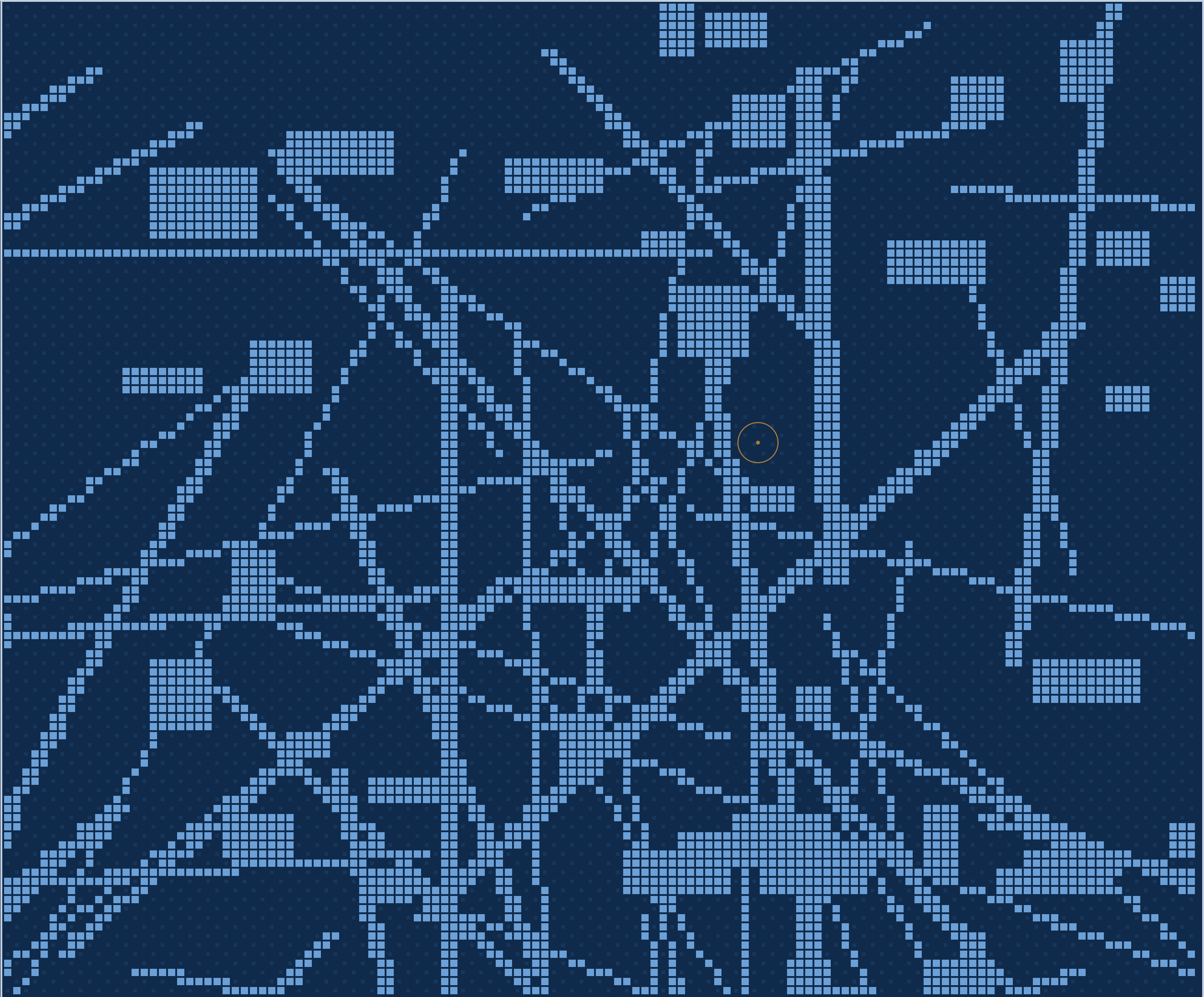




Why Nobody Knows How Much Ocean Is Unexplored

Is ninety percent of the ocean really unexplored?

§ 1	<i>Sourcing the claim</i>	<i>i</i>
§ 2	<i>One report carries two numbers</i>	<i>v</i>
§ 3	<i>The golden-ratio nautilus has the same problem</i>	<i>vii</i>

ARGO FLOATS STOP: 2 000 M

§ 4	<i>What are we truly measuring?</i>	<i>ix</i>
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MEAN DEPTH: 3 682 M

§ 6	<i>Mapping ≠ seeing</i>	<i>xv</i>
§ 7	<i>The published chart has no gaps, which is the problem</i>	<i>xvii</i>

DEEP ARGO, PLANNED: 6 000 M

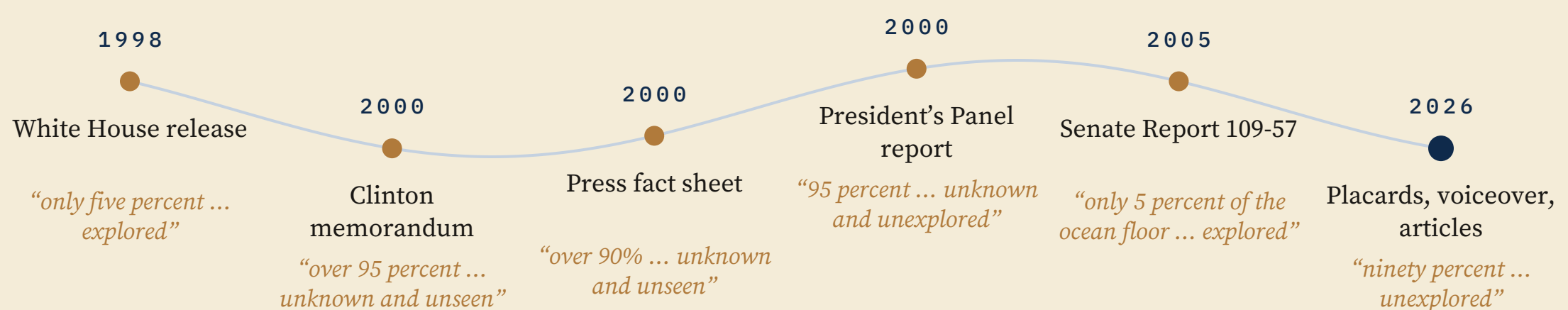
§ 8	<i>The water itself has no number</i>	<i>xix</i>
§ 9	<i>Writing the sentence to withstand scrutiny</i>	<i>xx</i>

“Until recently, we knew more about the surface of the moon than the ocean floor.”

THE WHITE HOUSE, OFFICE OF THE PRESS SECRETARY, 12 JUNE 1998

*Ninety percent of the ocean
is unexplored.*

DEPTH CONTOURS, CRISP WHERE A SHIP HAS PASSED AND INFERRED EVERYWHERE ELSE

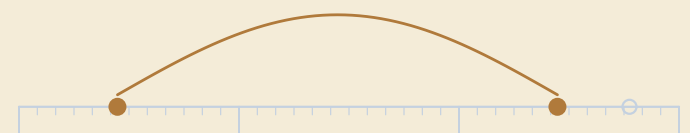


I'm sure you've heard the claim that "Ninety percent of the ocean is unexplored." It often appears on museum placards, is a staple of ocean documentary narration, and shows up in U.S. Senate committee reports from 2005 to 2022. Most articles about the deep sea begin with that number, whether they want to or not. This number has always puzzled me, especially now that my sister may pursue marine biology, and I still haven't seen it cited.

So, I went looking for one. I expected a study. Failing that, I expected a press release summarizing a study. What I found was a press release summarizing a memorandum summarizing an earlier press release, and then nothing. Meaning, the sad truth about this claim is that it really hasn't been confirmed... ever.

By the end of this paper I will have shown that the above claim is true, false, and a serious understatement, depending on which of three quantities you take it to mean; that those three answers differ by four orders of magnitude; and that every serious attempt to correct the figure has produced a new figure with the same defect. Honestly, that last part surprised me. Every number here is sourced in the notes at the end of this paper. Last but certainly not least, please feel free to debate any of the figures or the reasoning.

So without further ado, welcome to the new and improved Rainforest!



§ 1 SOURCING THE CLAIM

The President's Panel on Ocean Exploration released its report “Discovering Earth's Final Frontier: A U.S. Strategy for Ocean Exploration” on 10 October 2000. The opening paragraph of its executive summary ends, “Despite these gains, 95 percent of the oceans remain unknown and unexplored.” That sentence carries no footnote/citation whatsoever despite the oceanic expertise of the panel: Marcia McNutt (a geophysicist who ran the Monterey Bay Aquarium Research Institute) chaired it; Robert Ballard (the oceanographer who found the wreck of the Titanic), Sylvia Earle (a marine biologist and former NOAA chief scientist), and Larry Mayer (a seafloor-mapping scientist at the University of New Hampshire) served on it; and Mayer will matter again below. Here was a national strategy on ocean exploration with an explicit headline number and zero citations anywhere in its entire text. The document stands seventy-seven pages long, and twenty-two names are listed on its membership page.

It does repeat itself once within its own covers, however. Appendix A consists of the presidential memorandum that ordered this very report in the first place. It was dated 12 June 2000 and signed by President Clinton, who wrote therein, “over 95 percent of the underwater world is still unknown and unseen.” Zero citations. So the document's only internal support for its own headline figure is a copy of the order that asked for the document. The loop closes on itself in seventy-seven pages.

Those numbers disagree slightly the very same day. The White House Office of the Press Secretary issued a fact sheet the same day, summarizing Clinton's memorandum for reporters, and in that document the figure changes: “Even though the

10 OCTOBER 2000

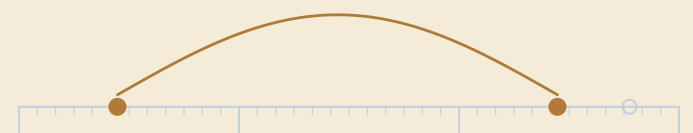
President's Panel on Ocean Exploration, “Discovering Earth's Final Frontier.” Seventy-seven pages. No bibliography, no reference section, no endnotes.

APPENDIX A

Presidential Memorandum, 12 June 2000: “over 95 percent of the underwater world is still unknown and unseen.”

12 JUNE 2000

White House fact sheet, same day: “scientists estimate that over 90% of our underwater world remains unknown and unseen.”



oceans cover 70% of the planet, scientists estimate that over 90% of our underwater world remains unknown and unseen.” And although I am nitpicking, 90 and 95 are very different percentages, as that five-point difference represents about 3.5 percent of Earth's entire surface.

The phrase “scientists estimate” is doing all of the evidentiary work in the version most reporters truly consume, and it names no scientist, nor estimate. This is why the claim circulates today in two incompatible versions, each of which can honestly say it came from the White House. Both are technically correct about where they came from; neither cites a primary source.

Those numbers diverge further still. A release titled “Exploring the Last U.S. Frontier” was issued by the same press office on 12 June 1998, during the National Ocean Conference in Monterey. It contains: “Oceans cover most of the Earth, yet only five percent of the ocean and sea floor have been explored. Until recently, we knew more about the surface of the moon than the ocean floor.”

