

**WORLDWIDE EMERGING ENVIRONMENTAL ISSUES AFFECTING THE U.S. MILITARY**  
Contract No: DAAD19-02-D-0001/ Delivery Order 0456 with Battelle Columbus Operations for the U.S. Army  
Environmental Policy Institute

**AUGUST 2006 REPORT**

Note to Readers: Pages 1-12 comprise the summary and analysis of this report. Expanded details for some items that might not be available via the Internet at a later date are in the Appendix beginning on page 13

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## Item 1. Unless Water Management Improves, Conflicts over Water Are Inevitable

The 16<sup>th</sup> annual conference on water took place in Stockholm, during World Water Week, August 20-26. Reports released during this week warned of possible consequences of future water scarcity, such as increased cost of water, civil unrest, mass migration, and economic collapse. There was consensus that poor management of water resources and soaring water usage are the main causes of water scarcity increasing worldwide faster than expected; and, unless there are drastic policy changes around the world, the grim statistics will only worsen, mostly in the densely populated and poor regions of China, Mexico, and India. A report by The World Wildlife Federation (WWF), *Rich countries, poor water*, warns that wealthy nations are threatened by a water crisis similarly to the drought-plagued poor countries, due to climate change, drought, loss of natural wetlands, and over-consumption by industry, agriculture and big cities. The report suggests seven ways to address the problem. The International Water Management Institute notes that while over the past 100 years water usage had increased six-fold, it is expected to double again by 2050.

The World Bank estimates that 20-40% of water sector finances are lost to corruption. Water experts and businesses formed the Water Integrity Network (WIN) to combat corruption in the water sector. WIN is open to all. Transparency International and water corporations are the initial principal members. WIN seeks reforms to improve regulations and transparency, as well as increase public awareness.

*Asia's Coming Water Wars*, a comprehensive analysis by The Power and Interest News Report, warns of water problems increasing conflicts in some Asian regions already beleaguered by long-standing historical animosities and internal instabilities. The most vulnerable regions for water-related conflicts are Central Asia, South Asia and the Mekong sub-region in Southeast Asia. Considering these regions' rapid development, growing populations and instabilities, water-related tensions might have wider regional and global significance.

*Business in the world of water—WBCSD Water Scenarios to 2025* presents the critical future water situation in three “H<sub>2</sub>O” scenarios: “H” (*Hydro*)—urbanization, technical and efficiency-focused, with serious water allocation problems; “2” (*Rivers*) is a world of water security based on compromise; “O” (*Ocean*) describes a functional society based on interconnectivity and cooperation of all systems' actors. (see the [Appendix](#) for scenarios' abstracts)

### **Military Implications:**

These findings should be used to argue for increased military attention to how it can prevent water-related conflicts. Key military water and/or corruption experts should join the Water Integrity Network.

### **Sources:**

World Water Week in Stockholm; 20-26 August, 2006

<http://www.worldwaterweek.org/>

Business in the world of water

<http://www.wbcd.org/DocRoot/OpBmbDCToPi3uCskR9Ie/h20-scenarios.pdf>

Report: Water crisis hits rich countries

[http://www.panda.org/news\\_facts/newsroom/index.cfm?uNewsID=77900](http://www.panda.org/news_facts/newsroom/index.cfm?uNewsID=77900)

New Alliance Seeks to Fight Water Sector Corruption

<http://www.enn.com/today.html?id=11110>

"Asia's Coming Water Wars"

[http://www.pinr.com/report.php?ac=view\\_report&report\\_id=545&language\\_id=1](http://www.pinr.com/report.php?ac=view_report&report_id=545&language_id=1)

See the [Appendix](#) for more details on the items and additional sources.

## **Item 2. UN Conflict Prevention Strategy Includes Environmental Dimension**

UN Secretary-General Kofi Annan's *Progress report on the prevention of armed conflict* is an in-depth review of UN capacities to help prevent crises from escalating into armed conflicts; it outlines a wide range of recommendations to strengthen the UN's conflict-prevention capacity around the world. Environmental factors are mentioned several times in this 54-page document; e.g., "Environmental degradation has the potential to destabilize already conflict-prone regions, especially when compounded by inequitable access or politicization of access to scarce resources." (par. 22) The report will be submitted for discussion to the General Assembly on September 7, 2006.

### **Military Implications:**

Relevant military personnel should study the *Progress report* to see if there are preventive measures that might be adapted to improve military practice and better anticipate emerging issues in UN policies to prevent conflicts, and to explore new areas for cooperation.

### **Sources:**

Annan maps out ways to bolster UN ability to prevent armed conflict, save lives

<http://www.un.org/apps/news/story.asp?NewsID=19587&Cr=Armed&Cr1=>

*Progress report on the prevention of armed conflict*. Report of the Secretary-General

<http://www.un.org/Docs/journal/asp/ws.asp?m=A/60/891> (select "English")

## **Item 3. New Environmental Think Tank for Asia**

The '3R'—Reduce, Reuse and Recycle—is a new initiative launched by the Asian Development Bank, Asian Institute of Technology, UNEP, and the UN Economic and Social Commission for Asia and the Pacific (UNESCAP) to promote sustainable use of natural resources and increase environmental efficiency. The center will be located at the Asian Institute of Technology in Bangkok. It will function as a think tank on environmental technology, knowledge dissemination, research capacity building, regulations, and policy related to 3R practices in cooperation with other related Asian initiatives.

### **Military Implications:**

Environmental security military personal with Asian regional responsibilities should liaise with this new think tank to share "best practices" and emerging environmental security issue information.

### **Source:**

Partnership Launched to Create '3R' Knowledge Hub in Bangkok

<http://unescap.org/unis/press/2006/aug/g33.asp>

## **Item 4. Technological Breakthroughs with Environmental Security Implications**

### **4.1 Revolutionary Techniques for Bio/chemical Detection**

Note: more detailed description of these techniques is available in the [Appendix](#)

#### 4.1.1 Digital Magnetofluidics Improves Biochemical Analysis

A technique for more rapid, more accurate, and less costly analysis of biochemical fluids, such as is needed in biological warfare surveillance, was developed by the Department of Bioengineering of the University of Arizona in cooperation with other scientists. Based on magnetic forces, this form of "lab on a chip" minimizes contamination of the sample by the substrate, and saves both time and expensive chemicals.

#### 4.1.2 Reliable Anthrax Antibodies Developed

Swiss scientists have developed reliable anthrax-specific antibodies. This is an important achievement, since the similarity of the anthrax spore surface to that of spores of other bacteria, which commonly occur in humans, has previously prevented development of an antibody that would be reliably anthrax-specific for identification.

#### 4.1.3 "Bar-coded" Nanowires May Yield Small, Fast Bio Detectors

A "nanowire bar-code" system developed by researchers at Lawrence Livermore National Laboratory in cooperation with several other institutions may facilitate creating portable sensors capable of identifying multiple airborne pathogens within minutes. The technique consists of coating a nanowire with a distinctive pattern of gold and silver stripes—analogue to a barcode—and then with an antibody for the target threat. The applications of such a system range from detection of biowarfare agents to use during an outbreak of an infectious disease.

#### 4.1.4 New Low-cost System for Bacteria Identification

Researchers at Purdue University's Bindley Science Center have developed a new low-cost high-speed system that analyzes scattered laser light to quickly identify bacteria. The technique uses computer analysis of 120 factors in laser light scattered by bacterial colonies growing in a petri dish, costs a tenth as much as conventional methods, and can be completed in five minutes after the culture has grown.

#### 4.1.5 Quantum Dot Device Provides Fast Detector for DNA Sequences

Researchers at Quantum Logic Devices, of Austin TX, have constructed a DNA sequence detector that can detect a piece of DNA in less than 30 minutes, compared to 24 hours for a fluorescence technique.

#### 4.1.6 Sensicore's Lab on a Chip Water Profiler Automates Lab Functions

This system applies chip technologies in a WaterPOINT device that dramatically shrinks the space and time required to perform sixteen standard water quality and treatment tests. Memory and software permit rapid comparisons and mapping of results for entire systems. The 0.4-millimeter pH electrode illustrates the degree of miniaturization achieved. Several wet chemistry procedures are reduced from hours to minutes in duration without the need for reagents. Additional testing capabilities are in development for promised availability in the near future.

**Military Implications:**

Those relevant military personnel with responsibilities for environmental surveillance, who are not already informed of these, should be made aware of these developments for potential applications.

**Sources:**

Magnetism and mimicry of nature hold hope for better medicine, environmental safety

<http://www.physorg.com/news72620450.html>

Anthrax Detector Developed

<http://www.physorg.com/news74967063.html>

Nanowires built to fight bioterrorism

[http://articles.techrepublic.com.com/2100-1009\\_11-6103410.html](http://articles.techrepublic.com.com/2100-1009_11-6103410.html)

Purdue creates new low-cost system to detect bacteria

<http://www.physorg.com/news73231402.html>

Digital DNA detector spots single molecules

<http://www.newscientisttech.com/article/dn9744-digital-dna-detector-spots-single-molecules.html>

Kahn, M. *Sensicore's Lab on a Chip Water Profiler Automates Lab Functions*, tech talk, G. Miner, ed., Journal of the American Water Works Association, July, 2006, 98(7), 46-48. (by subscription only; text of the article in the [Appendix](#))

**Item 5. UK Scientists List 100 Most Vital Ecological Policy Questions**

UK scientists have prepared a list of the 100 biggest questions facing the country's environment. According to Guardian Unlimited, "the list ... of Britain's most pressing ecological problems is based on the suggestions of more than 650 experts in universities, conservation groups and government institutes. It is intended to inform policy-makers and steer research over the next decade to answer key questions in areas such as farming, climate change, pollution and urban development."

**Military Implications:**

It is very likely that this list, published in the August 2006 issue of the *Journal of Applied Ecology*, will serve as a source of future UK and EU environmental regulatory efforts. Military personnel should review the list and the accompanying material to determine which of these problems may have military applications and implications.

**Source:**

The key questions at the heart of the UK's environmental future

<http://www.guardian.co.uk/science/story/0,,1854855,00.html>

**Item 6. Updates on Previously Identified Issues****6.1 Addressing Post-Conflict Environmental Security Issues**

Further on last month's item on the environmental consequences of the Hezbollah-Israeli war, UNEP announced the beginning of the cleanup operation of the massive oil spill caused by Israeli bombing of a fuel depot, which affected some 150 kilometers of Lebanese and Syrian coastline. It is estimated that the cleanup could take up to one year and might cost over \$64 million. The massive

damages to the ecosystem are already noticeable. [See also *Hezbollah-Israeli War Threatens an Already Precarious Environment* in July 2006 environmental security report.]

At the end of July 2006, the UN Compensation Commission announced the last disbursement to individuals who suffered because of Iraq's 1990 invasion of Kuwait. The total paid out to date is nearly \$21 billion, while 49 other claims, including environmental ones are still pending.

