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Ocean plastic waste is a problem with a GIS solution

Engaging Citizen Mappers to Visualize the Ocean Plastic Crisis

Esri Ocean, Weather & Climate GIS Forum

November 9, 2022

Kuta Beach, Bali Indonesia

The ocean plastic crisis has grabbed the world's attention

Often with one-off images like this sea horse holding a Q-Tip.

Credit: National Geographic, Justin Hofman

The ocean plastic crisis has grabbed the world's attention

With the image of this famous sea turtle with a plastic straw lodged in his nostril.

Credit: The Leatherback Trust // Nathan J. Robinson

The ocean plastic crisis has grabbed the world's attention

With graphic images of plastic pollution like this one of a boy with a soccer ball.

Juhu Beach, Mumbai India
Credit: Arab News // AFP

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Environment

2 minute read · February 21, 2022 4:56 PM PST · Last Updated 8 months ago

75% of people want single-use plastics banned, global survey finds

By John Geddie

A woman picks up plastic cups along the riverbank of Pasig river, in Manila, Philippines, June 10, 2021. REUTERS/Lisa Marie David

The ocean plastic crisis has grabbed the world's attention

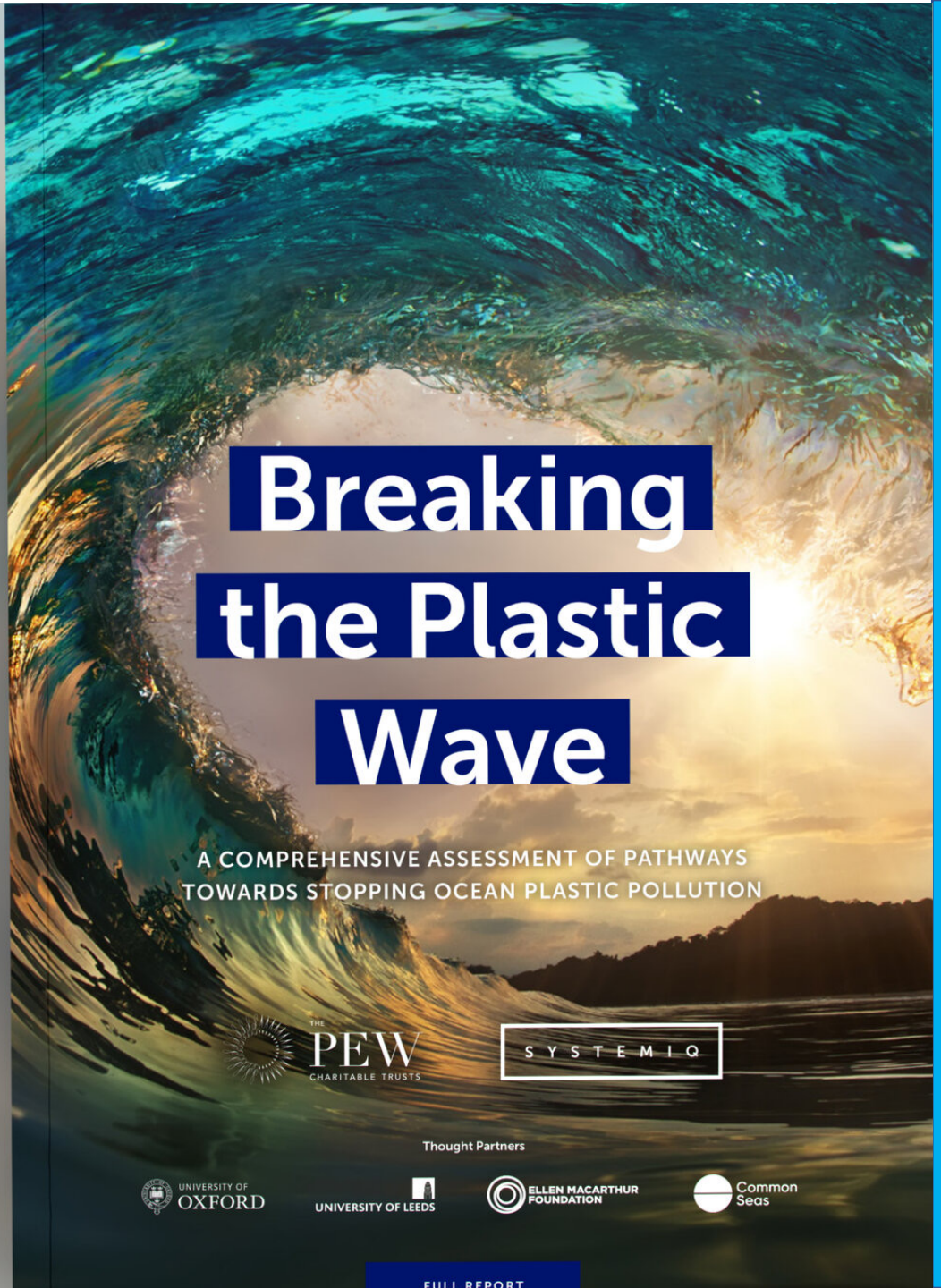
With headlines around the world calling for the end of single-use plastic.

Pasig River, Manila, Philippines
Credit: Reuters // Lisa Marie David

The solutions to the ocean plastic crisis require global system change

- Replacing single-use plastics with other materials
- Changing plastic production and design
- Creating consistent, universal regulations
- Dramatically reducing the amount of virgin plastic
- Improving landfill operations and waste collection in developing countries

Final Plenary of the United Nations Environment Assembly, March 2, 2022
Credit: United Nations Environment Programme



The mechanism for creating these systemic changes involves:

- Development of an international treaty with enforceable commitments
- Billions of dollars of investment by governments
- Trillions of dollars in investment by business
- Political alignment within the U.S. and other countries
- And much more

Breaking the Plastic Wave: A Comprehensive Assessment of Pathways Towards Stopping Ocean Plastic Pollution, July 23, 2022
Credit: Pew Charitable Trusts / SYSTEMIQ

So where are we?

- System changes are essential and should be aggressively sought.
- The likelihood of a timely and comprehensive solution is slim.

Plastic continues to flow into the ocean

- **The equivalent of one trash truck load goes into the ocean every minute**
- **Plastic leakage into the ocean is expected to nearly triple by 2040**
- **From 11 million metric tons to 29 million tons annually**

Dumping toxic waste in the Huallaga River, Peru
Credit: Averyaudio

Solving the ocean plastic crisis requires eliminating false perceptions

Some false public perceptions …

- Most plastic reaches the ocean from the U.S. coastline because the U.S. produces and uses a large amount of plastic.
- Eliminating plastic straws will solve the problem.
- Recycling and reusing plastic will solve the problem.
- Most plastic is floating in the middle of the ocean.
- The Great Pacific Garbage Patch is an island of plastic the size of Texas.

Credit: Esri's Living Atlas

Facts: where does most ocean plastic accumulate?

- 75% is on land - on beaches and on other shorelines.
- A relatively small percentage is in the deep ocean.
- The remainder can be found in coastal waters.

Credit: Sims Lifecycle Services

Facts: where does most plastic reach the ocean?

- Less than 1% comes from the shores of the U.S.
- As much as 70% comes from ten countries
- As much as 55% comes from the top five countries
- Yellow = top 5 countries
- Purple = countries 6 through 10.

