2003 found no evidence supporting claims that global warming is intensifying hurricanes. The findings of the study, which was conducted by climatologists Robert Balling and Randall Cerveny and published in the journal Meteorology and Atmospheric Physics, revealed no significant relationship between the intensification of cyclones and temperature anomalies between the sea surface and the lower troposphere. For more information go to http://www.springerlink.com/content/q3h2xk6424878670/?p=d9867cff278e4998adcf7f23f22b1a5e&pi=3.

*Just the Facts

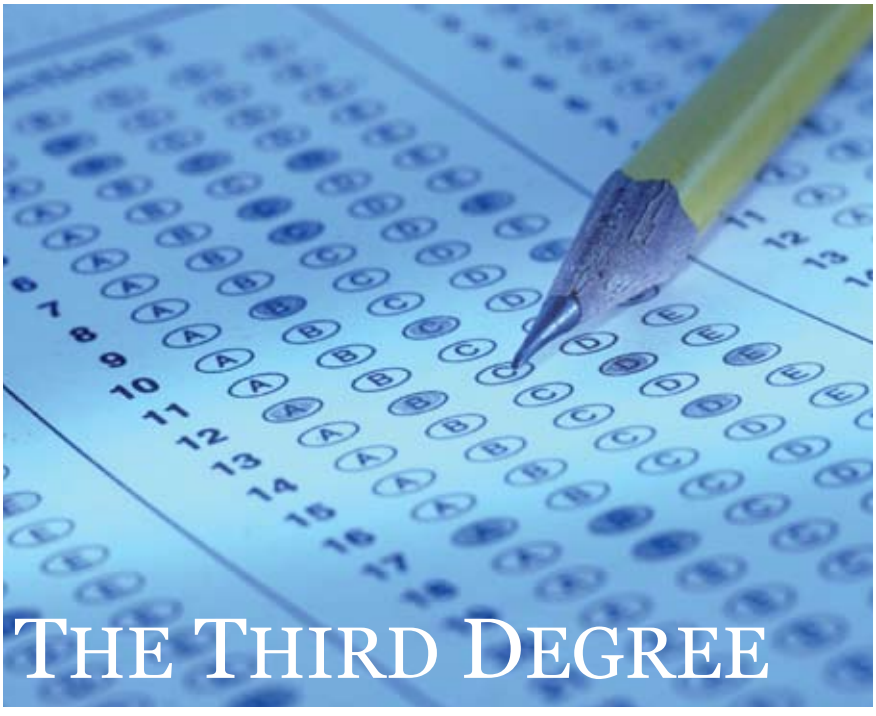
Hybrid vehicles, which combine a gasoline engine with a battery-driven electric motor, have garnered sizable government subsidies on the strength of their fuel economy. But the vehicles' real-world performance is less impressive than previously thought, according to mileage calculations recently adopted by the U.S. Environmental Protection Agency.

For the first time since 1984, the EPA has adjusted the method of estimating the fuel efficiency of new cars and trucks to account for faster driving speeds, aggressive acceleration, air conditioning, cold starts and stop-and-go traffic. The EPA mileage ratings are the only ones that can be used by automakers on vehicle window stickers.

Under the new formula, the mileage estimates for gas-electric hybrids drop the most, decreasing by 20 percent to 30 percent for city driving and 10 percent to 20 percent for highway driving. In contrast, the mileage estimates for most conventional vehicles decrease 12 percent for city driving and 8 percent for highway driving.

Since the 1970s, the mileage formula assumed top speeds of just 60 miles per hour and factored acceleration as 3.3 miles per hour each second. Currently, however, more than 25 percent of driving exceeds 60 miles per hour, and actual acceleration rates typically add 10 to 12 miles per hour each second.

Congress ordered the change in testing methods in 2005.



The Third Degree

What do you know about mercury?

1. **The source of most mercury in the atmosphere is:**
   A. Coal-fired power plants.
   B. Surface and undersea volcanoes.
   C. Soil and rock erosion.
   D. Automotive exhaust.

2. **The volume of mercury releases in Michigan related to human activity is:**
   A. 4.6 tons per year.
   B. 10 tons per year.
   C. 2.3 tons per year.
   D. 115 tons per year.

3. **The Environmental Protection Agency has concluded that the average IQ impairment of children born to mothers who, while pregnant, consumed fresh water fish exposed to power plant emissions of mercury is:**
   A. 0.009 of an IQ point.
   B. 5 IQ points.
   C. 10 IQ points.
   D. 50 IQ points.

4. **Blood tests administered by the Centers for Disease Control found that mercury levels in blood have:**
   A. Increased in recent years.
   B. Decreased in recent years.
   C. Stayed the same.

5. **In recent years, the industrial use of mercury in the United States has declined by:**
   A. 25 percent.
   B. 10 percent.
   C. 75 percent.
   D. No change.

6. **The percentage of mercury deposited annually in Michigan from the emissions of in-state utilities is:**
   A. 10 percent.
   B. 2 percent.
   C. 25 percent.
   D. 5 percent.

For more information go to http://www.mackinac.org/archives/2006/s2006-04.pdf

Answers: 1. B (Surface and undersea volcanoes); 2. C (2.3 tons); 3. A (0.009 of an IQ point); 4. B (Decreased in recent years); 5. C (75 percent); 6. B (2 percent).

Field Trips

Area science museums host special programs of interest to budding scientists and their families

Our Body: The Universe Within

Actual human bodies and organs are on display to reveal the workings of human anatomy. The specimens have been preserved with polymer injections in place of body fluids to inhibit decomposition. The exhibit also features anatomical studies from the past 1,000 years and a "MicroWorld display" featuring magnified images of skin, organs and cell samples.

Through May 28, The New Detroit Science Center, 5020 John R St., Detroit, 313-577-8400. Center is open Monday through Friday, 9 a.m.-3 p.m.; Saturday 10:30 a.m.-6 p.m.; and Sunday, 12 p.m.-6 p.m.

For more information go to http://www.detroitsciencecenter.org/events/OurBody_exhibit.htm.

Extreme Science: Cutting Edge Curriculum Connections

Teachers will learn how to use COSI Toledo resources for classroom activities across the curriculum. The workshop includes a two-hour presentation and demonstrations of hands-on lessons. Sample curriculum materials are aligned with Ohio and Michigan academic standards.

Feb. 8, COSI Toledo, 1 Discovery Way, Toledo, Ohio, 4 p.m.-6 p.m. Cost $10; includes materials and light refreshments. Reservations required. Call 800-334-2674 ext. 280 to register.

