Q&A: Researcher discusses the importance of visualizing undersea fiber-optic cables

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Hundreds of fiber-optic submarine cables crisscrossing the ocean floor transport 99% of transoceanic and international telecommunications traffic. Shown here are two cables landing in Figi. Credit: Nicole Starosielski

The internet is kind of like drinking water, says UC Berkeley Professor Nicole Starosielski. Most of us don't think much about how it's delivered

to our houses or wherever we need it, until we can't get it.

But Starosielski, who joined the UC Berkeley Department of Film and Media in the fall, thinks about it all the time. And she's made it a priority to help people learn about and visualize the internet—a communication system that has become essential to our everyday lives.

Unlike drinking water, she says, "the internet transforms our experience of space and time. So many people depend on it, and we need to know about how it works."

Berkeley News talked with Starosielski about how the backbone of the global internet is made up of close to a million miles of telecommunication cables laying on the bottom of the ocean and why we need the arts and humanities to make visible this invisible infrastructure.

I have to admit, I didn't know about undersea fiber-optic cables until I was preparing for this interview. Can you first explain what they are?

Most people don't know about undersea fiber-optic cables, so you would be totally forgiven for not knowing about them—until right now.

It's really counterintuitive, if you think of all our interfaces with the internet. A lot of them are wireless. Your phones are mobile. Your headphones are mobile. Your laptop is mobile. So why would the core of the internet be fixed in these tiny little tubes on the bottom of the ocean? It doesn't make any sense when you look at the rest of the internet's infrastructure.

Turns out only that last mile, only that last hop to your home, to your laptop, is wireless. Almost all the rest of the infrastructure is encased in

cables and in buildings. And those cables go underground and under the ocean. And they transport 99% of transoceanic and international telecommunications traffic—data traffic, internet traffic.

Can you briefly explain the history of the subsea cable network? When did these telecommunication cables first get put into the ocean?

It's a long history, but in a nutshell, there were three eras. Telegraphs were first. This started in the 19th century and telegraph lines were being laid on land. The companies laying telegraphs wanted to lay these cables across bodies of water, so they developed telegraphs that went underwater. They were used to send all sorts of messages—personal communications, but also news and information about trade and stock markets. So telegraph systems were laid all over the world. A lot of the British Empire was networked and this was definitely a colonial technology.

Radio came along, but the telegraph remained important because it was more secure. Radio didn't replace the telegraph, but emerged alongside it.

Then telephone systems were developed. And telephone cables essentially replaced the telegraph system. Those were laid across the oceans from the 1950s to '80s. Satellites were developed, but they didn't replace cables.

Then from the 1980s through today, we have fiber-optic cables, made of some of the same materials, being encased in plastic and having copper conductors inside. But at the heart of these cables are thin strands of glass—that's the fiber-optic part of the cable. And that's what transports all of our internet traffic today.

How were and are their routes determined?

If you look at the parts of cable networks globally, you'll see that they largely got layered onto major transportation routes and major traffic routes. The endpoint, historically, has always been population centers.

When you look at historical maps of telegraph cables, they often traversed British colonial routes, then U.S. imperial routes. They tracked with the interests of the states, whom companies were affiliated with, if not owned by. There are few cables, for example, between Africa and the U.S., Africa and South America.

Historical forms of power and relationships manifested in transportation routes. Transportation routes solidified those forms of power. Cables are sedimented in those historical routes. That's true globally. And while historically cables have been conduits that go between population centers, they are now extending between data centers.

So the cable geography is shifting because they're transmitting between places where data is stored rather than just between consumers. Although they're still extending between consumers, as well. But this historical layering is important.

Where are the main hubs in the world for the data centers today?

Data centers are concentrated in the United States, but also in Europe and China. In the past, there were no cables laid in the central East Coast of the United States. East Coast cables went to New York, they went to Miami, but you didn't see cables landing in Georgia or Virginia. That has changed, because now Virginia is the hub of data centers globally. A huge amount of traffic transits through Ashburn, Virginia, so now they

are laying cables directly to Virginia.

Another case is Ireland. For many years, cables have landed in Ireland. The telegraph landing in Ireland was extraordinarily important for transatlantic communications. But recently, Ireland has started to develop a lot of data centers, and this is possible because they already had cables.

