The University of Washington Ocean Restoration Technology Initiative

Confronting the collapse of the oceans through hyperlocal, technology-assisted remediation.

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Abstract

Oceans around the world are becoming warmer, more acidic, and more polluted. Based on all available evidence, it's extremely likely that oceanic systems will suffer a cascading biologic decline before effective remediation can take place. Even if the social and political will needed to confront the problem was already in place, the current rate of deterioration is too fast—and it's accelerating.

The Ocean Restoration Technology Initiative will confront oceanic collapse through hyperlocal, technology-assisted remediation. This approach presents an opportunity that's real and immediate, but also longterm. The first focus is creating a convergence opportunity within the University of Washington. Funded by outside partners and foundations, the Initiative will be a product of the University's cumulative expertise and reach. We will develop, test, and commercialize technological solutions that yield meaningful effects at the hyperlocal level.

These solutions will serve as the front-line defense to protect and nurture islands of relative health and biodiversity. They will serve as a form of life support, effectively buying time while humanity musters the resources to put systemic changes in place. And we can create tools of longterm benefit in the process.

Overview

An Array of Problems

Overall ocean health is in significant decline. A broad array of problems is converging on every ocean on the planet, including:

- Ocean acidification
- Hypoxia and harmful algae blooms
- Temperature increase
- Pollution
- Toxins and micro-plastics
- Over-fishing
- Habitat loss
- Sea-level rise

A handful of contributing factors could dramatically increase the rate and severity of climate change, including carbon sink loss, methane release due to warming permafrost, and volcanic activity. (For an overview of these problems and factors, see "Appendix: Problem Details" on page x.)

If unstopped, these forces attacking the biologic and life-supporting ocean systems will result in a collapse. As inputs and assumptions continue to shift, climate science models predicting failure are proving too conservative in all areas of climate change study. Change is happening faster than anyone thought possible.

So where are we headed? Almost anywhere you look, global trends are discouraging—from the number of coal plants in operation to the projected growth in combustion engines. And in the U.S., our divided culture and calcified politics do little to inspire hope.

Possible Solutions

Broadly, there are four categories that can help us reverse course: behavior change, policy change, increased conservation, and technology-assisted remediation. All of these are necessary for sustained and successful restoration. But it's the fourth that allows us to harness the human talent for innovating and spreading new technologies.

Hyperlocal Remediation

Can we "save the oceans" with technology? We can't. They're too big. But there's an opportunity to explore solutions at the local level. And there are multiple benefits to this approach—in short, we can make things better, but we can also learn a lot as we go.

The Initiative does not aim to start from scratch. Wherever possible, we want to develop technologies that already exist in some form, and then test them at the hyperlocal level. This approach will allow for what amounts to a stay of execution in small oases—Goldilocks zones and biodiversity hotspots in geographically controlled bodies of water like the Puget Sound.

For instance, hyperlocal technology solutions can be used to:

- Mitigate ocean acidification
- Re-oxygenate hypoxic dead zones
- Attenuate thermal peaks of habitat
- Filter chemicals, toxins and micro-plastics
- Assist in ecosystem regeneration through habitat creation and food web support