For more information go to http://www.cositoledo.org/calendar/index.htm.

Home School Support

One Thursday each month during the school year, Impression 5 Science Center presents a workshop for home schooling families. Each program is tailored to four different age groups ranging from preschool to fifth grade and up. The Feb. 8th program will focus on microscopes; the March 8th workshop will investigate gems.

Through May 10, Impression 5 Science Center, 200 Museum Dr., Lansing, MI 48933. Cost is $3.50 admission per person and a $3 lab fee. Museum is open Monday through Saturday, 10 a.m.-5 p.m.; Thursday 10 a.m.- 8 p.m.; Sunday 1 p.m.- 5 p.m.

For more information about the home school programs or to register, please call Micaela Balzer at 517-485-8116 ext 44; or go to http://www.impression5.org/content/view/35/83/.

Waste to Watts

Half of the gas produced by landfill decomposition is methane, which increasingly is used as a substitute for natural gas in the production of electricity. The "Waste to Watts" exhibit includes hands-on stations that allow students to observe what happens when trash is discarded and how methane gas is created, collected and converted to electricity.

Through summer 2007, Ann Arbor Hands-On Museum, 220 E. Ann St., Ann Arbor, 734-995-5439. Museum is open Monday through Saturday, 10 a.m.-5 p.m.; Sunday, 12 p.m.-5 p.m.

For more information go to http://www.aahom.org/exhibits/index.htm.

ALL'S FAIR IN SCIENCE COMPETITION

By Bruce Edward Walker

The season of science fairs is upon us, and students across Michigan are preparing to exhibit their knowledge and ingenuity in competition for scholarships and other lucrative prizes.

Science fairs originated in 1942, when the Westinghouse corporation joined with the Science Service, a nonprofit organization, to establish the Science Talent Search.[1] Today, there are hundreds of science fairs held annually at the local, state, regional, national and international levels.[2] Alumni include Nobel laureates and recipients of the National Medal of Science and Field Medal, and MacArthur Foundation Fellows.

While competitors of yesteryear were content to win a ribbon and bragging rights, today's students are competing for far more valuable awards. Nina Vasan, for example, collected more than $58,000 in prizes and an invitation to the 2002 Nobel Prize ceremony in Stockholm after winning the 2002 Intel International Science and Engineering Fair.

The proliferation of science fairs has spawned hundreds of Web sites offering project ideas and advice. Among them are presentation tips from Elmer's Glue and Dr. Shawn's Idea Bank, where "The most awesome collection of science

project ideas is just a click away." Meanwhile, Amazon.com lists 6,531 titles related to science fairs, including "Science Fair Projects for Dummies" and "Last-Minute Science Fair Projects: When Your Bunsen's Not Burning but the Clock's Really Ticking."

Michael Benda, a Michigan teacher and frequent science fair judge, said originality and scientific rigor are the most important elements of a successful project. "I want to know if the student has come up with something that a person their age could actually conceptualize, like the student who came up with what I considered a very original idea — the best way to maintain the sweetness of stored carrots," said Benda, who teaches science at Jeffers High School in Painesdale, in the Upper Peninsula.

Tim Fino, director of the Science and Engineering Fair of Metropolitan Detroit and a judge for the International Science Fair, evaluates five components of each project: creativity and scientific thought are both weighted at 30 percent; thoroughness and skill are weighted at 15 percent each; and, clarity at 10 percent. "For team projects, I add a component for teamwork of 16 percent and decrease the others proportionally," Fino said.

Nicholas Ekladyous, winner of the 2005 Flint Area Science Fair, describes science fairs as "an opportunity to reflect on all the ways science has positively impacted our lives.

"The best advice I can give is: Don't quit trying," he said. "Eventually you will achieve your goals with enough determination." ■

1 From "History of Science Service" at http://www.sciserv.org/history.html.

2 For list of fairs go to http://physics1.usc.edu/~gould/ScienceFairs/

Science Fair	Dates/Site	Description	Contacts
Science and Engineering Fair of Metro Detroit	March 20-24 Cobo Center	Open to students in grades 7-12 in Wayne, Oakland and Macomb counties.	SEFMD, P.O. Box 158, Farmington, MI 48332 248-471-9900 • SF2007@ SEFMD.org http://www.sciencefair.info
Southeast Michigan Science Fair	March 9-10 Washtenaw Community College	Open to students in grades 6-12 in Livingston, Washtenaw, Monroe, Hillsdale and Lenawee counties.	Washtenaw Community College, 4800 E. Huron River Dr. P.O. Box 1610, Ann Arbor, MI 48106 734-973-3300 http://www.wccnet.edu/events/sciencefair/
Michigan Envirothon	May 3-4 Camp Cavell Sanilac County	High school team competition.	Teresa Salveta, P.O. Box 30017, Lansing, MI 48909 517-241-7861 salvetat@michigan.gov www.michiganenvirothon.org
Discovery Channel Young Scientist Challenge	June – Sept.	Students in grades 5-8 nationwide.	http://school.discovery.com/sciencefaircentral/dysc/accept/details.html
SkillsUSA Championships	April 27-29 Lansing Community College	Members of SkillsUSA and National Technical Honors Society.	Tammy Brown, Eastern Michigan University, Ypsilanti, MI 48197 www.miskillsusa.org • http://www.miskillsusa.org/index.html
Michigan Science Olympiad	April 28 Michigan State University	Division B: Grades 6-9 Division C: Grades 9-12	Director: Mark A. Van Hecke 157 Loretta St., East China, MI 48054 810-765-4268 • 810-765-2803 FAX 810-217-6056 MOBILE • http://www.michiganso.org/
Intel Science and Engineering Fair	May 13-19 Albuquerque, New Mexico	Grades 9-12	http://www.intel.com/education/isef/index.htm
Intel Science Talent Search	March 8-13 Washington D.C.	High School Seniors	http://www.intel.com/education/sts/index.htm
Siemens Competition	December 2007 New York University, NY	Individual entries: High School Seniors; Team entries: Grades 9-12	http://www.collegeboard.com/student/pay/scholarships-and-aid/23619.html

AN OUNCE OF PREVENTION

HPV and the First Cancer Vaccine

By Wayne D. Lancaster, Ph.D.

Public health officials are heralding the availability of a vaccine that prevents a high percentage of cervical cancers, and Michigan lawmakers recently debated whether to require girls entering the sixth grade to be inoculated. A basic understanding of the new vaccine is necessary when considering public health policy.