Analysis of data from the Center For Ocean-Atmospheric Prediction Studies (COAPS), Florida State University

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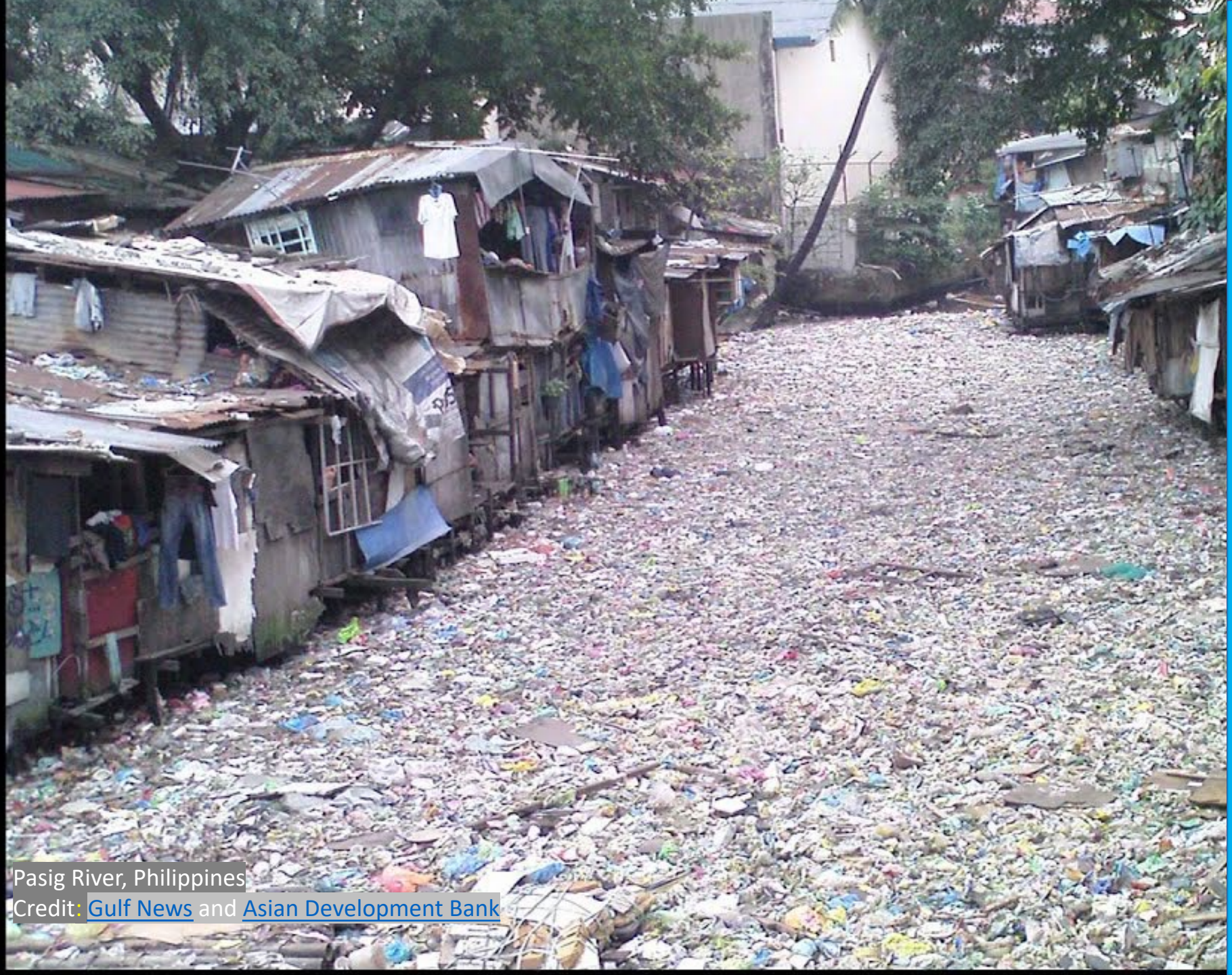


Pasig River, Philippines
Credit: Gulf News and Asian Development Bank

Facts: how does plastic reach the ocean?

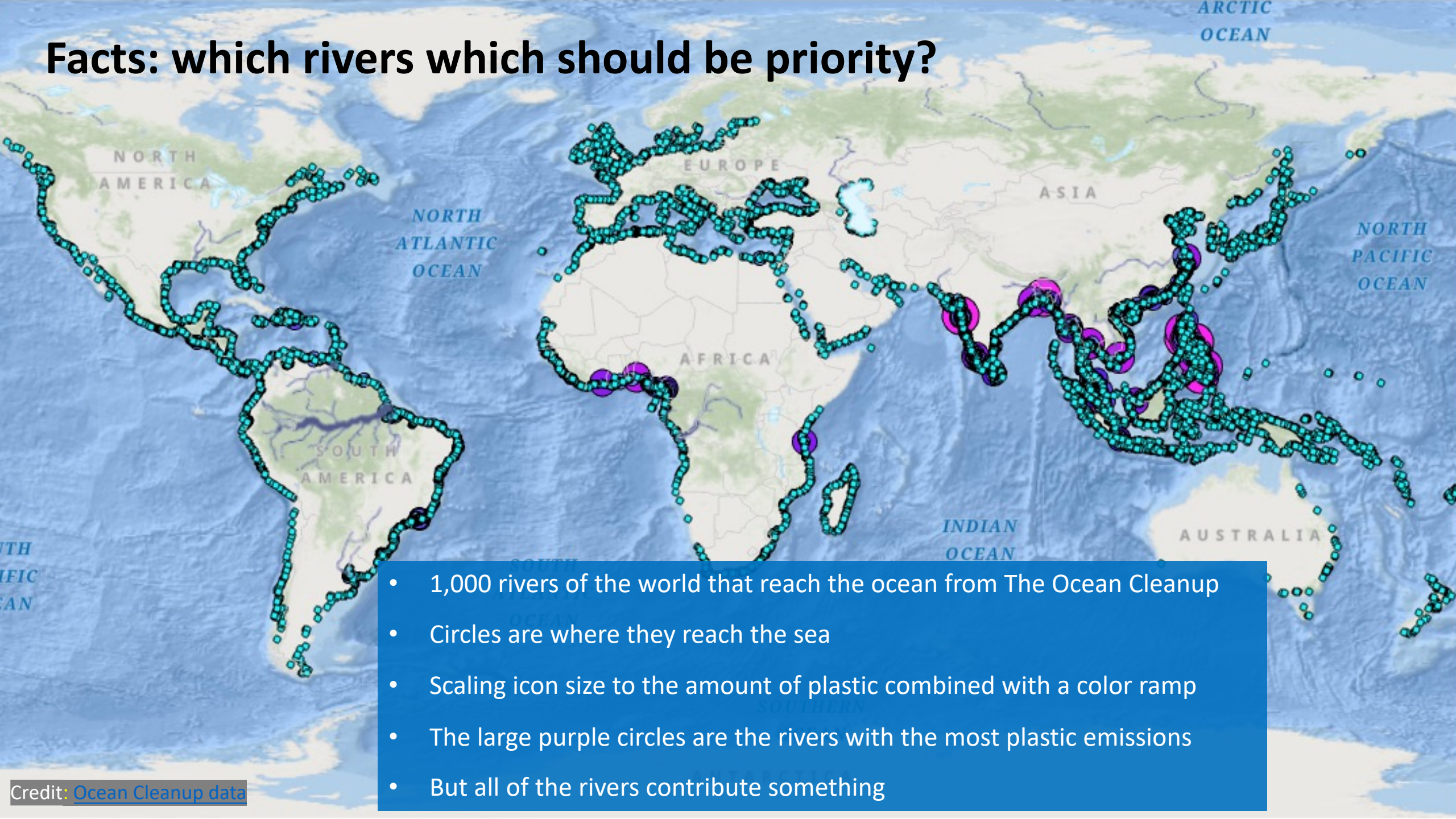
There are only three ways.

1. **Most plastic reaches the ocean via rivers**
2. Mismanaged waste or litter left on a beach or blown or washed onto a beach or into a river
3. Fishing vessels and other ship operations

Plastic reaching the ocean by any of these three sources can be carried to distant shorelines by ocean currents.

Pictured: The Pasig River sends more plastic to the ocean than any other river in the world.

Facts: which rivers which should be priority?



- 1,000 rivers of the world that reach the ocean from The Ocean Cleanup
- Circles are where they reach the sea
- Scaling icon size to the amount of plastic combined with a color ramp
- The large purple circles are the rivers with the most plastic emissions
- But all of the rivers contribute something

Credit: Ocean Cleanup data

Let’s look at the ocean plastic as a supply chain

Plastic Supply Chain

Oil Production → Manufacturing → Distribution → Retail Sales

Customer

Where can the plastic be stopped?

Current efforts focus on these parts of the supply chain:

- Reducing oil production
- Replacing plastic with other materials
- Banning certain types of plastic use (i.e., straws, bags)
- Consumer education

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Let’s imagine ocean plastic as a reverse supply chain

The supply chain continues all the way to the beach.

- **GIS can play an important role in breaking the plastic supply chain.**

The goals:

- Documenting and visualizing the points of contamination
- Sharing solutions that can be implemented at the points of contamination
- Finding solutions that can most efficiently and cost-effectively stem the flows

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Supply chains are all about geography.