### **Military Implications:**

The international community is still paying for environmental cleanups for past conflicts. Since weapons and technologies steadily become more sophisticated, resulting damages are worse and so are costs of restoration, mainly those of the environment. Hence, it is likely that there will be increasing pressure for increased precision with decreased environmental impact in future R&D products. Events with consequences, such as the oil spill in Lebanon, are likely to increase calls for updating laws, assigning liability, and defining redress issues concerning environmental damages in war. [See also related items in *Conflict and Post-Conflict Environmental Security Issues* section of *Chapter 9.1 Emerging Environmental Security Issues* on the CD accompanying the *2006 State of the Future* report by the ACUNU Millennium Project]

### **Sources:**

UN environment agency set to begin aerial surveillance of Lebanese oil spill  
<http://www.un.org/apps/news/story.asp?NewsID=19577&Cr=Leban&Cr1=>

Lebanon Oil Spill Cleanup May Take A Year

[http://www.terraily.com/reports/Lebanon\\_Oil\\_Spill\\_Cleanup\\_May\\_Take\\_A\\_Year\\_999.html](http://www.terraily.com/reports/Lebanon_Oil_Spill_Cleanup_May_Take_A_Year_999.html)

UN reparations panel pays out nearly \$396.5 million for Iraq's invasion of Kuwait

<http://www.un.org/apps/news/story.asp?NewsID=19318&Cr=Iraq&Cr1=>

## **6.2 New Measures for Regulating E-waste**

### **6.2.1 Green Standards to Counter E-waste**

In view of e-waste being the fastest growing category of waste, Greenpeace launched a new e-waste campaign on August 25th. In a preamble to the campaign, it compiled data on progress in eliminating hazardous chemicals and in recycling policies of the main mobile phone and PC-makers and ranked the companies based on their scores. The criteria used in the Greenpeace assessment are tougher than those stipulated by the European Restriction of Hazardous Substances (RoHS) directive, including polyvinyl chloride (PVC) and some brominated flame retardants (BFRs) on the restrictions list. Greenpeace also advocates the "precautionary principle", requesting companies to avoid chemicals with uncertain environmental impacts. [See also *RoHS Closer to Deadline* in May 2006, *Recycling Regulations in the EU* in August 2005 and *Two E-waste laws entered into force in the EU* in February 2003 environmental security reports.]

The Electronic Product Environmental Assessment Tool (EPEAT) produced by EPA also aims to encourage "green computers." After working for three years with major computer manufacturers, EPA produced a "greener computers" list that consumers can consult to see what models are more environmentally friendly and why. The standards were developed by the Institute of Electrical and Electronics Engineers and consider 23 required criteria and 28 optional criteria in eight categories,

including: content of environmentally sensitive materials (such as mercury, lead and cadmium); power requirements; lifespan; and the "end of life" recycling plans offered by the manufacturers.

**Military Implications:**

Considering the increasing e-waste issue and the influence these organizations have in the global arena, it is fair to speculate that versions of these green measures will be considered for future e-waste regulations. The military should follow these new developments and be prepared to comply with eventual new directives. Also, it should not wait to begin using the lists in its acquisition of electronics to encourage greener companies. That would be consistent with the stewardship goal in the Army's Environmental Strategy.

**Sources:**

How green is your Apple? The Economist print edition, Aug 25th 2006

[http://www.economist.com/business/displaystory.cfm?story\\_id=7836504](http://www.economist.com/business/displaystory.cfm?story_id=7836504) (by subscription only; full text in the [Appendix](#))

Your guide to green electronics

<http://www.greenpeace.org/international/news/green-electronics-guide-ewaste250806>

EPEAT <http://www.epeat.net>

### 6.2.2 China Issues Electronic Waste Rules

The Chinese State Environmental Protection Administration has issued new rules to require manufacturers, retailers and users to take responsibility for electronic waste. The rules are partly inspired by China's thriving (and illegal) industry of importing electronic waste and scavenging it in occupationally unsafe small or family workshops. [See also *Global Environmentally Sound E-waste Disposal System is Needed* in November 2005 environmental security report.]

**Military Implications:**

Considering the huge problem of e-waste pollution from electronic imports in developing countries, Chinese measures are likely to inspire other countries in the region to institute tougher restrictions in line with the Environmentally Sound Management (ESM) of Electronic and Electrical Wastes (e-waste) program of action for the Asia-Pacific region. Military organizations, especially those operating in East Asia, should review their policies and practices on electronic waste to ensure that they are prepared to cooperate with such actions.

**Source:**

China Targets Rising Mountain of High-Tech Junk

<http://www.enn.com/today.html?id=11121>

## **6.3 Climate Change**

### 6.3.1 Increasing Risk of Natural Disasters

Global warming will increase the risk of natural disasters over the next two centuries, even if harmful emissions were cut now, warn climate scientists from the University of Bristol's Department of Earth Sciences. Compiling data from more than 52 climate models looking at the impact of greenhouse gas emissions, the researchers calculated the risks induced by climate change to the world's key ecosystems based on levels of warming (less than 2°C (3.6°F) to over 3°C (5.4°F)) and for each group assessed the probability of changes in forest cover, the frequency of

wildfires, and changes to freshwater supplies over the next 200 years. The findings are expected to be used to explore measures to reduce hazards as much as possible.

### 6.3.2 Melting Rates Are Increasing

Greenland's ice melting rate had tripled between April 2002 and November 2005, compared to the rate between 1997 and 2003, according to research by Jianli Chen and colleagues at the University of Texas in Austin and published in the journal *Science*. Although controversial, the results definitely indicate that rise in sea levels this century will likely be higher than originally forecasted. "If the Greenland cap melted completely, it would raise global mean sea level by about 6.5 meters. If this were to occur, most of the world's coastal regions would be subject to flooding," warn the authors. Meanwhile, the glaciers of Southeast Alaska are shrinking twice as fast as previously estimated, according to a study by Fairbanks and Juneau glaciologists, published in the *Journal of Geophysical Research*. Sea ice is also melting at a record pace near the North Pole, due to a record hot summer that arrived in many northern settlements a full month earlier, following an unusually mild winter and spring, say locals. Inuit peoples of the far north in Canada began ordering air conditioning. The town of Kuujuaq, at about 1,500 kilometers north of Montreal, has purchased 10 air-conditioning units as the inside temperature reached 31° Celsius (88° F.) in late July.

### 6.3.3 Coastline Erosion due to Rising Sea Waters Signaled Around the World

Coastline erosion as one of the effects of rising sea levels is increasingly felt around the world by low-lying communities. Hundreds of people are being displaced on the Carteret Islands, Papua New Guinea, and millions are threatened along the shorelines from Sri Lanka and Bangladesh, to coastal Louisiana and England. Experts warn that England's coastline erosion might accelerate as global warming leads to rising sea levels and harsh weather. Over the next century, half of the 1,125 kilometer coastline in the administration of the National Trust charity—Britain's largest owner of coastline—is expected to be severely affected by erosion. Lyme Regis in Southwestern England is already threatened by rising seawaters that are carving away its harbor and coast. To this, should be added the increasing acidity of ocean waters—due to CO<sub>2</sub> levels that are over the ocean's natural buffering capacity—dissolving calcium and therefore severely affecting marine ecosystems, especially coral reefs that are the main support to many geologically new islands. [See also *Climate change—Research Documents Continued Global Warming Effects* and *Rising Sea Level Triggers Rising Refugee Move* in April 2006 and other previous environmental security reports.]

#### **Military Implications:**

Coastal early warning and impact forecasting systems and evaluation procedures should be developed in cooperation with local military and civilian first responders. [Similar to previous on the same issue] There is compelling evidence of the consequences of anthropogenic climate change, and the growing world option for action. The military should continue to accelerate efforts to reduce their own greenhouse gas emissions. New international environmental security-related policies and cooperation to avoid potentially large-scale disasters and conflicts seem inevitable.

#### **Sources:**

More fires, droughts and floods predicted

<http://www.bristol.ac.uk/news/2006/1053.html>

Greenland ice cap may be melting at triple speed

<http://www.newscientist.com/article/dn9717-greenland-ice-cap-may-be-melting-at-triple-speed.html>

(by subscription only; full text in the [Appendix](#))

Once-icy Arctic now Great 'Wet' North

<http://www.canada.com/edmontonjournal/news/story.html?id=aa5d2a48-6a62-4bb0-a0fe-0d7ff4cedef3&k=86833>

The Ocean is Slowly Claiming Malasiga. They Say it's Global Warming.

[http://www.stopglobalwarming.org/sgw\\_read.asp?id=534508212006](http://www.stopglobalwarming.org/sgw_read.asp?id=534508212006)

Britain is falling into the sea (or bits of it, anyway)

<http://www.canada.com/montrealgazette/news/insight/story.html?id=f3247666-19da-4a02-9c8e-ea2fe464b728> (article available free for a limited time; full text in the [Appendix](#))

See additional sources in the [Appendix](#)

#### **6.4 New Canadian Strategies for Monitoring the Northwest Passage**

Further on the opening of the Northwest Passage, the Canadian government is undertaking serious military and strategic operations for increased monitoring of the area for actions that might affect its sovereignty over the territory, as well as ecological impacts. In spite of strong disagreement between the Canadian Department of National Defence and Environment Canada on projections concerning the timing of the Passage's accessibility for commercial and other navigation, new capabilities, funding and apparatus are being considered for increasing control. Those include: enforcing the Arctic Waters Pollution Prevention Act for avoiding ecological disasters; a highly mobile Rapid Reaction Battalions (based in B.C., northern Quebec, Newfoundland, and Ontario); armed icebreakers; and a deep-water port at the passage's eastern entrance. [See also *Northwest Passage to Become "Canadian Internal Waters"* in April 2006, and *Arctic Northern Passage Opens New International Issues of Regulation* in February 2006 environmental security reports.]

#### **Military Implications:**

[Similar to previous on the same issue] It is likely that discussions for clear international regulations concerning Northwest Passage navigation will increase rapidly and more military action will be called for to ensure the safety of individuals and ecosystems. Relevant military personnel should cooperate with their counterparts in other countries and international organizations in developing adequate national and international regulations and enforcement procedures regarding the Arctic region. By exercising sovereignty, Canada could regulate future shipping through the passage and impose its own rules for the Northwest Passage, including the right to require vessels to conform to certain environmental and construction standards to avoid disasters in this ecologically fragile region.

#### **Source:**

Northwest Passage 'could open in 2015'

<http://www.canada.com/vancouversun/news/story.html?id=a2af425d-74ca-4f49-963b-9795fed6d754&k=8211>

#### **6.5 Scientific Community's Questions Concerning Biodefense Standards**

The American Type Culture Collection (ATCC) convened an Expert Panel on the Development of Standards for Biodefense in Washington, DC, 5-6 April 2006. Considering the critical point reached in the evolution of the biodefense industry, the scientific community agreed that standards are needed to accelerate product development for biodefense-related diagnostics, therapeutics, and reagents. However, on debating the standards issue, a panel of experts generated a range of questions that still require resolution in several areas, including standard handling protocols—that would include protocols for handling, storage, transport, inactivation, and disposal of biomaterials.

[See also *Better International Controls Needed to Prevent Bioterrorism* in July 2006, *Assessment and Recommendations for Biosecurity* in June 2006, and *Recommendation for a Biosecurity Watchdog* in February 2006 environmental security reports.]

**Military Implications:**

Although the panel focused on the U.S., the problem is of international concern. Relevant military personnel should consider the outcomes of this panel's discussions along with other material on biosafety and advance the issue at the concerned forums to accelerate the adoption of international standards for the biodefense industry and related activities.

**Source:**

The Need for Biodefense Standards

<http://www.the-scientist.com/article/display/24075/> (by subscription only; full text in the [Appendix](#))

Expert Panel on the Development of Standards for Biodefense

<http://www.biodefensestandards.org/>

## 6.6 New Developments Regarding Nanotechnology

### 6.6.1 FDA Forms Internal Nanotechnology Task Force

The US Food and Drug Administration has announced the formation of an internal Nanotechnology Task Force for determining regulatory approaches that encourage the continued development of innovative, safe and effective FDA-regulated products that use nanotechnology materials, and to identify and recommend ways to address any knowledge or policy gaps that exist, so as to better enable the agency to evaluate possible adverse health effects from FDA-regulated products that use nanotechnology materials.