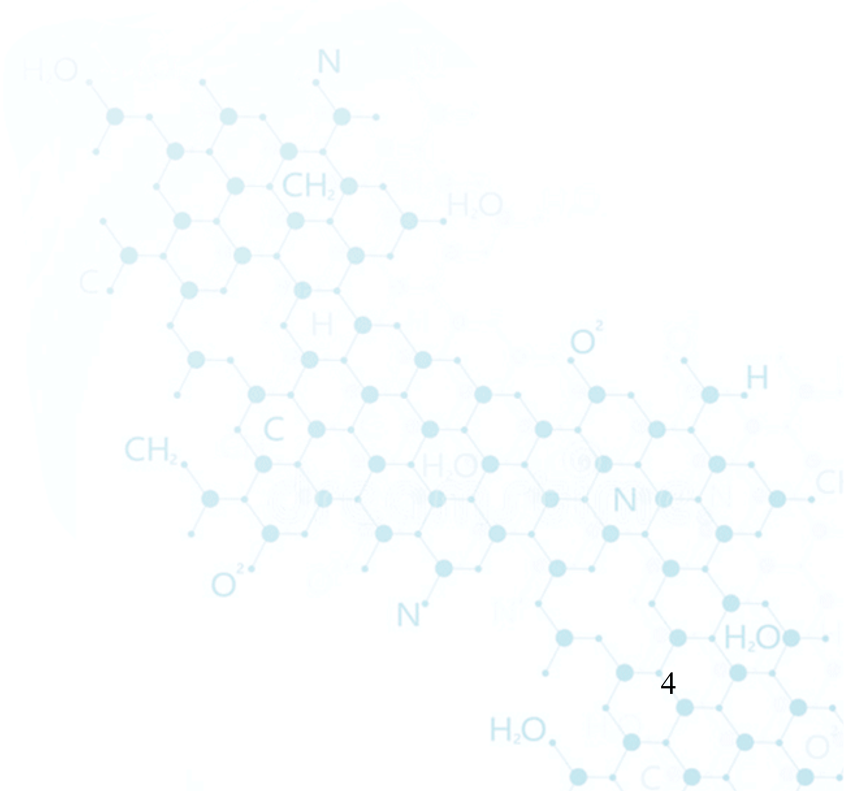
The most effective technologies can be commercialized. Coastal communities can arm themselves with these tools, allowing them to preserve and nurture areas of aquatic biodiversity and productivity.

Scale & Placement

The oceans are far too vast to fix at scale—roughly 362 million square miles. Large-scale geo-engineering projects are unlikely to work, or to work without yielding unintended consequences. But by combining technologies that already exist with observational capacities already in place, we can target localized areas.

Strategic placement will augment results. Rivers, for example, carry pollution, debris, sewage, micro-plastics, chemicals, and agricultural runoff into the ocean, in varying amounts depending on the river. A filtration system placed at or near the river mouth would be able to take advantage of the concentration of contaminates prior to mixing and dilution. A device that dispenses calcium carbonate could be placed at a location where a strong current would increase distribution in the affected area.

Micro-geoengineering enables us to experiment safely and test effectively. The best solutions can then be proliferated to other locations facing the same problems.



The University of Washington

An opportunity for convergence

The University brings a host of relevant strengths to the table. As well as multiple relevant Engineering disciplines, including the Department of Civil & Environmental Engineering and the College of Environment, it is a world leader in Oceanography, Atmospheric Sciences, and Climate Modeling.

In addition, the University is positioned to provide complementary expertise. Related disciplines—including the Evans School of Public Affairs, the Law School, and the Foster School of Business—will allow the Initiative to consider policy aspects, legal aspects, and economic aspects. The Initiative presents the kind of opportunity that can have all manner of positive ripple effects.

While related, the University's EarthLab has a broader mission, with interests and funds spread across many different leaders and initiatives—and that means it wouldn't be able to raise the targeted funds necessary. The Initiative, meanwhile, will be able to raise significant endowments, gifts, and grants—in no small part because of the immediate value those funds can create by being focused.

Positive ripple effects of the Initiative

- Provide an area of convergence for multiple disciplines in which the University is a leader
- Create significant opportunities for public/private partnerships
- Encourage endowments from top foundations and philanthropists who are committed to the ocean and passionate about technology
- Serve as a magnet for future students and prominent outside faculty
- Receive positive coverage from the press and like the State Relations Office

Technological Remediation Categories

Overview

The hyperlocal approach presents an opportunity that's real and urgent but also longterm. Broadly, our technology mission is to develop a range of devices that will reverse or mitigate conditions of imbalance in local areas of water. The questions that guide us will pertain not just to what technologies are acceptable, but also to how we can rigorously measure their effects.

Where possible, the Initiative will explore ways to repurpose existing technologies with new parameters and specifications in mind. A key part of the design, prototyping, and iteration process will involve technology components that are either already on the market or have been invented by other research labs with which we forge partnerships. The projects that emerge will be products of scientific rigor, creating opportunities for department and student projects across closely related disciplines.