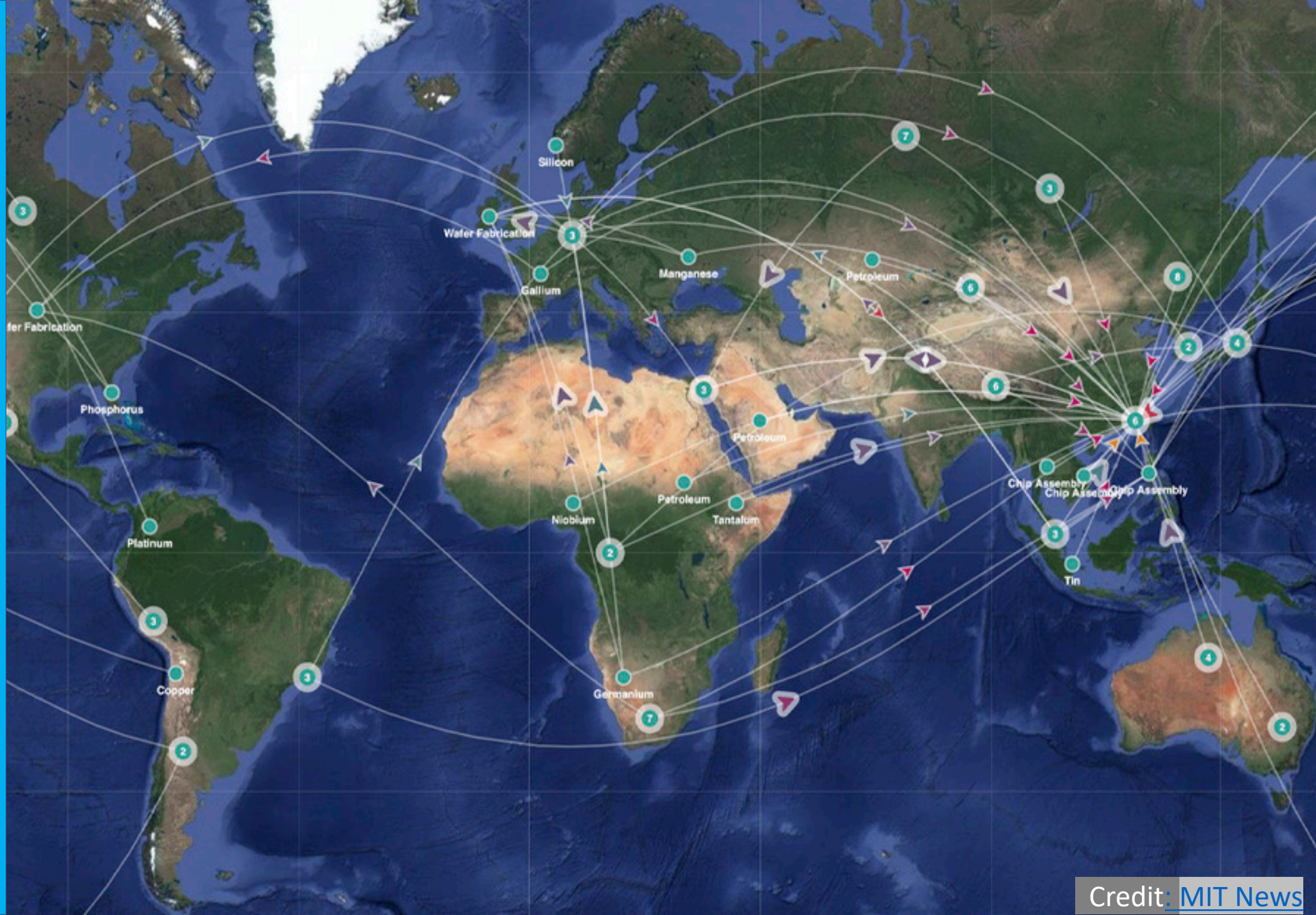
Imagining ocean plastic waste as a reverse supply chain is a perfect role for GIS tools.

- ArcGIS Online
- Survey123
- ArcGIS Pro
- Living Atlas

Traditional supply chains are mappable.

They start with the raw material needed.

Supply chain mapping is the process of discovering and documenting the precise source of every material, every process, and every shipment involved in bringing goods to market.[1]



Credit: MIT News

1 Supplier Assurance

Reverse ocean plastic supply chains are mappable, too.

They start with the beaches fouled by plastic. As shown on the OpenOcean Global Plastic Trash Map

And citizen scientists are the key to finding them.

Reverse supply chain mapping for plastic pollution is the process of discovering and documenting the precise points of contamination at every place involved in carrying plastic pollution to the ocean.

Plastic Trash on Beaches

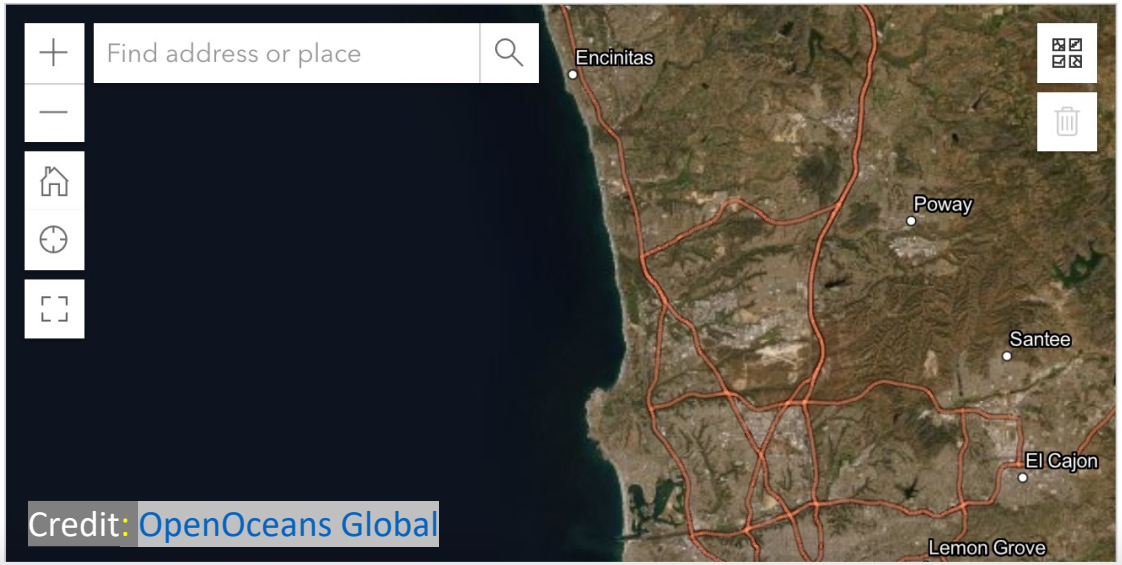
Survey Description

This survey collects data about beaches and other coastal areas around the world that are impacted by plastic and other trash. OpenOceans Global will use this data to unify people globally who are addressing the same problem and will seek to find the sources of the plastic and trash so the flows can be stopped at the source by sharing best practices from others.

Name of Beach or Coastal Area*

The location of the beach.*

Use this map to share the location of the beach or coastal area where plastic and trash regularly accumulates. Use the + and - buttons or use the search field to find the location. Once you have found the location, click on that spot and latitite and longitude will automatically be added to the survey.



