Teeming tunicate bloom
Virginia Gewin

In October 2008, researchers discovered the greatest density of salps yet recorded. The bloom of these 1- to 2-cm-long gelatinous tunicates flourished inside a nutrient-rich, cold-water eddy produced by the East Australian Current.

Researchers from the University of New South Wales documented the three-dimensional structure of the *Thalia* *democratica* bloom over the 2-week duration of the event, which, at its peak, contained roughly 5000 individuals per cubic meter within a 15-km diameter disc located 20–40 m below the sea surface (J Geophys Res-Oceans 2011; doi:10.1029/2011JC007310).

Salps are multicellular organisms characterized by exceptional growth rates – up to 10% per hour. “Small salps have the same nutritional value as the abundant tiny crustaceans known as copepods, but have been underappreciated in planktonic food webs until now”, says study coauthor Iain Suthers, a marine ecologist at the University of New South Wales (Sydney, Australia).

Indeed, comparable blooms probably occur in other systems, including the California Current off the west coast of the US, says Mark Ohman, a biological oceanographer at Scripps Institution of Oceanography (La Jolla, CA). What’s interesting, adds Ohman, is that this bloom was linked to a cold-water eddy, which might make it possible to forecast long-term salp dynamics.

“Salp populations merit further study because the blooms have the potential to affect water-column dynamics, outcompete other zoo-plankton, and accelerate the flux of carbon to the deep sea”, explains Ohman. Data suggest that salp populations may be on the rise in the southern oceans, filling the niche left by declining krill populations.

Suthers is working to quantify the importance of salps both to the marine food web and to carbon sequestration. “Salps may contribute to the krill decline, or be moving in on the Antarctic ice decline”, he says. A complex predator–prey relationship exists between salps and krill; krill will feed on salps, yet salps consume krill eggs and newly hatched krill.

The authors estimate that this bloom tied up 264 metric tons of carbon and 72 metric tons of nitrogen. “If we want a better understanding of carbon shunted to 4000-meter depths, we may want to pay salps more attention”, notes Suthers.

Puget Sound threatened by ocean acidification
Noreen Parks

In a water-quality report submitted to the US Environmental Protection Agency (EPA) last December, Washington State's Department of Ecology (DE) identified Puget Sound as “waters of concern”, based on impacts to local shellfish from ocean acidification, climate change, and urbanization. It was the first such official action undertaken by a coastal state.

The Pacific Northwest is particularly vulnerable to ocean acidification. Studies have revealed seasonal pH declines in coastal marine waters, and researchers have linked mass die-offs of oyster larvae to acidified water. The US Clean Water Act (CWA) recognizes pH as a conventional pollutant, and EPA criteria specify a “pH range of 6.5 to 8.5 for marine aquatic life (but not varying more than 0.2 units outside of the normally occurring range)”. In 2007, the Center for Biological Diversity (CBD; San Francisco, CA) petitioned Washington State to declare its marine waters “impaired”, which would require government action to curb carbon pollution causing acidification. Citing studies showing global ocean surface waters are already 30% more acidic than pre-industrial levels, CBD alleged that the state was ignoring its own policy. When the state refused to act, CBD sued. As part of the court settlement, EPA directed all states to consider ocean acidification as a threat to water quality under the CWA.

The state’s recent assessment again bypassed listing offshore waters for ocean acidification. Instead, Puget Sound – which supports a $100 million shellfish aquaculture industry – was essentially placed on a watch list. “We understand there's acidification in Washington's marine waters”, says Ken Koch, a DE Water Specialist (Olympia, WA), “but we don’t have credible monitoring data showing we’re in violation of standards. Washington [State] is studying the problem, recognizing it is a global issue”.

CBD Senior Attorney Miyoko Sakashita (San Francisco, CA) contends that, “The state fell short of what it should have done. It has taken a very narrow view of the science that has shown acidified waters along the entire Pacific coast, including Washington.”