We're also next door to a great resource: the Puget Sound offers a wealth of opportunities to explore remediation at the hyperlocal level. When, for example, an engineering team sets out to develop and test devices that help re-oxygenate hypoxic dead zones, there's a natural opportunity to work in collaboration with the University's marine biologists studying the effects of hypoxia on Hood Canal's oyster beds.

This section will take a look at the following categories of technological remediation:

1. Pollution Filtration
2. Re-Oxygenation
3. Thermal Attenuation
4. Carbon Sequestration
5. Biologic Support
6. Power
7. Materials
8. Maritime Improvement

Pollution Filtration

Garbage debris, plastic, micro-plastics, agricultural nitrates and chemical toxins contribute to poor ocean health and kill marine life. Is it possible to build a filtration system that cleans a local area of water of some or all of these pollutants? The four categories of filtration—active, passive, biologic, and chemical—all present opportunities for technological innovation.

Re-Oxygenation

Hypoxic dead zones, whether stemming from agricultural runoff or HABs, are sharply on the rise. We can develop devices to re-oxygenate an area – either through sea-level mixing, directly pumping oxygen, or a combination of both. As mentioned above, Hood Canal's waters range from low-oxygen to occasionally severe hypoxia, providing a ready test zone.

Thermal Attenuation

Changing the thermal state of bodies of water is prohibitively energy-intensive. Take the Great Barrier Reef: Lowering the temperature of its roughly 3.4 trillion cubic meters of water volume by one degree Celsius would require the output of two gigawatt power plants running at full capacity for 228 years. We will experiment with lower-energy solutions that aim to keep coral cool within a confined radius.

Carbon Sequestration

More experiments are needed by the global scientific community to determine the most efficient approaches to this puzzle piece – whether through fertilizing targeted areas of water with urea or iron, mixing layers, or creating more seaweed farms. We'll examine and employ technologies that can be innovatively used to distribute calcium carbonate, iron, and other materials that promote carbon sequestration.

Biologic Support

Broadly, the goal is to promote habitat life support – whether that means coral support, artificial reef development, or developing technologies to assist the food web. In the Pacific Northwest, we've seen a massive decline in salmon during the past 50 years, in significant part due to habitat loss. And now we're witnessing further salmon fry decline stemming from river temperature increase.

Power

In many of these cases, the technology in use will require electricity. We can develop miniaturized ocean energy applications, or partner with existing ocean energy organizations to run remediation devices. Alternatively, we can partner with ports and other coastline entities for use of power.

Materials

Material science will be a key part of the advancement of ocean technologies. Where possible, we will want to use partnerships with existing entities for the use of advanced materials and material processing for technological applications. Graphene is an example of one material that could be useful in multiple ways – including as a filtration membrane.

Maritime Improvement

Merchant ships, cargo ships, cruise ships and oil tankers all produce a disproportionately high amount of pollution. We will build partnerships that assist in the technological development of pollution solutions in the maritime industry. Sewage, bilge dumping, sulfur diesel emissions, noise pollution – all of these present opportunities for innovations that cut into maritime pollution levels.

Implementation Approach & Concepts

Part of the mission of the Institute will be to spin out actionable businesses that positively effect change in the context of a demand. Whether that buyer is a corporation or a government, we must create technologies that solve a real-world problem for a customer, at an economically viable cost. This business-driven approach will help maximize the proliferation of remediation technologies, monetizing innovations that prove out based on peer-reviewed scientific direction.

A few examples include technologies that produce food, whether penned aquaculture or free range aquaculture; pollution filtration technologies for marinas, ports, municipalities, and merchant ships; and projects that can be sponsored by technology companies or even citizens via social campaigns.

The Center also plans to create partnerships to address problems cooperatively. Ports and the maritime industry provide excellent partnership opportunities due to their use of, and proximity to, the ocean. The Port of Seattle is already willing to allow the Center to deploy an experimental prototype for pollution filtration at their docks.

Below are quick snapshots of some of the concepts we've begun designing solutions around.

Potential Concepts for Exploration

Rethinking Ports

In the U.S., ports are public entities, and operations are funded by annual tax levies, which opens the door for potential partnerships. For instance, the Port of Seattle's 2018 budget allocates funds for pollution remediation and other environmental projects.