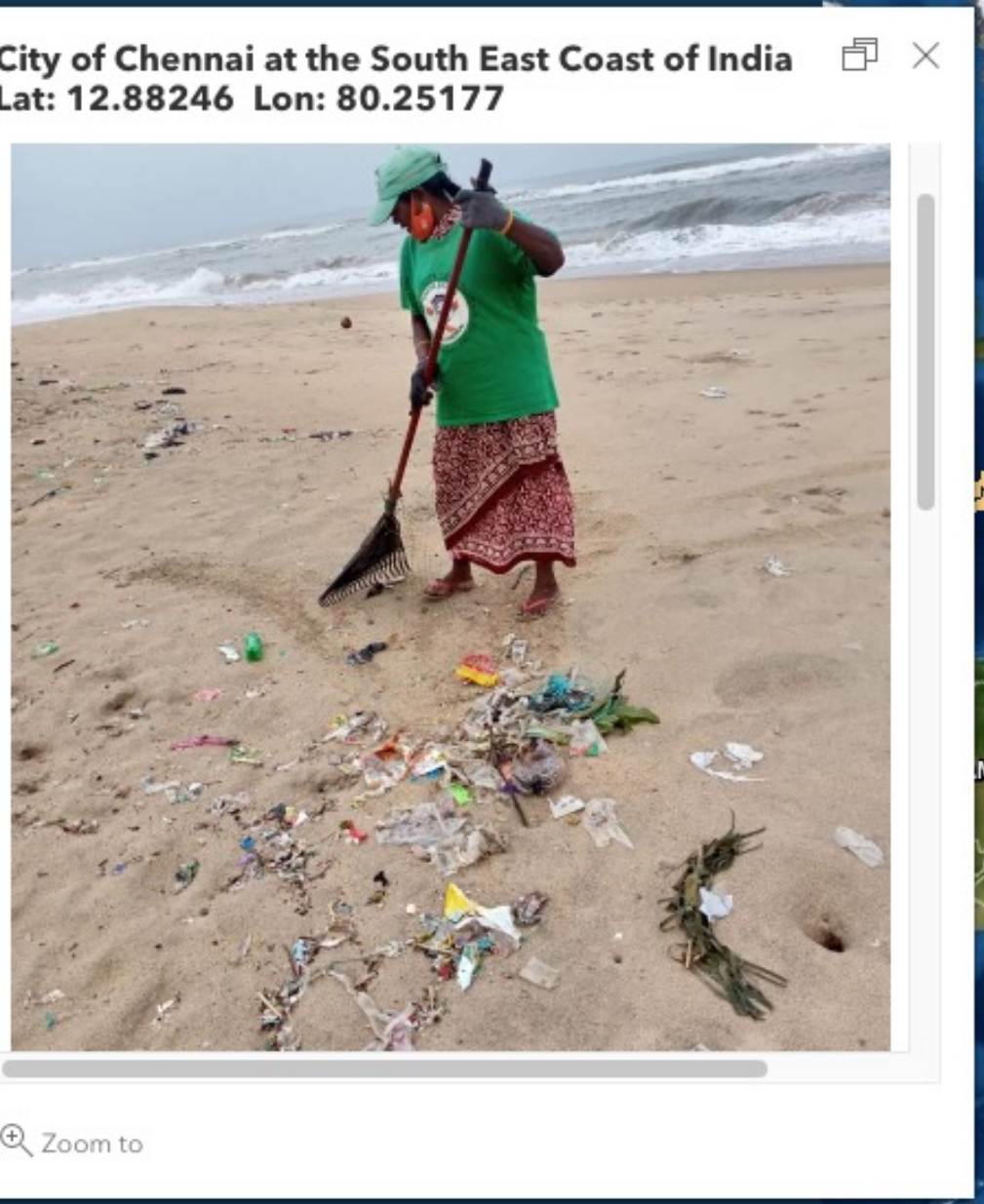
Becoming a citizen scientist

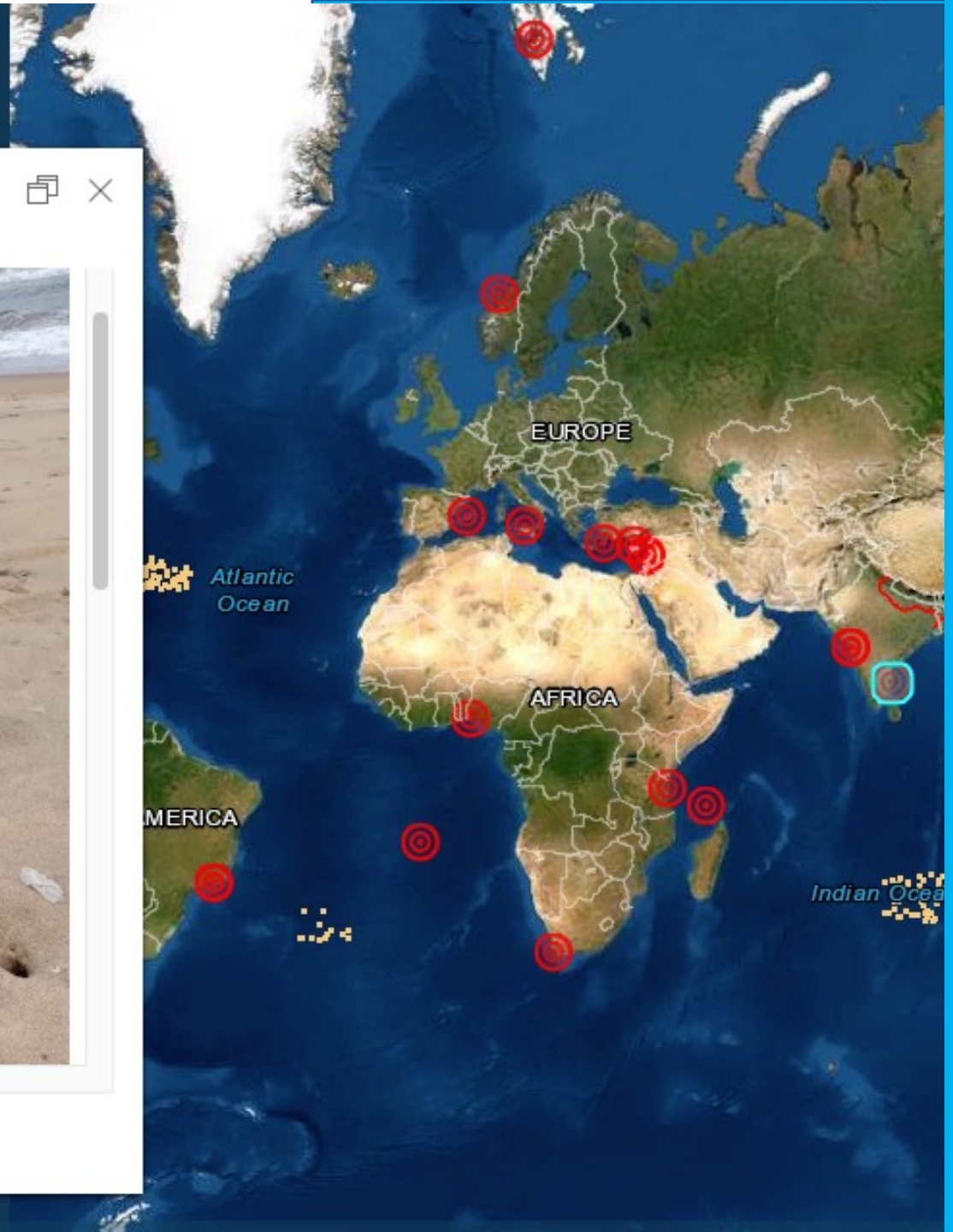
In Chennai, India, a city of 11 million, surfer Karan Chakravarthy learned about OpenOceans Global's map of beaches and became a citizen scientist.

Using an online app **created with Survey123,** Karan put his home beach in Chennai on the plastic trash map and told us about his work with a nonprofit called Namma Beach, Namma Chennai ("Our Beach, Our Chennai").

- In 2021, the NGO removed 176,000 pounds of plastic waste from Chennai's beaches
- Purchased concrete trash bins so there would be place to collect plastic
- Conducted community and school education programs
- Worked with the local beach-based fishing fleet

However, Karan felt more could be done and used our app.





Chennai Beach Popup

Karan provided the image on the left and the following:

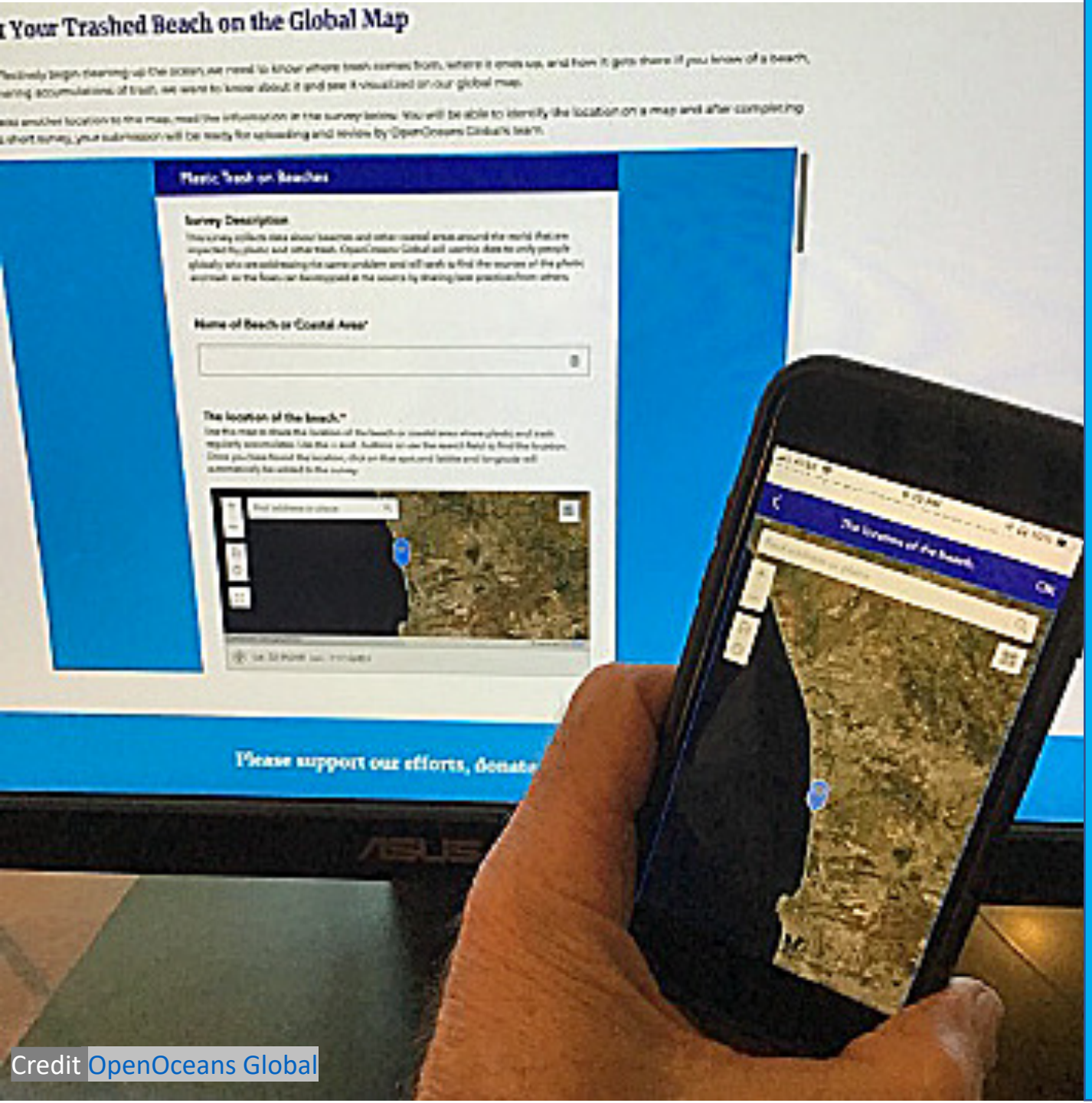
The beaches of Chennai, a city along the southeast coast of India, are fouled by plastic left by beach users and by waste from the nearby Couum River. Namma Beach, Namma Chennai, (NBNC), an NGO, is taking action to clean the beaches.

The primary source of trash: local litter, local river, regional river

Other sources of trash: ocean currents from the north dump trash on beaches

What is being done: beach cleanups, enforcing litter laws, education programs

What else is being done: NBNC pickups and collects trash



The Survey123 online app works great on laptops, tablets and smart phones

Next steps:

1. Continuing to reach out to audiences with potential citizen scientists.

Our campaign has included:

- Traditional media, where we received outstanding coverage on NBC, in San Diego publications, and in some international trade media.
- Social media.
- Direct contact with organizations that will benefit from this work.

Challenge – how do we define a beach as one that should be on the map.

Answer - Creating a fact sheet called “This, Not That” to clarify what we want.

2. Continuing the dialogue with satellite providers and AI specialists to create a layer of plastic accumulations not requiring citizen science.

While local knowledge correctly assessed the source of trash on Karan's beach, the Living Atlas layers on the map confirmed it.

The Esri-authenticated Global Rivers and Other Waters overlaid on the Oceans basemap showed all the major rivers along the eastern Indian coast.

These rivers are potential sources of plastic debris.

Ganges - 6,221,800 kg annual plastic emissions to the sea (major river)

Godavari - 64,800 kg, regional river)

Krishna - 263,300 kg (regional river)

Penner River - 878,900 kg (local river)

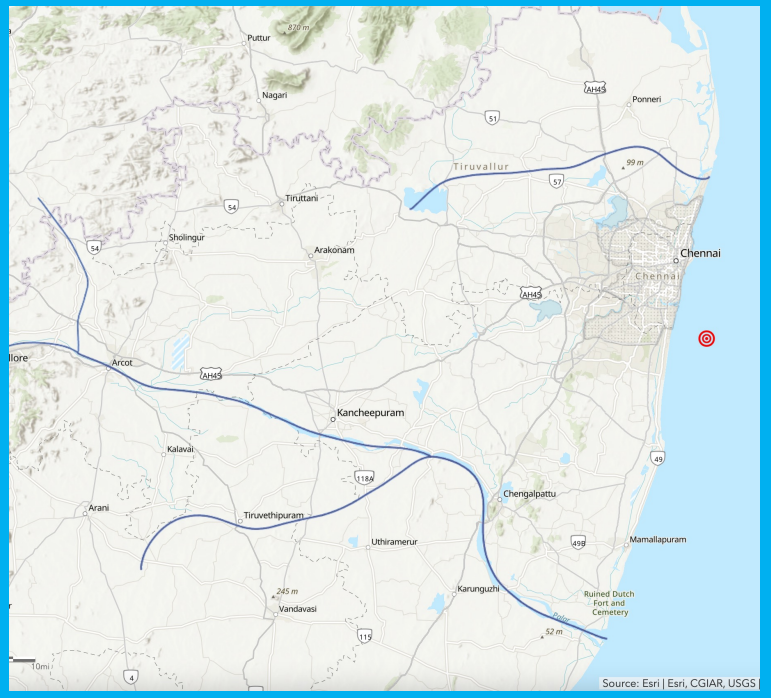
Cooum River - 967,600 kg (local river)

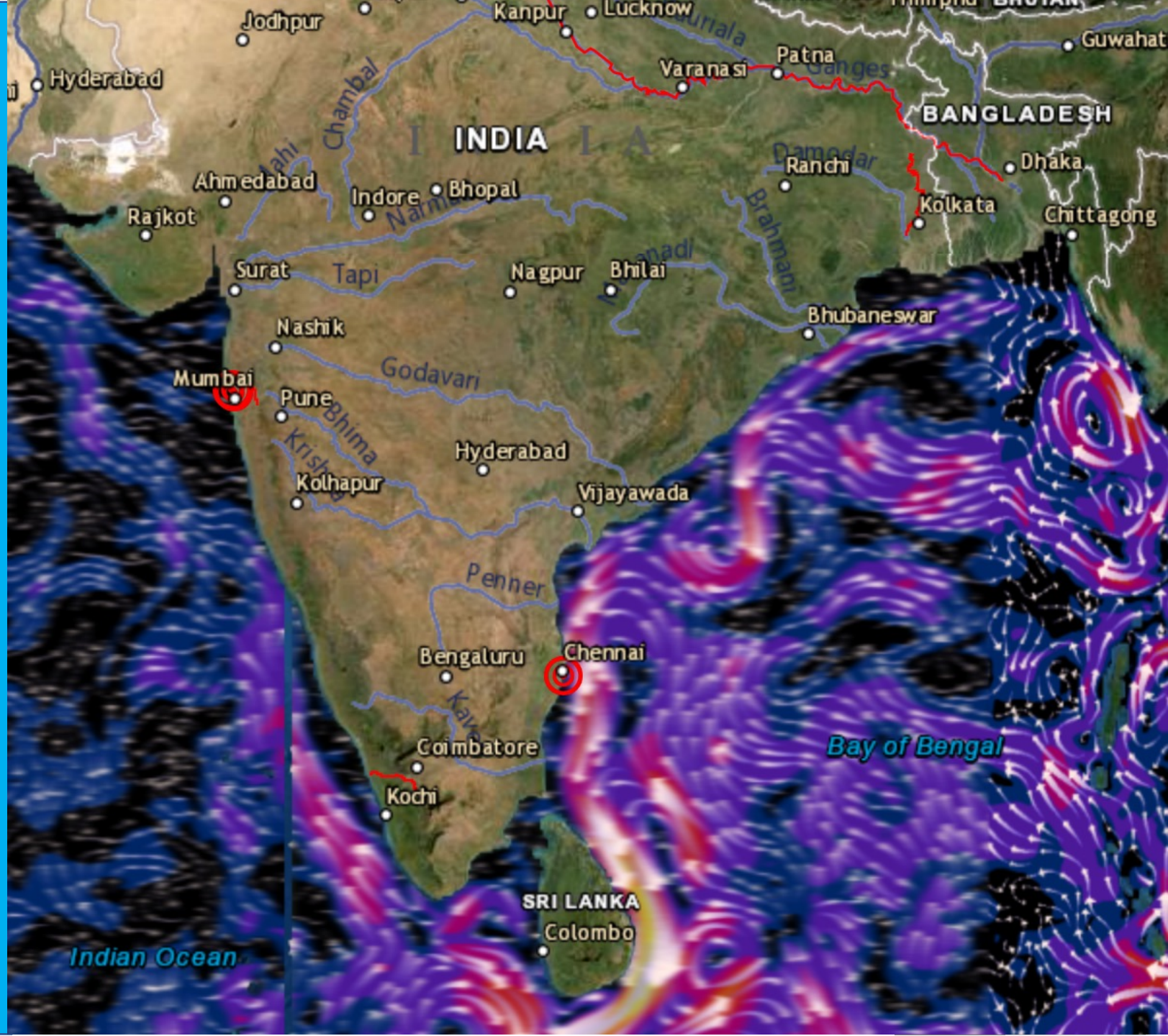
Adyar River - 819,700 kg (local river)