Nonetheless, the Puget Sound listing signals a potential for ocean acidification to be addressed under the CWA, notes Lisa Suatoni of the Natural Resources Defense Council (Washington, DC). “CBD's lawsuit raised awareness of ocean acidification in government circles, but funding for associated research has declined. Estuaries like Puget Sound are hotspots for acidification from various causes, and proper water monitoring can parse them out. I hope that Washington’s decision, though moderate, will translate directly into greater funding for ocean science.”
**Waste not, want not**

Jen Fela

In late January, agriculture ministers gathering in Berlin, Germany, emphasized the need to reduce food waste, stressing that the amount of food discarded – during production and processing, as well as by consumers – in developed countries is enough to alleviate global hunger. Jose Graziano da Silva, who began his tenure as Director-General of the UN Food and Agriculture Organization on January 1, stated at the meeting that 1.3 billion metric tons – or one-third of the food produced for humans in the world annually – goes to waste.

While almost 1 billion people in developing countries are going hungry, consumers in rich countries dispose of massive amounts of food by rejecting imperfect produce, buying more food than they can use, and tossing out edible food because of confusion about expiration dates. According to Graziano da Silva, consumers in wealthy countries discard 222 million metric tons of food each year, almost as much as the entire net food production of sub-Saharan Africa (230 million metric tons).

The renewed focus on this problem follows a resolution passed on November 23, 2011, by the European Parliament’s Agriculture Committee, calling for the European Commission and member states to slash food waste in Europe by 50% by 2025 and to declare 2013 to be the “European Year Against Food Waste”.

Scientists in other parts of the world are drawing attention to the issue as well. Dana Gunders, Project Scientist for the Natural Resources Defense Council (San Francisco, CA), says, “It’s estimated that the average American family of four spends $175 per month on food they never eat” and that unused food in the US accounts for “25% of all fresh water used in the US, 4% of total US oil consumption, $90 billion per year (over $40 billion from households), $750 million per year to dispose of the food, and 31 million tons of landfill waste (leading to greenhouse-gas emissions)”. She continues, “For those trying to reduce their environmental input, reducing the amount of food you waste has an enormous impact”.

Miranda Mirosa, a researcher at the University of Otago (Dunedin, New Zealand), adds “There is a general consensus amongst consumers and the state and private sector that food waste is both morally and economically outrageous. As the impacts of climate change, peak oil prices, and food insecurity start to hit home, ‘food waste’ looks set to become one of the major environmental and social justice issues of our time.”

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**The choosy bird gets the caterpillar**

Lindsay Deel

Insectivorous birds eat caterpillars, certain caterpillars munch on tree leaves, and a new study (Am Nat 2012; doi:10.1086/664080) shows that birds preferentially select trees that are likely to have more caterpillars. For a leaf-eating caterpillar, this means that feeding on more nutritious and better tasting trees can be a risky business. What’s more, scientists found that the risk of being eaten by birds can increase by up to 90% or more for caterpillars on particular trees, such as black cherry (Prunus serotina). As coauthor Kailen Mooney (University of California, Irvine) says, “It’s really incredible…the magnitude of the variation in bird effects among [tree species in the study] ranges from practically no effect to 97% of caterpillars being depredated. This starkly demonstrates the importance of host-plant selection for herbivores, not only because plants vary in quality but also because of the associated predation risk.” The research highlights basic tradeoffs faced by prey species, between consuming higher quality food and ensuring greater safety from predators.

The study examined interactions between eight co-occurring deciduous tree species, 40 species of lepidopteran larvae, and several abundant bird species, at an unusually large community scale. Mooney explains that such a scale allowed for an analysis of the whole system, focusing on individual components. “A typical ecosystem-level study would measure ‘the’ effect of birds on ‘the’ tree, but this would subsume really meaningful and interesting variation among the components of that system.” Given the authors’ more robust approach, many new questions arose about the nature of tree–caterpillar–bird interactions. For example, what specific traits of individual trees, birds, and caterpillars influence this relationship? And how might other predators change the dynamic?