Cervical cancer is the leading gynecological malignancy in the United States, causing an estimated 9,710 new cases and 3,700 deaths in 2006. It is a serious problem worldwide, causing about 275,000 deaths annually.

In a breakthrough for cancer prevention, Merck & Co. Inc. on June 8, 2006, received approval from the U.S. Food and Drug Administration for the use of Gardasil® to prevent the majority of cervical cancers. It is the first vaccine to prevent a cancer. The Centers for Disease Control and Prevention's Advisory Committee on Immunization Practices has recommended inoculation for girls and women aged 11 to 26. Proper inoculation requires three injections over six months. A second cervical cancer vaccine, developed by GlaxoSmithKline, is awaiting review by the FDA.

Cervical cancer is the leading gynecological malignancy in the United States, causing an estimated 9,710 new cases and 3,700 deaths in 2006.

Cervical cancer is most often caused when particular strains of the human papillomavirus are transmitted sexually. HPV is considered the most common sexually transmitted disease, with about 60 percent of women acquiring the infection within five years of becoming sexually active. However, only a very small proportion of women persistently infected with high-risk strains of HPV actually develop cervical cancer.

There exist more than 100 types of HPV, only a few of which cause cervical cancer. Many types of HPV simply produce common warts. Others may produce genital warts and lesions in the larynx (which may become malignant on rare occasions). A group of about 15 HPV types, characterized as "high-risk," can cause changes to cells of the cervix that can lead to cervical cancer.

HPV are small, very simple viruses composed of an outer layer of two proteins and a core of DNA (the genetic code of the virus). Infection by high-risk HPV strains can interfere with the normal function of the cells in the cervix. Consequently, these cervical cells may divide abnormally and result in cancer.

Although the presence of HPV is necessary for cervical cancer to develop, it is not sufficient to cause the disease. Other risk factors — including smoking, multiple sex partners and infection from other sexually transmitted diseases — increase the likelihood of cancer. Genetics probably also play a role in the body's susceptibility to HPV infection.

Unlike some vaccines, the HPV vaccine does not contain the live virus and, therefore, is not infectious. Instead, the vaccine is produced from the outer layer of HPV proteins.

Clinical trials involving more than 20,000 women have shown the HPV vaccine to be about 99 percent effective in blocking HPV infection. The vaccine does not cure an existing HPV infection, but instead protects

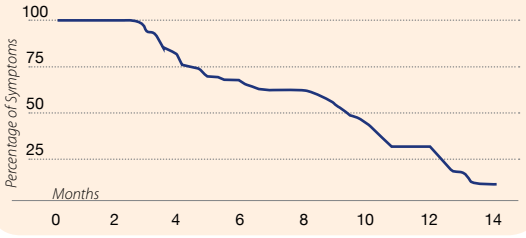
Hailed by many doctors as a breakthrough in cancer prevention, the human papillomavirus vaccine, Gardasil, prevents infections from two strains of the sexually transmitted human papillomavirus, or HPV, that may lead to cervical cancer. (AP Photo/Charles Rex Arbogast)

against new infection. It is not known precisely how long the vaccine protects against infection by high-risk HPV, although antibodies were present in women five years after inoculation. Other than temporary soreness at the injection site, there appear to be no serious side effects from the vaccine.

Annual PAP tests are still recommended for vaccinated women because the vaccine protects against only two of the HPV strains that cause cervical cancer. About 30 percent of cervical cancers caused by other high-risk HPV will not be prevented by the vaccine.

Over Time, Most HPV Infection Symptoms Are Difficult to Detect

After two years, many symptoms of HPV infections are greatly reduced or disappear altogether.



Source: Giuliano AR. J Infect Dis. 2002; 186:462-469

Development of an HPV vaccine involved contributions by scientists at Georgetown University in Washington, D.C., the University of Rochester in Rochester, N.Y., Queensland University in Brisbane, Australia, and the National Cancer Institute in Bethesda, Md. It took 10 years of legal wrangling before the U.S. Patent Office ruled on overlapping claims. The dominant patent for the technology was granted to Georgetown University. Merck and GlaxoSmithKline have cross-licensed the technology.

There are no recommendations for vaccinating men at present. However, high-risk HPV strains are associated with cancers of the male genitals, oral cavity and tonsils. The inoculation of men might also help to reduce transmission of HPV and thus the incidence of cervical cancer.

Annual PAP tests are still recommended for vaccinated women because the vaccine protects against only two of the HPV strains that cause cervical cancer.

Since the vast majority of cancers are not caused by viruses, the HPV vaccine cannot be used as a model for preventing most other forms of cancer. Nevertheless, Gardasil® and GlaxoSmithKline's Ceravix® represent the remarkable progress being achieved in cancer research. These are unique vaccines — the first ever developed to protect against infection by viruses that can lead to cancer. ■

MichiganScience
SPECIAL FEATURE

By Bruce Edward Walker

DISCARDING FALSE NOTIONS

The facts about solid waste disposal in Michigan

Gov. Jennifer Granholm and members of the Michigan Legislature are considering various regulations and taxes to discourage the importation of Canadian trash to Michigan landfills. We examine below the regulation of landfills in the state, their capacity and Michigan's trash imports and exports to better assess policy options.

Modern landfills are among the most regulated industries nationwide. From site selection and design to construction and operation, landfills are managed to minimize environmental contamination and maximize reuse of sites in the briefest possible time. Waste companies presently invest between $750,000 and $1 million per landfill acre to comply with state and federal regulations.

The Riverview Highlands Golf Practice Facility was built on 43.8 acres of closed solid waste disposal area at the Riverview Land Preserve, a sanitary landfill owned and operated by the city of Riverview, Mich. Riverview spent $4.2 million to reclaim the landfill. The golf practice facility features a putting green, two teeing areas and a three-hole practice course.

The Emergence of Landfill Regulation

Municipal garbage collection and disposal began in the 19th century, and largely consisted of horse-drawn wagons carrying solid waste to incinerators or to open dumps outside the city. Some waste was loaded onto barges for disposal at sea, while other municipalities used garbage to fill wetlands for construction.