These cables are not going to Virginia to serve the population of Washington, D.C. They're going for the data centers. Same with Ireland. So there has been a shift. These large facilities, where all the internet's content is stored, are having a sort of gravitational effect on the internet's structure.

How are these subsea cables put onto the ocean floor?

People often imagine that because they're called submarine cables, that they're laid by submarines, but they're actually just unspooled off of a ship. They're first coiled up into a ship, and they essentially send them out as the ship moves across the ocean. The cables drop to the sea floor. So it's actually quite a 19th century sort of simple technology. The navigation is very complex—there are lots of facets to the process—but fundamentally, it is not advanced or complex as you might imagine it to be.

Do the cables impact marine life?

The interesting thing about these cables is that they're relatively benign. And I, as an environmentalist and as somebody who does environmental media, know that there are not many things that are benign. There's relatively little impact of the subsea cables on the seafloor. And that's because they are the size of a quarter or a garden hose—they're really

tiny.

Somebody told me that if you laid every transatlantic cable next to each other, their combined diameter could fit through an average size room in a house. That's the entire continent's data traffic—North America to Europe. All that traffic could be routed through a single room. In terms of space that's taking up, it's not a huge footprint on the seafloor. And they don't have effects on marine life around them. It's one of the most benign infrastructures that goes down to the bottom of the ocean, and they don't touch it for, like, 25 years, best-case scenario.

So it was actually quite a challenge when we started running the Sustainable Subsea Networks project to look at the carbon emissions of a cable system and the internet. It turns out carbon emissions were far lower than I had initially thought, for being such a significant infrastructure that supports all of our global communications.

The Sustainable Subsea Networks project began in 2021 to investigate the sustainability of the global subsea telecommunications network. How have you been involved in this project?

As a professor at NYU, where I taught for 10 years before I came to Berkeley, I worked with professors in the UK and in Canada for two years to catalog best practices in subsea telecommunications sustainability and published a report.

This report goes through the different aspects of the life cycle of the cable, all the way from the manufacturing through recovering and recycling cable at the end of its life. We outline what things can be done from an industry perspective. We feel that even though this is not responsible for the bulk of the internet's carbon emissions, it is still

critical for every sector to do its part. The subsea cable industry has been very supportive and has even driven these efforts forward.

There are companies out there that are transitioning to renewable energy, including using new heat recovery processes in their factories. We see in the installation that when ships go at slower speeds, it consumes less fuel and is more efficient. The report includes many examples like this.

People sometimes say, "We need to green the entire fleet of ships. We need to transition entirely and immediately to sustainable fuels." We found in our research that the cable industry is very small. There aren't a lot of cable ships. To get to sustainable fuels, you need to transition infrastructure at ports, as well. You need to have those fuels available long before you develop a new boat that runs on ammonia.

We found that in many ways, the cable industry has to follow the decarbonization plans that are being set by other larger industries or the International Maritime Organization, for example. So what we've focused on are the things like speed of transit that are within the control and purview of the industry, and we're trying to identify some of those pathways to greening the system.

Has there been pushback to making the industry more sustainable?

I haven't experienced any with the cable industry. People have asked, "How do we do this economically?" Many people will say, "We need frameworks to make decisions about how we're going to do this and still survive as a business." So I think people are worried because they still see sustainability as something that is opposed to economic survival, because the cable industry does not have a huge margin when compared to some other businesses in tech.

I think there's more of a reticence to try things that might compromise the integrity of the infrastructure, because the culture of the industry is really one that is focused on stability and continuity. These systems have to operate without failure for decades on the bottom of the ocean, so maintaining quality remains key. Not that this is opposed to sustainability, but I think there's not as much wiggle room to experiment and try out new ways of doing things.

Who are the people in the subsea cable industry?

There is a globally dispersed workforce that works together to build, operate and maintain cable systems.

There are people who work for marine companies that maintain the cables. There are people who manufacture the fiber, the cable, the equipment at the end of the system. There are consultants and people who build cable systems, and then those who recover and recycle cable systems. There are the cable owners and operators. There's a network operations center, where they monitor all these cables. There are people constantly watching all of the equipment, watching the operation of the system, so they will know immediately if anything goes wrong or endangers the cable. Or if the cable is out, they will be able to tell exactly where the fault is.