### 6.6.2 European Commission Opens Nano2Life Network

According to an announcement from its coordinator, "Nano2Life (N2L) is the first European Network of Excellence in nanobiotechnology supported by the European Commission under the 6th Framework Programme. Its objective is to support ... [Europe's] position as a competitive player and to make it a leader in nanobiotechnology transfer by merging existing European expertise and knowledge in the field of Nanobiotechnology." It comprises 64 organizations and companies, with associate members from South Korea, Japan, Australia, and North America. One of the points in its Programme of Activity is founding the first European Ethical, Legal and Social Aspects Board (ELSA) in the field of Nanobiotechnology. This body will undoubtedly concern itself in a major way with questions of nanotechnology risk, the environment, and regulation.

**Military Implications:**

Relevant military personnel should ensure they are informed on the work of such organizations and eventually establish liaison with them in order to exchange information on policies and techniques for nanotechnology environmental risk management.

**Source:**

FDA Forms Internal Nanotechnology Task Force

<http://www.fda.gov/bbs/topics/NEWS/2006/NEW01426.html>

Nano2Life [www.nano2life.org](http://www.nano2life.org)

### 6.6.3 Inhaled Nanoparticles May Have Easy Path to Brain

Studies by scientists at the University of Rochester Medical Center found that nano-sized materials inhaled by rats had rapid and efficient pathways from the nasal cavity to several regions of the brain. They also caused changes in gene expression in the invaded regions. These are preliminary results, in an animal model, and have not shown actual cellular damage, but later proof of deleterious effects in higher models would have a strong effect on the regulation of airborne nanoparticles. [See also *Nanotechnology Health Concerns Highlight Need for International Technology Convention* in April 2004 and *Nanotech Health Dangers Increasingly Understood around the World* in January 2004 environmental security reports.]

#### **Military Implications:**

[Similar to previous on this issue] Following such studies as they emerge about nanoparticles' toxicity would be advantageous to the military in order to prevent unintended long-range health impacts on the future force and to minimize political threats to militarily necessary technologies.

#### **Source:**

Tiny inhaled particles take easy route from nose to brain  
<http://www.urmc.rochester.edu/pr/news/story.cfm?id=1191>

## **Item 7. Reports Suggested for Review**

### **7.1 European Environmental Agency's Annual Report 2005**

The European Environment Agency's *Annual Report 2005* is a review of the organization's performance as a major contributor to the European Community's (EU) 6th Environment Action Programme in 2005. Issues reviewed in the report include: tackling climate change, biodiversity loss, understanding spatial change; protecting human health and quality of life; supporting sustainable use and management of natural resources and waste; sustainable development and other environmental policies; as well as the role of the EEA on a global level.

#### **Military Implications:**

Considering the increasing role EEA is playing in the European Union's policy formulation and effectiveness evaluation, the report is likely to constitute a source of input into eventual new European strategies concerning the environment, with possible new directives and regulations. For that reason, EEA activities, reports and news should provide military managers with valuable precursor alerts to environmental political emphases and regulatory developments in the EU.

#### **Source:**

EEA Annual report 2005  
[http://reports.eea.europa.eu/report\\_2005\\_0802\\_115659/en](http://reports.eea.europa.eu/report_2005_0802_115659/en)

### **7.2 Reports Addressing Nanotechnology Safety**

*RCRA Regulation of Wastes from the Production, Use, and Disposal of Nanomaterials*, by the American Bar Association's Section of Environment, Energy, and Resources, discusses a number of issues related to the EPA's regulation of nanomaterial wastes under the Resources Conservation and Recovery Act (RCRA). Topics include the possible need for new definitions of hazardous nanomaterial characteristics, injunctive relief against imminent and significant risks, and the current practice of relying on the waste generator's process knowledge.

The Nano Science and Technology Institute (NSTI) has published the Proceedings of its 2006 Conference. Vol. 1, Chapter 6 of that work is entitled Environmental, Health and Societal Impacts of Nanotechnology, and includes a paper, *A Framework for Responsible Nanotechnology Standards*, describing a joint effort of Environmental Defense and DuPont. The Proceedings are available in print, or in a 2677-pp. CD-ROM.

The new report by Woodrow Wilson International Center's Project on Emerging Nanotechnologies, *Nanotechnology: A Research Strategy for Addressing Risk*, makes several recommendations for nanotechnology risk assessment, including that the government: institute a top-down strategic framework for risk-based nanotechnology research, prioritize research, establish joint industry funding, and coordinate research activities internationally.

The final report of Defra (UK organization), *Environmental Regulatory Gaps Study on Nanotechnologies*, addresses environmental regulation gaps concerning potential risks posed by products and applications of nanotechnologies, and it identifies measures that can be put in place to ensure adequate protection for human health and the environment. It is a comprehensive overview, analyzing each sector concerning nanotech—from substances, production and application, to environmental impacts—with respect to existing regulations, and highlighting the eventual gaps.

#### **Military Implications:**

Military personnel concerned with regulation of environmental hazards from nanomaterials should consider these reports along with other sources for insights into nanotech-related policy issues.

#### **Sources:**

RCRA Regulations of Wastes from the Production, Use, and Disposal of Nanomaterials

Report: <http://www.abanet.org/environ/nanotech/pdf/RCRA.pdf>

Technical Proceedings of the 2006 NSTI Nanotechnology Conference and Trade Show, Volume 1 Chapter 6: Environmental, Health and Societal Impacts of Nanotechnology. A Framework for Responsible Nanotechnology Standards

<http://nsti.org/procs/Nanotech2006v1/6/W37.06>

*Nanotechnology: A Research Strategy for Addressing Risk*

<http://www.nanotechproject.org/67/7-19-06-nanotechnology-a-research-strategy-for-addressing-risk>

A scoping study to identify gaps in environmental regulation for the products and applications of nanotechnologies

[http://www.defra.gov.uk/science/project\\_data/DocumentLibrary/CB01075/CB01075\\_3373\\_FRP.doc](http://www.defra.gov.uk/science/project_data/DocumentLibrary/CB01075/CB01075_3373_FRP.doc)

### **7.3 Human Biomonitoring for Environmental Chemicals**

*Human Biomonitoring for Environmental Chemicals*, a report by the National Research Council's Committee on Human Biomonitoring for Environmental Toxicants covers, among other topics, a framework for characterizing biomonitoring data, considerations in the design of biomonitoring studies, interpretation of biomonitoring data, and research recommendations.

#### **Military Implications:**

Human biomonitoring is a highly useful but complex means of checking the environmental health of an area's population. This report is a comprehensive account of the problems and solutions associated with the technique, and should be reviewed by military personnel responsible for such studies.

**Source:**

Human Biomonitoring for Environmental Chemicals

<http://newton.nap.edu/catalog/11700.html>

## APPENDIX

### Reference Details

This Appendix contains expanded background information on some items, and the full text for the articles that are not available on the Internet or are usually stored for a limited time on the respective Web sites.

### Item 1. Unless Water Management Improves, Conflicts over Water Are Inevitable

#### Scenarios on the Future of Water

*Business in the World of Water - Water Scenarios to 2025* presents the future of business and society by relation to the water situation. The project was launched by the World Business Council on Sustainable Development (WBCSD) and about 180 leading corporate users of fresh water from 30 countries participated. The three scenarios developed by the world's 200 are (excerpt from the book):

- “*H*” (*Hydro*) is the story of efficiency (more value per drop and more drops for less). It highlights avoiding or unlocking legacies inherited from the past – in ways of thinking as well as in technologies, business practices, and public policies – to create new business opportunities in the world of water. The story focuses on the ‘H’ of H<sub>2</sub>O – ‘Huge’ economic opportunities in this new, urbanized world through innovations, especially in technology. In *Hydro*, there is a strategic advantage to being the first to market with the flexible, right-choice solutions rather than being locked out. While the geographical focus of the story is China, *Hydro* raises serious questions about other parts of the world. Where else is urbanization at risk from a multitude of water challenges? Where else are governments and their societies likely to respond with market-enabled solutions? The implicit warning in this world of increasing hydro opportunities is that current business and technical solutions cannot be continually or effectively scaled up to solve the growing water stress. In addition, technical and efficiency-focused solutions are not likely to solve the resource allocation problems – that is, who should have the water?
- “*2*” (*Rivers*) is the story of security – enough water of sufficient quality for both the haves and the have-nots. In this story, cast in the form of a cautionary tale, business recognizes that there are many different sides to security. Some businesses increasingly risk losing the license to operate where they are competing with basic human needs or are out of touch with political realities. The story focuses on the ‘2’ of H<sub>2</sub>O – 2 sides of the water question (although sometimes there are more than two sides); 2 sides of a water dispute – often, literally, on opposite banks of a river that divides one territory from another or between upstream and downstream interests; 2 ingredients for meeting future water needs – market-driven solutions and far-sighted government policies; and, most importantly, the necessity of solving water problems ‘2-gether’, in partnership with other stakeholders. How do we allocate water fairly for all users in a community, not just the highest bidders? In *Rivers* business cannot choose to operate only in the economic realm, which is just one side of the management challenge, if it wants water security.

- “O” (*Ocean*) is the story of interconnectivity –accounting for the sustainability of the whole system. It focuses on how business begins to recognize its role in a world of bigger, more complex, interconnected, and dynamic water challenges and natural systems in which economies, societies, cities, and individual human lives are embedded. In the world of Ocean, business realizes that it cannot help particular communities survive and prosper at the expense of causing water stress elsewhere. Ocean is a world that offers new opportunities to help societies and governments achieve more inclusive and integrated forms of security. Like the entirety of the ocean, the enormous whole round ‘O’ of the H2O scenario set is difficult to see, much less to act in relation to – but if we could imagine...

### **Rich countries, poor water suggestions**

*Rich countries, poor water*, report by WWF, suggests seven ways to address the problem, including: conserving catchments and wetlands; balancing conservation and consumption; changing attitudes to water; repairing ageing infrastructure; reduce water contamination; and continued study of the water systems.

#### Additional sources and information:

World Water Week in Stockholm; 20-26 August, 2006

<http://www.worldwaterweek.org/>

Business in the world of water

<http://www.wbcsd.org/DocRoot/OpBmbDCToPi3uCskR9Ie/h20-scenarios.pdf>

Cost of water shortage: civil unrest, mass migration and economic collapse

<http://www.guardian.co.uk/water/story/0,,1851712,00.html>

WBCSD Floats Water Scenarios Project

[http://www.greenbiz.com/news/news\\_third.cfm?NewsID=33576&CFID=13072466&CFTOKEN=61764226](http://www.greenbiz.com/news/news_third.cfm?NewsID=33576&CFID=13072466&CFTOKEN=61764226)

Report: Water crisis hits rich countries

[http://www.panda.org/news\\_facts/newsroom/index.cfm?uNewsID=77900](http://www.panda.org/news_facts/newsroom/index.cfm?uNewsID=77900)

New Alliance Seeks to Fight Water Sector Corruption

<http://www.enn.com/today.html?id=11110>

"Asia's Coming Water Wars"

[http://www.pinr.com/report.php?ac=view\\_report&report\\_id=545&language\\_id=1](http://www.pinr.com/report.php?ac=view_report&report_id=545&language_id=1)

Water, water everywhere?

