LETTERS

Killer whales (*Orcinus orca*) are vulnerable to environmental pollutants.

Edited by **Jennifer Sills**

Pollution threatens toothed whales

In their Report "Ancient convergent losses of *Paraoxonase 1* yield potential risks for modern marine mammals" (10 August, p. 591), W. K. Meyer *et al.* show that marine mammals are particularly vulnerable to adverse health effects from organophosphorus pesticide pollution because of a functional loss of the primary mammalian metabolic defense mechanism—the *Paraoxonase 1* gene. Unfortunately, this finding is just one example of an evolutionary deficiency that puts marine mammals at increased risk for modern-day pollution.

Toothed whales, which originated in the mid-Eocene from herbivorous artiodactyls (cloven-hooved land mammals) (*1*), also show a reduced metabolic ability to eliminate persistent environmental pollutants such as biomagnifiable polychlorinated biphenyls (PCBs) compared with carnivorous predators such as polar bears (*Ursus maritimus*), seals and walruses, and humans (*2*, *3*). Because they lack the ability to filter these chemicals, extreme concentrations of PCBs and mercury have been found in high trophic-feeding cetaceans, including killer whales (*Orcinus orca*) (*4*, *5*). Moreover, toothed whales lack the keratinous pollutant sequestration routes, such as hair, that relieve carnivorous marine mammals from their contaminant burden, including mercury (*5*).

Given the vulnerability of marine mammals, global regulation and remediation of harmful marine pollutants, including organophosphorus compounds and PCBs, should be urgently prioritized by the United Nations Environment Programme, the Stockholm Convention, and the U.S. Environmental Protection Agency (*6*, *7*). Failing to protect these cetaceans could lead to pollution-mediated population collapses (*8*, *9*) and an irreversible loss of biodiversity and ecosystem services.

Christian Sonne,[1]* Paul D. Jepson,[2] Jean-Pierre Desforges,[1] Aage K. O. Alstrup,[3] Morten T. Olsen,[4] Igor Eulaers,[1] Martin Hansen,[1] Robert J. Letcher,[5] Melissa A. McKinney,[6] Rune Dietz[1]

[1]Aarhus University, Roskilde, Denmark. [2]Institute of Zoology, Zoological Society of London, London, UK. [3]Aarhus University, Aarhus, Denmark. [4]University of Copenhagen, Copenhagen, Denmark. [5]Environment and Climate Change Canada, Carleton University, Ottawa, ON, Canada. [6]McGill University, Ste-Anne-de-Bellevue, QC, Canada.
*Corresponding author. Email: cs@bios.au.dk

REFERENCES

1. J. G. M. Thewissen *et al.*, *Nature* **450**, 20 (2007).
2. M. A. McKinney *et al.*, *Environ. Toxicol. Chem.* **30**, 7 (2011).
3. S. Kim *et al.*, *Genome Biol.* **17**, 211 (2016).
4. R. J. Letcher *et al.*, *Sci. Total Environ.* **408**, 2995 (2010).
5. R. Dietz *et al.*, *Sci. Total Environ.* **443**, 775 (2013).
6. A. M. Milner, I. L. Boyd, *Science* **357**, 1232 (2017).
7. R. J. Law, P. D. Jepson, *Science* **356**, 148 (2017).
8. P. D. Jepson, R. J. Law, *Science* **352**, 1388 (2016).
9. P. D. Jepson *et al.*, *Sci. Rep.* **6**, 18573 (2016).

10.1126/science.aav2403

Good governance for migratory species

In their Policy Forum "Preparing ocean governance for species on the move" (15 June, p. 1189), M. L. Pinsky *et al.* discuss the need to cooperatively govern fisheries affected by climate change. This idea is not new to Pacific Island states, which supply 30% of the global tuna catch (*1*). The Parties to the Nauru Agreement (PNA) (*2*) provide a shining example of how to equitably share the benefits from fishing for skipjack tuna, which move not only among the exclusive economic zones (EEZs) of the island countries but also in response to climate (*3*). The PNA's "vessel day scheme" (VDS) (*4*) was developed explicitly to cooperatively manage these highly migratory tuna species within the combined EEZs of the PNA members.

The cap and trade VDS sets the total annual purse-seine fishing effort at ~45,000 days (i.e., fishing by all vessels must add up to no more than the ~45,000 days mandated for the year) and allocates the days to PNA members based on the past 7 years of catch history. The VDS provides a trading mechanism among PNA members, allowing them to respond to the profound effects of the El Niño Southern Oscillation on the prime fishing grounds for skipjack tuna (*3*). During La Niña episodes, the best catches are made toward the west of the region (*3*, *5*). During El Niño events, fishing is most efficient up to 4000 km to the east (*5*). During La Niña events, countries in the west buy days from members in the east to enable fleets to keep fishing in their EEZs. The reverse occurs during El Niño episodes. Thus, regardless of where the fish are caught, all PNA members receive license revenue. The stock for skipjack tuna has remained robust under this cooperative arrangement (*6*).

The VDS is also designed to govern the fishery as skipjack tuna redistribute to the east due to climate change (*7*, *8*). Over time, PNA members located in the east

will progressively accumulate a greater catch history and receive more days. Cooperative arrangements will need to be more common as climate change drives shifts in species distribution, and the Pacific Islands are leading the way.