Five percent explored is ninety-five percent unexplored. The claim in its modern form is already fully assembled in 1998, moon comparison included, and the 2000 documents are its second appearance rather than its first. The date is worth noting for another reason: Clinton revisited the same topic two years to the day after its previous iteration. The 2000 announcement was pegged to the second anniversary of the 1998 conference, which means the figure is partly an anniversary artifact. It was restated because a restatement was due.

Again.

90 and 95

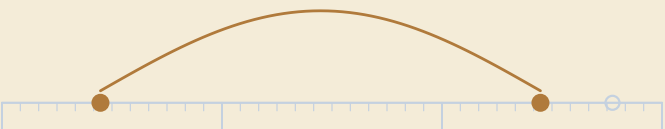
One press office, one morning, two numbers. Neither cites a source.

12 JUNE 1998

“Exploring the Last U.S. Frontier,” White House Office of the Press Secretary, during the National Ocean Conference in Monterey.

12 JUNE, TWICE

The 2000 memorandum marked the second anniversary of the 1998 conference.



Neither version cites anything. I could not get further back than 1998, and I want to be precise about why. The searchable record I had access to runs out there; however, the claim itself may not. Newspaper morgues, Google Books, and full-text archives were unavailable to me, so 12 June 1998 is the earliest instance I can demonstrate rather than the origin I can prove. I do not know when someone first wrote that exact figure down. If you can find an earlier one, I would love to see it. It would actually sharpen this section rather than break it.

That repetition laundered the original figure into history. The claim began as part of a technology-initiative handout from the Office of the Press Secretary, moved into a signed presidential memorandum in 2000, and from there into a formally transmitted national strategy, and that is the step that made it quotable for the next twenty-six years. At each stage the claim retained the same content while gaining progressively more prestige. Nothing about the sentence changed in those two years except its letterhead. None of these documents ever says which waters the headline figure covers, or at what resolution. That is odd, because one of them contains a sentence that says both.

EARLIEST FOUND

12 June 1998 is the earliest instance I can demonstrate. The origin is not.

THE LADDER

Handout, 1998 → memorandum, 2000 → national strategy, 2000 → Senate report, 2005.

THE MEMBERSHIP PAGE

PRESIDENT'S PANEL ON OCEAN EXPLORATION		
<i>Chair</i> DR. MARCIA McNUTT Monterey Bay Aquarium Research Institute	DR. FRED GRASLE Rutgers University	DR. JEFFREY STEIN Quorum Pharmaceuticals, Inc.
<i>Members</i> DR. VERA ALEXANDER University of Alaska, Fairbanks	DR. SUE HENDRICKSON Underwater Archaeologist	DR. GEORGE BOEHLERT* National Oceanic and Atmospheric Administration
MR. JESSE AUSUBEL Alfred P. Sloan Foundation	MS. PAULA KEENER-CHAVIS National Marine Education Association	DR. JOAN CLEVELAND* United States Navy
DR. ROBERT D. BALLARD National Geographic Society Institute for Exploration	DR. LARRY HAYER University of New Hampshire	DR. THOMAS CURTIN* United States Navy
MR. THOMAS CHANCE C & C Technologies, Inc.	DR. ARTHUR E. MAXWELL University of Texas, Austin	DR. ROBERT EMBLEY* National Oceanic and Atmospheric Administration
MR. PETER DOUGLAS California Coastal Commission	DR. WILLIAM J. MERRELL H. John Heinz III Center for Science, Economics, and the Environment	DR. ERIC LINDSTROM* National Aeronautics and Space Administration
DR. SYLVIA EARLE National Geographic Society Sustainable Seas Expedition	DR. JOHN MORRISON North Carolina State University	DR. MICHAEL PURDY* National Science Foundation
DR. JAMES ESTES University of California, Santa Cruz	DR. JOHN ORCUTT Scripps Institution of Oceanography	DR. MICHAEL REEVE* National Science Foundation
DR. DANIEL J. FORNARI Woods Hole Oceanographic Institution	DR. ELLEN PIKITCH University of California, Santa Cruz	DR. WILLIAM SCHWAB* United States Geological Survey
DR. ARNOLD L. GORDON Lamont-Doherty Earth Observatory, Columbia University	DR. SHIRLEY POMPONI Harbor Branch Oceanographic Institution	DR. MICHAEL SISENWIENE* National Oceanic and Atmospheric Administration
	MS. URSULA SEXTON National Science Teachers Association, Teacher of the Year	DR. RICHARD SPINRAD* United States Navy
		* Agency Science Advisor

THE REFERENCE SECTION



FIG. I Signatures and what they rest on.

The panel's membership page from the 2000 report, and the space its reference section would occupy. The document carries a headline number and zero citations.

§ 2 ONE REPORT CARRIES TWO NUMBERS

FIG. II *Media encounters.*

Two are facsimiles of the report itself: the sentence on page 1, which cites nothing, and the sentence on page 15, which names a jurisdiction and a standard. The other four are the documents the figure passed through on its way to being quotable.

This brings us to my first major point about the claim: its popularization conflates two different numbers. Page fifteen of the 2000 document, in a chapter about mapping priorities, states, “For example, less than five percent of the total U.S. EEZ has been mapped in high-resolution.” That sentence refers specifically to the Exclusive Economic Zone, the belt of ocean a country controls out to 200 nautical miles from its coast, and it refers specifically to high-resolution bathymetry. At the time of publication it was accurate and verifiable, and I can imagine a hydrographer contesting it, which is exactly what makes it a real claim.

So five percent and 95 percent occur together in one report. One is about American waters and one is about the whole ocean. One is about being mapped, and one is about being unknown. They sit fourteen pages apart, and they are never compared. Interestingly, they sum to one hundred, and I sus-

pect that is part of why the vague one felt like a measurement at all (or at least it is why it felt like one to me).

Then watch how the verbs work. Clinton's memorandum referred to an underwater world that remains unknown and unseen. The panel report, four months later, changed unseen to unexplored, and it named a different object: the oceans rather than an underwater world. This highlights a critical, temporally driven limitation of knowledge. Unexplored implies something far more measurable than unseen, and it is the word that sounds like somebody measured it.

By 2005 the Senate, having inherited the number, omits any mention of jurisdiction altogether: “only 5 percent of the ocean floor has been explored to date.” In one breath that sentence lost both the jurisdiction (U.S. waters only) and the resolution standard (high-resolution mapping) without altering any percentage. The underwater world has become the ocean floor, which is a different object with a different area. It borrowed credence from its neighbor's precision. You could not design a better trap on purpose.

THE UNDERWATER WORLD, A VOLUME

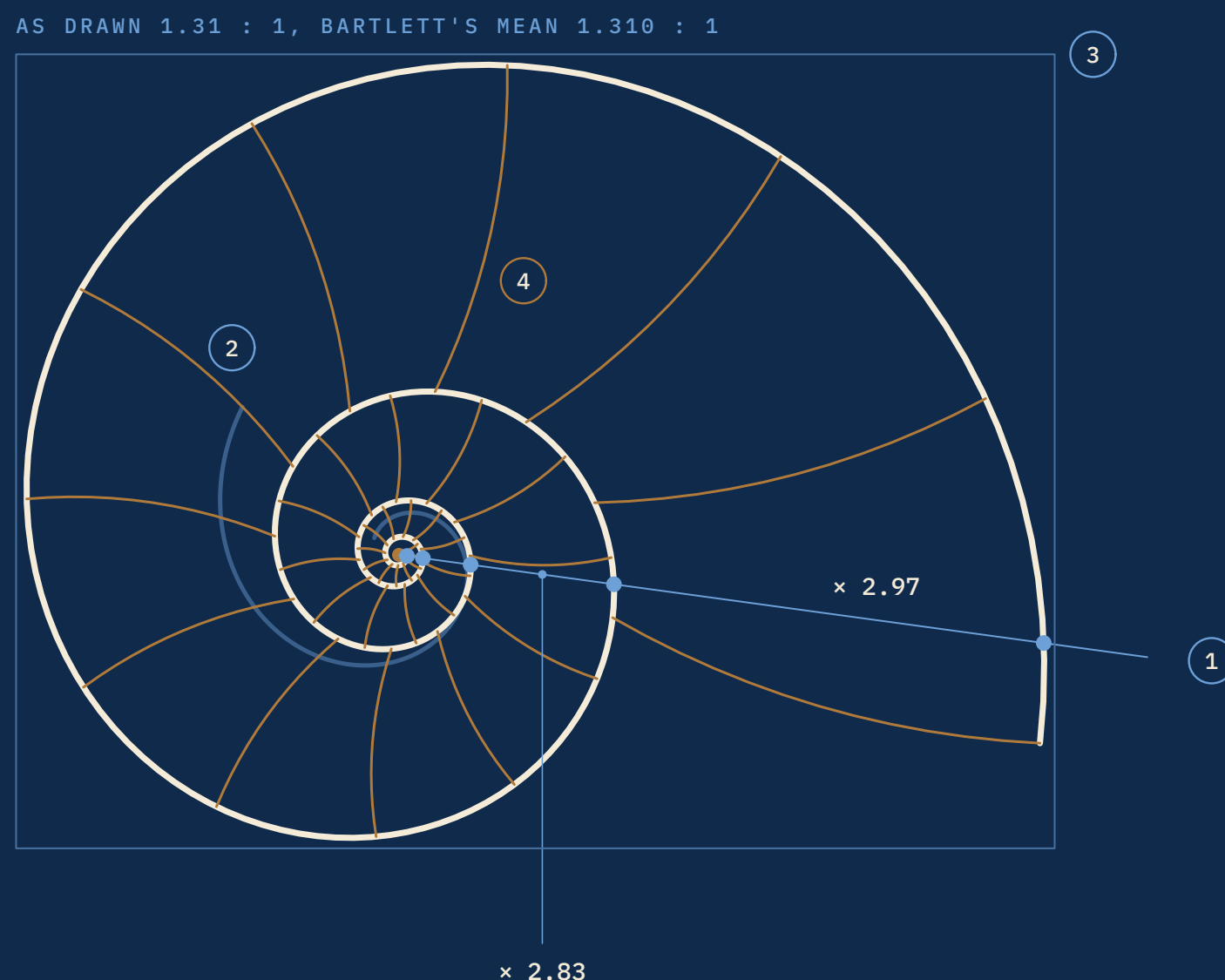
THE OCEAN FLOOR, A SURFACE



§ 3 THE GOLDEN-RATIO NAUTILUS HAS THE SAME PROBLEM

① Sharp, 2002. One specimen, four complete turns, measured along a ray: 2.95, 3.02, 2.83, 2.97. Mean 2.94.

③ Bartlett, 2018. Eighty shells from the Smithsonian, mean aspect ratio 1.310, “clearly not the widely quoted 4:3.”



② The golden spiral on the same axis. It widens by $\phi^4 = 6.854$ every turn; one turn of it already leaves the page.

④ Septa at equal angle: a logarithmic spiral, Moseley 1838, Raup 1961. True, and not the spiral everyone names.