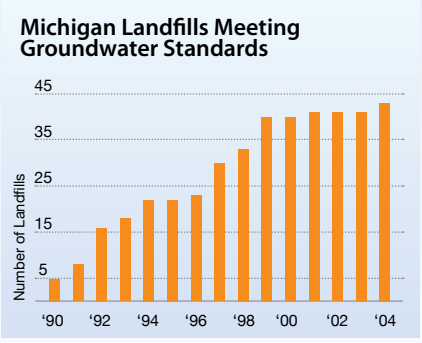
By most accounts, the first modern American landfill was created in 1935 in California. While rudimentary by current standards, this landfill was an improvement over open-air dumps. In 1959, the American Society of Civil Engineers crafted landfill guidelines for municipal solid waste, including compacting waste and covering it with a layer of soil each day to reduce odors and control rodents.

The proliferation of landfills prompted Congress in 1965 to enact the Solid Waste Disposal Act. The statute imposed environmental standards on landfills, including a prohibition on the common practice of burning trash to preserve landfill capacity.[1] The Michigan Department of Natural Resources developed the state's initial solid waste regulations. The Michigan Department of Environmental Quality initiated subsequent regulations.

The U.S. Environmental Protection Agency was granted federal authority over landfills in 1976, under the Resource Conservation and Recovery Act. Among the new regulations crafted by the agency were floodplain restrictions; surface and groundwater protections; insect, bird and rodent controls; and fire and noxious gas controls.

Additional rules were imposed in 1982 for control of "leachate" (water that acquires contaminants as it percolates through landfill waste). Thereafter, operators were required to equip new landfills with "liners" and a collection system to prevent gases and leachate from contaminating the air and groundwater.[2] By 1993, every Michigan landfill required to install a liner system had done so.

As the chart below illustrates, the number of Michigan landfills meeting federal groundwater standards has steadily increased.



Source: Michigan Department of Environmental Quality

Landfill Numbers

In the 1970s, there were more than 20,000 landfills in the United States. There are far fewer today, numbering 1,654[3], but they are more centrally located and larger than previous sites. Landfills handle about 131 million tons[4] of municipal solid waste disposed of in the United States, or more than half of the more than 236 million tons disposed of in 2003 (the most recent data).[5]

There are 50 landfills in Michigan that handle municipal solid waste. The aver-

1 USEPA Compliance and Enforcement, "Basic Information – Major Laws: Solid Waste." Available on the World Wide Web at http://www.epa.gov/compliance/basics/majorlaws/solidwaste.html.

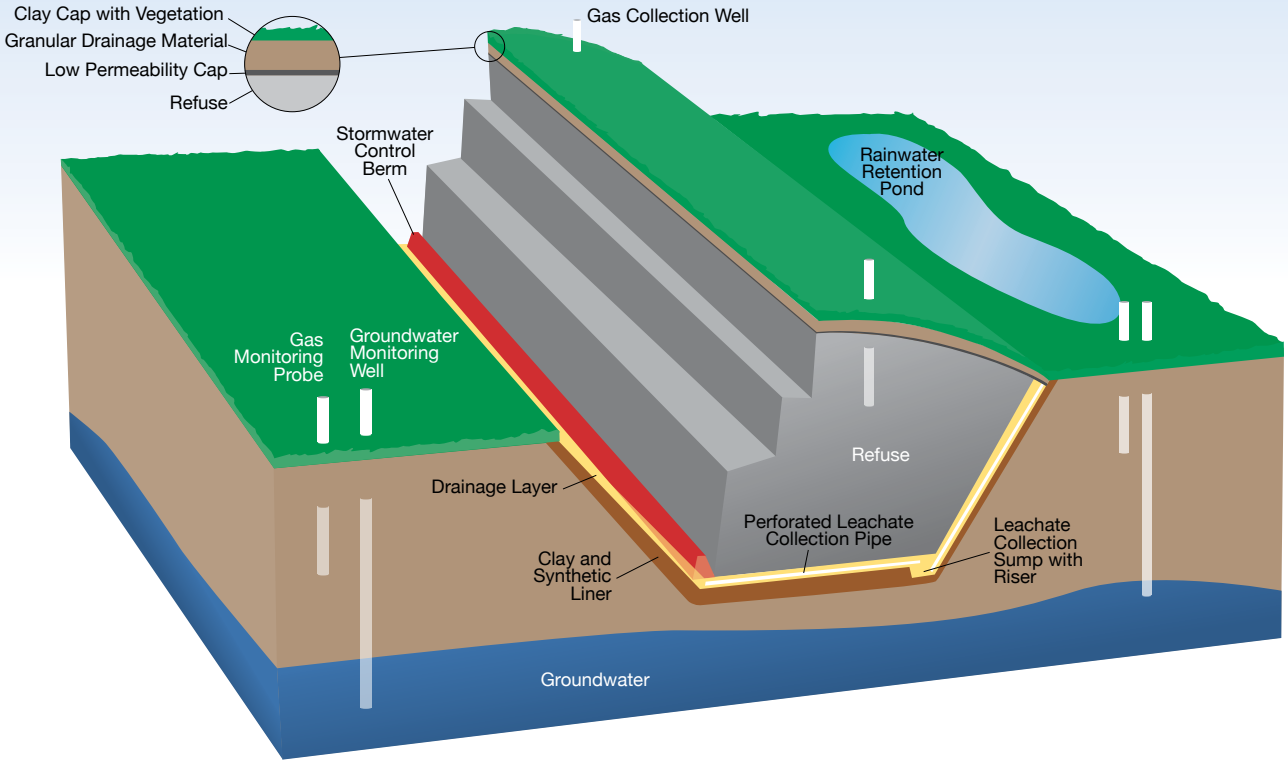
2 These liners are typically comprised of compacted clay, often combined with high-density polyethylene.

3 USEPA Municipal Solid Waste, "Basic Facts: Municipal Solid Waste (MSW)." Available on the World Wide Web at http://www.epa.gov/msw/facts.htm.

4 According to the MDEQ, 1 ton is roughly equal to 3 cubic yards. Because the compaction of solid waste varies according to shipping requirements, we opt in this article to use the more precise unit measurement in each instance cited.

5 "Modern Landfills: A Far Cry from the Past," National Solid Wastes Management Association. Available on the World Wide Web at http://wastec.isproductions.net/webmodules/webarticles/articlefiles/478-white%20paper%20landfill%20final.pdf.