[http://www.economist.com/agenda/displaystory.cfm?story\\_id=7815561&fsrc=nwl](http://www.economist.com/agenda/displaystory.cfm?story_id=7815561&fsrc=nwl) (by subscription only; see full text further in this [Appendix](#))

A Third of the World Population Faces Water Scarcity Today

[http://www.iwmi.cgiar.org/Press/releases/CA%20Launch%20Press%20Release\\_Final.pdf](http://www.iwmi.cgiar.org/Press/releases/CA%20Launch%20Press%20Release_Final.pdf)

“A Thirsty World”, Eds. Yeston, Coontz, Smith & Ash, *SCIENCE*, 313, 25 Aug 2006, pp 1067-1090. (by subscription only)

## Water, water everywhere?

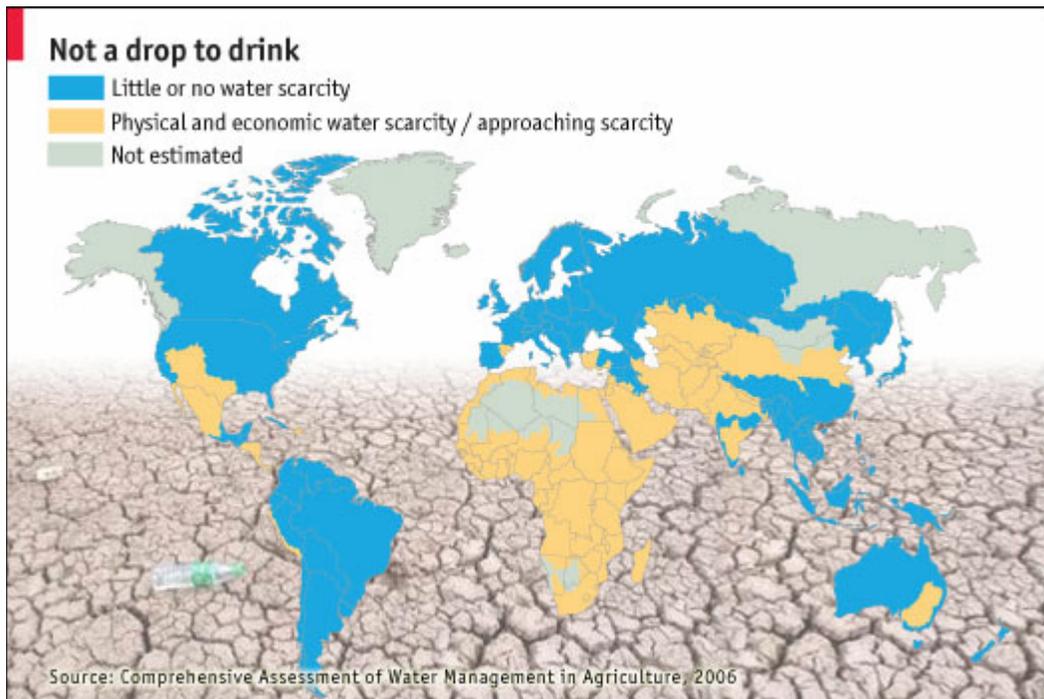
Economist.com Aug 21st 2006 | STOCKHOLM

From The Economist Global Agenda

[http://www.economist.com/agenda/displaystory.cfm?story\\_id=7815561&fsrc=nwl](http://www.economist.com/agenda/displaystory.cfm?story_id=7815561&fsrc=nwl) (by subscription only)

Some two billion people are short of water. But, with a little ingenuity, there should be more than enough to go round

IS THE world running out of water? A group of scientists, economists and development experts who have been studying the question for the past five years think they have the answer. Their “Comprehensive Assessment”, backed by the UN’s Food and Agricultural Organisation and various research institutes, governments and aid groups, will be released in November. But at the World Water Week, a conference now underway in Sweden, they have revealed some early findings. The bad news is that a third of the world’s population, some two billion people, are already short of water. But things do not have to be this way.



Roughly 900m people, the assessment finds, live in river basins where there is barely enough to keep rivers flowing and lakes filled. Another 700m live in basins rapidly approaching this “closed” state, and a billion more live within reach of adequate water supplies but cannot afford to make use of them. The water table is falling fast in densely populated and poor regions of China, Mexico and India. If current trends in water consumption continue, these grim statistics will only worsen.

The main culprit is agriculture. It takes roughly 3000 litres of water to grow enough for one person for one day, or about a litre for each calorie. Demand for water will grow as the world’s population increases and as people eat more—and more meat in particular. Raising livestock requires more

water, per calorie, than growing crops. So the assessment suggests that, by 2050, agriculture will consume twice as much water as it does today. Industry and domestic use, which now account for only a small fraction of water consumption, are also growing quickly. Global warming adds another layer of uncertainty and risk.

In theory, the world would still have more than enough water to feed everyone, under most scenarios. But it might require much more food to be traded from sodden parts of Europe, North America and Russia to parched bits of Africa and Asia. Needless to say, subsistence farmers in those continents are in no position to pay for imports of food—and will become even poorer, presumably, if their water runs short. A few poor, dry and teeming countries, such as Egypt, already depend on food imports, along with the odd rich one, like Japan. But most governments are loth to put their consumers at the mercy of the world's imperfect markets.

Instead, governments have traditionally tried to increase agricultural output through huge and expensive irrigation projects. But smaller investments, in simple devices such as pumps to tap groundwater, are faster to deploy, yield greater returns on capital, and bring fewer environmental and social problems. Modest outlays on rain-fed agriculture, in particular, could sharply raise farmers' productivity in poor countries, and so help both to lift their incomes and to reduce the need for an expansion of agriculture elsewhere.

Over half of world's food comes from rain-fed farms, as opposed to irrigated ones. Most of the world's poorest farmers, including the vast majority in Africa, rely on rain for their livelihoods. If the rains fail, so do the crops. Channels to harvest and direct rainfall, and small, sealed reservoirs or tanks to store it, would not only see them through dry spells, but also allow them to eke bigger harvests out of the same fields. If adopted on a grand scale, the assessment argues, such techniques could double crop yields. In that case, the area under cultivation globally would only have to rise 10% to meet rising demand for food—and there would be plenty of water to go round.

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## **Item 4. Technological Breakthroughs with Environmental Security Implications**

### **4.1 Revolutionary Techniques for Bio/chemical Detection**

More detailed description of the technologies:

#### 4.1.1 Digital Magnetofluidics Improves Biochemical Analysis

An international science team at the University of Arizona's Harrington Department of Bioengineering and elsewhere has developed a technique for more rapid, more accurate, and less costly analysis of biochemical fluids, such as is needed in BW surveillance. A tiny droplet of the fluid, injected with magnetic particles, balls up on a superhydrophobic surface and can then be manipulated by magnetic forces past the tips of 200-atom-wide analyzing nanotubes. This form of the "lab on a chip" scheme minimizes contamination of the sample by the substrate, and saves both time and expensive chemicals.

#### 4.1.2 Reliable Anthrax Antibodies Developed

Scientists from the Swiss Federal Institute of Technology (ETH) in Zürich, the Swiss Tropical Institute, and the University of Bern have developed a reliably anthrax-specific antibody. They were able to obtain suitable monoclonal antibodies from mice that had been exposed to a synthesized copy of a carbohydrate that appears on the surface of anthrax spores. This is an important achievement, since the similarity of the anthrax spore surface to the surfaces of spores of other bacteria that commonly occur in humans has prevented until now the development of an antibody that would be reliably anthrax-specific. Antibodies form the basis for various efficient techniques for detecting pathogenic organisms in the environment.

#### 4.1.3 "Bar-coded" Nanowires May Yield Small, Fast Bio Detectors

A "nanowire bar-code" system developed by researchers at Lawrence Livermore National Laboratory in cooperation with several other institutions may facilitate creating portable sensors capable to identify multiple airborne pathogens within minutes. The technique consists of coating a nanowire with a distinctive pattern of gold and silver stripes—analogue to a barcode—and then with an antibody for the target threat. When exposed to the environment being tested, if a pathogen is present, it binds to the respective antibody. The wire is then "developed" by being coated again with a copy of the antibody—this time incorporating a fluorescent marker—that will also bind to the pathogen, which can now be detected by its fluorescence and specifically identified by the pattern of stripes on the wire. The applications of such a system range from detection of biowarfare agents to use during an outbreak of an infectious disease.

#### 4.1.4 New Low-cost System for Bacteria Identification

Researchers at Purdue University's Bindley Science Center have developed a new low-cost high-speed system that analyzes scattered laser light to quickly identify bacteria. The technique uses computer analysis of 120 factors in laser light scattered by bacterial colonies growing in a petri dish, costs a tenth as much as conventional methods, and can be completed in five minutes after the culture has grown.

#### 4.1.5 Quantum Dot Device Provides Fast Detector for DNA Sequences

Researchers at Quantum Logic Devices, of Austin TX, have constructed a DNA sequence detector by modifying an existing transistor design. The new device consists of a 5-nanometre-wide gold particle (a quantum dot) flanked by two electrodes and a 36-base-long fragment of DNA that acts as a control element. When a matching sequence of DNA binds to the attached piece, current is allowed to flow between the two electrodes. It does not require amplification of the DNA sample and it is claimed that the new detector can detect a piece of DNA in less than 30 minutes, compared to 24 hours for a fluorescence technique.

### **4.2 Miniaturized Powerful Water Testing and Remediation Technologies**

#### 4.2.2 New Laboratory for Nanotech Applications in Groundwater Remediation

##### **Sensicore's Lab-on-Chip: Water Profiler Automates Lab Functions**

A new patented lab-on-chip technology miniaturizes, integrates. And automates laboratory functions and has the potential to significantly alter the practice of water quality management.

By Malcolm Kahn

Tech Talk, Gary Miner, Section Editor, Journal of the American Water Works Association  
July 2006, 98(7), pp 46-48. (by subscription only)

Sometimes a technological innovation not only improves one's ability to perform a task, but it does so in a way that opens up a whole new area of possibilities. Many analysts expect lab-on-chip technology to have this type of effect on research-based industries such as drug development. The technology miniaturizes, integrates, and automates laboratory functions, which could have the effect of radically altering work practices, staff requirements, and infrastructure costs. Yet potential applications for lab-on-chip technology extend far beyond scientific research and include such areas as medical diagnosis and forensic investigation. This technology could also have a significant effect on the water quality monitoring and analysis necessary to protect public health and maintain municipal and industrial water treatment and distribution infrastructures. This article discusses the capabilities of Sensicore's WaterPOINT, a patented lab-on-chip water profiling system.

WaterPOINT's technology opens up major new possibilities for active water quality management, especially when combined with Sensicore's WaterNOW Internet service.

#### Sensicore's Technical Innovation

The most obvious innovation of Sensicore's lab-on-chip technology is, of course, miniaturization—WaterPOINT radically reduces the instrumental footprint of water quality monitoring. For example, the traditional method for measuring pH requires a master electrode about 4-5 in. long and 0.5 in. in diameter. WaterPOINT's pH detector is virtually flat with a diameter of 0.4 mm, which is almost 30 times smaller. The electrodes for ammonia, calcium, and other analytes are all reduced in size by a similar factor.

Miniaturization enables consolidation. Traditional water monitoring usually requires technicians to use several instruments on several water samples. In addition, they often have to send grab samples to the lab for tests that are too difficult and time-consuming to perform onsite. WaterPOINT is a single hand-held device that technicians can use to simultaneously test for key analytes and obtain a complete picture of a single sample of water. Specifically, WaterPOINT measures the following 16 items:

- free chlorine,
- total chlorine,
- monochloramine,
- calcium,
- calcium hardness,
- carbon dioxide,
- total alkalinity,
- free ammonia,
- total ammonia,
- ammonia-to-chlorine ratio,
- Langelier index (LI),
- PH,
- oxidation-reduction potential,
- conductivity,
- total dissolved solids, and

- temperature.

Consolidation and computer automation combine to radically simplify and accelerate comprehensive onsite water monitoring. The Water-POINT profiler is a sophisticated instrument that does almost all of the work and requires very little training to use. The same tests that would take a highly skilled technician 30-60 min (or sometimes days of lab analysis) to complete can all be performed in 4 min— with very little sample preparation—by a relative novice using WaterPOINT.