FIG. III NAUTILUS POMPILIUS, DRAWN TO ITS OWN EXPANSION, WITH ITS NUMBERS WRITTEN ON IT

Now, I want to show the same failure in a field that has nothing to do with the ocean, because this is a category of error rather than an oceanographic accident. The golden-ratio nautilus is invoked everywhere in design philosophy and mathematical aesthetics. Textbooks illustrate it and seminars open with it. Yet the golden-ratio nautilus is a myth, and the arithmetic is easy. A golden spiral widens by a factor of ϕ^4 , which is 6.854102, with every full revolution. A nautilus widens by about three. John Sharp measured a specimen across four complete turns in 2002 and got 2.95, 3.02, 2.83 and 2.97, for an average of 2.94.

A logarithmic spiral nonetheless describes the shell, meaning it grows by a constant factor for every equal turn of angle. That part is true, and it is the lovely fact. Henry Moseley

established it in the *Philosophical Transactions* in 1838, and David Raup gave it its modern quantitative form in 1961. The shape has been in the literature for 188 years. However, it is simply not the particular logarithmic spiral everyone names.

But this is no case of fraud. Sharp names the fallacy exactly and calls it the most common misconception: “Spirals of shells, particularly the nautilus are logarithmic spirals. The Golden Section can be used to draw a logarithmic spiral. Therefore shell spirals are related to the Golden Section and in particular, the nautilus shell spiral is a Golden Section spiral.” A mathematically true attribute lies adjacent to an aesthetically beautiful one, lending credence to its neighbor's claim without actually having one. In this game of

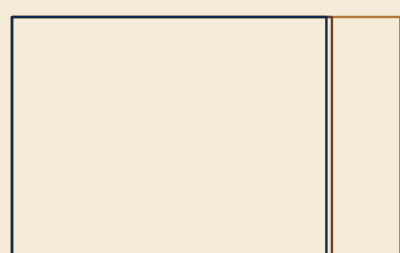


telephone, nobody lied; everyone just simply repeated.

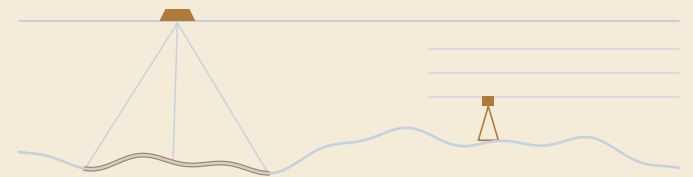
Nor am I exempt. Confession: In my original draft of this paper, I cited Clement Falbo's 1999 measurements of nautilus shells at the California Academy of Sciences, reporting ratios nearer 1.33 than 1.618. I can justify this decision, and it is what most of the debunking literature says, but on the best available evidence it was incorrect. In 2018, Christopher Bartlett measured eighty specimens in the Smithsonian's National Museum of Natural History collections. He calculated a mean aspect ratio of 1.310, writing that the genus “is clearly not the widely quoted 4:3 (1.333).”

Read that phrase again. Widely quoted. The number that debunks the golden ratio had itself become a widely quoted figure that needed debunking, inside thirteen years. And I should admit the second half of it, because it is worse: like almost everyone who cites Falbo, I was citing him through Ivars Peterson's 2005 summary in *Science News* rather than through the *College Mathematics Journal*, because the original is paywalled. I cited secondary literature one step removed from the primary source, in a paper about exactly this... and had not noticed. For lack of a better word, that was humbling, and the way it humbled me is the most useful thing in this paper.

Finally, one more point about provenance. In 2015, Paul Gailiunas went looking for the origin of the golden-ratio nautilus and found that Theodore Cook, the man usually blamed for it, explicitly disclaimed it, writing that the artist had no more “preconceived idea of using the ϕ proportions” than “the Nautilus had any conscious plan.” The earliest explicit connection between the shell and the golden rectangle that Gailiunas could find dates from the 1980s, and he suggests a misprint in a 1914 appendix may have seeded it. A claim sold as ancient natural harmony is younger than the Walkman, and it may descend from a typesetting error.



— THE GOLDEN RECTANGLE: 1.618
— THE WIDELY QUOTED 4:3 RATIO: 1.333
— BARTLETT'S MEAN OF EIGHTY SHELLS: 1.310



§ 4 WHAT ARE WE TRULY MEASURING?

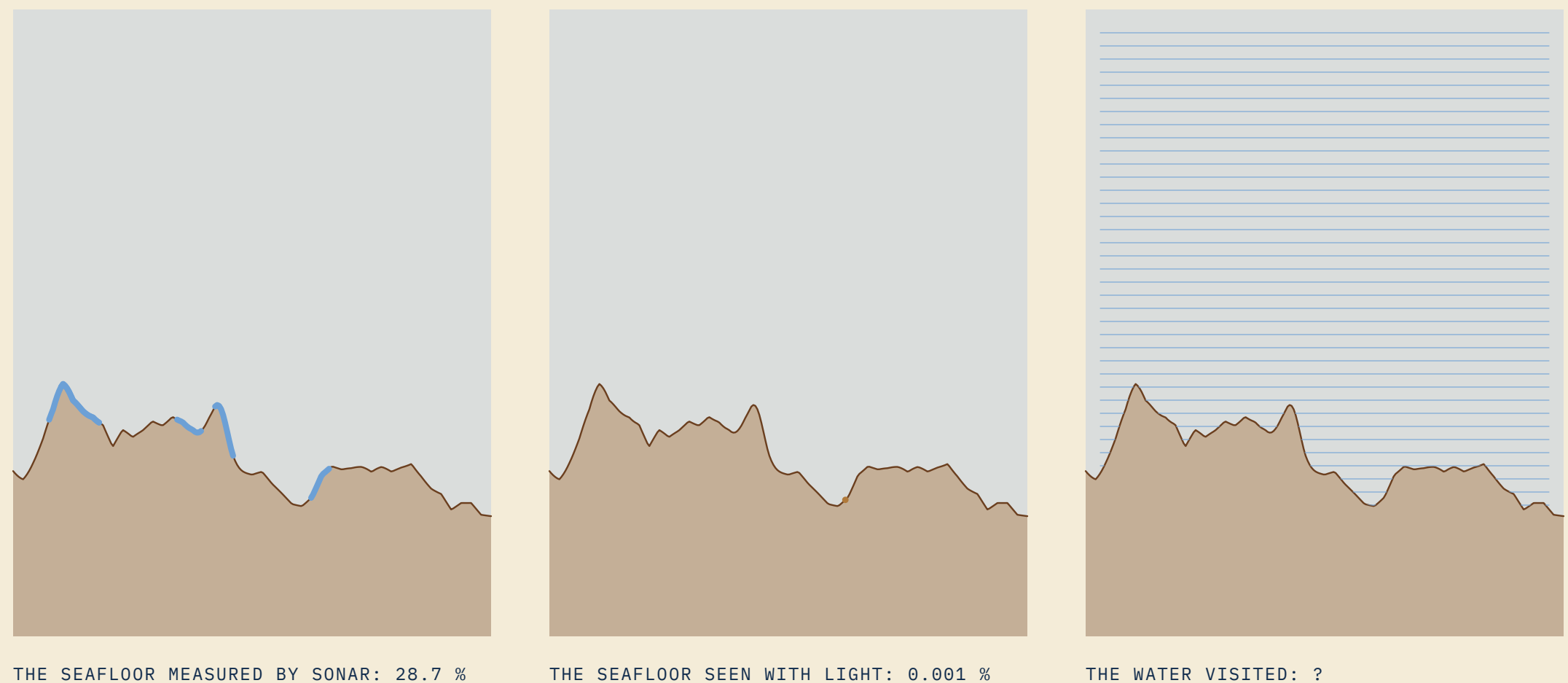


FIG. IV Sonar coverage and direct sight along one stretch of seafloor, and the water above it.

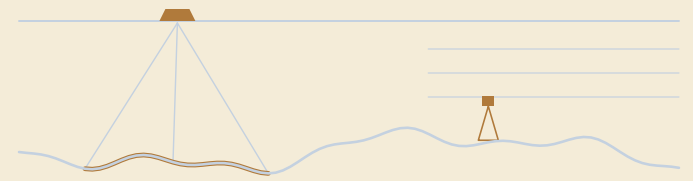
Left, the floor with the share measured by sonar marked along it. Middle, the same floor with the share anyone has seen: one point. Right, the water above it, which nobody has gridded and for which no number exists.

As humans, we have the beautiful ability to logically sort the world into categories. However, we often do so before we can talk about it, and we hold on to the categories long after they stop fitting. For example, the ocean gets sorted as a floor. But what kind of object is the sentence actually about? It concerns three entirely different questions that share the appearance of one quantity, and their answers differ by four orders of magnitude.

How much of the seafloor has been measured, by sonar, with sufficient resolution to fill a cell of a gridded map? That is a well-defined question about seafloor area, and we can answer it, because a bathymetric grid either holds a measured depth in a given cell or it does not. Bathymetric just means depth-measuring. You can count the cells.

How much of the seafloor has anyone ever actually looked at, with light, at close range? Again an answerable question about area, with a very different and very much smaller answer.

How much of the entire ocean has been visited at all? That is a question about volume in the water column, and it cannot be answered, because there is no grid of the water column and no agreed definition of a visit. It is also the one the 2000 memorandum and fact sheet came nearest to asking when they wrote unknown and unseen.



Confusing the first with the third is one of the mistakes we have made over the years, explaining why the statistics quoted outside marine science are so consistently inflated. It survives because the ocean gets discussed as though it were a floor. It is a floor with an average of 3,682 meters of water standing on top of it, and a great deal of what lives in the ocean lives in that water rather than on the bottom. Mapping the floor tells you about the floor.