Modern Landfills Require Complex Engineering



age resident in the state produces more than four pounds of trash per day, most of which ends up in one of Michigan's landfills. Statewide, more than 15 million tons of waste was generated in 2005.[6]

Landfill Design and Operation

New deposits of solid waste are covered daily with six inches of soil or an alternative cover such as compost, ash, foam or tarps. These covers reduce odors, discourage rodents and keep trash from blowing away. Landfill waste sits atop a liner that is engineered to direct leachate to a collection pipe, then through a filter and drainage layer and into a collection layer. Landfill operators either treat the leachate onsite or transport the leachate to offsite treatment facilities. The leachate treatment must meet stringent federal and state discharge requirements.[7]

Landfills and Energy Production

Landfills are also required to control emissions of noxious gases such as methane, which are produced by the decomposition of organic wastes. Some use flares that capture and combust the gases, while others use the gas to generate electricity.

The Ottawa Electric Generation Station, in Coopersville, Mich., is one of several electric generation stations in the state where recovered landfill gas is used to fuel generators that produce electricity. Landfill-derived methane burns much cleaner than petroleum or coal, but only has about one-half the BTU value of natural gas.

At present, some 375 landfills nationwide convert methane to energy, according to the U.S. EPA. For example, Allied Waste's Ottawa County Farms Landfill in Coopersville, Mich., processes 3,000 tons of solid waste daily, on average. About 50 percent of the land-

6 "Report of Solid Waste Landfilled in Michigan: October 1, 2004 – September 30, 2005," Michigan Department of Environmental Quality, Jan. 31, 2006. Available on the World Wide Web at http://www.deq.state.mi.us/documents/deq-whm-stsw-ReportSolidWasteLandfilledFY2005.pdf.

7 "Modern Landfills: A Far Cry from the Past," National Solid Wastes Management Association. Available on the World Wide Web at http://wastec.isproductions.net/webmodules/webarticles/articlefiles/478-white%20paper%20landfill%20final.pdf.

fill gas is methane, which is used for fuel by power generators such as the Ottawa Electric Generation Station.

The burned gas drives a generator that produces electricity. The electricity is sold to local utilities or other customers. There are 12 active gas recovery projects in Michigan, which produce an estimated 60.3 megawatts of electricity annually. Nationwide, nearly 74 billion cubic feet of landfill gas generates 9 billion kilowatt-hours of electricity per year, which is equivalent to the electricity produced by more than 154 million barrels of oil.

Methane from landfills also is transported via pipeline to processing facilities that forward the processed gas to nearby factories.[8]

Landfill gas collection and control systems have resulted in a 54 percent reduction in methane emissions from landfills between 1970 and 2003 (from 61.3 million metric tons to 28.2 million metric tons).[9]

8 Readers are directed to MichiganScience No. 1, "The Trade-offs of Renewable Energy." For more information on landfill gas conversion to electricity, see the Ann Arbor Hands-On Museum's Waste to Watts exhibit in this issue's Field Trips.

9 "Modern Landfills: A Far Cry from the Past," National Solid Wastes Management Association, page 6.

Current Landfill Capacity

The existing capacity of Michigan landfills is estimated to be 17 years, on average, according to documents filed with the Michigan Department of Environmental Quality.[10] Some landfills in the state could remain open for as many as 100 years if current disposal volumes remain constant.[11]

Industry analysts say new technologies are significantly extending existing capacity. For example, bioreactor processes add liquids and/or air to solid waste to accelerate decomposition. The reduction in the mass and volume of garbage creates more landfill capacity. Moreover, accelerated decomposition can dramatically cut the time before the landfill area can be reused — from 30 years to 10 or 15 years.[12]

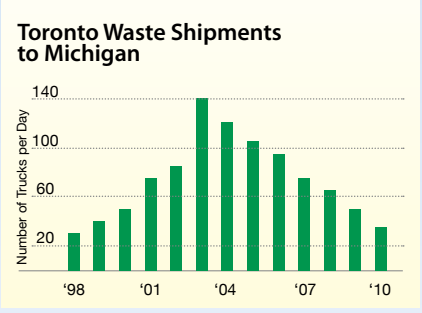
"New designs, engineering and operational changes over the past 10 to 15 years have improved landfill space efficiencies," said Paul Sgriccia, solid waste manager of Golder Associates in Wixom. "Better design of landfills, including increasing landfill air space by constructing perimeter berms, and operational changes, including heavier equipment and advancements in increasing in-place waste density, are adding years of capacity to our existing landfills."

Smiths Creek Landfill in St. Clair County is one of the first Michigan landfills to test a bioreactor. State legislation passed in 2005 allows Smiths Creek to pump septic liquid from residential septic tanks into

10 "Report of Solid Waste Landfilled in Michigan: October 1, 2004 – September 30, 2005," Michigan Department of Environmental Quality, January 31, 2006. Available on the World Wide Web at http://www.deq.state.mi.us/documents/deq-whm-stsw-ReportSolidWasteLandfilledFY2005.pdf.

11 For more details on Michigan's MSW landfills, see landfill chart on the MichiganScience Web site, www.MichiganScienceOnline.org.

12 "Modern Landfills: A Far Cry from the Past," National Solid Wastes Management Association. Available on the World Wide Web at http://wastec.isproductions.net/webmodules/webarticles/articlefiles/478-white%20paper%20landfill%20final.pdf.



Source: Metropolitan Toronto Solid Waste Management Services

Landfill Gas Recovery Projects Deliver Environmental Benefits

Michigan's 12 active landfill gas recovery projects produce an estimated 60.3 megawatts, according to Granger Electric. Using EPA calculations, this amount of electricity generated has the following environmental benefits:

Methane Emissions Reduced Annually by Landfill Gas Recovery Projects Are Equal to One of the Following Benefits:

- Removing emissions equivalent to 442,552 vehicles
- Planting 630,637 acres of forest
- Offsetting the use of 11,312 railcars of coal
- Averting electricity usage of 4,135,324 lightbulbs

Carbon Dioxide Emissions Reduced Annually by Landfill Gas Recovery Projects Are Equal to Any One of the Following Benefits:

- Removing emissions equivalent to 62,229 vehicles
- Planting 88,676 acres of forest
- Offsetting the use of 1,591 railcars of coal
- Averting electricity usage of 581,484 lightbulbs

Total Methane and Carbon Dioxide Emissions Reduced Annually by Landfill Gas Recovery Projects Are Equal to Any One of the Following Benefits:

- Removing emissions equivalent to 504,781 vehicles
- Planting 719,313 acres of forest
- Offsetting the use of 12,902 railcars of coal
- Averting electricity usage of 4,716,808 lightbulbs

Imported Waste by Origin – Fiscal Year 2005

Origin	Volume (cubic yards)
Canada	11,878,091
Connecticut	223,541
Florida	280
Illinois	1,249,614
Indiana	2,193,915
Maine	3,265
Maryland	5,640
Massachusetts	55,137
New Hampshire	45,808
New Jersey	686,576
New York	192,860
Ohio	1,213,777
Rhode Island	96,302
Wisconsin	645,514
Total	**18,490,320**

Source: Michigan Department of Environmental Quality

the landfill to make the garbage decompose up to 10 times faster, according to Dr. Te-Yang Soong, director of solid waste services for CTI Associates in Brighton.