Augmenting Offshore Wind Farms

A recent study in marine ecosystem effects of off shore wind farms in the North Sea found that the structures these wind turbines are built upon are changing the marine ecosystem around them in a positive way. By providing habitat, these wind farms serve a second purpose. By partnering with offshore wind companies, we can and add a more conscious approach to this regenerative effect.

The Modern Marina

We can design smarter docks. Docks that clean and filter pollution at the source, for concentrated effect. Marinas also go through a lot of freshwater because boats need to fill up. Small-scale desalination at the marina level could be a value-add to the marina owners.

A Cause & a Cruise

The simple truth is that there's no surer way to feel invested in the ocean than spending time on it. Millions of people take cruises to Alaska from Seattle or Vancouver every year. By partnering with the cruise ship industry and doing a combination of environmental education and outreach aboard their cruises, we can create more ocean-conscious citizenry.

Tributary Treatment

Rivers bring a lot of pollution and agricultural runoff to the ocean. In fact, a recent study found out that the majority of the plastic debris in the oceans today originates from 10 rivers (two in Africa and eight in Asia). By designing pollution filtration systems that live at the mouths of rivers, we can be more effective at pollution and nitrate filtration.

Smart Buoys

Smart buoys are floating robots that serve a variety of regenerative purposes. There are a number of possibilities for a smart buoy deployment, including outfitting compressed air and multi-depth tubing devices to a buoy in a hypoxic dead zone, to calcium carbonate dispensing systems that are attached to buoys.

Jumpstarting Depleted Habitats

We know that building habitats in the ocean typically results in an increase in marine life. We can design low-cost habitat structures that are suited for targeted types of marine life in a multiplicity of regions.

Hyperlocal Thermal Cages

Changing the temperature of a body of water is extremely energy-intensive. We can repurpose refrigeration technology to cool a limited radius throughout a hyperlocality (like coral) or to build a safe area for salmon fry in rivers.

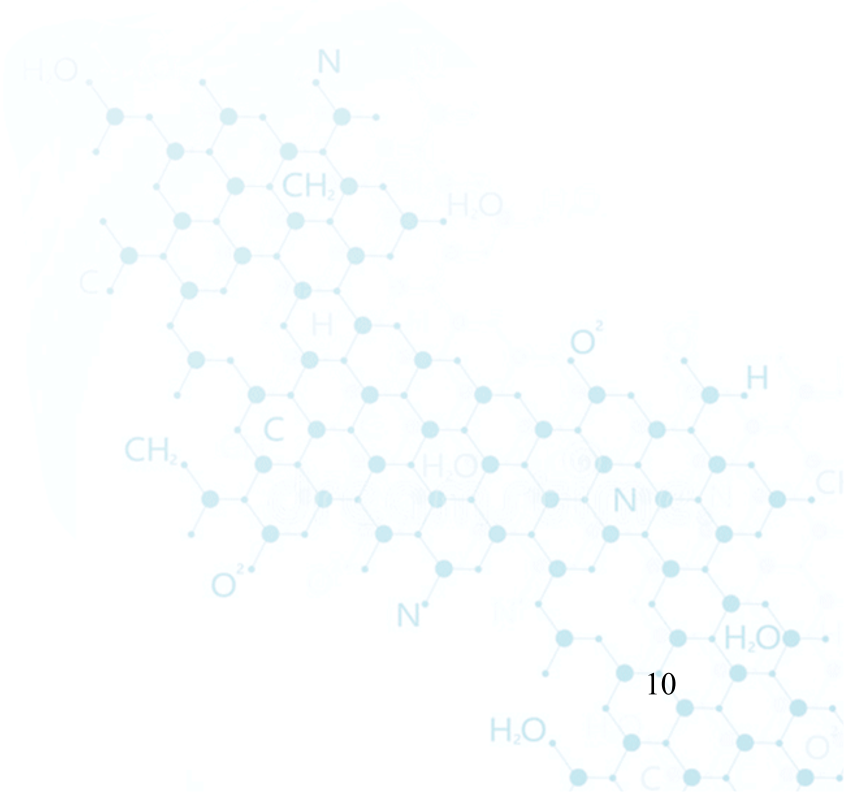
Conclusion

The Challenge

The march toward total collapse of the marine ecosystem is well underway, and its pace is accelerating. Vulnerable populations worldwide have become keenly aware of both the state of decline and the lack of solutions at hand.