The Bluetooth®-enabled system also expedites and simplifies data transfer. WaterPOINT can store more than 250 water profiles, and users can quickly download these to a laptop or to a server via a laptop or a cell phone. This eliminates time-consuming manual transcription and the inevitable transcription errors. This process can also transfer a huge amount of data: each profile includes not only measurements for the 16 core analytes but also the calibration/validation data and diagnostic flags, manually entered auxiliary measurements, test location information, sample identification information, sensor and handheld device information, and a technician name—anything that can be associated with the core measurements. Because each of the 250 profiles contains 50 fields, a single handheld device can transfer 12,500 data points within a few minutes.

Sensicore does not sacrifice the quality of results for simplicity and speed. In reality, automation eliminates much of the opportunity for human error, and the sampling method ensures a high degree of accuracy. The technician takes all of the WaterPOINT measurements on a single fresh sample, and the system's sophisticated algorithms correct for temperature and interfering compounds. Technicians use the Water-POINT rinse solution as a quality-control standard that is built into each 4-min test procedure. The rinse solution contains known concentrations of analytes, and the system uses these measurements to offset any drift and to confirm that the sensor is working properly. The rinse solution also functions as a housekeeping tool to clean-the sensor after testing is complete.

The technological advantages of Sensicore's lab-on-chip system—the unified platform, the comprehensive panel of measurements, the accuracy, the simplicity, and the gain in speed— have significant implications for the cost, efficiency, and practice of water quality management. Because Water-POINT testing is easy and intrinsically accurate, water quality managers can optimize their use of personnel and perform more tests at more sites with the same number of people.

Other important efficiencies derive from the fact that WaterPOINT's panel includes measurements often considered too difficult and expensive to be a regular part of daily onsite testing. For example, tests for the LI, alkalinity, and hardness often require expensive, time-consuming lab analysis. These measurements are thus performed less frequently than disinfection tests and often only when there is a special reason. Yet these tests measure properties that have very significant effects on such water distribution infrastructure as pipes, valves, etc. By automatically including the tests in day-to-day monitoring, WaterPOINT helps utilities take active and preventive steps to maintain the physical system. Water quality managers can use such measurements to resolve blending, treatment, conditioning, and other issues, which can have the effect of significantly prolonging the health of the infrastructure or saving substantial funds on repair and equipment.

Sensicore's strategy for its WaterPOINT System is to create a single platform for all water analysis. To accomplish this goal, Sensicore is upgrading WaterPOINT with optical measurement

capabilities that will make onsite monitoring even more comprehensive. The optional tests will be performed after the 16 chip-based electrochemical measurements have been completed. Customers will be able to use this optional integrated system to add more than 20 additional tests for such things as turbidity, intrinsic color, fluoride, nitrates, nitrites, phosphates, iron, and copper.

#### Mapping and Visualizing an Entire Distribution System

In addition to its effect on day-to-day single-site monitoring, a WaterPOINT device can also quickly transfer up to 250 water profiles to a central server—a server that can store similar information from many devices at many sites. Sensicore has used this capability, along with modern Internet and business intelligence technology, to create a web-based service called WaterNOW. This service enables a more holistic and active approach to monitoring and maintaining water distribution systems.

WaterNOW can consolidate all WaterPOINT data from a city's monitoring locations onto a secure Internet site and can display the information on a map overlay of the geographical area. Whereas individual WaterPOINT devices allow users to quickly measure multiple parameters at a single site, WaterNOW allows them to correlate and visualize real-time measurements of a single parameter (or multiple parameters) at multiple sites. The service also enables trend analysis based on stored historical information and can incorporate data from non-WaterPOINT sources, including laboratory information management systems, supervisory control and data acquisition systems, programmable logic control systems, information from spreadsheets and databases, and customer complaint data.

WaterNOW is a powerful troubleshooting tool. For example, if WaterPOINT or an online sensor detects contamination, analysts can visualize and compare the different levels at multiple sites and the different rates of increase over time. The mapping function is dynamic and presents changing water chemistry much like television weather maps display weather conditions with Doppler radar. This helps users pinpoint the source and extent of the problem, determine quickly where to perform additional tests, and initiate action to stop and eliminate the contamination. The service is particularly valuable now that the US Environmental Protection Agency and the US Department of Homeland Security are showing increasing concern for the safety and security of water distribution systems.

Technicians can use the very same WaterNOW troubleshooting methods to better preserve physical infrastructure. For example, dynamic trend mapping will help analysts identify the source, quantity, and distribution patterns of corrosive elements within the system. They can then use this information to replace hit-and-miss repair strategies with informed plans about where to dig the next hole. They can also use trend and pattern information to establish preventative maintenance schedules that extend equipment life and solve minor problems before they become more significant. Thus, WaterNOW enables a proactive approach to maintenance that can significantly cut costs over the long term.

Sensicore plans to combine lab-on-chip and Internet technologies in another way to facilitate monitoring that is far more active than what is now possible with the company's tools. The plans call for stationing unmanned sensors throughout a water distribution system to automatically test at customer-specified intervals and immediately send the results to WaterNOW. Sensicore's use of

reagentless chip technology in combination with its ability to deploy multiple sensor carousels would enable such online systems to run for long periods without constant maintenance and calibration—the Achilles heel of today’s online monitors. In addition, the small sizes of these sensors and their low-volume sample requirements make such online devices deployable in many more locations.

A ubiquitous unmanned sensor network has obvious advantages over today’s grab-sampling approach. First, the analysis occurs in real time, providing instantaneous results of key water quality measurements on a 24/7 basis. Such a system, however, will also help municipalities monitor normal water quality chemistry and the rate at which it changes and—when combined with the continuous monitoring capability of the WaterNOW System and smart algorithms—predict the type and extent of a contamination event through chemical “fingerprints.” Even the most ambitious program of manual monitoring could not match this real-time capability. In addition, low-cost, low-maintenance sensor nodes will make it possible for municipalities to blanket their water systems to help ensure water quality and security.

#### Preventive, Cost-Effective Technologies

Sensicore’s WaterPOINT and WaterNOW have the ability to simplify and accelerate comprehensive data collection, integration, analysis, and display. The company’s lab-on-chip technology and dynamic district-wide water quality visualization could significantly alter the practice of water quality management—making it far more preventive, efficient, and cost-effective than it is today.

—Malcolm Kahn is president and chief executive officer of Sensicore, 755 Phoenix Dr., Ann Arbor, MI 48108; (734) 528-6300. Kahn has extensive experience in analytical instruments, water and wastewater treatment, and medical diagnostics markets. He has been president and chief executive officer of three companies over a 20-year period—including Membrex, a membrane technology company, and Kratos, an analytical instruments company. Before Kratos, he worked for two divisions of Millipore Corp., a bioscience and bioprocess company, and spent 9 years at the pharmaceutical company Pfizer in various capacities from controller to director of marketing within its medical diagnostics businesses. Kahn has a BA in finance from Pennsylvania State University and an MBA from Fordham University.

Information in Tech Talk may describe products offered by companies in the water industry. AWWA does not endorse these products, nor is it responsible for any claims made by the companies concerned.

## **Item 6. Updates on Previously Identified Issues**

### **6.2 New Measures for Regulating E-waste**

#### 6.2.1 Green Standards to Counter E-waste

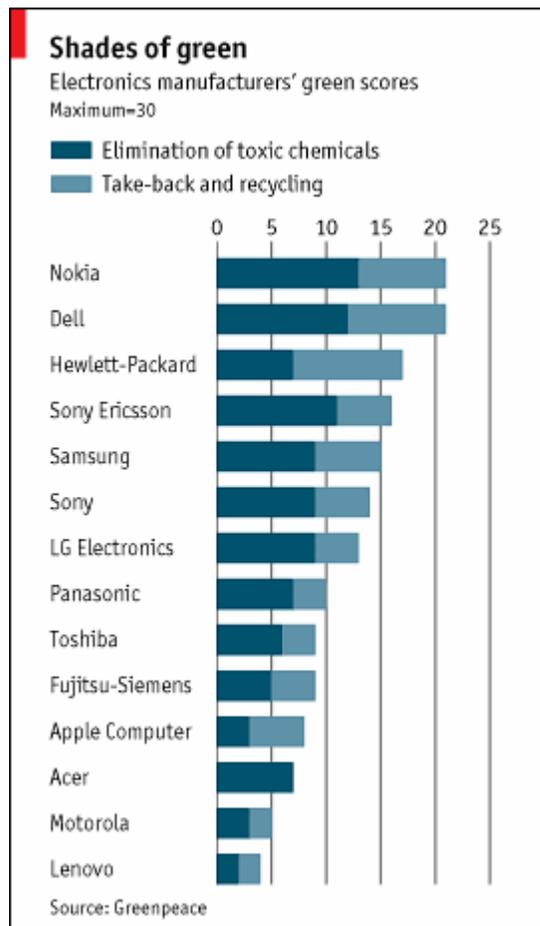
#### **How green is your Apple?**

From The Economist print edition, Aug 25th 2006

Not very, according to Greenpeace

[http://www.economist.com/business/displaystory.cfm?story\\_id=7836504](http://www.economist.com/business/displaystory.cfm?story_id=7836504) (by subscription only)

DISPOSING of computers, monitors, printers and mobile phones is a large and growing environmental problem. Some 20m-50m tonnes of “e-waste” is produced each year, most of which ends up in the developing world. According to the European Union, e-waste is now the fastest-growing category. Last month new rules came into force in both Europe and California to oblige the industry to take responsibility for it. In Europe the Restriction of Hazardous Substances (RoHS) directive limits the use of many toxic materials in new electronic products sold in the European Union. In California mobile-phone retailers must now take back and recycle old phones.



Many technology firms are already eliminating certain chemicals and offering recycling schemes to help their customers dispose of obsolete equipment. Yet there is a wide variation in just how green different companies are, according to Greenpeace, an environmental lobby group that launches a new e-waste campaign on August 25th. It has ranked the top mobile-phone and PC-makers based on their progress in eliminating chemicals and in taking back and recycling products (see chart).

The RoHS rules ban products containing any more than trace amounts of lead, mercury, cadmium and other hazardous substances, including some nasty materials called brominated flame-retardants (BFRs). To do well in Greenpeace's rankings, firms must make sure both products and production processes are free of polyvinyl chloride (PVC) and some BFRs that are not on the RoHS list. Greenpeace also wants companies to adopt a “precautionary principle” and avoid chemicals if their environmental impact is uncertain.

Although not everyone will agree with Greenpeace's methodology, its ranking still has some merit. Nokia does well: the world's biggest handset-maker has already got rid of PVC from its products and will

eliminate all BFRs from next year. But, Greenpeace grumbles, it is not sufficiently “precautionary” in other areas. Dell, however, scores well in this regard and on recycling, but loses marks for not having phased out PVC and BFRs yet, though it has set a deadline for doing so.

Perhaps the biggest surprise is the poor rating of Apple. Despite having an image steeped in California's counterculture, it is one of the worst heel-draggers, says Zeina Al-Hajj of Greenpeace. The company insists that it has a strong record in recycling and has eliminated BFRs and PVC from the main plastic parts in its products. It scores badly because it has not eliminated such chemicals altogether, has not set time limits for doing so, does not provide a full list of regulated substances

and is insufficiently precautionary for Greenpeace's tastes. As for recycling, the 9,500 tonnes of electronics Apple says it has recycled since 1994 is puny given the amount of equipment the firm sells, says Ms Al-Hajj. Apple responds that many of its products (such as the iPod music-player) are small and light. Greenpeace points out that Nokia also makes tiny devices, but is much better at recycling them.

Alas for Apple, whatever the pros and cons of Greenpeace's ranking criteria, consumers are likely to be influenced by it anyway. Comically, Greenpeace is now considering a plan to promote its e-waste campaign via podcasting—a technology that Apple helped to popularise.