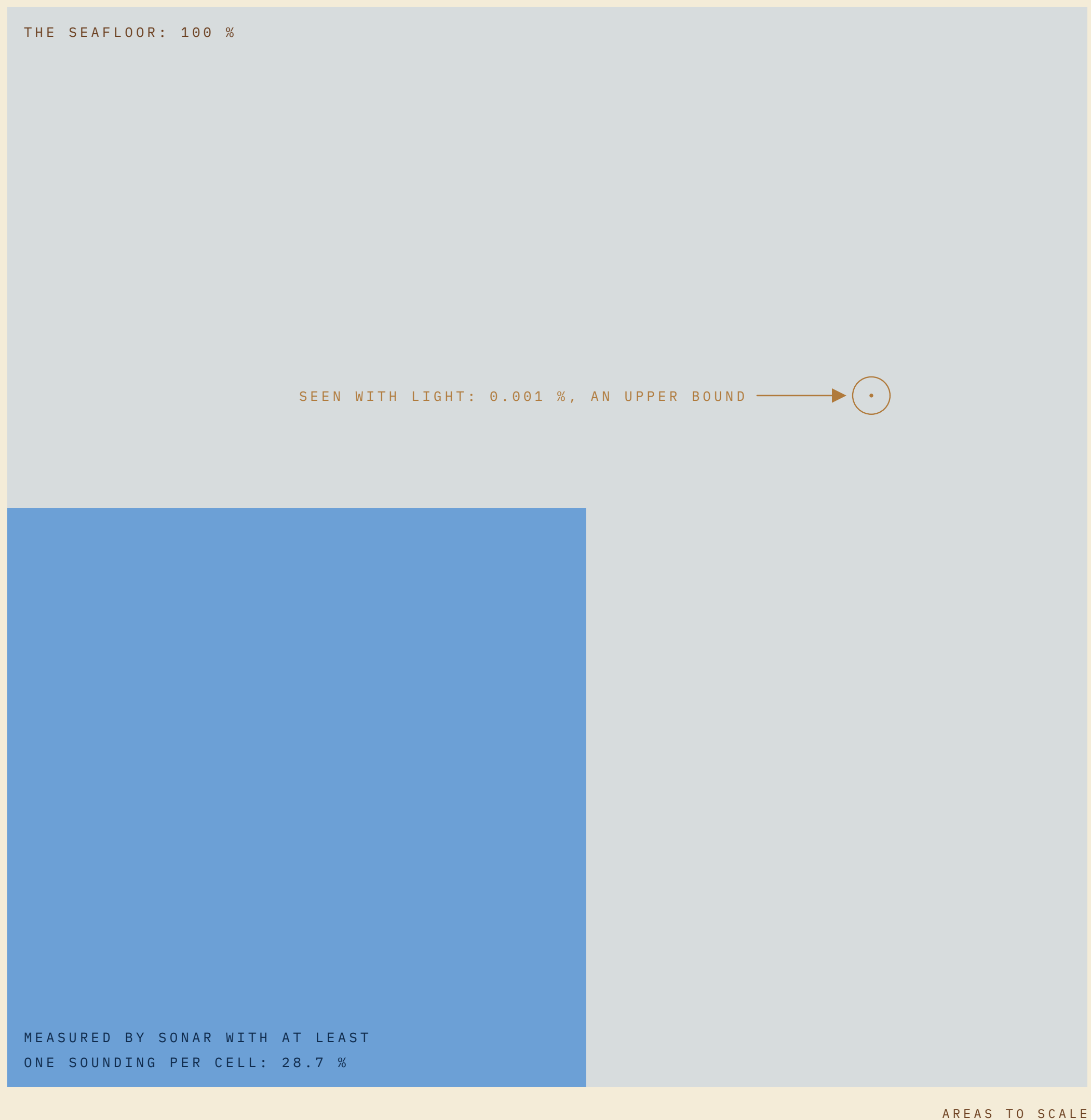


FIG. IV b *The two countable quantities, drawn at true area.*

The measured share of the seafloor and, to the same scale, the share anyone has seen. The third quantity, the volume visited, has no square to draw.



§ 5 WHAT IS “MAPPING”?

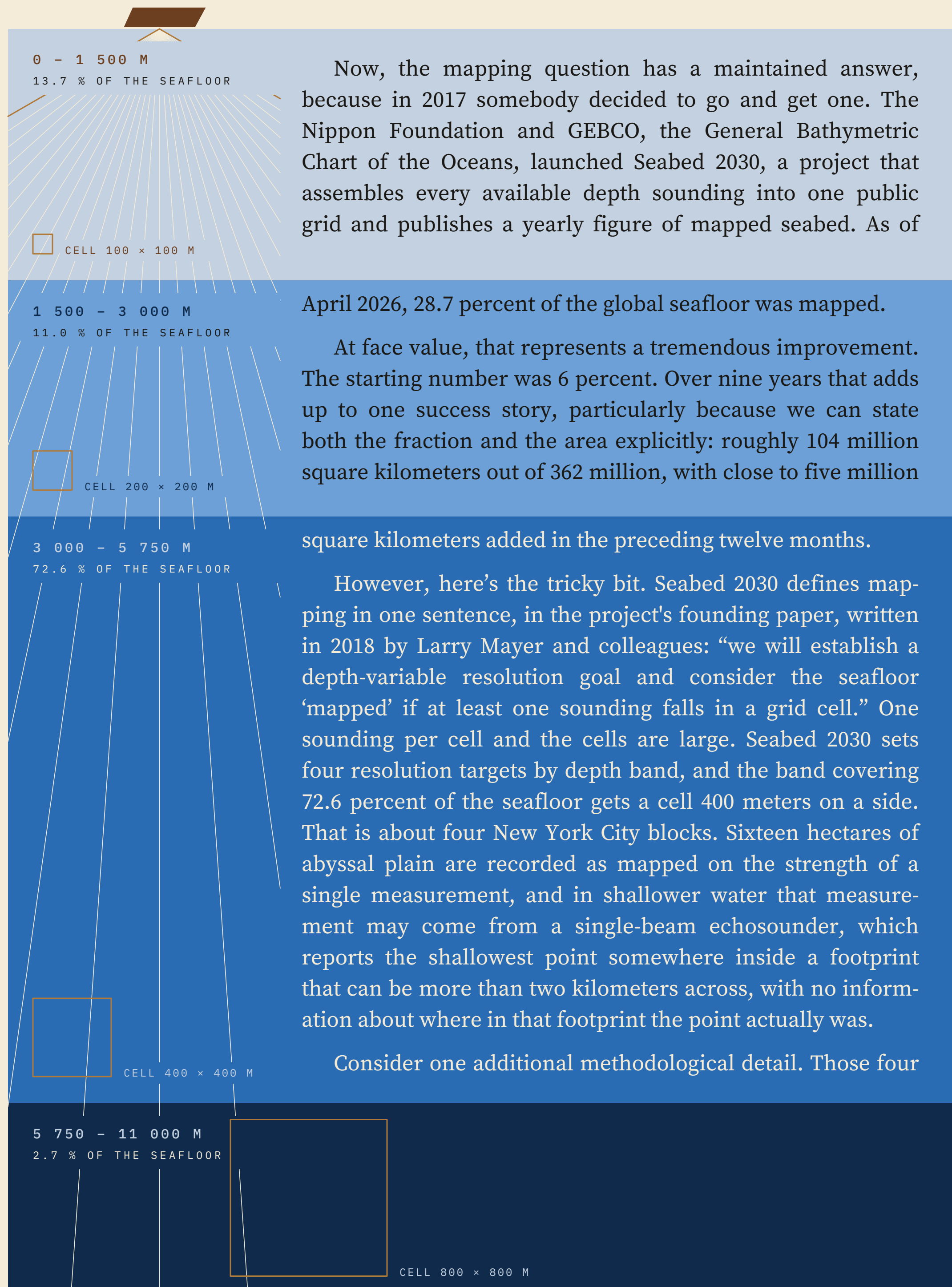


FIG. V Seabed 2030's four resolution targets, drawn to depth.

A two-degree multibeam at sixty degrees off nadir sweeps a swath about 3.5 times the water depth, so one pass of the same instrument covers eight times the cell in the abyss that it covers on the shelf. The target cell is what the physics allows rather than what the science wants.



cell sizes derive from physical capability rather than from scientific need. Mayer and colleagues state that they chose them from what a good ship's sonar can physically achieve at each depth, from the beam geometry of a two-degree multibeam at sixty degrees off nadir. Mapped means as well as one pass of a modern instrument can manage, and the standard gets eight times coarser as the water gets deeper.

Because the standard is fixed by the instrument, it gives the simplest proof possible that the coverage percentage is a property of the question rather than of the ocean. The same 2018 paper reports two coverage figures for the same seabed in the same year, and the project's own releases supply a third. Eighteen percent of the cells in the then-current grid held a depth control point, at 30 arc-second resolution. Nine percent was covered by high-resolution multibeam. And six percent met the Seabed 2030 depth-varying targets, by the project's own account of the 2014 grid. Three vastly different percentages from the same seabed in the same year. Nothing was surveyed between those three numbers; only the inclusion criteria vary. The six is the one that became the world's baseline. Why? My guess is that it was the one attached to a deadline, and a deadline makes a better story than a grid.

The trajectory is the part I find most interesting, and it has a hole in it. The published series runs 6 percent in 2017, 15 in 2019, 19 in 2020, 20.6 in 2021, 23.4 in 2022, 24.9 in 2023, 26.1 in 2024, 27.3 in 2025 and 28.7 in 2026. Also, weirdly, no percentage is cited for 2018 in any release. A project presentation in March 2019 was still saying six.

Now, the 2020 entry is absolutely critical, and it is missing from most retellings, including my own first draft, hence the delay of this paper. Coverage went from 15 percent to 19 in twelve months, an addition of 14.5 million square kilometers. That constitutes the greatest annual increase the project has ever published, and it is nearly three times the five million added in the year to April 2026.

Which makes the trade coverage of the April 2026 release worth a paragraph of its own. Hydro International reported it under the headline “Record-breaking five million square kilometres of seabed mapped last year,” and wrote that it set “a new record for the project.” This is misleading in at least two respects. First: the project added 14.5 million square kilometers in 2020 and 10.1 million in 2022, both from its own releases. Second: Seabed 2030's April 2026 statement merely says that a further five million square kilometers