Transform Aqorau,[1,2,3] Johann Bell,[3,4*] John N. Kittinger[4,5]
[1]iTUNA Intel and Pacific Catalyst, Honiara, Solomon Islands. [2]School of Government, Development, and International Affairs, University of the South Pacific, Suva, Fiji. [3]Australian National Centre for Ocean Resources and Security, University of Wollongong, Wollongong, NSW 2522, Australia. [4]Center for Oceans, Conservation International, Honolulu, HI 96825, USA. [5]Julie Ann Wrigley Global Institute of Sustainability, Center for Biodiversity Outcomes, Arizona State University, Tempe, AZ 85281, USA.
*Corresponding author.
Email: jbell@conservation.org

REFERENCES

1. Pacific Islands Forum Fisheries Agency, "FFA economic and development indicators and statistics 2016" (2016); www.ffa.int/node/1877.
2. PNA Tuna, Nauru Agreement (2010); www.pnatuna.com/content/nauru-agreement.
3. P. Lehodey *et al.*, *Nature* **389**, 715 (1997).
4. PNA Office, Purse Seine Vessel Day Scheme (Majuro, Parties to the Nauru Agreement Office, 2011).
5. P. Lehodey *et al.*, in *Vulnerability of Tropical Pacific Fisheries and Aquaculture to Climate Change*, J. D. Bell *et al.*, Eds. (Secretariat of the Pacific Community, Noumea, New Caledonia, 2011), chap. 8.
6. Pacific Islands Forum Fisheries Agency, "Tuna fishery report card 2017" (2017); www.ffa.int/system/files/Tuna_fishery_report_card_2017.pdf.
7. J. D. Bell *et al.*, *Nat. Clim. Change* **3**, 591 (2013).
8. J. D. Bell *et al.*, in "Impacts of climate change on fisheries and aquaculture," M. Barange *et al.*, Eds. (FAO Fisheries and Aquaculture Technical Paper 627, Rome, 2018), chap. 14; www.fao.org/3/I9705EN/i9705en.pdf.

10.1126/science.aav2051

TECHNICAL COMMENT ABSTRACTS

Comment on "U-Th dating of carbonate crusts reveals Neandertal origin of Iberian cave art"

Ludovic Slimak, Jan Fietzke, Jean-Michel Geneste, Roberto Ontañón

Hoffmann *et al.* (Reports, 23 February 2018, p. 912) report the discovery of parietal art older than 64,800 years and attributed to Neanderthals, at least 25 millennia before the oldest parietal art ever found. Instead, critical evaluation of their geochronological data seems to provide stronger support for an age of 47,000 years, which is much more consistent with the archaeological background in hand.

Full text: dx.doi.org/10.1126/science.aau1371

ERRATA

Erratum for the Report "Precursors of logical reasoning in preverbal human infants" by N. Cesana-Arlotti *et al.,* *Science* **361**, eaav4136 (2018). Published online 21 September 2018; 10.1126/science.aav4136

OUTSIDE THE TOWER

Science outreach in the Borneo jungle

A group of high school students at a remote school in the Borneo jungle surrounded my outreach team. They asked us to autograph their books, friend them on Facebook, and pose with them for selfies, all smiles and excitement as we set up for a farewell chemistry show 8000 km from our home in New Zealand.

Three days before, we had spent 5 hours on a boat to reach the boarding school at Balleh. The indigenous Iban students and their teachers live at the school during the week and spend only weekends with their families. Our host, a teacher training college in Kuching, had invited us to forge a partnership with the Balleh school. To make it work, we knew that we would have to overcome language and cultural barriers. Throughout the activities, we encouraged the teachers to participate by asking them to translate important words into Malay and Iban and help us with pronunciation. Although the 200 students were accustomed to book-focused lessons, we used humor and charm to encourage their participation in our hands-on activities. We showed them how to use local flowers and leaves as pH indicators and practiced measuring skills by finding the density of liquids and preparing acetate stalagmites for a class competition.

Call for submissions
Outside the Tower is an occasional feature highlighting scientists' advocacy experiences. Submit your advocacy story at http://cts.sciencemag.org.

As darkness descended on the final day, we began our show. "Oohs" and "aahs" echoed up into the night as we shared some of our favorite chemistry demonstrations. Afterward, the kids went off to bed chattering excitedly, and I sat down with the team, themselves buzzing with creative energy and already discussing plans to return next year.

This successful pilot visit marked the beginning of a 3-year partnership between the institutions. Otago volunteers learned to appreciate a variety of cultures as they worked with schools around Sarawak, the high school students experienced science and scientists in a different light, and their teachers benefited from workshops that helped them develop a new, more engaging, approach to their science teaching.

Dave Warren
Department of Chemistry, University of Otago, Dunedin, Otago 9054, New Zealand. Email: dwarren@chemistry.otago.ac.nz

10.1126/science.aat6367

PHOTO: DAVE WARREN

Students at a boarding school in Borneo conduct hands-on science experiments.

Good governance for migratory species

Transform Aqorau, Johann Bell and John N. Kittinger

Science **361** (6408), 1208-1209.
DOI: 10.1126/science.aav2051