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### 6.3 Climate Change

#### Additional Sources:

More fires, droughts and floods predicted

<http://www.bristol.ac.uk/news/2006/1053.html>

A climate-change risk analysis for world ecosystems

<http://www.pnas.org/cgi/content/abstract/0601816103v1?maxtoshow=&HITS=10&hits=10&RESULTFORMAT=&fulltext=Marko+Scholze&searchid=1&FIRSTINDEX=0&resourcetype=HWCIT> (Abstract)

Disaster-Prone China Takes Heed of Global Warming

<http://www.planetark.com/dailynewsstory.cfm/newsid/37869/story.htm>

No Dice for Greenland Ice

<http://sciencenow.sciencemag.org/cgi/content/full/2006/810/3>

Greenland ice cap may be melting at triple speed

<http://www.newscientist.com/article/dn9717-greenland-ice-cap-may-be-melting-at-triple-speed.html>

(by subscription only; full text in the [Appendix](#))

Greenland Ice Sheet Is Melting Faster, Study Says

[http://news.nationalgeographic.com/news/2006/08/060810-greenland\\_2.html](http://news.nationalgeographic.com/news/2006/08/060810-greenland_2.html)

Greenland Ice Sheet Is Melting Faster, Study Says

<http://www.cosmosmagazine.com/node/539>

Alaska glacier melt rate a surprise

[http://www.agrnews.org/?section=archives&cat\\_id=39&article\\_id=1056](http://www.agrnews.org/?section=archives&cat_id=39&article_id=1056)

Once-icy Arctic now Great 'Wet' North

<http://www.canada.com/edmontonjournal/news/story.html?id=aa5d2a48-6a62-4bb0-a0fe-0d7ff4cedef3&k=86833>

Hydro-Quebec adjusts rates as air-conditioners appear in north

<http://www.canada.com/montrealgazette/news/story.html?id=1f9bf9a9-0872-4bb0-995c-557894a39854>

In Warmer World, Even Inuit Buy Air Conditioners

<http://www.planetark.com/dailynewsstory.cfm/newsid/37558/story.htm>

The ocean is slowly claiming Malasiga. They say it's global warming

<http://www.chicagotribune.com/news/nationworld/chi-0608200380aug20,1,3457454,print.story?ctrack=1&cset=true> (by free subscription only)

Britain is falling into the sea (or bits of it, anyway)

<http://www.canada.com/montrealgazette/news/insight/story.html?id=f3247666-19da-4a02-9c8e-ea2fe464b728> (article available free for a limited time; full text further in this [Appendix](#))

Ocean acidification: the other CO2 problem

<http://www.newscientist.com/channel/earth/mg19125631.200> (by subscription only; see full text further in this [Appendix](#))

### Greenland ice cap may be melting at triple speed

NewScientist.com news service, 10 August 2006

<http://www.newscientist.com/article/dn9717-greenland-ice-cap-may-be-melting-at-triple-speed.html> (by subscription only)

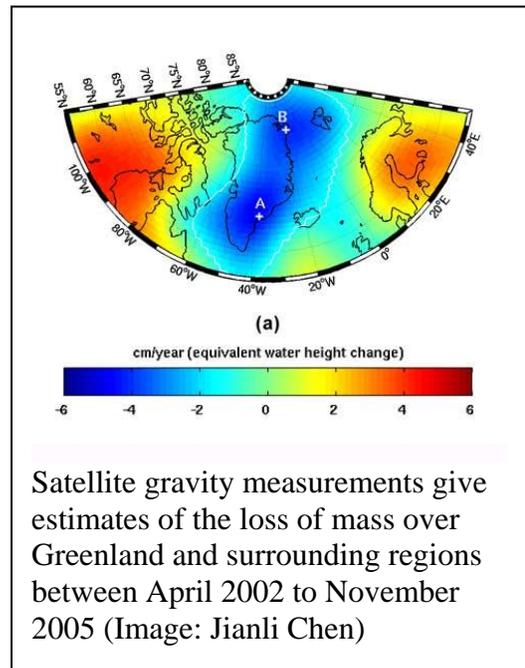
The world's second largest ice cap may be melting three times faster than indicated by previous measurements, according to newly released gravity data collected by satellites.

The Greenland Ice Sheet shrank at a rate of about 239 cubic kilometres per year from April 2002 to November 2005, a team from the University of Texas at Austin, US, found. In the last 18 months of the measurements, ice melting has appeared to accelerate, particularly in southeastern Greenland.

"This is a good study which confirms that indeed the Greenland ice sheet is losing a large amount of mass and that the mass loss is increasing with time," says Eric Rignot, from NASA's Jet Propulsion Laboratory in Pasadena, California, US, who led a separate study that reached a similar conclusion earlier in 2006 (See Greenland's glaciers are speeding to the ocean). His team used satellites to measure the velocity of glacier movement and calculate net ice loss.

Yet another technique, which uses a laser to measure the altitude of the surface, determined that the ice sheet was losing about 80 cubic kilometres of ice annually between 1997 and 2003. The newer measurements suggest the ice loss is three times that.

"Acceleration of ice mass loss over Greenland, if confirmed, would be consistent with proposed increased global warming in recent years, and would indicate additional polar ice sheet contributions to global sea level rise," write the University of Texas researchers in the journal *Science*.



## Identical twins

The satellites that provided the new data are results the Gravity Recovery and Climate Experiment (GRACE) pair. These identical US and German satellites fly 220 kilometres from one another. They use a microwave ranging system and Global Positioning System to measure precisely the distance between one another. Tiny changes in that distance reflect changes in the Earth's gravity field, which in turn is a measure of the density of part of the Earth.

"The gravity data are spectacular in providing precise information about what is happening to the ice sheets," says NASA climatologist James Hansen, director of the Goddard Institute for Space Studies in New York, US. "They provide the net effect of mass change, due to both melting and snowfall changes. It confirms our expectation that the warming climate will cause Greenland ice to shrink."

Based on the glaciology of the region, Rignot says he does not think that the north-eastern part of Greenland's ice cap has lost as much ice as the Texas team suggests - 74 cubic kilometres annually.

Other factors could account for the discrepancy, acknowledges Clark Wilson, one of the University of Texas team. For instance, scientists do not fully understand the ocean tides in the Arctic Ocean, and there are not a lot of weather stations to monitor air pressure there. GRACE only measures changes in gravity due to changing mass - it cannot tell if that results from changes in air, water, rock or ice.

So to find changes due to ice loss alone, the researchers have to subtract the estimated contribution of water and air. If that is not well known, it results in higher uncertainties in the interpretation.

"We're hoping as time goes on, we'll have improved tide models, improved atmospheric pressure estimates and also better ways to use the GRACE data themselves," Wilson told New Scientist.

## Thwarted plans

The Greenland Ice Sheet holds about 2.85 million cubic kilometres of ice - 10% of the world's ice mass. If it all melted, it would raise the average sea level about 6.5 metres.

This is not GRACE's first measurement of an ice sheet. Another team at the University of Colorado, Boulder, US, similarly used the GRACE system to show that the Antarctic ice sheet was losing about 152 cubic kilometres annually from 2002 to 2005 (See Gravity reveals shrinking Antarctic ice).

"We should be making plans for the next generation of gravity satellites, but with the cutback in NASA funding for Earth science, this is not happening," says Hansen, who earlier in 2006 accused officials at NASA headquarters of trying to stop him from speaking out on greenhouse gas emissions (See Top climatologist accuses US of trying to gag him).

Journal reference: Science (DOI:10.1126/science.1129007)

**Britain is falling into the sea (or bits of it, anyway)**

Lyme Regis is crumbling along with other chunks of the fabled British coastline. It's not hard for many to blame the greenhouse effect

BEN HIRSCHLER, Reuters, Sunday, August 06, 2006

<http://www.canada.com/montrealgazette/news/insight/story.html?id=f3247666-19da-4a02-9c8e-ea2fe464b728>

Breathtaking beauty, but it's all falling apart. This section of England's southern coast has become known as the Jurassic Coast. A rich seam of fossils are uncovered when cliffs, eroded by waves, collapse.

The quaint seaside town of Lyme Regis with its narrow, winding streets seems a million miles from the melting polar ice caps or the flooded coral atolls of the Pacific.

But the exposed steel piling behind the promenade and the newly reinforced beach, designed to stop Lyme from crumbling into the sea, show that this, too, is a corner of the planet threatened by climate change.

Many scientists reckon the world is warming due to the "greenhouse effect" caused by emissions from fossil fuels trapping heat in the atmosphere.

The heat wave currently sweeping across large parts of Europe and North America is seen by some as a sign of climate change.

For the past year Lyme, made famous as a setting for Jane Austen's novel *Persuasion* and John Fowles's epic *The French Lieutenant's Woman*, has been in the grip of gut-wrenching engineering works.

Vacationers lounging on the new beach may not realize it, but Lyme, on the southwest coast of England, sits in the middle of one of the most unstable stretches of coastline in the country with a long history of landslips.

Its very instability is the reason this section of England's southern coast has become known as the Jurassic Coast, in recognition of the rich seam of fossils that are uncovered when cliffs, eroded by the waves, collapse.

Now experts say the pace of landslips is set to accelerate as global warming leads to rising sea levels and fiercer winter storms battering the fragile blue lias or sea limestone cliffs.

Locals got a taste of things to come in January this year when 750,000 tonnes of rock and clay fell on neighbouring Charmouth beach, stranding a handful of people, in the biggest landslip for 30 years.

In a bid to hold back the waves, Lyme has embarked on a \$42-million Canadian program to double the length of rock armour at the end of the ancient Cobb harbour, put more sand and shingle on the beach and stabilize the sea front.

The work has been noisy, dirty and disruptive but Mayor Ken Whetlor reckons the town has no choice.

"You have to put up with that if you want to save your town," he said.

"With the forecasts of rising sea levels, the defences we had in place would not have lasted the course. The decision was either to save this heritage coast or let it go."

Just eight kilometres along the coast, the National Trust charity, Britain's largest owner of coastline, is beating a retreat on Golden Cap, the highest point on England's southern coast.

With the rate of land erosion expected to increase to about two metres a year, the Trust has decided to move its cliff-top path up to 25 metres inland.

Over the next century, the organization expects more than half the 1,125 kilometres of coastline in its care will face similar serious erosion damage.

Britons, none of whom live more than 120 kilometres from the sea, will have to learn to live with the growing impact of climate change, according to the National Trust's assistant director of policy Ellie Robinson.

"We need to explain to people that it is happening here and now in the U.K.," she said.

"It's not just about ice caps and Bangladesh and hurricanes in the U.S. and drought in Africa. It is happening here at home and we can't kid ourselves that it's just the rest of the world that will be affected."

On England's east coast, other towns are also under threat and farmland is being lost to the sea. Climate change there adds to the gradual sinking of the southeast corner of Britain as the Earth's crust continues to adjust to the end of the last ice age 10,000 years ago.

Some larger East Coast towns will be protected, as Lyme has been, but smaller communities such as the Norfolk village of Happisburgh are not lucky enough to be given extra sea defences and may go under. It is a policy known as managed retreat.

The government may be investing to defend notable coastal towns like Lyme, Brighton, Blackpool, Bournemouth and Scarborough but environment minister Ian Pearson argues it is unrealistic to try to maintain the status quo everywhere.

Such a selective approach angers homeowners in Happisburgh and other small places, who fear they will be left without compensation if their houses tumble into the waves.

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**Ocean acidification: the other CO2 problem**

NewScientist.com news service, 05 August 2006

<http://www.newscientist.com/channel/earth/mg19125631.200> (by subscription only) A few years ago, Victoria Fabry saw the future of the world's oceans in a plastic jar. She was aboard a research vessel in the frigid waters of the North Pacific, carrying out experiments on a species of pteropod called *Clio pyramidata* - frisky little molluscs with shells up to a centimetre long and flaps on their bodies that they use to swim in a way that resembles butterfly flight.