Analysis of kg emissions from a layer created by The Ocean Cleanup

Living Atlas ocean current Layer

NOAA's Oceanographic Forecast Model Guidance - Global Ocean on the aerial basemap confirms local knowledge that prevailing currents from the north are sweeping plastic from a river or rivers in the north. Two local rivers, the Cooum and the Adyar are on either side of Chennai. The Adyar is south of Karan's beach. Leaving the Cooum as the most obvious suspect





Once you know the source, can you stop plastic from reaching the ocean?

Can any of the solutions below stop plastic at the mouth of the Cooum River?

Credit: CC-by-sa PlaneMad/Wikimedia

Alpha Mers Barrier

Credit: Headlines of Today

Baltimore's Mr. Trash Wheel

Credit: Healthy Harbor Initiat9ve

The Ocean Cleanup's River Interceptor

Credit: The Ocean Cleanup

Image Credit: The Hindu

Moving up the reverse supply chain, where can you stop plastic from getting into the river or farther down the river?

In the Cooum River, the Chennai government placed booms in eight places across the river upstream from the mouth.

Mapping the booms helps to see where additional interception is required.

In 2018, the booms captured 22,000 tons of waste (including sludge).

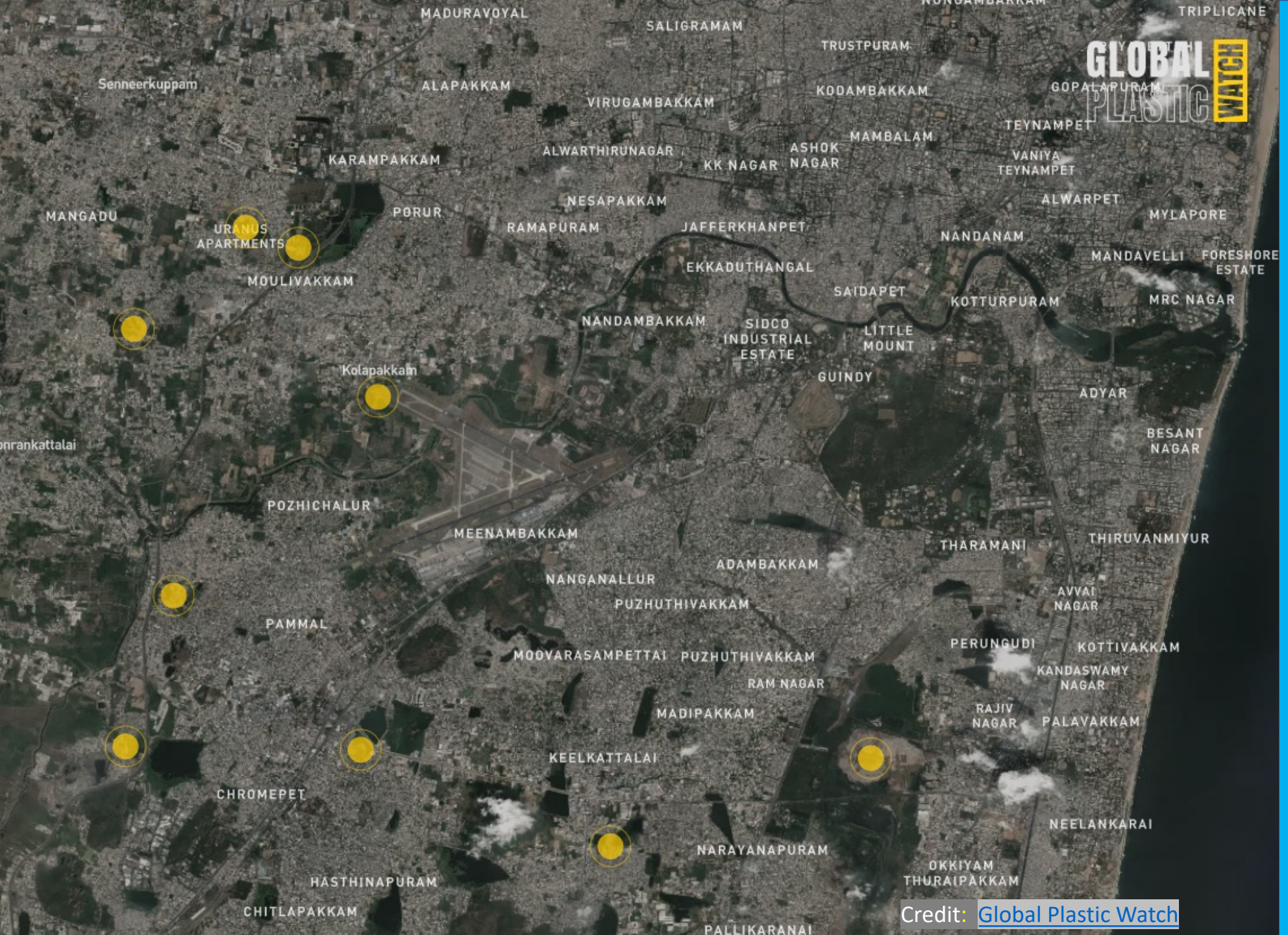
Credit: The Hindu

Farther up the supply chain basin, inlets contribute pollution to the river.

Are these locations places where plastic can be intercepted at the river or where water flows into the inlet before it reaches the river?

These and other tools can help trace the source of the plastic pollution.

In the Cooum, another factor is lack of funding and changes in willingness to address the problem based on political leadership.