Lead author Michael Singer (Wesleyan University, Middletown, CT) sees this type of work as the future of community and ecosystem ecology. He concludes, “It’s an important step toward a mechanistic understanding of the structure and dynamics of ecological communities. In this era of rapid environmental change, this is especially important because patterns observed in the past might not hold in the future. An understanding of process will yield better understanding and predictive power.”
California sues San Diego over transportation plan

Robin Meadows

This January, the California Attorney General’s office threw its weight behind a lawsuit charging that San Diego’s new 40-year transportation plan threatens public and environmental health. Filed late last year by environmental groups, the lawsuit contends that the plan puts freeway expansion over public-transit projects and so will exacerbate the region’s dirty air and contribute to climate change. “Our goal is cleaner air for the people of San Diego and it is achievable”, says Lynda Gledhill, press secretary to Attorney General Kamala Harris (Sacramento, CA).

Seen as a test case, San Diego’s transportation plan is the first under a 2008 state law (SB 375) requiring lower regional greenhouse-gas (GHG) emissions. Under SB 375, regions must meet GHG reduction targets set by the California Air Resources Board (CARB). San Diego’s plan meets the 2020 and 2035 GHG reduction targets of 7% and 13% per capita, respectively, and CARB approved it in November.

“They met the letter of the law but not the spirit – GHGs go back up again by 2050”, says Jack Shu, President of the Cleveland National Forest Foundation (La Mesa, CA), which co-filed the suit with the Center for Biological Diversity (Sacramento, CA).

Because San Diego’s transportation plan satisfies SB 375, the lawsuit instead hinges on the California Environmental Quality Act, which requires agencies to identify and minimize environmental impacts. The plaintiffs contend that the San Diego plan does not adequately analyze the effects of air pollution on public health. “They consider bus lanes to be transit, so the focus is on expanding freeways, and they don’t show how this will impact aggravated asthma and lung cancer – this is a major flaw”, according to Shu. That said, the plan does project sizeable decreases in the total amounts of smog components by 2050. For example, between 2018 and 2050, NOx (nitric oxide and nitrogen dioxide) is expected to drop by one-quarter and carbon monoxide by one-third.

The plaintiffs also charge that the plan failed to consider shifting the initial focus from carpool and bus lanes to light rail. However, in approving the plan, CARB highlighted the provision that 80% of San Diego’s housing will be within half a mile of a public-transit station by 2035.

Wheat warning for a warming world

Jane Bradbury

A satellite-imagery-based study of wheat growth in northern India suggests that extreme heat (temperatures above 34°C) significantly accelerates wheat senescence and that warming the region by 2°C could shorten the growing season’s photosynthetically active period by about 9 days. Importantly, says lead author David Lobell (Stanford University, Stanford, CA), “simulations with two commonly used process-based crop models failed to capture this effect, underestimating yield losses due to the effect of heat on senescence by 50% for some sowing dates”.

Extremely high temperatures will likely become more common as climate change progresses, but little is known about how crops respond to such temperatures. High temperatures affect the growth of wheat, the most widely grown food crop, in many ways, but toward the end of the growing season, their most pronounced effect is to shorten the duration of grain growth by accelerating senescence.

Lobell and his colleagues analyzed 9 years’ worth of satellite measurements of wheat growth in northern India, a region at the edge of wheat’s growing range, and ground-based weather data to identify the distinctive effects of extreme heat on wheat. They also compared predictions from a regression model on the effects of warming on wheat yields with forecasts from two deterministic crop-simulation models (Nat Clim Change 2012; doi:10.1038/NCLIMATE1356).

According to Lobell, “our results suggest that heat is more of a challenge to wheat than previously thought. They also emphasize the need to adapt our agricultural methods to higher temperatures by developing new management strategies and new crops, and the need to maintain genetic diversity so that we can find the genes that will help food crops deal with high temperatures.”

“The researchers’ use of satellite data to infer crop outcomes on a fine geographic scale is new and interesting and likely to be of increasing importance for research in developing countries”, comments Michael Roberts (North Carolina State University, Raleigh), who also studies climate-change effects on food crops. Moreover, adds Roberts, “their comparison of predictions made by statistical models and deterministic crop-simulation models implies more generally that climate impacts may be much worse than previously thought.”
Mining groundwater
Janet Pelley

News that the global population passed the 7 billion mark last October has focused attention on how to sustainably feed the burgeoning number of people. Among the factors limiting food production, perhaps none is as critical as water. Now, a new study (Water Resour Res 2012; doi:10.1029/2011WR010562) finds that 20% of the water used for irrigating crops is non-sustainable.