As Dr. Soong explained, "Residential septage contains approximately 95 percent water and 5 percent solids. A portion of the septage solids consists of organic materials such as microorganisms that are capable of decomposing solid waste. Septage also contains large quantities of phosphorous, which is one of the essential nutrients for biological activities that maintain the pH-level in a biosystem."

Landfill Reclamation

When a landfill reaches capacity, it is sealed with groundcover and, within time, reclaimed for one of three categories of uses created by the National Solid Wastes Management Association.

Category 1 involves converting landfills to open-space applications such as farmland, cemeteries, airport runways and hiking trails. Category 2 reclamations entail slightly more complex uses, including industrial and commercial development, parking, and recreation such as golf courses, ski slopes, fairgrounds, trails and sports fields. Category 3 reclamations consist of residential, commercial and municipal uses such as stadiums, shopping malls, post offices, libraries and university buildings.

Michigan Landfills Accepting Canadian Trash

Landfill	Volume (tons)	Percent of Total From Canada
Arbor Hills, Washtenaw County	101,816	10.7%
Brent Run, Genesee County	384,334	71.5%
Carleton Farms, Wayne County	1,341,945	67.5%
Dafter Sanitary Chippewa County	12,283	18%
Pine Tree Acres, Macomb County	1,784,376	73.3%
Richfield, Genesee County	36,451	19.4%
Sauk Trail Hills, Wayne County	49,575	4.5%
Woodland Meadows, Wayne County	70,391	5.0%

Sources: Michigan Department of Environmental Quality; U.S. Environmental Protection Agency

Michigan's Imports and Exports of Trash

More than 21 million tons of waste was disposed of in Michigan landfills in 2005. Trash imported to Michigan accounted for 29 percent, or about 6.2 million tons, of that landfill waste. Of the total waste disposed of in Michigan landfills, 18.6 percent, or about 4 million tons, originated in Canada with approximately 10.3 percent (or 2.2 million tons) coming from other states.[13]

Canadian trash imports to Michigan peaked in 2003, with daily shipments averaging 140 truckloads, each carrying between 33 tons and 52 tons of solid waste.[14] Currently, metropolitan Toronto ships between 80 and 90 trucks per day to one of the eight Michigan landfills with Canadian contracts. The decline in shipments is forecast to continue in coming years.

Toronto officials expect trash imports to decrease to 35 truckloads per day by 2010 due to the government purchase of a landfill in Ontario's Elgin County. Although Toronto intends to honor its contracts with Michigan landfills, which expire in 2010, the contracts

13 "Report of Solid Waste Landfilled in Michigan: October 1, 2004 – September 30, 2005," Michigan Department of Environmental Quality, Jan. 31, 2006. Available on the World Wide Web at http://www.deq.state.mi.us/documents/deq-whm-stsw-ReportSolidWasteLandfilledFY2005.pdf.

14 The variation in the waste volume per truck reflects the differences in landfill contracts.

"Okay, fill 'er up!"

allow for the immediate diversion of as much as 50,000 metric tons of waste per year to the Ontario landfill.

Like Toronto, Michigan exports a substantial portion of its waste. But unlike Toronto, Michigan exports hazardous waste — totaling 205,397 tons in fiscal year 2005, according to the Michigan Department of Environmental Quality. Some 77 percent of this hazardous waste is shipped by Michigan to other states, while 23 percent is sent to Canada.[15]

Most of this hazardous waste requires additional treatment before it can be placed in landfills. For example, some medical waste is incinerated while low-level radioactive waste typically is allowed to degrade under controlled conditions before being shipped.

Michigan also exports municipal solid waste. In 2003, for example, the state exported 223,310 tons[16] of solid waste to various destinations, including Ohio (56,464 tons),[17] Indiana (84,368 tons)[18] and Wisconsin (1,676 tons).[19] As with Toronto, some Michigan municipalities find that landfills elsewhere offer lower rates for waste disposal.

Conclusion

Waste disposal has evolved from the toxic dumps of yesteryear to today's high-tech facilities in a relatively short time. New waste treatment methods have decreased the number of landfills while increasing the capacity of those that remain. These factors have rendered the disposal of solid waste cleaner and less costly. ■

15 Michigan Department of Environmental Quality, "2005 Hazardous Waste Quantities in Michigan," May 8, 2006, internal memorandum (not available on the World Wide Web).

16 James E. McCarthy, Congressional Research Service, "Interstate Shipment of Municipal Solid Waste: 2004 Update," Sept. 9, 2004; available on the World Wide Web at http://wastec.isproductions.net/webmodules/webarticles/articlefiles/430-CRS%2004%20Waste%20Numbers.pdf.

17 State of Ohio Environmental Protection Agency Fact Sheet, "2005 Out-of-State Waste," August 2006; available on the World Wide Web at http://www.epa.state.oh.us/dsiwm/document/swmdclear/2005_sw_import_export.pdf.

18 Sarah Germann and Michelle Weddle, Indiana Department of Environmental Management, "2005 Solid Waste: Summary of Indiana Solid Waste Facility Data"; available on the World Wide Web at http://www.in.gov/idem/catalog/documents/land/far05.pdf.

19 Wisconsin Department of Natural Resources, Waste & Materials Management Program Landfill Tonnage Reports, "2005 Tonnage Report." Available on the World Wide Web at http://www.dnr.state.wi.us/org/aw/wm/solid/landfill/tonnagerpts/2005tonnage.pdf.

GREAT LAKES, GREAT CONUNDRUM

By Diane Katz

NO SIMPLE REMEDY FOR TREATING BALLAST WATER

On January 1, Michigan became the first state in the nation to regulate ballast water that is pumped into and out of tanks in ocean-going vessels for stability. The new regulations are intended to prevent the introduction of non-native species into the Great Lakes. Opinions vary about the utility of Michigan's regulatory approach, but there's broad agreement that more research is needed to improve ballast water treatment methods.