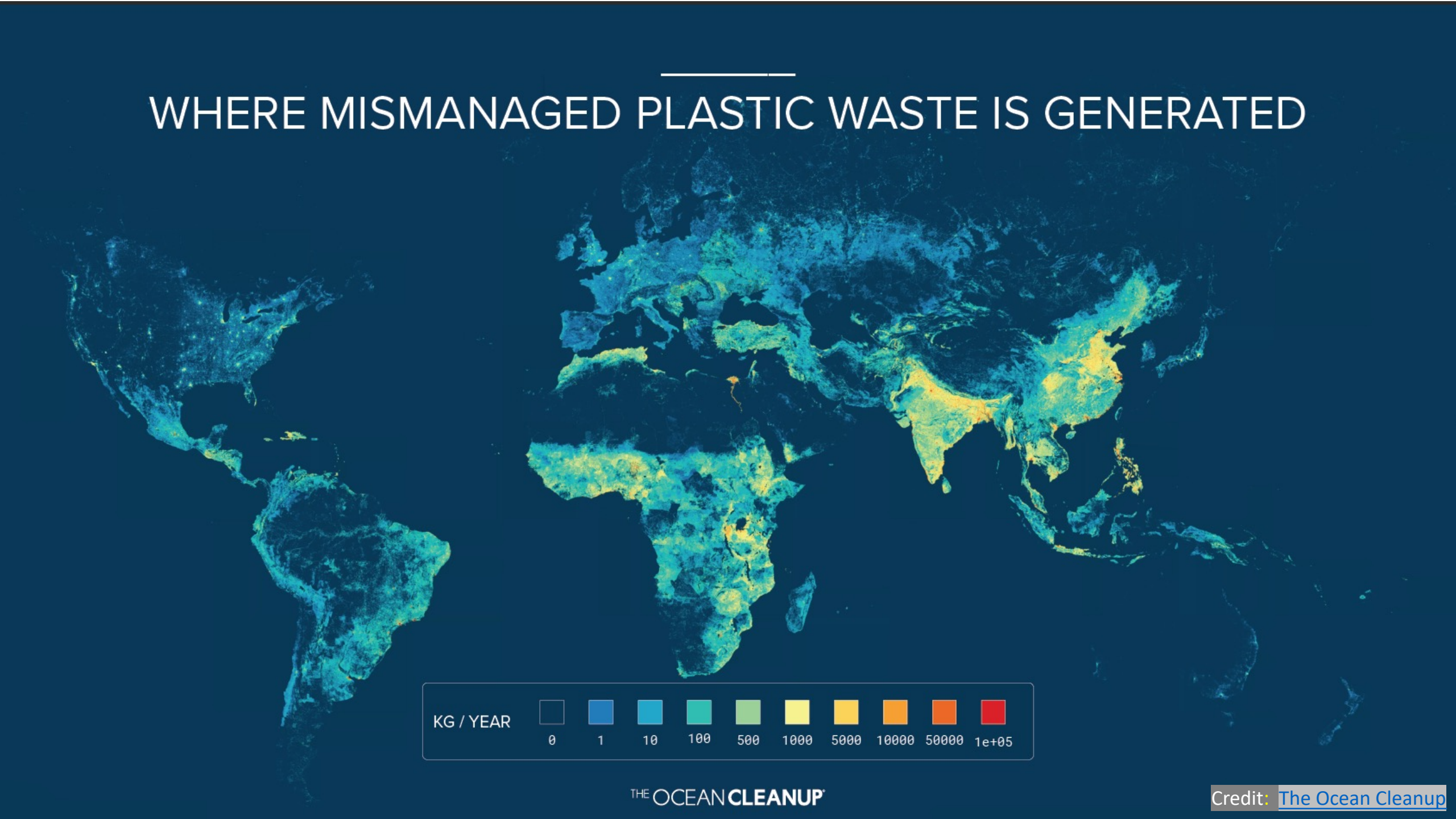


Credit: Global Plastic Watch

Even farther up the supply chain basin, are landfills contributing plastic pollution to the drainage systems and the river?

Do landfills need better cover and management?

WHERE MISMANAGED PLASTIC WASTE IS GENERATED



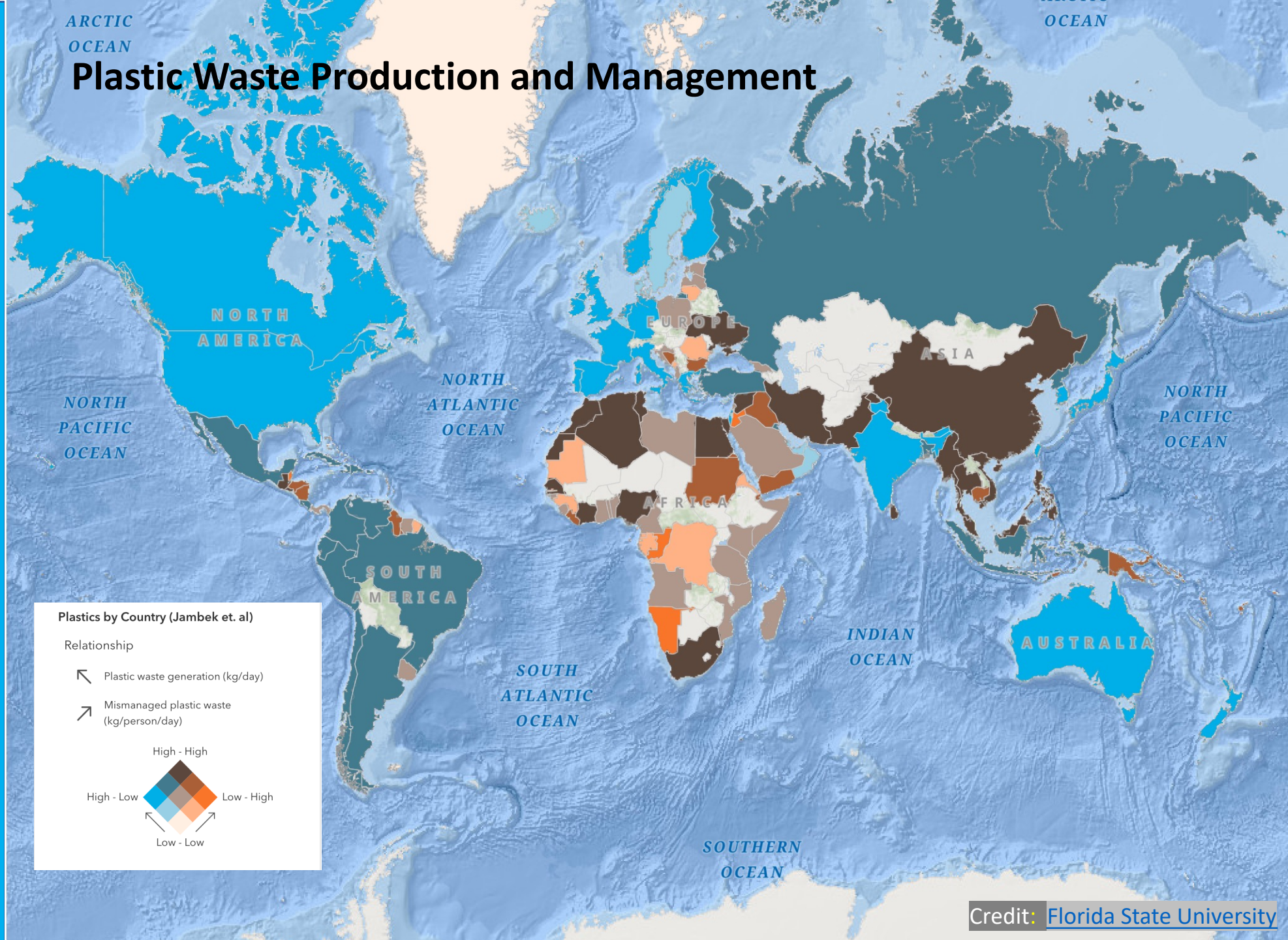
Credit: The Ocean Cleanup

We save money by polluting the ocean with plastic.

An ArcGIS Online layer. The Global Litter Model, helps understand how and where countries produce and manage plastic waste. This is critical to understanding the problem.

Much of the plastic is generated by the U.S. and other developed countries; it just reaches the ocean overseas in at least three ways.

- Developed countries that produce the most plastic ship plastic waste to the most plastic-polluting countries.
- Manufacturers save money by producing products in countries with poor or non-existent trash management.
- Tourists from developed countries have lower-cost vacations because the waste from their visits is not managed well, particularly in island nations.



What if you are on an island or a coastal area where the plastic comes from the deep ocean?