“Irrigation is responsible for about 70% of global water withdrawals, yet no previous estimates of how much irrigation water comes from renewable and non-renewable sources were available”, says Yoshihide Wada, a hydrogeologist at Utrecht University (Netherlands). Water for irrigation is considered renewable when the water withdrawn is replaced by rainfall either refilling surface water bodies or percolating down to aquifers. But when groundwater withdrawals exceed groundwater recharge, farmers can deplete aquifers to critically low levels.

Earlier studies quantified regional examples of groundwater exploitation, but the new study is the first to estimate the worldwide scale of the problem. Wada and his colleagues used a global hydrological model to simulate the amount of groundwater recharge across the globe and combined that with statistics measuring groundwater withdrawals to estimate the amount of groundwater for irrigation that comes from non-renewable sources.

Their analysis revealed that the biggest users of non-renewable groundwater for irrigation are India, Pakistan, the US, Iran, China, Mexico, and Saudi Arabia. When Wada reconstructed the trend of groundwater withdrawals for irrigation, he found that unsustainable use almost tripled, from 75 to 234 cubic km of water, between 1960 and 2000. “Further abstraction of non-sustainable groundwater will result in a lower groundwater level, thus becoming unreachable for local farmers with limited technology, casting large uncertainties on their livelihoods, and threatening regional and global food security”, according to Wada.

“We have to either find new sustainable sources of water or change what we do with our water to get more crop per drop”, says Peter Gleick, President of the Pacific Institute, a non-partisan research institute in Oakland, CA. Solutions include improving the efficiency of irrigation methods and growing crop varieties that require less water, he explains. Meat production requires an enormous amount of water, and thus large-scale adoption of a vegetarian diet by people who are willing to do so could also help farmers divert more of their crop for direct human consumption while using less water. “There are all sorts of efforts underway to grow more food with less water”, concludes Gleick.

Glad tidings for green sea turtles
Adrian Burton

Figures released by the Philippines Department of Environment and Natural Resources (DENR) show that in 2011 the tiny island of Baguán – located northeast of Borneo but part of the Philippines – logged a record 14 220 green sea turtle (Chelonia mydas) nests, in which about 1.44 million eggs were laid.

Achieved by roughly 2844 female turtles, some of which may have come ashore on five separate occasions to lay 100 eggs each time, the 2011 figures easily outstrip the previous record of 12 331 nests observed in 1995. The totals are all the more surprising given that Baguán’s beach, where the turtles nest, is only about 1 km long. With a 90% hatching rate and a 1% rate of survival to sexual maturity, these 1.44 million eggs could increase the adult green sea turtle population by 13 000.

These numbers are good news for this endangered species, which has suffered from the overharvesting of its eggs, poaching, habitat destruction, and poor enforcement of protection laws. Long migrations between its feeding and reproductive grounds also leave the turtles exposed to risks. Indeed, in 2003, only 4000 nests were recorded on Baguán; the new record is therefore a welcome upturn in the species’ fortunes.

The success of 2011 may in large part reflect the efforts of the DENR, the local government, the Malaysian Sabah Parks Department, and Conservation International in protecting turtles on the nine islands that make up the Turtle Islands Protected Heritage Area, of which Baguán is part. “These efforts included delineating absolute protection and no-take areas around Baguán; training wardens, local volunteers, and the local police; and stepping up the protection offered by the Philippines military”, explains Corina Bernabe, Communications Coordinator, Conservation International Philippines (Manila).