Ballast water is used to fill the hulls of ships that have been emptied of cargo and thus require weight for safe passage. In the days of wooden ships, sailors used rocks, sand, wood and other substrata from shore as dry ballast. Modern steel-hulled ships are better suited to ballast water, which can be pumped in greater volumes more quickly.

Ballast water is uploaded or discharged depending on the weight and placement of cargo. One freighter alone can carry tens of millions of gallons of ballast water — and thousands of species therein. When ballast is discharged at a destination harbor, foreign organisms are introduced into the local waters. The speed and reach of modern vessels allows a greater variety of species to survive transatlantic journeys to many more non-native shores. This phenomenon is not unique to the Great Lakes, nor is it of recent origin; from both dry and wet ballast, it has occurred for centuries along virtually all coastal waters.

The opening of the St. Lawrence Seaway to the Great Lakes in 1959 accelerated the introduction of non-native species into the basin. The number of such species is estimated at upwards of 180, with some having arrived in the 1800s. The majority of non-native species in the Great Lakes — some 70 percent — are believed to have originated from the Ponto-Caspian region (which includes the Black, Caspian and Azov seas).[1]

Invasive species proliferate in non-native waters due to the absence of natural predators and diseases that would otherwise constrain them. Their effect on the indigenous ecosystem may be profound and, in some instances, beneficial. Given the changes in ecosystems across the millennia and the near-infinite pathways of species relocation, the classification of native vs. non-native species is not exact.

In hopes of stemming yet more introductions, the Michigan Legislature in 2005 directed the state Department of Environmental Quality to craft a permit regime for all ocean-faring vessels operating at Michigan ports as of Jan. 1, 2007. To obtain a permit, applicants must prove that the vessel will not discharge any ballast water that has not been treated to prevent the introduction of exotic species into the Great Lakes. Four specific treatments are permitted: the use of chlorine dioxide and hypochlorite, both chlorine-based disinfectants; ultraviolet light radiation, which deactivates viruses and bacteria; and, deoxygenation, which displaces oxygen in water.[2] (The benefits and drawbacks of these and other ballast water treatments are discussed beginning on page 18.)

Relatively simple as the permit requirements may seem, the effective treatment of ballast water is exceedingly complex. There does not exist at present any single treatment capable of eliminating the variety of species that exist — even thrive — in ballast water and the sediment that collects in ballast tanks.

The complexity stems, in part, from the variation in vessels. Crude tankers, bulk carriers, container ships, cruise ships and pontoons, to name a few, all possess ballast tanks of varying volume, and geometry and pumping configurations, which together defy a uniform technology or process.[3] Devising an effective treatment also must account for myriad

1 Gracki, J.A., R.A. Everett, H. Hack, P.F. Landrum, D.T. Long, B.J. Premo, S.C. Raaymakers, G.A. Stapleton and K.G. Harrison. 2002. Critical Review of a Ballast Water Biocides Treatment Demonstration Project Using Copper and Sodium Hypochlorite, September 2002. Michigan Environmental Science Board, Lansing.

2 Michigan Department of Environmental Quality, Ballast Water Control General Permit. http://www.deq.state.mi.us/documents/deq-water-npdes-generalpermit-MIG140000.pdf.

3 Glosten-Herbert LLC and Hyde Marine, "Full-Scale Design Studies of Ballast Water Treatment Systems," April 2002. http://www.nemw.org/full_scale_design_study.pdf.

The Great Lakes and St. Lawrence Seaway

Connecting the Atlantic Ocean and the Great Lakes, the St. Lawrence Seaway opened in 1959.

operational challenges such as:

- The safety of crew members and passengers with toxic chemicals onboard.
- The disposal of toxic chemicals used in treatment. (Biocides and pesticides are tightly regulated by the U.S. Environmental Protection Agency.)
- Older vessels with limited capacity for retrofitting.
- Interference with ship operations. (Treatment requires additional power, crew and space.)
- Disruption of trade schedules and routes (for retrofitting).
- The effects on treatments and equipment from the vibration, pitching and rolling that are unavoidable during ocean voyages.

Exacerbating matters is the astonishing array of organisms present in ballast water, including zooplankton, phytoplankton, bacteria and viruses, all of which respond differently to treatment depending on life cycles, water quality and a host of other factors.

Summarizing the challenge, the research team of Glosten-Herbert LLC and Hyde Marine concluded: "A single technique has not yet been found that can handle all of the target organisms with reasonable dosages or equipment parameters. The biodiversity is just too great (in terms of size and sensitivities). Differences in the size of ships and the quantities of ballast water handled add to the complexity of the ideal solution. Finally, a ship's trade route may alter the primary target organisms when a risk-based approach to control of species is introduced or regional standards are encountered."[4]

Federal law currently requires ocean-going ships destined for the Great Lakes to exchange ballast water with salt water at least 200 miles before entering the St. Lawrence Seaway. Organisms from coastal waters are unlikely to survive in the open ocean. However, ballast water exchange is never 100-percent complete. Even ships loaded with cargo and without "pumpable" ballast water may still transport non-native species into the lakes through tank sediment.

The U.S. Coast Guard is currently developing national standards for the discharge of ballast water. Similarly, the United Nations' International Maritime Organization is seeking ratification among its 30 member states of a ballast treatment "convention."

Whether the treatment methods prescribed by Michigan regulators will prove effective is a matter of debate. According to Curtis Hertel, executive director of the Detroit/Wayne County Port Authority, "The treatment methods endorsed by MDEQ have not yet been proven to be effective."[5]

In deciding on treatments for permitting, the DEQ

4 Glosten-Herbert LLC and Hyde Marine, "Full-Scale Design Studies of Ballast Water Treatment Systems," April 2002. http://www.nemw.org/full_scale_design_study.pdf.

5 Letter from Curtis Hertel, executive director of the Detroit/Wayne County Port Authority, to William Creal, Chief of Permits Section, Water Bureau, Michigan Department of Environmental Quality, March 10, 2006. http://www.portdetroit.com/materials/mdeq-ballast_water.pdf.