Something strange was happening in Fabry's jars. "The pteropods were still swimming like billy-o, but their shells were visibly dissolving," says Fabry, a biologist from California State University San Marcos. "I could see it with the naked eye."

She realised that the animals' respiration had increased the carbon dioxide concentration in the jars, which had been sealed for 48 hours, changing the water's chemistry to a point where the calcium carbonate in the pteropods' shells had started to dissolve. Fabry and her colleagues were aware that at some point in the future the massive influx of carbon dioxide from human activity might reduce the alkalinity of the oceans. "But this was way before anybody thought such a trend would affect organisms like these." What Fabry had stumbled on was a hint of "the other CO2 problem".

It has taken several decades and hundreds of millions of dollars' worth of research for climate change to be recognised as a serious threat. But another result of our fossil fuel habit - ocean acidification - has only begun to be researched in the last few years. Its impact could be momentous, says Joanie Kleypas of the National Center for Atmospheric Research in Boulder, Colorado, lead author of a report on ocean acidification released last month.

CO2 forms carbonic acid when it dissolves in water, and the oceans are soaking up more and more of it. Recent studies show that the seas have absorbed about a third of all the fossil-fuel carbon released into the atmosphere since the beginning of the industrial revolution, and they will soak up far more over the next century. Yet until quite recently many people dismissed the idea that humanity could alter the acidity of the oceans, which cover 71 per cent of the planet's surface to an average depth of about 4 kilometres. The ocean's natural buffering capacity was assumed to be capable of preventing any changes in acidity even with a massive increase in CO2 levels.

And it is - but only if the increase happens slowly, over hundreds of thousands of years. Over this timescale, the release of carbonates from rocks on land and from ocean sediments can neutralise the dissolved CO2, just like dropping chalk in an acid. Levels of CO2 are now rising so fast that they are overwhelming the ocean's buffering capacity.

In 2003 Ken Caldeira of the Carnegie Institution in Stanford, and Michael Wickett at the Lawrence Livermore National Laboratory, both in California, calculated that the absorption of fossil CO2 could make the oceans more acid over the next few centuries than they have been for 300 million years, with the possible exception of rare catastrophic events. It was in their *Nature* paper that the phrase "ocean acidification" appeared in the scientific literature for the first time.

The potential seriousness of the effect was underlined in 2005 by the work of James Zachos of the University of California at Santa Cruz and his colleagues, who studied one of these rare catastrophic events. They showed that the mass extinction of huge numbers of deep-sea creatures around 55 million years ago was caused by ocean acidification after the release of around 4500 gigatonnes of carbon (New Scientist, 18 June 2005, p 19). It took over 100,000 years for the oceans to return to their normal alkalinity.

Around the same time as the Zachos paper, the UK's Royal Society published the first comprehensive report on ocean acidification. It makes grim reading, concluding that ocean acidification is inevitable without drastic cuts in emissions. Marine ecosystems, especially coral reefs, are likely to be badly affected, with fishing and tourist industries based around reefs losing billions of dollars each year. Yet the report also stressed that there is huge uncertainty about the effects on marine life.

"On the one hand the chemistry of ocean acidification is very certain," says James Orr of the Laboratory of Sciences of the Climate and Environment (CEA-CNRS) in France. "On the other hand the biological and ecological impacts are very complex. The consequences for ocean life are far harder to predict."

So what progress has been made since the report came out? How serious an issue is acidification given all the other threats to the oceans, from overfishing and pollution to warming waters and changes in currents?

The sea creatures most likely to be affected are those that make their shells or skeletons from calcium carbonate, including tiny plankton and massive corals. Their shells and skeletons do not dissolve only because the upper layers of the oceans are supersaturated with calcium carbonate (see Graphic). Acidification reduces carbonate ion concentrations, making it harder for organisms to build their shells or skeletons. When the water drops below the saturation point, these structures will start to dissolve.

Calcium carbonate comes in two different forms, aragonite and calcite, aragonite being more soluble. So organisms with aragonite structures, such as corals, will be hardest hit. Early studies suggested that calcification rates of corals would decrease by 10 to 30 per cent during a rapid doubling of atmospheric CO<sub>2</sub>, as is happening now. More recent studies have tended to widen the range of uncertainty, suggesting that CO<sub>2</sub> doubling might cause anything from a 3 to 54 per cent decrease in carbonate production. "In experiments with lower pH that simulate future conditions, the corals don't die. They just grow more slowly," says Kleypas.

Unable to compete

That may not sound too bad, but the long-term effects could be severe. "Corals undergoing these sorts of stresses may become unable to compete for space. They may reach sexual maturity more slowly," says Kleypas.

Another complication is that the oceans are warming at the same time as becoming more acidic. A few researchers have suggested that slower coral growth due to declining carbonate levels will be more than offset by faster growth due to higher ocean temperatures. Such arguments are flawed,

says Carol Turley, director of the Plymouth Marine Laboratory in the UK and a lead author of the Royal Society report.

This is because even fairly short periods of abnormally high temperatures - as little as 1 °C higher than the long-term average for a month - can cause corals to expel the algae that supply most of their food, resulting in bleaching and sometimes the death of the coral. Bleaching events are already increasingly common and it is not clear whether corals will be able to adapt as temperatures continue to soar.

Could reef-building corals move to cooler waters further north and south to escape the heat? Acidification puts a kibosh on that too, says Turley. Corals thrive in waters three times past the aragonite saturation point, but carbonate levels are lower towards the poles.

A recent review by Ove Hoegh-Guldberg of the University of Queensland, Australia, concluded that corals could become rare by the middle of this century because of the double whammy of rising temperature and falling carbonate levels. Caldeira's view is even starker: "If you look at the business-as-usual scenario for emissions and its impact with respect to aragonite on surface waters, by the end of the century there is no place left with the kind of chemistry where corals grow today."

If the outlook for tropical corals is bleak, the consequences of acidification for organisms in more southerly and northerly waters causes even more concern. "Tropical surface waters will be affected by ocean acidification last," says Ulf Riebesell of the Leibniz Institute of Marine Sciences in Kiel, Germany. "In higher latitudes the waters could tip much sooner into being corrosive."

Early studies suggested that high-latitude surface waters would become undersaturated with respect to aragonite only if atmospheric CO<sub>2</sub> reached four times pre-industrial levels. But in September 2005, Orr, Fabry and colleagues published evidence suggesting that some polar and sub-polar surface waters will become undersaturated at just twice pre-industrial levels - conditions that are likely to occur within the next 50 years.

In shipboard experiments, they found that the shells of pteropods started dissolving after just two days in water at the pH predicted for 2050. This is worrying because pteropods are an important part of the ecosystems in the Southern Ocean and Arctic and sub-Arctic waters, where animals such as cod, salmon and whales eat them. "In standard ocean surveys their abundance is used as an indicator of ecosystem health," says Orr.

Could the pteropods simply move to warmer waters that are not approaching the saturation horizon so fast? "We think it unlikely, as they would have to outcompete organisms already living there," says Orr. The fate of all the creatures that feed on pteropods will depend on whether species less vulnerable to acidification take their place in the food chain.

There's also great concern about another major ecosystem in high latitudes: cold-water coral reefs. These corals are far less studied than their distant tropical cousins because they are found deep down in dark cold waters, typically at 100 to 1000 metres but sometimes much deeper. Only in the last dozen years or so has a picture of their true extent and astonishing nature begun to emerge.

One system stretches from Norway down to the coast of Africa. At around 4500 kilometres, it is roughly two-and-a-half times as long as Australia's Great Barrier Reef. The richness of these reefs is also astonishing. In terms of biomass production and even biodiversity, cold-water corals may be as important as warm-water corals. Over 130 species were found on one reef in the north-east Atlantic, says Murray Roberts of the Scottish Association for Marine Science in Oban. He stresses how poorly understood they are. "For example, we think they are very important as fish habitats, but to what extent and exactly how we really don't yet know."

Deep-water trawling is already destroying many cold-water corals, which grow far more slowly than their tropical cousins. They are also found in waters that are closer to the aragonite saturation horizon, and could therefore easily tip over into being corrosive. Little work has been done to find out if these corals will stop growing in such conditions, but many researchers think it likely.

Besides affecting calcification, increased CO<sub>2</sub> levels could also have a direct impact on many sea creatures by making their blood more acidic. This can have a range of effects, including reducing the ability of the blood to carry oxygen. Most of what we know comes from studies on the short-term impact of big CO<sub>2</sub> increases, rather than the small, long-term increases that ocean acidification will bring, but such experiments are now starting to be carried out.

One study last year showed that the growth of the edible Mediterranean mussel *Mytilus galloprovincialis* slowed and its shell started to dissolve when kept for three months in seawater with a pH of 7.3, about the lowest level to which surface waters might fall. The team concluded that such conditions might be fatal for the mussel, a vigorous species that is invading many parts of the world.

In another study, two species of sea urchin and an edible conch, *Strombus luhuanus*, were exposed to smaller increases in CO<sub>2</sub> for six months. The growth of all three species slowed, and the shells of one of the sea urchin species thinned. Sea urchins play an important role in coastal ecosystems by grazing on algae, so any reduction in their numbers could have a big impact.

No one knows how many other important species, such as fish, will be affected. One key question is the extent to which life will be able to adapt to changing levels of CO<sub>2</sub>. A recent study, for instance, showed that some corals can switch to making calcite instead of aragonite. However, they did so in response to lowered levels of magnesium rather than higher levels of CO<sub>2</sub>, and the calcite-producing corals grew far more slowly.

"We need to understand much more about the effects on physiology of various animals, including coral larvae. What if they can't glue themselves down?" says Kleypas. "We are messing with entire food webs, and we have no idea of the consequences." Some of these questions may only be resolved by observing what actually happens. In the meantime, researchers are trying to find out more through modelling and other techniques, including field experiments conducted in mesocosms - essentially large aquariums.

These experiments are throwing up a few surprises. This spring for instance, Riebesell and his colleagues looked at the effects of higher CO<sub>2</sub> levels during the spring bloom in phytoplankton. The researchers put huge bags in a Norwegian fjord, exposed the water in them to present-day, twice

present-day and three times present-day CO<sub>2</sub> levels, and monitored them over five weeks. Many of the findings are still to be published, so Riebesell is cautious in describing them, but some broad trends emerge.

As expected, coccolithophores - single-celled algae that are among the ocean's most important primary producers - found it increasingly difficult to produce their elaborate calcite plates, or liths, as CO<sub>2</sub> levels increased. However, it made little difference. "These organisms normally expend quite a bit of energy to build their liths," says Riebesell. "They must be important to them, and yet we are not seeing any immediate ill effects from having thinner ones."

The same could not be said for plankton tentatively identified as the larvae of marine snails. Their numbers fell when CO<sub>2</sub> levels doubled and they almost vanished at three times pre-industrial levels. "This was completely surprising," says Riebesell. "In lab experiments, we saw the organisms were affected but they did not disappear altogether."

He stresses that such findings must be treated with caution, because they are based on a small number of limited studies. All the experiments have been done near the shore, for example, rather than in open seas. "You really have to be out there," says Riebesell, whose group is testing a prototype open-ocean facility in the Baltic Sea this summer.

So far the picture looks relentlessly gloomy, but could there actually be some benefits to adding so much CO<sub>2</sub> to the seas? One intriguing finding, says Riebesell, concerns gases that influence climate. A few experiments suggest that in more acidic conditions, microbes will produce more volatile organic compounds such as dimethyl sulphide, some of which escapes to the atmosphere and seeds cloud formation. More clouds would mean cooler conditions, which could potentially be an important negative feedback that might slow global warming.