“These numbers suggest that Baguán could serve as a model for conserving other populations of marine turtles across the globe”, says Jesse Senko, a marine conservation biologist and sea turtle researcher at Arizona State University (Tempe). “While this is great news, continued protection of nesting beaches and mitigation of in-water threats, such as bycatch in fisheries, are needed to maintain these trends.”
An Australian resistance movement
Pete Mooreside

Like much of Australia’s endemic fauna, the charismatic bluetongue lizard (Tiliqua spp) – a large omnivorous skink – has been jeopardized by the infamous non-native cane toad (Rhinella marina or Bufo marinus). Typically toxin-sensitive, any chunky bluetongue unlucky enough to consume this bufotoxin-rich toad rarely survives the event. For the skink, however, this isn’t necessarily a species-level death sentence, given that chemical tolerance may arise in predators whose distributions overlap with those of their poisonous prey. Indeed, although some bluetongues now appear resistant to cane toad toxins, field scientists have noticed something peculiar – this resistance extended to toad-occupied portions of the bluetongues’ current range (Am Nat 2012; doi:10.1086/664184). “What really astonished me was the resistance of the New South Wales bluetongues – because they and their ancestors had never encountered toads, it couldn’t be a simple case of adaptation to the toads themselves”, remarks Richard Shine (School of Biological Sciences, University of Sydney, Australia), one of the study’s coauthors.

As it turns out, the most likely explanation is that the toad-tolerant skink populations previously stumbled upon another toxic invasive species – an herbaceous plant, native to Madagascar, known as mother-of-millions (Bryophyllum spp). In an elegant instance of convergent evolution, in which unrelated species develop similar adaptive traits, the cane toad and the herb possess nearly identical versions of bufadienolide – a defensive compound used by each organism to discourage predation or herbivory, respectively. Over time, after gaining tolerance to the plant toxin via natural selection, generations of herb-consuming bluetongues surviving beyond the toad invasion front may have become physiologically “pre-adapted” to the toad toxin.

So, through a twist of evolutionary fate, a former plant invasion appears to have equipped a native reptile to better withstand a subsequent amphibian invasion. Could invasive species management in today’s world be any less challenging? Concludes Shine, “To understand the effect of cane toads, you have to see conservation problems in a broader perspective – incorporating the possibility of interactions between species that, at least at first sight, seem to be completely unaffected by each other. Our study shows just how complicated the jigsaw of conservation can be.”

Great Barrier Reef “on ice”
Claire Miller

Coral sperm and embryonic cells collected from Australia’s Great Barrier Reef (GBR) have been deep-frozen and stored at a zoo in the Australian outback, in case they may be needed in the future to rebuild a natural wonder under threat from coastal pollution and climate change.

Project director Rebecca Spindler (Taronga Zoo, Sydney, Australia) said that while the GBR was still relatively healthy, it was important to bank its genetic diversity now, before it suffered from the diseases, pollution, and warming water that is causing reefs elsewhere to disappear. “We know that these threats are imminent and we will never have more genetic diversity there than we do right now. So it’s imperative that we start to save that down now”, she explained.

The Reef Recovery Initiative is a collaboration of the Australian Institute of Marine Science, the Smithsonian Institute, Melbourne’s Monash University, and the Taronga Zoo. It is the first attempt in Australia to apply technology developed by the Smithsonian’s Mary Hagedorn for Caribbean and Hawaiian reefs.

The initial goal is to show that the technique works for two common and important reef-building staghorn species, Acropora millepora and Acropora tenuis. To maximize the amount of gametes collected, scientists cut away sections of reef last November, just before the coral was due to spawn for three nights after the full moon. The sections were taken to land-based tanks to spawn, and then returned – literally glued back into place.

The roughly 70 billion coral sperm and 22 billion embryonic cells are now stored in liquid nitrogen at −196°C in the “Frozen Zoo” at the Western Plains Zoo in Dubbo, Australia, 1700 km away from the reef’s balmy tropical waters in an arid location better known for its free-ranging menagerie of giraffes, elephants, and rhinos.

The coral sperm and embryonic cells are being studied as part of an international, multidisciplinary effort to work through the challenges of thawing gametes, fertilizing eggs, and raising coral larvae.

“There are several roadblocks still, in terms of the biology and understanding how to get from that point through to a living, thriving community on the reef”, said Spindler. “But we have every confidence that we will be able to knock down those roadblocks and be successful in re-establishing and re-seeding parts of the reef whenever it is needed.”

However, reefs destroyed by climate change could only be re-established once ocean temperatures have been lowered and acidification reversed.