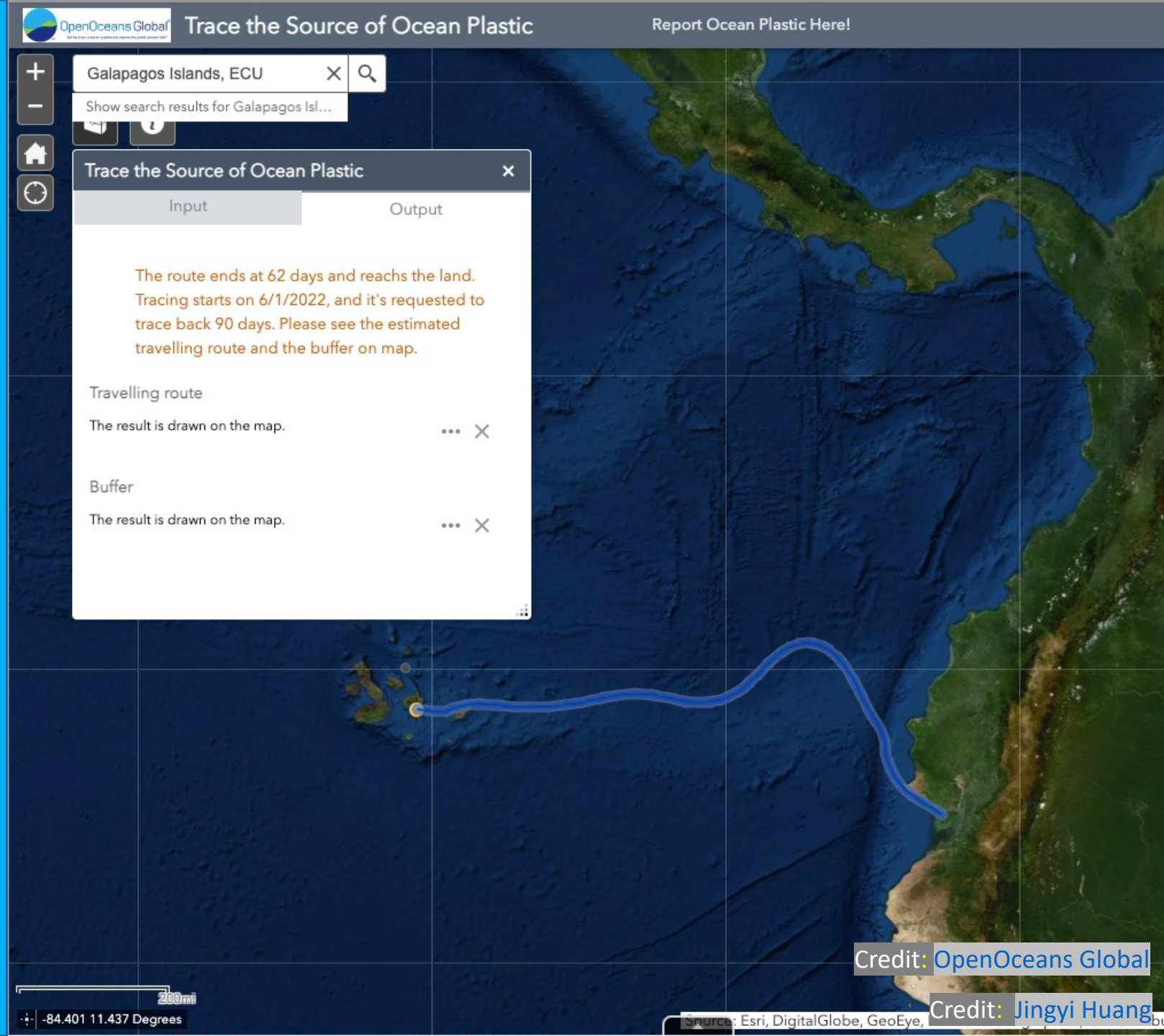
OpenOceans Global built a plastic tracing tool prototype using:

- Ocean Surface Current Analysis Real-time (OSCAR) data
- Ocean current data from NOAA
- Satellite data from NASA.

We tested it using the Galapagos, which in 2019 accumulated 20 tons of debris, 90% of which was plastic.

The tool showed much of the plastic comes from Ecuador and Peru and was validated by Galapagos Conservation Trust forensic data.

- 60% comes from the mainland (30% each from Peru and Ecuador
- 30% from fishing boats
- 10% from litter on the islands



"Once we can see it, we can solve it."

It will take the collective power of individuals to solve the ocean plastic crisis.

- Visualizing the problem is the first step to understanding and solving the problem.
- **Citizen scientist mappers** can make a significant impact by documenting the beaches that regularly accumulate large amounts of plastic. **This is the starting point of the reverse plastic supply chain.**

When decision-makers can see where the ocean plastic problem is, and are shown the sources of contamination, they can do something about it by:

- Implementing solutions **locally.**
- Providing **international resources** from governments, corporations, and philanthropies.
- Establishing **international policies** and treaties.
- Making **substantial changes** to how, when, and where plastic is used.

A Global Approach to Preventing Plastic from Reaching the Ocean

Like many coastal areas around the world today, the beaches in Chennai, India, attract large amounts of plastic debris. For teenage surfer and local resident Karan Chakravarthy, the presence of plastic at his favorite surf spots was distressing. So he decided to do something about it.

Chakravarthy joined other volunteers to collect trash with a nonprofit called Namma Beach. Namma Chennai (which translates to "Our Beach, Our Chennai"). In 2021, the organization removed 176,000 pounds of plastic waste from Chennai's beaches. But Chakravarthy felt that more could be done.

He contacted his grandfather, Mandyam Venkatesh, who lives in San Diego, California, and obtained a $5,000 grant from Venkatesh's Sunrise Rotary Club to further support Namma Beach, Namma Chennai. Through his grandfather's Rotary connections, Chakravarthy also met Carl Nettleton, the founder of OpenOceans Global, a San Diego-based organization that employs geospatial technology and citizen science to help stop the flow of plastic to the world's oceans.

Nettleton set up Chakravarthy with an ArcGIS Survey123 form that he used to record information about beaches in Chennai that are consistently littered with plastic. The data was then uploaded to the OpenOceans Global geospatial portal. Now, on the organization's web-based *Ocean Plastic Map*, a red bull's-eye symbol sits on India's southeastern coast, and a pop-up displays information about the plastic waste found on Chennai's beaches, including where it likely comes from and what is being done to clean it up.

Nettleton hopes that citizen scientists all over the world will do what Chakravarthy has done and record data for OpenOceans Global about beaches that are consistently fouled by plastic trash. In particular, he would like GIS practitioners to take the lead.

How Plastic Waste Gets to the Ocean

Eleven million metric tons of plastic reach the ocean each year, and that number could triple by 2040 if large-scale solutions aren't developed quickly, according to research by The Pew Charitable Trusts and sustainability consultancy SYSTEMIQ.

"The common perception is that most ocean plastic is in the Great Pacific Garbage Patch, which is estimated to be twice the size of Texas," Nettleton said, referring to the largest of five garbage patches in the world's oceans.

However, according to a recent Florida State University study published in *Frontiers in Marine Science*, from 2010 to 2019, about 75 percent of mismanaged plastic waste turned up on beaches.

"Plastic ends up on shorelines because the majority of ocean plastic comes from land, and most of that comes from rivers," Nettleton said.

OpenOceans Global seeks to identify how plastic flows into the ocean and accumulates on those shorelines. According to a study funded by the nonprofit The Ocean Cleanup and published in *Science Advances*, about 80 percent of plastic that traverses rivers and ends up in oceans comes from more than 1,000 rivers—many of which are in Asia, Latin America, and Africa. Researchers found that small urban rivers in places with poor trash management practices convey the most plastic pollution to the ocean. But this doesn't mean that the trash necessarily originates there. Many countries with upper-income economies—such as the United States, Japan, and France—outpace the rest of the world in plastic consumption and then ship more than a million tons of recyclable plastic overseas each year, often to places with trash management issues.

"We think there are ways to stop plastic waste from reaching the ocean if we know where it comes from geographically," said Nettleton. "Even though the United States and other developed nations produce most of the plastic, the Florida State study found that 55 percent of ocean plastic reaches the ocean from five countries: China, the Philippines, India, Brazil, and Indonesia. If the Philippines sends almost 16 percent of the world's plastic to the ocean via its rivers, as this study discovered, the world could focus on developing solutions for this one country and bring global resources behind it to get the Philippines as close to a zero ocean plastic contribution as possible. We could see which solutions work best there—whether it's implementing river intervention technologies to stop the plastic from reaching the ocean, developing new products to replace plastic, or implementing new processes for trash management—and then replicate those models in other high-plastic polluting countries."

A Global View of Where Plastic Pollution Originates

To get started with this ambitious project, the team at OpenOceans Global employed ArcGIS Online and ArcGIS Living Atlas of the World to develop a map that focuses on where plastic litters the world's coastlines.

"You can click on the map and see the rivers of the world, major ocean currents, and a highly detailed point-in-time snapshot of ocean currents," said Nettleton. "These tools help people better understand how plastic debris travels."

Map users can activate layers that show the top 20 rivers that contribute plastic to the ocean and where plastic collects in ocean gyres.

→ Karan Chakravarthy used ArcGIS Survey123 to record data about beaches in Chennai, India, that are consistently littered with plastic. (Photo courtesy of Karan Chakravarthy.)

To read more about OpenOceans Global's work, see the fall 2022 issue of ArcNews.

Thanks to the great team at Esri for publishing this story!

To become a citizen scientist mapper and share a beach fouled by plastic, go to: https://www.openoceans.org/trash-survey

Esri's global network of users can be a critical source of data needed to help the world visualize the ocean plastic crisis.

Thank you!

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