In theory, more CO<sub>2</sub> also means more "fertiliser" for the planktonic photosynthesisers at the base of the food chain. Could this boost the productivity of the oceans and help mop up some of the excess carbon, thus slowing global warming?

Up to a point, says Riebesell. Some of his experimental work suggests there could be an enhancement of up to 30 per cent in the rate at which carbon could be fixed and transported down into the deep ocean. If correct, it could be another negative feedback for climate change, tempering a runaway greenhouse effect.

This issue is complex because the formation of calcium carbonate releases CO<sub>2</sub> into the water. So in theory a slowing down in calcification by marine life could be seen as a good thing. However, all the organic parts of calcifiers are built from carbon, which is safely locked away in sediment if the bodies of these creatures reach the ocean floor. Overall, calcifying organisms act as a massive carbon pump. "They are the major means by which carbon is sent to the deep ocean," says Orr.

Hitherto, the consensus has been that extra carbon dioxide will not increase productivity in the oceans because the limiting factors are light and nutrients. In fact, one study last year predicted that changes in ocean currents caused by global warming will reduce the supply of nutrients, slashing productivity by a fifth (New Scientist, 15 April, p 42).

## The fertilisation effect

Even if there is a fertilisation effect, says Fabry, most photosynthesisers decay and release their CO<sub>2</sub> long before their remains reach the seafloor. The dense shells of calcifying organisms help them sink, so if calcifiers produce smaller shells or are replaced by non-calcifying organisms, less carbon dioxide could be locked away in the deep ocean despite higher productivity. Riebesell agrees that he may have seen a temporary boost in productivity with few positive consequences.

Fertilisation is just one of a whole array of questions that urgently need to be answered. Ecosystem-scale research is vital, says Caldeira, along with a better understanding of how marine life responded to and recovered from other catastrophic events in the past.

As well as the event 55 million years ago, during the Palaeocene Eocene Tertiary Maximum, acidification may also have occurred at the Cretaceous-Tertiary (KT) boundary 65 million years ago. Caldeira thinks that the meteor thought to have wiped out the dinosaurs also released vast quantities of sulphur dioxide, acidifying the surface layers of the oceans for at most a year or two. At that time most of the calcareous plankton went extinct. Corals disappeared from the fossil record for 2 million years. When they did reappear, the reefs were much less diverse.

Human-induced acidification might not be as bad as the KT event, but it will almost certainly be worse than that in the Palaeocene Eocene Tertiary Maximum. "We may release about the same amount of CO<sub>2</sub>," says Caldeira, "but instead of releasing it over tens of thousands of years, we will do it in hundreds."

Calculating the effect on people and economies is virtually impossible, given all the uncertainties, but it could be enormous. Take the impact on tropical corals, assuming that warming and other pressures such as pollution do not decimate them first. Estimates for the number of people deriving substantial benefits from the reefs are sometimes put in the range of 500 million to 1 billion, many millions of whom depend directly on reefs. Reefs also protect the shorelines of many countries and form the foundation of many islands. Acidification could start eating away at reefs just when they are needed more than ever because of rising sea levels, and possibly stronger storms.

"No serious scientist believes the oceans will be devoid of life or even that there will be less photosynthesis," Caldeira says. "Wherever there is light and nutrients something will live. A likely outcome will be a radical simplification of the ecosystem."

That will mean the loss of many species. "Our children will no longer be able to see the amazingly beautiful things that we can," says Orr. "I tell my son, go to see the corals now because soon it will be too late."

What is ocean acidification?

The oceans are naturally alkaline, with an average pH of around 8.2, although this can vary by up to 0.3 units depending on location and season. When CO<sub>2</sub> dissolves in seawater it forms a weak acid, lowering the pH.

The rate at which extra CO<sub>2</sub> is being injected into the oceans far exceeds the rate at which natural processes can neutralise its acidity. The average pH of the oceans has already fallen by about 0.1 units compared with pre-industrial levels. This may not sound like much, but because the pH scale is logarithmic, a 0.1 unit change means a 30 per cent increase in the concentration of hydrogen ions. Even if all carbon emissions stopped today, it would still take thousands of years for the oceans to recover. If global emissions of CO<sub>2</sub> continue to rise, the average pH of the oceans could fall by 0.5 units by 2100, equivalent to a threefold increase in the concentration of hydrogen ions.

Some claim the term "ocean acidification" is a misnomer, because the oceans are becoming less alkaline rather than actually becoming acidic (falling below pH 7), but most scientists think it is correct to describe any process that lowers pH as acidification.

Can we prevent ocean acidification?

There are two options: try to neutralise the additional acid by large-scale engineering projects or stop it at source by cutting carbon emissions.

There is probably no practical way of neutralising the acid. To dump enough chalk into the sea to counter acidification, for example, would mean denuding an area of pure chalk 60 kilometres square and 100 metres deep every year.

As for reducing emissions, a report by the UK's Royal Society concluded that to avoid irreversible damage, particularly in the Southern Ocean, total future emissions would need to be considerably less than 900 gigatonnes of carbon by 2100. This would require drastic action, as we are emitting about 7 gigatonnes a year and this figure is rising.

Ken Caldeira of the Carnegie Institution in Stanford, California, thinks that the target needs to be zero emissions. "People laugh at this," he says, "until I point out a few simple facts." The oceans naturally absorb just 0.1 gigatonnes more CO<sub>2</sub> per year than they release. Now they are soaking up an extra 2 gigatonnes a year, more than 20 times the natural rate, Caldeira says. "Even if we halve emissions, that will merely double the time until we kill off your favourite plant or animal."

Caldeira also points out that the US Environmental Protection Agency's water quality criteria stipulate that the pH of open ocean waters should not be changed more than 0.2 units outside the range of naturally occurring variation. "They were thinking of acidity caused by direct industrial pollution, of course, but the logic applies for CO<sub>2</sub>."

## **6.5 Scientific Community's Questions Concerning Biodefense Standards**

### **The Need for Biodefense Standards**

Seven questions for the industry to answer as it moves forward

By Scott Jenkins and Joseph Perrone

<http://www.the-scientist.com/article/display/24075/> (by subscription only)

The biodefense industry has reached a critical point in its evolution. To accelerate product development for biodefense-related diagnostics, therapeutics, and reagents, we urgently need

biological consensus standards - which generally do not exist. These standards can have an impact on overall R&D productivity and quality as profound as any technological advance, a fact readily acknowledged by biodefense leaders.

Within biodefense-related R&D, standard biological materials and processes are critical in three general areas. First, standards help properly validate instruments and assays used in measuring, producing, or testing products for biodefense applications. For example, scientists need standard microorganisms to validate an instrument designed to identify threat agents from environmental samples in the field. Second, we need standard biodefense-related materials and protocols to train personnel and confirm the capabilities of a biodefense laboratory; standards are invaluable for evaluating an individual's or laboratory's performance at identifying or assaying particular bioagents. Third, standards help compare experimental results among different researchers and different laboratories, enabling groups across the hall or across the globe to weigh results meaningfully. This enables high-quality and efficient research and testing, and it also stimulates innovation.

Standards are most effective when developed by the cadre of people who have the most to gain by their use. A provision of the National Technology Transfer and Advancement Act (1996; P.L. 104-113) states: Wherever possible, groups should use voluntary consensus standards developed by a community of interested stakeholders, rather than federally mandated regulations.

To jumpstart development of these standards, the American Type Culture Collection (ATCC) convened the Expert Panel on the Development of Standards for Biodefense in Washington, DC, in early April. The meeting represented a launching point for a process that will culminate in the development of voluntary consensus standards for critical materials and protocols for biodefense-related research and product development. A group of approximately 60 experienced biodefense experts gathered from a range of government agencies, academic institutions, and private companies.

Instead of writing specific standards, participants first delineated the areas of need for biodefense materials and processes. In discussion over the course of the two-day meeting, a broad agreement was reached on a handful of areas of need for biodefense standards. Participants also generated even more questions and issues that still require resolution. The areas of need include:

>> Standard reference materials - Participants strongly agreed that a major unmet need exists for universally accepted reference standard biological materials, including microorganisms posing public health threats. Such reference materials would be used as benchmarks in the study and testing of bioagents. Discussion at the meeting, however, focused more on how to define a reference material than on which bioagents should have standards. To define a material as a reference standard, what characteristics of the organisms constitute required knowledge? Much consideration and decision-making remains before, for example, experts can establish a reference standard *Bacillus anthracis* Ames strain. Nonetheless, meeting participants acknowledged that the set of information should include genetic profile, phylogenetic position, microbe source, purity, and chain of custody.

>> Standard measurement protocols - Once a set of requisite information is established, the next critical step is to define and agree to measurement protocols for each piece of information, the participants reasoned. For example, how should the purity of cultures and reagents be assessed, and what levels of impurity, if any, would be acceptable? How should one measure infectivity, virulence, or stability of an organism in various environments? Any group setting out to develop standard measurement protocols must consider what types of measurement devices and instruments on which to seek agreement, as well as what levels of specificity vs. sensitivity are acceptable. As a sample problem, what would be the criteria for successful decontamination of an area where a bioagent was detected? Panelists suggested that experts set standards on methods of bioagent characterization, and managing the information associated with the biological materials as well as evaluating countermeasures.

>> Harmonization of terms - Biodefense experts from academia, industry, and government alike strongly endorsed the concept of harmonizing definitions of key terms, and agreeing on a set of common biodefense-related terminology. Standardized definitions for key terms were viewed almost as a prerequisite to standards development. More work is needed in this area, but some of the terms identified by the group as needing common definitions included: sensitivity, specificity, shelf life, inactivation, limits of detection, and validation. The panel advocated obtaining help in this area from such organizations as International Standards Organization (ISO) and Clinical Laboratory Standards Institute (CLSI).

>> Standardized communication methods - The group clearly saw a need for a standard set of information and standard format for communicating and reporting descriptions of biomaterials, modeled after materials safety data sheets (MSDS) for chemicals. In addition, the group felt that experts should develop a standard format for certificates of analyses (C of A).

>> Standard surrogates - Even after taking extensive and redundant precautions, biodefense-related organisms, by definition, carry hazards even to experienced laboratory professionals. Consequently, the meeting participants agreed that a substantial need exists for standardized surrogates. These materials would be useful as models for biodefense-threat organisms in research and product development, but would not pose the same level of threat.

>> Standard animal models - Testing biodefense prophylactic and therapeutic products pose some obvious major challenges to manufacturers - namely, that human testing is virtually impossible. As a result, vaccines, drugs, or diagnostics require robust and specific animal models for testing, and panelists agreed that the biodefense industry needs standardized animal models of biodefense-related diseases. These models would bolster confidence in research results by allowing valid comparisons and experimental reproducibility. Future work in this area will need to determine the best models for various bioagents and different environments.

>> Standard handling protocols - Panelists also saw a significant demand for standard methods for manipulating and working with biomaterials. Important areas lacking standards include: protocols for handling, storage, transport, inactivation, and disposal of biomaterials.

#### Special needs for end-user groups

The panel acknowledged that certain standards - such as transport - could be of general use, while others, such as limits of sensitivity and specificity, would be specific to different end-user groups. They acknowledged the reality that biodefense standards would be employed by different groups with potentially different needs, including groups involved with food and water testing, environmental surveillance, diagnostics, or forensics. As a result, standards must address the differences in needs for the various end-user communities.

Meeting materials, an attendee list, slides from the presentations, and notes from the discussion sessions are available online at the conference Web site: [www.biodefensestandards.org](http://www.biodefensestandards.org). To move toward developing voluntary consensus standards, a wider group of stakeholders will be assembled to sustain momentum and maximize participant buy-in. In the next year, a series of follow-up conferences to the April expert panel gathering will be held in order to begin development of specific biodefense standards.

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