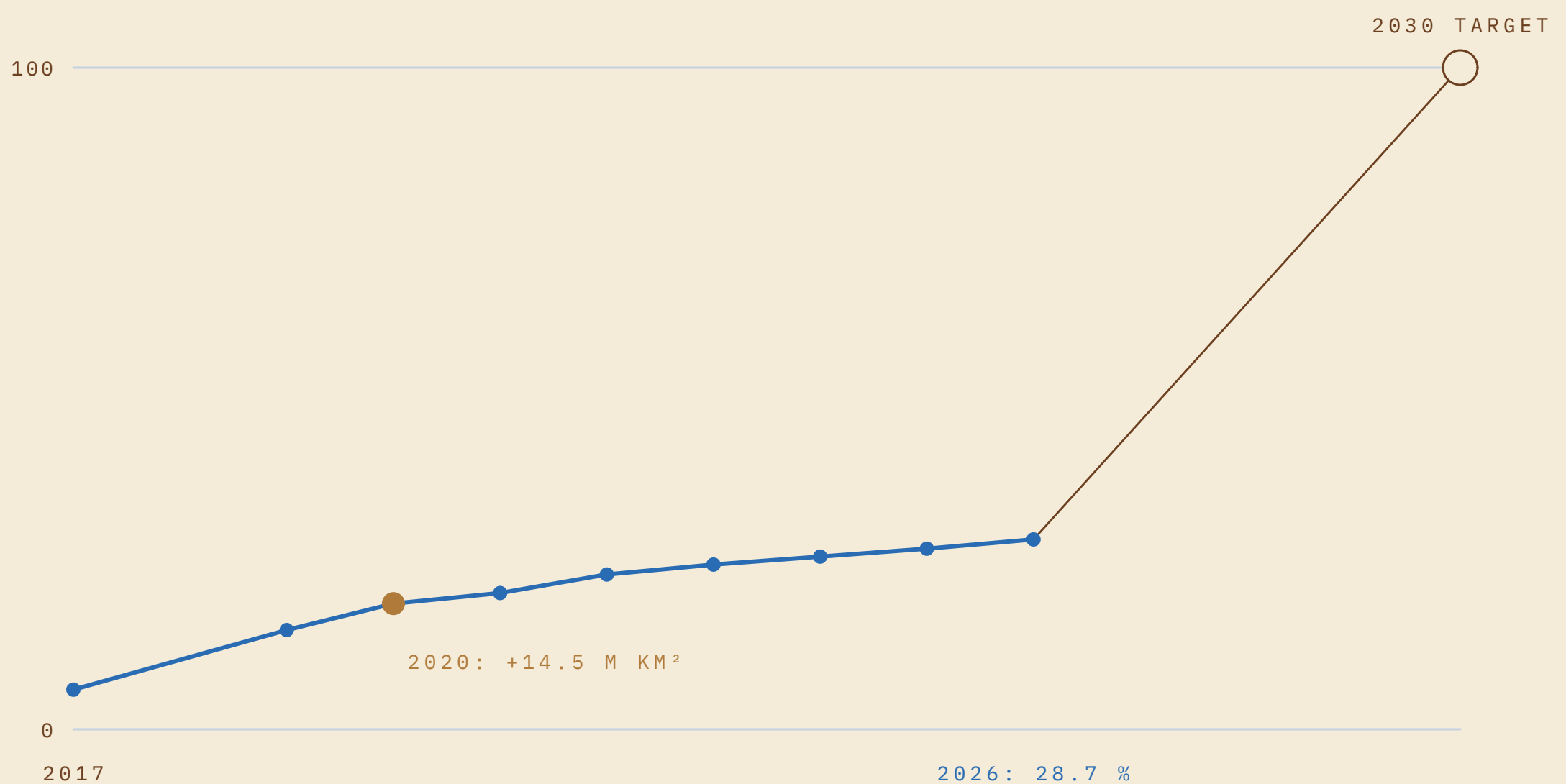


FIG. V b *Seabed 2030's published coverage, 2017 to 2026.*

No figure was published for 2018. The 2020 step, 15 to 19 percent, is the largest annual increment in the series and is missing from most retellings.

of data have been incorporated. It never mentions any record whatsoever. A superlative was manufactured in the retelling, from a source that made no such claim, and it is refuted by the same organization's own back catalog. That happened in April. Checking it takes two clicks.

Regarding the deadline: coverage has averaged about 2.5 points a year over nine years. Finishing by 2030 from 28.7 would require 17.8 points a year, four years running, against a best-ever year of four points on the published series. In 2025, researchers led by Yousef Niyazi published an independent estimate in *Frontiers in Marine Science* forecasting completion in 2047. They are more optimistic than the project about current coverage, putting 2024 at 28.5 percent against Seabed 2030's 26.1, and they still land seventeen years past the deadline. The April 2026 release does not mention 2030 at all.

The cost of this operation is also public. Smithsonian reported in 2021 that a fleet of 200 vessels mapping around the clock could finish the job in a year, and the project's director put the cost of that at somewhere between three and five billion dollars. The Nippon Foundation committed two million dollars annually at launch as seed money, which pays for coordination rather than survey, since the project's model is aggregating other organizations' data. Both figures are valid, and the gap between them is roughly two thousand to one.



Lastly, it takes a curious amount of time to map shallow water relative to deep water. From the same 2018 paper: surveying everything unsounded with a single ship would take about 970 ship-years. Everything deeper than 3,000 meters, which is 75.3 percent of the ocean, accounts for 188 of them. Water shallower than 200 meters, which is 7.3 percent of the ocean, accounts for 619. Shallow water needs a 100 meter cell and gives you a narrow swath, so you mow the lawn in strips. In other words, the deep ocean is the cheaper part of this operation. Almost every popular account of ocean mapping has this backwards, and so did I until I read the table.

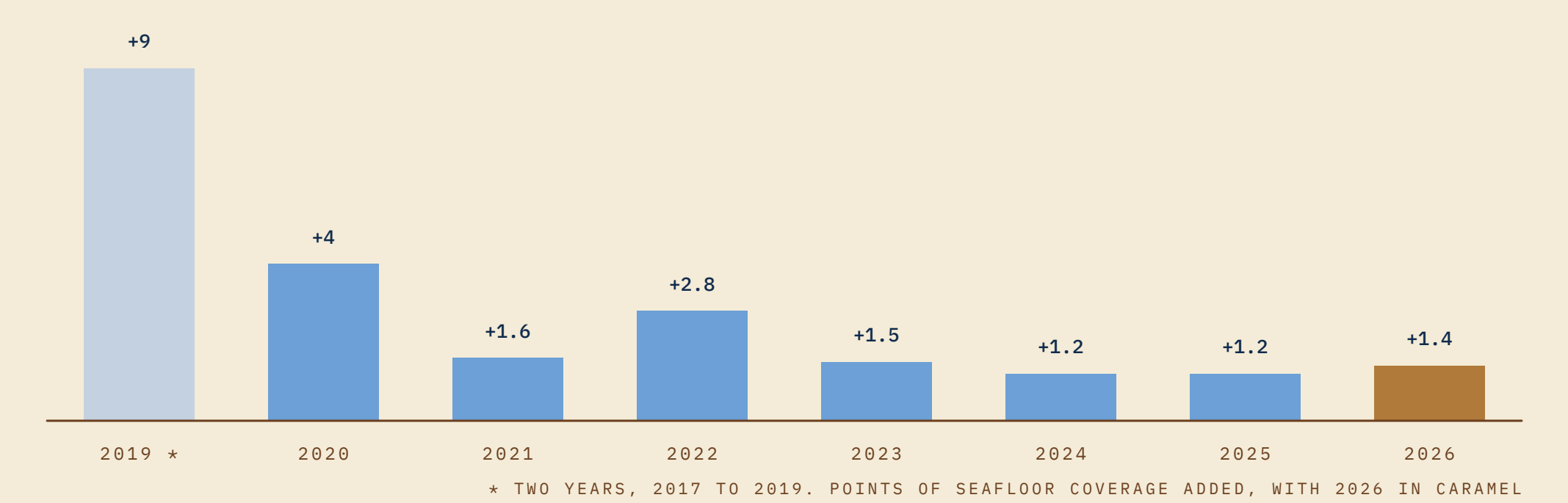


FIG. V c *Annual changes in the published series, in percentage points.*
The year the trade press reported as record-breaking added 1.4 points, one of the three smallest steps the project has published. My arithmetic on Seabed 2030's own figures.

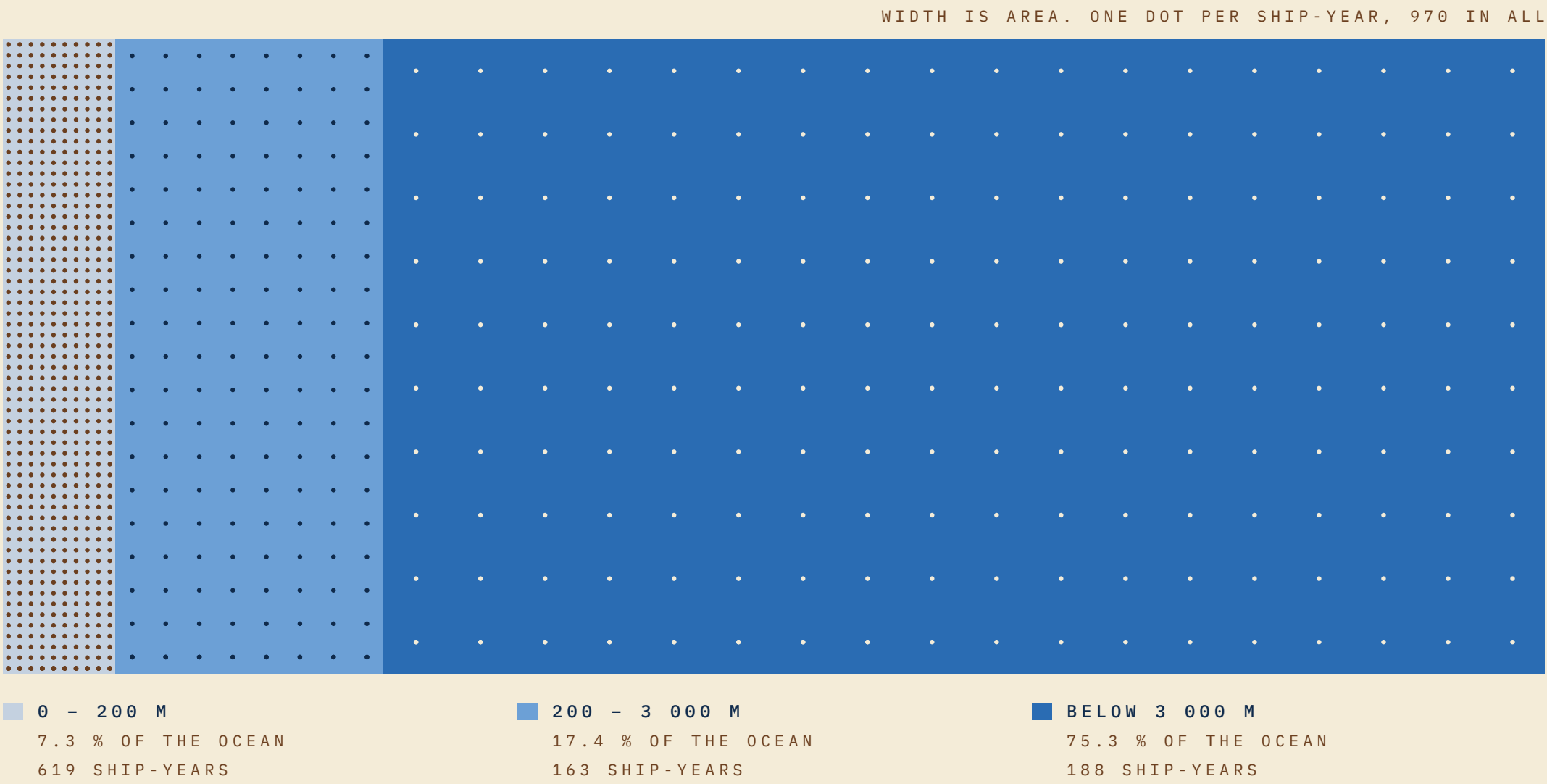
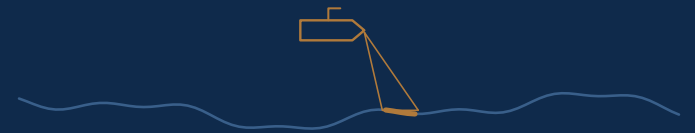
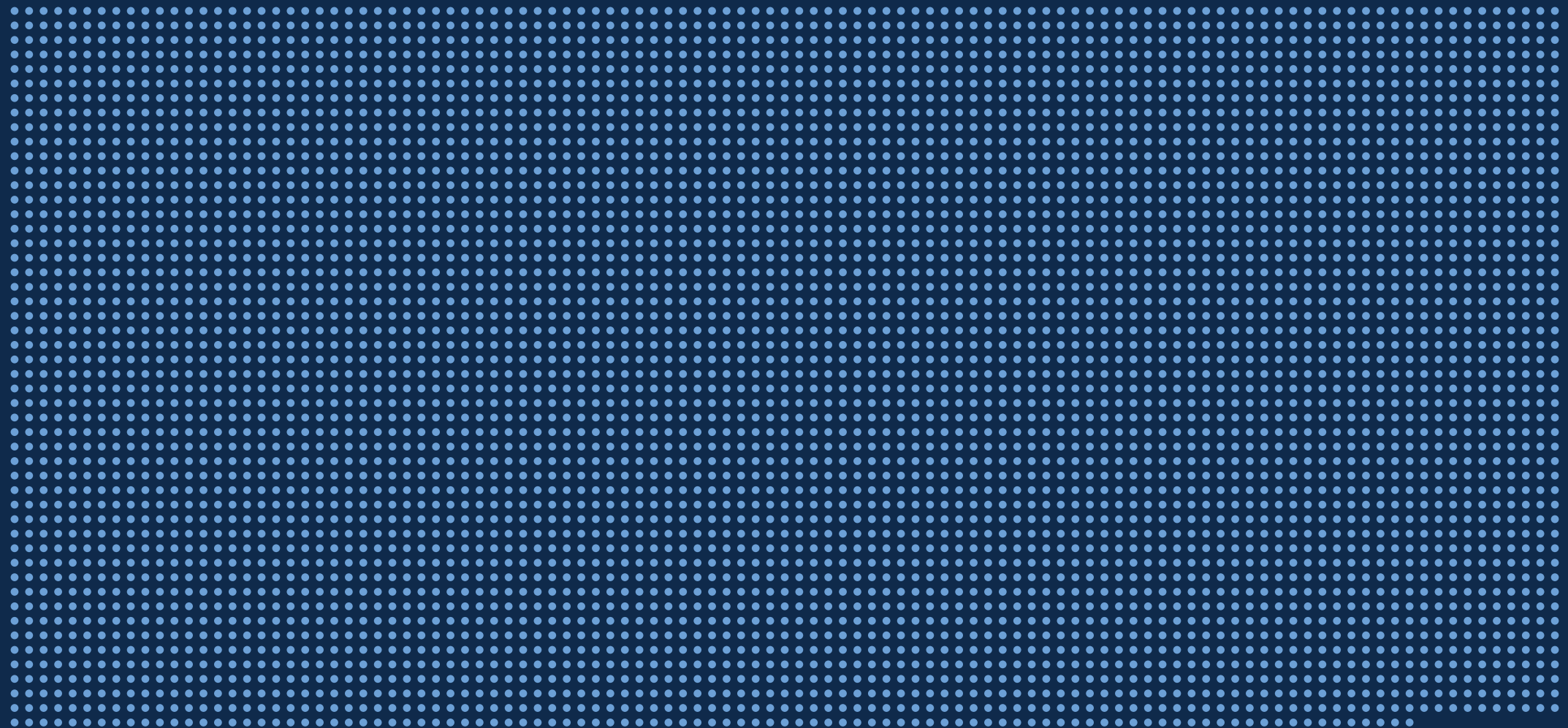