Benefits and Drawbacks of Ballast Treatment Alternatives

Treatment Type	Procedure	Benefits	Drawbacks
Acoustics	Sound waves destroy organisms.	No chemical byproducts. Effective against microorganisms.	Ineffective against larger organisms. Undeveloped for large volume ballast. Expensive.
Biocides	Chemicals such as chlorine, bromine or iodine added to ballast water destroy organisms.	Can be effective on all organisms at varying concentrations. Easily stored.	Chemicals can corrode tanks, pipes and pumps. Potential for environmental contamination and toxic exposure to crew. Expensive. Lack of research on interaction between biocides and sea water.
Closed ballast system	Purification of ballast water at ports.	Containment of organisms and toxic chemicals.	Impractical logistics. Costly to retrofit.
Deoxygenation	Inert gases or bacteria displace oxygen in ballast water.	Non-toxic. Prevents hull corrosion. Effective on fresh water and salt water.	Expensive. Requires specialized crew and equipment. Potentially ineffective on some species in cyst stages and anaerobic bacteria.
Electric Pulses	Bursts of energy electrocute organisms.	Potentially effective.	Experimental. High power requirements. Specialized crew.
Filtration	Filters prevent organisms from entering/exiting ballast tanks.	Speedy. Can retain organisms in natural habitat. No chemical byproducts. Removes suspended solids. Readily available.	Expensive. Not effective against bacteria and viruses. Potential for clogging and slowing flow rate.
Heat	Use of engine cooling system to raise temperature of ballast water.	No chemical byproducts. Effective with large organisms such as fish.	Less effective against microorganisms. Limited by engine size. Potential for tank corrosion. Dangerous for use on chemical tankers.
Hydrocyclone	Centrifugal force separates organisms from water.	Effective removal of species heavier than saltwater. Available technology.	Ineffective against microorganisms. Storage and removal of captured organisms.
Electro-Ionization	Sequential processes involving introduction of ionized gas; air is then passed through ultraviolet and magnetic fields to create oxygen and nitrogen ions; ions are injected into water, causing organisms to coagulate for removal.	No known environmental impacts. Safe for crew.	Experimental. Large footprint and complex instrumentation requiring specialized crew.
Ozone	Ozone gas reacts with chemicals in sea water to destroy organisms.	Particularly effective against microorganisms.	Space requirements for generators. Corrosive. May require neutralization before discharge.

reviewed a variety of studies that measured the effectiveness against specific "indicator" organisms. Critics contend, however, that the agency failed to review studies that measured the type and number of organisms overall that remained in the ballast water following treatment — the type of measurement called for by the International Maritime Organization.

Moreover, the Michigan Environmental Science Board, in reviewing the results of a ballast treatment demonstration project involving one of the DEQ's treatment options, warned that the conclusions regarding the effectiveness of sodium hypochlorite "can only be considered preliminary at best.[6]

"Considerable more work will need to be conducted before any definitive statement regarding its efficacy within an actual ballast water tank environment can be made. … Insufficient information (too few tests and lack of data as to what requirements would need to be met throughout the Great Lakes jurisdictions) was provided to definitively address the question regarding if such discharges could be safely and legally discharged into Great Lakes waters."

Jurisdictional challenges also exist. There are 15 major international ports and some 50 smaller, regional ports on the Great Lakes-St. Lawrence Seaway.[7] The Michigan regulations apply only to ports within the state, and thus will not affect releases of ballast water elsewhere in the basin. ■

6 Gracki, J.A., R.A. Everett, H. Hack, P.F. Landrum, D.T. Long, B.J. Premo, S.C. Raaymakers, G.A. Stapleton and K.G. Harrison. 2002. Critical Review of a Ballast Water Biocides Treatment Demonstration Project Using Copper and Sodium Hypochlorite, September 2002. Michigan Environmental Science Board, Lansing.

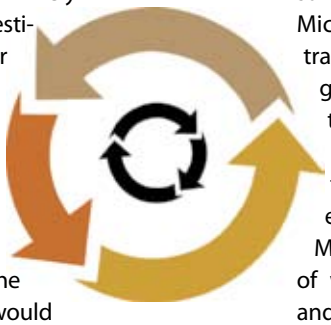
7 Great Lakes Information Network. http://www.great-lakes.net/teach/business/ship/ship_4.html

Looking Ahead

With recent changes in the leadership of the state House, more emphasis on environmental regulation is expected in coming months. Lawmakers will likely debate the following:

RECYCLING TAX

State legislation to levy an additional 1 cent tax on all retail purchases over $2 will likely be introduced to raise an estimated $44 million annually for additional recycling subsidies in the form of grants to local governments. Proponents of the proposed legislation argue that Michigan has the lowest recycling rate in the Great Lakes region and that the money raised by the new tax would jump-start recycling activity in the state. Opponents counter that the proposal's broad constraints on local governments' use of the money will not do much to help recycling, and that Michigan's faltering economy does not need a tax increase. The state's sales tax is currently 6 percent.



GREAT LAKES WATER WITHDRAWAL AGREEMENT

State legislation that would bind Michigan to stricter water use requirements under the U.S.-Canadian Great Lakes Water Quality Agreement will likely be introduced. Each of the eight Great Lakes states and the Canadian province of Ontario must endorse the proposed requirements, known as "the Annex," before the new rules can take effect. Efforts to pass the legislation in Ohio have failed and, to date, no state has agreed to implement the Annex. Proponents of the legislation argue that the lakes are endangered by overuse and that Michigan as the "Great Lakes State" must set the example by passing the legislation. Opponents of the legislation argue that passing it would not guarantee that other states would follow suit and that human impact on water levels is small and decreasing.

TRASH TAX

The Granholm administration has called for a surcharge of $3 per ton on trash deposited in Michigan landfills. The tax would apply to both trash imported from out of state and trash generated in Michigan. The tax is intended to dissuade the disposal of Canadian trash in Michigan landfills. Expect the debate to focus on the merits of making it more expensive to deposit out-of-state trash in Michigan landfills against the increased cost of waste disposal to Michigan households and businesses (for more information see "Discarding False Notions" on Page 10).

By Russ Harding

BALLAST WATER TREATMENT

As of Jan. 1, 2007 all ocean-going vessels must comply with new state ballast-water treatment requirements in order to dock at ports in Michigan. The regulations, devised by the Michigan Department of Environmental Quality under legislation approved in 2005 are intended to prevent the introduction of non-native species into the Great Lakes. The shipping industry, arguing that the MDEQ's proposed treatments have proven impractical or ineffective, is seeking a delay of the new permitting regime and warning that ships will not dock at Michigan ports if a delay is not granted. Such a delay would require the approval of Gov. Jennifer Granholm and the Michigan Legislature (for more information see "Great Lakes, Great Conundrum" on Page 16). ■

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