

Sea otters are crucial to kelp-forest ecosystems.



ECOLOGY

The sea-otter whisperer

Jane Lubchenco applauds James Estes's chronicle of his 45 years studying the complexities of an apex predator.

The sea otter (*Enhydra lutris*) has had a turbulent history. A cultural icon for tribes living around the coast of the North Pacific Ocean, it became an irresistible target for fur traders who almost drove it to extinction, triggering an international hunting ban in 1911. Then, as the species began to recover in parts of its former range, it became a magnet for tourists, a symbol of hope for marine conservation and the equivalent of Darwin's finches for one scientist: ecologist James Estes. Sea otters are now in decline again in most areas. Estes has relentlessly unpacked insights into the species' history and ecological complexities for more than four decades, in one of the most remote places on Earth.

In *Serendipity*, Estes chronicles that research — in Alaska's Aleutian Islands and beyond — on this relatively small marine mammal, its voracious appetite for crabs, clams, fish and especially sea urchins, and its consequent ability to control the very presence or absence of entire kelp forests and their inhabitants.

In his refreshingly honest and humble narrative, Estes shares the intriguing insights that he gained through careful observation, intentional perturbations of environmental conditions, long-term monitoring, rigorous analysis, willingness to collaborate and openness to new ideas. He acknowledges the often circuitous pathways and serendipitous events

that yielded new ideas to test. For example, he relates a pivotal conversation with ecologist Robert Paine, who coined the concept of keystone species, which have a disproportionately large effect on their ecosystems (see *Nature* 493, 286–289; 2013). That led Estes to pose what would become the defining question of his career — ‘What impact do sea otters have on kelp forests?’ — rather than his initial query, ‘What impact do kelp forests have on sea otters?’

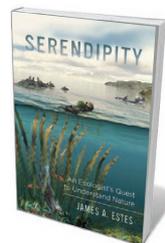
The study of top-down control of an ecosystem by an apex predator and the use of perturbations to test ecological hypotheses were in their infancy in the 1970s, when Estes began his Alaska studies. The Aleutian otters' ongoing recovery from near-extinction provided the perfect mosaic of conditions: in some places, there were many otters; in others, there were few; and in yet others, otters were still absent. Estes' early work demonstrated conclusively that otters in Alaska did control much of the rest of the near-shore community by eating sea urchins, the primary consumers of kelps, and controlling

their abundance. Where otters are present, so too are kelp forests and the plethora of other species (fish, crabs, starfish, mussels, snails, seals, seaweeds, birds and more) that depend on the plants for habitat or food. Where otters are absent, urchins thrive, gobble up kelp and keep the seascape barren.

Estes and his colleagues went on to demonstrate multiple aspects of ‘trophic cascades’, in which an apex predator's influence ripples through the food web through complex, indirect interactions. Thanks to the team's work, we know that the diets of gulls and bald eagles, the abundance of fish, the growth of mussels and the size and abundance of starfish are all strongly influenced by the presence or absence of otters in Aleutian kelp forests.

Some of the most intriguing ideas that emerged from Estes's studies focus on the surprising and precipitous decline of Aleutian sea otters that began in the early 1990s. Observations of increasing numbers of killer whales, or orcas (*Orcinus orca*), and of killer whales preying on otters, coupled with calculations about otter demography and killer-whale energetics, led to a startling suggestion by Estes and his colleagues: predation by killer whales was driving down otter populations. The team's subsequent hypothesis was even more surprising.

Realizing that something must have changed in the open sea to drive killer whales from their normal oceanic habitats to coastal



Serendipity: An Ecologist's Quest to Understand Nature
JAMES A. ESTES
University of California Press: 2016.

FRANCOIS GOHIER/VWPICS/ALAMY

ones, Estes and his colleagues began to consider broader-scale events in space and time. They knew that after the Second World War, intense industrial whaling in the North Pacific Ocean had reduced whale biomass 'sevenfold to eightfold', up until implementation of the international ban on commercial whaling in the late 1960s and early 1970s. They reasoned that if killer whales had previously fed on great whales, the demise of the latter might have forced killer whales to forage more widely and switch to alternate prey.

Piecing together data from the seas up to 370 kilometres around the Aleutian archipelago, they presented a compelling hypothesis of sequential collapses that spanned four decades. First, great-whale populations plummeted because of whaling. Then, killer whales switched to and decimated first one species, and then another, causing the collapse of populations of harbour seals (*Phoca vitulina*), then Steller sea lions (*Eumetopias jubatus*) and finally sea otters. This 'mega-faunal collapse hypothesis', articulated by Estes, Alan Springer and their colleagues, was not received warmly by some scientists who had been studying individual species, but evidence for it continues to mount. Moreover, these ideas raise more intriguing questions: as at least some great whales recover from decimation by whaling, what will killer whales prey on? And what will then happen to seals, sea lions, otters and kelp-forest communities? Let us hope that Estes will continue to provide insights.