FIG. V d *Where the ship-years go, sorted by depth.*
This figure represents the ocean as one rectangle, split by area into the three depth bands. Each dot is one of the ship-years Mayer and colleagues estimated it would take to sound that band, spread evenly across it, so the crowding is the effort per unit of area. The middle band is by subtraction.



§ 6 MAPPING ≠ SEEING



EVERY DIVE ALVIN HAS MADE, 1964 – 2025: 5,340 POINTS AND 37,290 HOURS ON THE BOTTOM

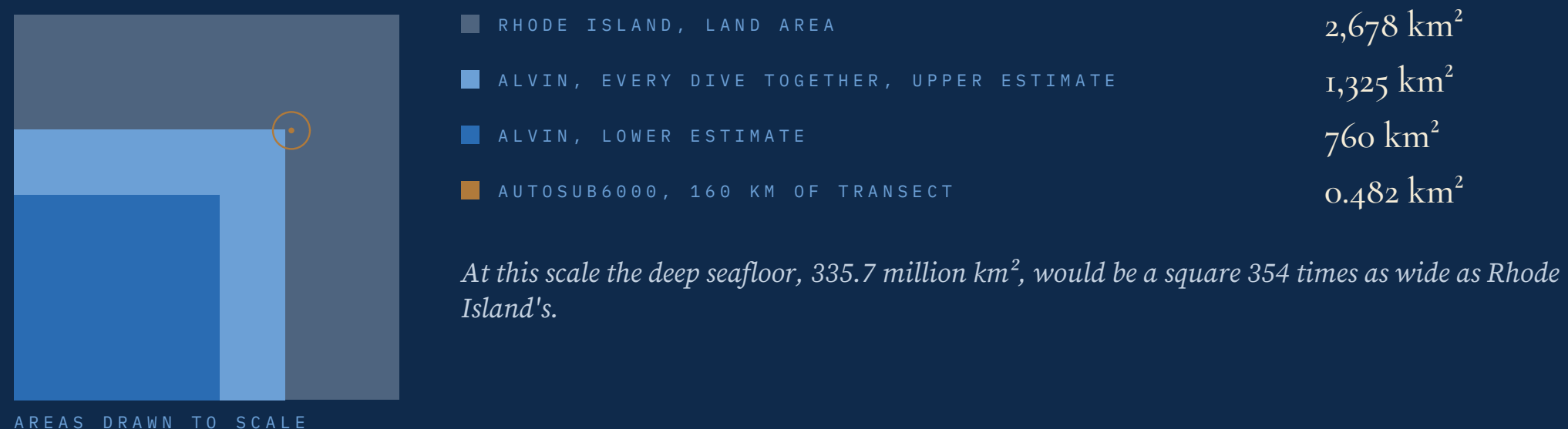
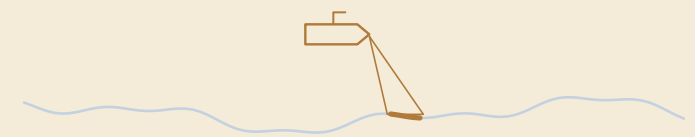


FIG. VI Sixty-one years of the most productive crewed submersible in history, and what all of it saw.

The number worth being awed by is the one for seeing, and I think that is where the original sentence was pointing all along when it said “unknown and unseen.”

Depth mapping means determining depth by measurement from a ship, or via orbital remote sensing. It doesn't require being there, let alone seeing it. Consider how different it feels to deduce that a pond is four feet deep versus putting your face in it. In May 2025, a team led by Katy Croff Bell released the first serious attempt to quantify how much of the deep seafloor has ever been visually surveyed. By aggregating 43,681 records of deep submergence activity since 1958 and estimating coverage in two divergent ways, dive-based at 2,130 square kilometers and time-based at 3,823, the group concluded that humans have laid eyes on between 0.0006 and 0.001 percent of the 335.7 million square kilometers constituting the deep seafloor.



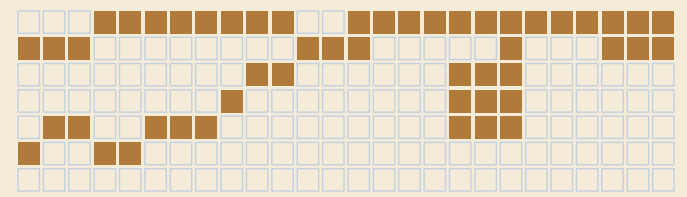
NOAA currently states this as a flat fact: “explorers have seen less than 0.001% of the deep ocean seafloor, that's roughly the size of Rhode Island.” It links to the paper, omitting the range and the underlying assumption. I must be clear that NOAA is doing nothing unusual here, and the figure is essentially true.

However, three transformations occur when the figure makes the trip from paper to webpage. A range with a factor of nearly two in it becomes a point. A method resting on an assumed camera field of view of between ten and twenty meters becomes an unqualified number. And the comparison changes: the paper's own preferred image was a tenth of Belgium, while Rhode Island appears once, in the discussion, where the authors compare their maximum estimate of 3,823 square kilometers to Rhode Island's land area of 2,678. The figure that traveled is 43 percent larger than the thing it is said to be the size of.

Coverage here is determined geometrically rather than financially, and one instance suffices to make the point. Autosub6000, one of the most capable autonomous deep-sea vehicles yet produced, flew about 160 kilometers of photographic transect across an abyssal plain and returned having imaged 0.482 square kilometers. At three meters above the seafloor a camera sees a few meters of ground, and there are 335.7 million square kilometers of it.

Similarly, Alvin demonstrates the same ratio over sixty years of history. Since 1964 the submersible has conducted 5,340 dives spanning 37,290 hours submerged, or four and a quarter years of continuous bottom time. At Bell's measured per-dive coverage, its career totals somewhere between 760 and 1,325 square kilometers. The most productive crewed deep submersible in history has seen less of the seafloor than Rhode Island's area.

One might ask whether sample bias poses an important caveat here, and it absolutely does. Bell's group found that five nations performed 97.2 percent of all deep dives, that operators from high-income countries ran 99.7 percent of them, and that not a single dive in the dataset was led by an operator from Africa. Their own comparison bears repeating: assessing all terrestrial life from 0.001 percent of the land would mean assessing it from an area smaller than Houston. Imagine compiling the textbook on everything living on land from inside one city, and then imagine that almost all of your visits to that city were made by five countries. That is the deep seafloor, as of 2025.



§ 7 THE PUBLISHED CHART HAS NO GAPS, WHICH IS THE PROBLEM

Seventy-one point three percent of the seafloor has never been measured by any modern standard, and nothing on the chart shows it. I repeatedly opened the map, the GEBCO_2026 Grid, searching for the gaps, only to find no trace of them.

The GEBCO grid leaves nothing blank. It is a continuous global terrain model of 3.7 billion cells, 43,200 rows by 86,400 columns, and nobody has measured every one of them. Where nobody has, the number comes from satellite altimetry.

The physics behind it is quite exquisite. A satellite measures the height of the sea surface; a seamount's mass pulls water toward it, producing a bump in the surface shape, which we invert to infer what's underneath. It works, and it is one of the most beautiful pieces of applied physics I know of.

It is coarse, though. Karen Marks and Walter Smith found that altimetric amplitudes come within 90 percent of ship-measured amplitudes for seamounts with characteristic radii of at least 14 kilometers, and fall off below that threshold because of the smoothing filters used in processing. I initially read this figure as a hard floor; it is not. The same authors argue that two compensating errors leave linear filtering usable for seamounts considerably smaller than 14 kilometers. However, 14 kilometers is where the inference reaches 90 percent fidelity rather than where it stops.