Have there been instances when something has happened to an underwater cable and caused a major disruption?

Yes. In 2022 in Tonga, for example, there was a volcanic eruption that severed the only subsea cable and cut off the country from communication. The plume also prohibited satellite communications. The country went dark. That was a huge issue because they were

experiencing a crisis, a catastrophe. People needed help, and there was no communication network. That's an extreme example. It doesn't happen every day. But there are other examples where internet outages have been produced by cable cuts or faults. Luckily, volcanic eruptions are rare.

Why are the arts and humanities essential in the movement to make subsea cables more sustainable?

There are several great artists out there who are doing amazing cable art. Some of my favorites include Ruy Cézar Campos, Juan Pablo Pacheco Bejarano and Fiona Marron. You could also look at the cable art of UC Berkeley alumnus Trevor Paglen.

Artists are essential to making invisible infrastructure visible. We need artists. We need people who can communicate. We need to be able to show people what's happening with the backbone of the internet. Otherwise, people will not know how or why or why not to participate in development. They will not even know how they could act. They wouldn't speak from an informed position.

In order to even be able to have a politics of infrastructure, you have to have conversation first. You have to know what the infrastructure is. How do you do that? How do you make something that is seemingly opposed to our current imagination of communication both visible and interesting? You need people who are dynamic thinkers, who can think across contexts that are changing in real time, and let those be informed by history.

I think the humanities are essential because this deep cultural and historical knowledge, understanding context, understanding geography, understanding the ways that change happens, understanding the nuances

of human sociality, all of that is essential if you want to do any sustainability work in a global context.

What courses are you teaching at Berkeley related to digital communication?

We're building out an introduction to digital infrastructure course that I'm going to teach this summer and next spring. We are going to cover all of these different aspects of the cable systems and data centers of the global backbone of the internet.

We're also developing a broader curriculum that will help us understand all the different dynamic parts of these systems and help spread information about them. The pilot class for this project is running this semester. It's a film and media class where students are looking at the visualizations of these infrastructures and making their own films about cables and data centers.

In addition to teaching, I'm working to help build up the cable industry workforce. When I talk to people in the industry, they tell me, "We need younger people. We need people from around the world. We need gender equity. We need to expand the workforce as people retire." A lot of this knowledge about how to build the internet, essentially, is stored in people.

I recently went to a symposium by the SubOptic Foundation in Egypt with a student of mine, Iago Bojczuk, and we presented on sustainability. One of the goals of these symposia that take place all over the world is to be able to communicate, typically in the local language, about the importance of subsea cables. The global backbone of the internet should be built globally and needs to be a collaboration between people from different countries that are being connected.

I'm also working with four brilliant Berkeley undergraduate students right now—Michael Brand, Isabelle Cherry, Ella Herbert and Isabel Jijon—to develop connections with other students.

When I was in Egypt, I met students there, and some really excellent young people—Mariam Reda, Habiba Salem and Hesham Youssef—are now working with the Berkeley students on a global research team. This process takes a little bit of work—how do you collaborate with people who you might have little experience in common with, and yet you share a goal of making the internet sustainable? The students and the young people on this project are really driving this forward.

Why do you think relatively few people know about underwater cables and data centers?

I think the problem is twofold. One problem is seeing infrastructure, in general. People in the United States—students at Berkeley, for example—often don't think about the vast range of infrastructures that their everyday lives depend on. People aren't thinking a lot about what the water system is like until it goes out. They don't think about the power lines until there's a power shutdown. Same thing with the internet.

But then, I think digital media is a special case of this because, whereas, you know, you drink water, and you expect it to flow to you, the internet appears to come from nowhere and annihilate space and time.

There's a long belief held by many over the years that communication systems are making geographies disappear. We are talking here on this app. It's recording us. It's making it seem as if we're in the same room. I can talk to you. I can see you. I can think with you. We are together.

That's something that communication systems do as an infrastructure

that water doesn't: They enable proximity. And that's so in opposition to the idea of a very long, long cable going on the ocean floor. And yet, it feels like our lives now depend on it.

So many people depend on the internet. We need more to know about how it works and need to work together, with others around the world, to build sustainable infrastructure.

Provided by University of California - Berkeley

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