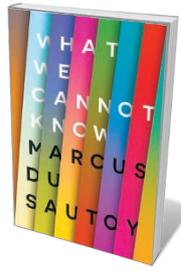
Many of the findings in the book, especially the early ones, are classics of ecology. For non-specialists, Estes's account is a fascinating introduction to key ecological concepts. For the cognoscenti and for students seeking understanding of how science actually works, *Serendipity* is an honest, behind-the-scenes peek at what really happened in the Aleutians and the Pacific more broadly, and what a now-esteemed scientist was thinking and feeling along the way. A rare and delightful insight into timely science. ■

"This relatively small marine mammal has an ability to control the very presence or absence of entire kelp forests."

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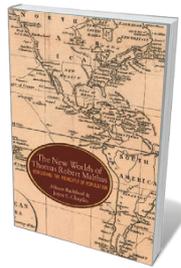
The views expressed are solely those of the author and not necessarily those of the US Department of State.

Books in brief



What We Cannot Know: Explorations at the Edge of Knowledge
Marcus du Sautoy FOURTH ESTATE (2016)

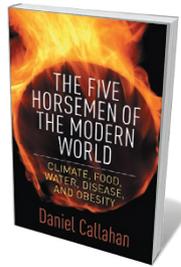
Science bristles with 'known unknowns', from dark matter to the origins of life. But are some of these conundrums unknowable? In this finely synthesized study, mathematician Marcus du Sautoy explores the edges of our understanding in maths, mind and beyond. Each spiralling investigation begins with an object: casino dice kick-start a foray into probability; a wristwatch propels us into grappling with time. A dazzling journey, vivified by conversations with the likes of neuroscientist Christof Koch on psychophysics and cosmologist Max Tegmark on the mathematical Universe.



The New Worlds of Thomas Robert Malthus: Rereading the Principle of Population

Alison Bashford and Joyce E. Chaplin PRINCETON UNIVERSITY PRESS (2016)

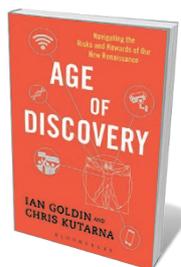
"For more than two hundred years, people have loved to hate Thomas Robert Malthus," declare historians Alison Bashford and Joyce Chaplin. In their penetrating reappraisal of the philosopher's *Essay on the Principle of Population*, first published in 1798, they argue that his theory of population growth outstripping agricultural production has been decontextualized. He was less a critic of the English poor than of a swelling European population in his era of colonization, and its impact on people in the New World.



The Five Horsemen of the Modern World: Climate, Food, Water, Disease, and Obesity

Daniel Callahan COLUMBIA UNIVERSITY PRESS (2016)

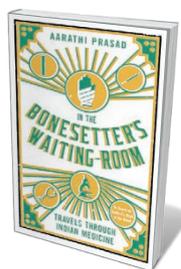
In this trenchant treatise, bioethicist Daniel Callahan investigates why five global issues — water and food shortages, climate change, disease and obesity — remain intractable, despite the billions of dollars thrown at them. Callahan examines cross-cutting problems such as an ageing population, and analyses the role of policy and governance. To ramp up the "intensity level" needed for solutions, he envisions coordinated efforts by grass-roots activists, corporations and national and international agencies. Pragmatic and measured.



Age of Discovery: Navigating the Risks and Rewards of Our New Renaissance

Ian Goldin and Chris Kutarna BLOOMSBURY INFORMATION (2016)

The grit and glory of the Renaissance is mirrored in our own age, from looming risks such as pandemics to the transcendent genius needed to overcome them. So aver globalization expert Ian Goldin and political scientist Chris Kutarna in this bold mega-analysis of global education, health, prosperity and technology, then and now. Their parsing of revolutions — from the introduction of the Copernican principle to the digital explosion — is incisive and rich in context and granularity, but not every sweeping statement holds up.



In the Bonesetter's Waiting Room: Travels Through Indian Medicine
Aarathi Prasad PROFILE (2016)

Indian medicine is a complex landscape where six traditional systems jostle with Western biomedicine. Science journalist Aarathi Prasad's focused and fascinating journey through the intricacies takes her to Mumbai's sprawling slum Dharavi, where *sanghinis*, or female counsellors, help the hordes of local women subjected to rape and domestic violence. She also visits a clinic that integrates Western labwork with ancient Ayurvedic practice; a project mixing paediatric eye surgery with neuroscience research; and much more. [Barbara Kiser](#)