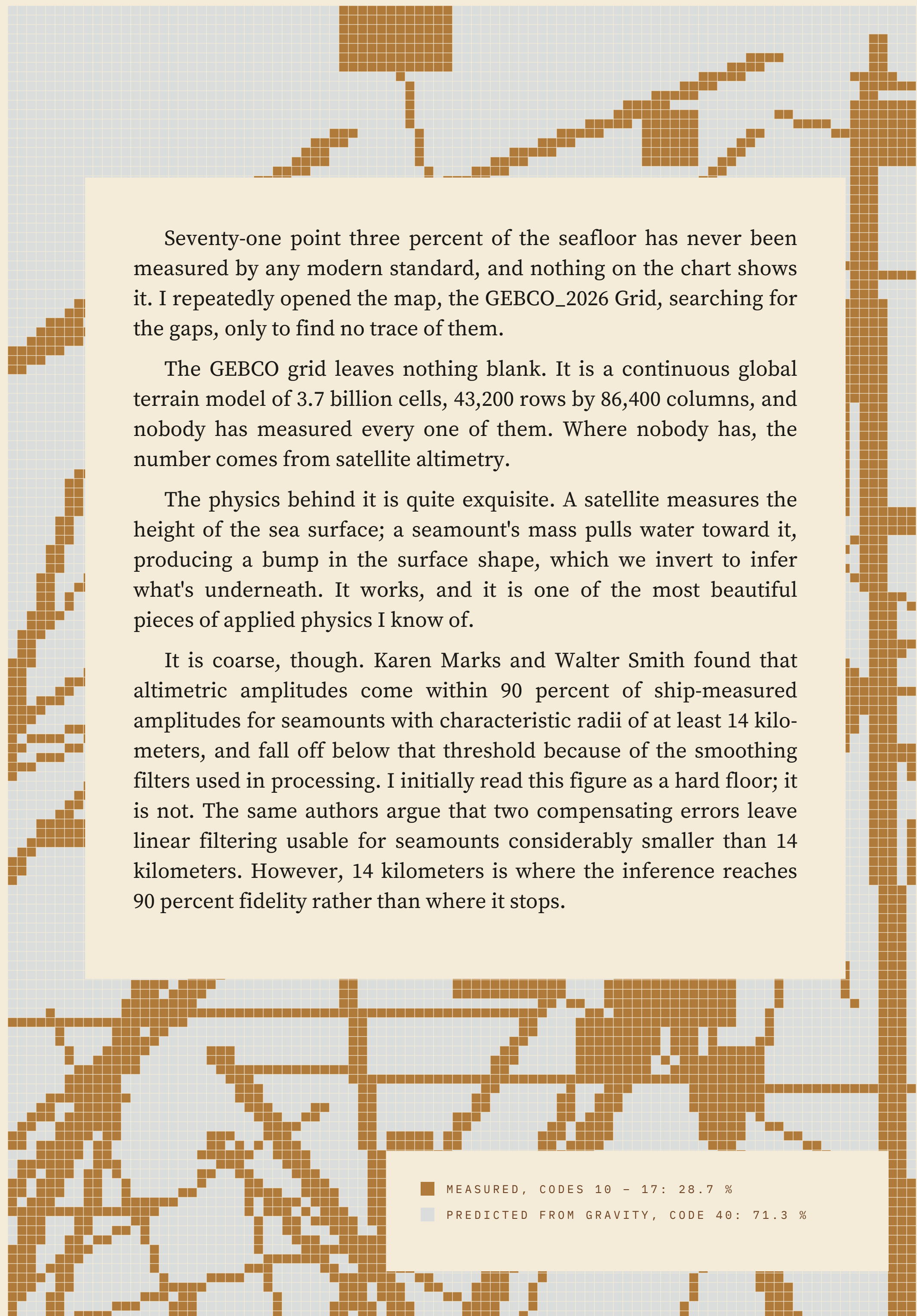
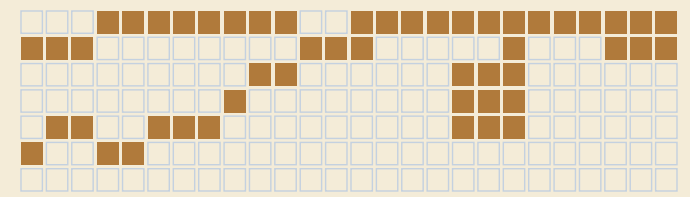


FIG. VII 43 200 × 86 400 CELLS, EVERY ONE HOLDING A NUMBER (GEBCO TYPE IDENTIFIER GRID)

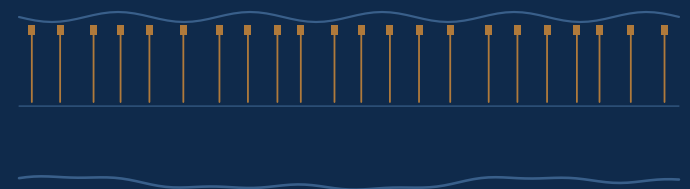


Each number carries provenance, too. Alongside the elevation grid, GEBCO ships a parallel raster called the TID grid, for Type Identifier, which says where each cell's number came from. Codes 10 to 17 are direct measurements. Code 40 is “Predicted based on satellite-derived gravity data.” Thus the map has been complete since inception, and the coverage percentage everyone quotes measures something else: the fraction of cells whose number was measured rather than computed.

Now back to the title question. The published map of the seafloor was designed not to have holes, and for now it doesn't. Marie Tharp and Bruce Heezen drew the North Atlantic in 1957 from sparse sounding lines. The resulting diagram, shaded by hand, took the form of a physiographic presentation rather than rigorous contours, making no pretense of accuracy beyond what the available soundings allowed (and one that, historians note, also sidestepped the Navy's classification of contoured bathymetry). The truthfulness lay in the illustration technique. The modern grid renders a gravity inference and a full multibeam swath in the same color ramp.

A practical example presented itself midway through writing this. SWOT, a satellite launched in December 2022, significantly improved gravity-derived bathymetry. In July 2024, CNES reported that roughly 44,000 seamounts rising a kilometer or more are known, and that this figure “could be more than doubled, and possibly to as many as 100,000.” In March 2025, NASA wrote of “potentially increasing the number of known seamounts from 44,000 to 100,000.” Finally, in April 2025, SciTechDaily published the headline, “NASA's Satellite Just Uncovered 100,000 Hidden Mountains Beneath the Ocean.”

Consider the progression involved. Could be more than doubled. Potentially increasing. Just uncovered. Every modal verb vanished, and the tense moved from conditional future to completed past. The 100,000 was never a SWOT result. A 2023 paper by Julie Gevorgian and colleagues already cites an earlier estimate of 50,000 to 100,000 seamounts above a kilometer. A pre-existing model extrapolation was re-attributed to a new satellite and then re-tensed into a discovery in the nine months between July 2024 and April 2025. The very mechanism I have been describing was running while I wrote this sentence.



§ 8 THE WATER ITSELF HAS NO NUMBER

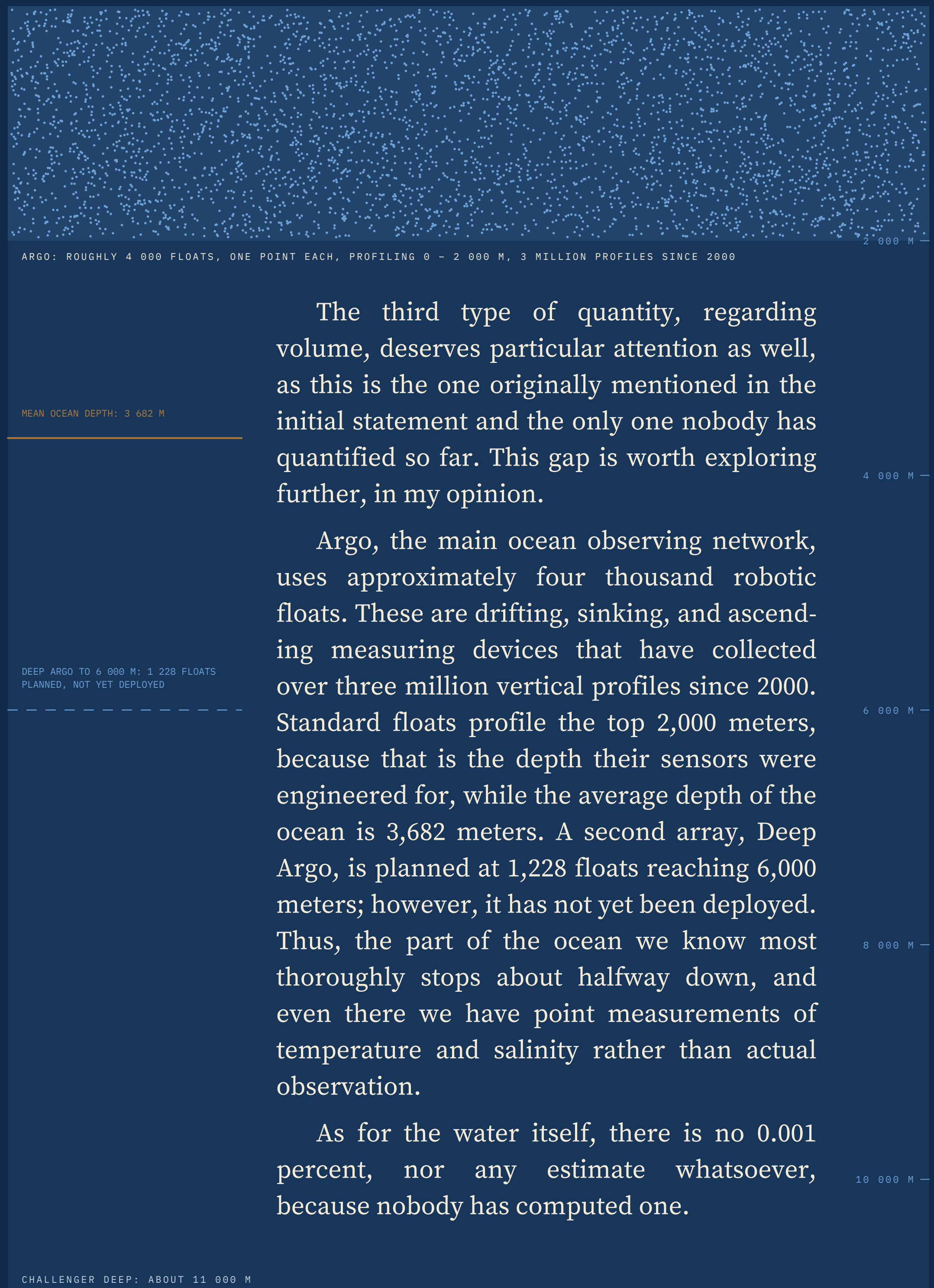
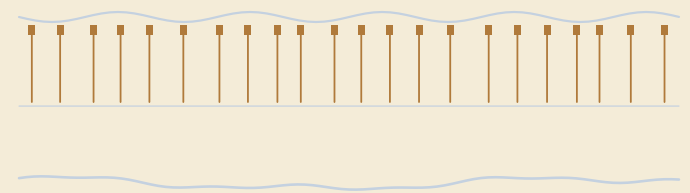


FIG. VIII THE WATER COLUMN, DRAWN TO DEPTH (1.335 BILLION KM³), WITH POINTS ONLY WHERE THERE ARE INSTRUMENTS



The closest published work I know of dates back to 2010, when researchers led by Thomas Webb sorted seven million records of marine species by depth and concluded that more than half of them came from the continental shelf (less than a tenth of the ocean's area). Less than a tenth came from the abyssal plain (close to half of it). For those interested, a single 200-meter-thick layer over the abyssal plain accounts for approximately three and a half million cubic kilometers of water.

For this investigation, we shall call that water what the authors call it: biodiversity's big wet secret. So the largest habitat on Earth, with a volume of 1.335 billion cubic kilometers, has no number at all. There is neither an approximation, an upper bound, nor even a lower bound. Perhaps this should be regarded as the truest answer to the question in the title?

§ 9 WRITING THE SENTENCE TO WITHSTAND SCRUTINY

To be entirely accurate, the true sentence must contain both a quantity and its resolution. Approximately seventy-one percent of the seafloor has yet to be mapped to modern resolution, in other words, to have at least one sounding in a grid cell of up to eight hundred meters. More than 99.999 percent of the deep seafloor has never been seen. Stated as negatives, they resemble each other and hence have been used interchangeably, but in positive form (28.7 percent and 0.001 percent) they differ by a factor of approximately thirty thousand.

Among the three quantities discussed here, the third cannot be a number at all. Although initially resistant, I have come to believe this is acceptable. It has never claimed to be a number. Instead, it belongs to a press release, expressing a simple sentiment: the ocean is enormous, and we have barely started exploring it. This sentiment is perfectly valid. Adding decimal points cannot improve its accuracy. The error lay in publishing the vague statement alongside an exact one, which lent the former the latter's authority.

Now, the extent to which correcting the figure fails surprised me. NOAA Ocean Exploration, the division NOAA set up in 2001 to act on the report this paper began with, stopped claiming 95 percent. Now it reports 28.7 percent, with a date attached. The Ocean Literacy principles revised theirs from less than five percent to less than twenty percent by their January 2024 edition. Both corrections are public.

Yet National Geographic Education continues asserting five percent, and an academic website affiliated with at least one university does the same. In 2022,



a Senate report attached a real footnote to the claim that over 80 percent of the ocean is unmapped, unobserved, and unexplored. The paper it cited is by Larry Mayer, who sat on the 2000 panel, and what Mayer measured were depth soundings in grid cells.

The corrections do not spread, because the percentage itself never carried any factual weight. It serves only as a descriptor, essentially stating the following observation: the ocean is large, and humans haven't gone far into it. To describe that, eighty percent and ninety-nine percent mean the same thing (ish). Hence the ease with which the figure has shifted. In my opinion, the sentence needs to name the quantity, its resolution, and its date. Twenty-eight point seven percent of the seafloor had been mapped at modern resolution as of April 2026. Less than 0.001 percent of the deep seafloor has ever been seen. Humans have done little exploration of Earth's oceans. Argue with either of the first two if you wish. You needn't add decimals to the last one; it never deserved any.

My overall conclusion is that some things are unbelievably difficult to quantify. Every statistic is a superposition of effort, much of it from the people who came before. The very fact that we can now check this question against the evidence is exciting enough to keep us pursuing it.

And I think I finally understand what the sentence has been trying to convey all along. Almost everything can be quantified; every measurement comes at some resolution; every measurement was taken at some point in history. Underneath all three lies the water, filling the basins, mostly unvisited. True awe lies there.

AUTHOR'S NOTE

All facts mentioned in this manuscript have been verified by direct reference to the documents themselves: the PDF of the original report, the White House archive pages, the individual scientific papers involved, agency webpages, and GEBCO database materials, a total of sixty-one verifications and cross-references as of September 2026. Two of my previously made statements failed verification in exactly the way this paper describes, and were corrected within the text itself. If I have failed here again, please tell me. Thank you.



NOTES

- 1 President's Panel on Ocean Exploration, "Discovering Earth's Final Frontier: A U.S. Strategy for Ocean Exploration," 10 October 2000, printed p. 1: "Despite these gains, 95 percent of the oceans remain unknown and unexplored." No bibliography, no endnotes, no citation on the sentence. The membership page lists a chair and twenty-one members plus ten agency science advisors; Appendix E describes a 23-member panel. Affiliations on the membership page: McNutt, Monterey Bay Aquarium Research Institute; Ballard, National Geographic Society, Institute for Exploration; Earle, National Geographic Society, Sustainable Seas Expeditions; Mayer, University of New Hampshire. Ballard led the 1985 expedition that located the Titanic; Earle was NOAA's chief scientist from 1990 to 1992.
- 2 Same report, printed p. 15: "For example, less than five percent of the total U.S. EEZ has been mapped in high-resolution." NOAA's Coast Survey put US waters at about 56 percent mapped as of early 2026.
- 3 Presidential Memorandum, "A New Era of Ocean Exploration," 12 June 2000: "over 95 percent of the underwater world is still unknown and unseen." Reprinted as Appendix A of note 1.
- 4 White House Office of the Press Secretary fact sheet, 12 June 2000: "Even though the oceans cover 70% of the planet, scientists estimate that over 90% of our underwater world remains unknown and unseen."
- 5 White House Office of the Press Secretary, "Exploring the Last U.S. Frontier," 12 June 1998: "only five percent of the ocean and sea floor have been explored." The release itself does not name the conference; the 2000 fact sheet places it at the National Ocean Conference in Monterey two years earlier.
- 6 US Senate Report 109-57, 13 April 2005: "only 5 percent of the ocean floor has been explored to date." No citation.
- 7 John Sharp, "Spirals and the Golden Section," Nexus Network Journal 4(1), 2002. Four measured revolutions at 2.95, 3.02, 2.83, 2.97, mean 2.94. The fallacy statement is quoted verbatim from this paper, where Sharp introduces it as "the most common misconception."
- 8 Christopher Bartlett, "Nautilus Spirals and the Meta-Golden Ratio Chi," Nexus Network Journal, published online 12 December 2018. Eighty shells from the Smithsonian; mean aspect ratio 1.310; "clearly not the widely quoted 4:3 (1.333)."
- 9 Clement Falbo, "The Golden Ratio: A Contrary Viewpoint," College Mathematics Journal 36(2), March 2005. I have not read the original, which is paywalled. My figures come from Ivars Peterson, "Sea Shell Spirals," Science News, 1 April 2005, and are attributed accordingly. Falbo's measurements were made in 1999.
- 10 Paul Gailiunas, "The Golden Spiral: The Genesis of a Misunderstanding," Bridges 2015 Conference Proceedings, pp. 159–166. Cook's disclaimer, the 1980s dating, and the 1914 misprint in the appendix of Cook's Curves of Life.
- 11 Henry Moseley, Philosophical Transactions of the Royal Society 128, 1838. David Raup, PNAS 47(4), April 1961, for the whorl expansion rate parameter.
- 12 Seabed 2030, 20 April 2026: 28.7 percent, about 104 million km², about 5 million km² added in the year. The release does not mention the 2030 deadline. The 362 million km² ocean area is my arithmetic from those two figures and matches the area Niyazi et al. use (note 16).
- 13 Mayer et al., "The Nippon Foundation-GEBCO Seabed 2030 Project," Geosciences 8(2):63, 2018. The one-sounding definition, the four depth bands, the 18 and 9 percent figures, and the 970 ship-years estimate with 619 in the 0–200 m band and 188 below 3,000 m. The 6 percent figure is from GEBCO's release of 13 June 2019, describing the 2014 grid at target resolutions.
- 14 Published series: 6 (2017), 15 (2019), 19 (2020), 20.6 (2021), 23.4 (2022), 24.9 (2023), 26.1 (2024), 27.3 (2025), 28.7 (2026). No figure published for 2018. The 2020 release reports 14.5 million km² added; 2022 reports 10.1 million. The 2021 figure is taken from contemporaneous reporting and the 2022 release's arithmetic; the 2021 release page is no longer online.
- 15 Hydro International, 21 April 2026, "Record-breaking five million square kilometres of seabed mapped last year." Compare note 14.
- 16 Niyazi et al., "Status of global seafloor mapping effort and priority areas for future mapping," Frontiers in Marine Science, 30 May 2025. Completion projected at 2047; their 2024 coverage estimate is 28.5 percent against Seabed 2030's 26.1.
- 17 Cost: Smithsonian Magazine, 28 June 2021. The one-year figure is the writer's; the three to five billion dollars is Jamie McMichael-Phillips's direct quote. Nippon Foundation seed funding of two million dollars a year, GEBCO, February 2018.
- 18 Bell, Johannes, Kennedy and Poulton, "How little we've seen: A visual coverage estimate of the deep seafloor," Science Advances 11(19), 7 May 2025. 43,681 dive records from 1958; 2,130 km² dive-based (their minimum) and 3,823 km² time-based (their maximum); 0.0006 to 0.001 percent; the ten-to-twenty-meter field of view assumption; Belgium and Rhode Island; 97.2 percent of dives by five countries.
- 19 NOAA Ocean Exploration, "How much of the ocean has been explored?," last updated 20 April 2026. The 0.001 percent sentence links to Bell et al. but carries no range. Rhode Island land area 2,678 km², US Census Bureau.
- 20 Milligan et al., Scientific Reports 6:26095, 2016. Autosub6000 flew about 160 km of transect at a target altitude of 3.2 m and imaged 0.482 km² with the oblique camera.



- 21 Woods Hole Oceanographic Institution, Alvin dive statistics as of 31 December 2025: 5,340 dives, 37,290 hours submerged. The 760 to 1,325 km² range is my multiplication of Bell's per-dive coverage for Alvin (0.143 to 0.248 km²) by that dive count.
- 22 Marks and Smith, “Some remarks on resolving seamounts in satellite gravity,” *Geophysical Research Letters* 34, L03307, 2007, via the authors' NOAA NESDIS page. The qualifying sentences about linear filtering are from the same page.
- 23 GEBCO_2023 Grid documentation for the TID grid and the remove-restore procedure. TID 40: “Predicted based on satellite-derived gravity data.” The grid is 43,200 × 86,400 cells.
- 24 CNES, 15 July 2024; NASA, 19 March 2025; SciTechDaily, 8 April 2025. Gevorgian et al., *Earth and Space Science*, 2023, for the pre-existing 50,000 to 100,000 estimate, which they attribute to Wessel (2007) and Kim and Wessel (2011).
- 25 Argo program, argo.ucsd.edu: roughly 4,000 floats, three million profiles since 2000, core floats to 2,000 m, Deep Argo target array of 1,228 floats. Mean depth 3,682 m and ocean volume 1.335 billion km³, NOAA.
- 26 Webb, Vanden Berghe and O'Dor, *PLoS ONE* 5(8):e10223, 2 August 2010. Seven million OBIS records; the shelf and abyssal plain shares; “biodiversity's big wet secret.”
- 27 Ocean Literacy Guide v3.2, January 2024, Principle 7, “less than 20%.” US Senate Report 117-76, 15 February 2022, footnote 2, citing Mayer et al. 2018. Doel, Levin and Marker, *Journal of Historical Geography* 32, 2006, for the Tharp and Heezen account.

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The White House, Office of the Press Secretary.

Presidential Memorandum “A New Era of Ocean Exploration” and the accompanying fact sheet, both 12 June 2000. And “Exploring the Last U.S. Frontier,” 12 June 1998.

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Paper № VI of an occasional series.
Written and set by Christopher Gilmartin in New York.
Cormorant Garamond, Source Serif and IBM Plex Mono.
Plates drawn from the mathematics rather than traced.
The radiolarian is a geodesic lattice, the nautilus a
logarithmic spiral of expansion three, the medusa
tetramerous after Aurelia aurita.
All figures current to April 2026.
MMXXVI

Jack, for a paper about the sea.