The Opportunity

The moment is right for a new model of action: Hyperlocal technology-assisted remediation. We can protect and preserve islands of biodiversity and aquatic productivity. By forming partnerships with foundations committed to the cause, we can fund a multidisciplinary Initiative at the University of Washington to develop and test technologies that remediate problems at the hyperlocal level. When a technique or device proves effective, we can commercialize it for use in similar localities across the globe. A thousand points of light to weather the darkness: We can buy humanity time to make systemic corrections.



Appendix: Problem Details

The following is an overview of the problems and factors contributing to the significant decline of overall ocean health:

Ocean Acidification

OA is killing plankton. The PH imbalance caused by OA makes the water too acidic for young pteropods and plankton to grow exoskeletons, and they die. If OA is going to continue apace—and it will, because it's the direct result of carbon emissions—we're headed for catastrophic loss of plankton, which will lead to a massive collapse of the food chain in multiple parts of every ocean.

Carbon emissions are the main cause of ocean acidification. And some of the biggest CO_2 contributors are growing at breakneck pace:

- Nearly 77,000 new coal-fired power plants (above the 30mw threshold) were built in 2016, globally. This brings the worldwide total to 1.96 million coal plants
- Roughly 1.2 billion vehicles in use globally, 99.8% of them powered by combustion engines. That number is expected to rise to 2 billion by 2030
- Merchant ships (oil tankers, cargo ships, etc) numbers are roughly 90,000 in operation world-wide. These ships emit carbon in mega volume due to their higher than regulatory-acceptable levels of sulfur diesel, sheer size and continual days of operation.

As a planet, we're not getting away from carbon. As more populations are becoming wealthy enough to get electrical power, or to where their average citizenry can buy a car, they are joining the rest of the advanced world, and they're doing it via coal-powered plants and combustion engine-powered cars.

Carbon emissions that go up in the atmosphere eventually come down—only to be absorbed by the ocean and contribute to ocean acidification. Even if we went cold turkey and put no CO_2 into the atmosphere starting today, there's already enough carbon in the atmosphere that it will still be coming down 20 years from now. If we just stop cold turkey—which we're not doing—we'll have ocean acidification happening for the next 20 years.

Hypoxia

Hypoxic dead zones are decimating fish populations. When algal blooms die, all their toxins are released, which sucks all the oxygen out of that area, resulting in a dead zone that can kill millions of fish.

One primary cause of algae blooms is temperature increase caused by carbon emissions. As water temperatures increase, we're getting a lot more algae blooms. Varying types of algae will bloom up in a multiple square-mile area. Once that algae bloom starts to die, the process of decomposition sucks all the oxygen out of the water, leaving behind a hypoxic dead zone. So, if fish swim into it, they die.

Another cause of hypoxic dead zones is often found in basins at the mouths of rivers. Take the Gulf of Mexico. The Mississippi River carries so much agricultural runoff from up river that its waters are packed with nitrates by the time they reach the Gulf. The nitrates then devour the oxygen in the area, resulting in one of the largest hypoxic dead zones. And the problem is worsening rapidly.

Temperature Increase

There's not a lot we can do about the general thermal increase of our oceans' water. After all, we're increasing the temperature of the planet; therefore, the temperature of the oceans will increase.

But it's a major problem, and particularly so, since it's just going to exacerbate a whole bunch of other problems that already exist, like coral reefs dying and the corresponding habitat destruction.

The Great Barrier Reef is one of the most astonishing ocean habitats on earth, and we're watching it be bleached to death by rising ocean temperatures. Australia is on the verge of losing a significant portion of its $3 billion tourism industry—and yet, the current conversation centers not on what to do about the Great Barrier Reef, but rather how many more coal plants to build.

Rising ocean temperatures are bleaching many types of coral around the equator. As global temperatures rise, so do ocean temperatures, which is bleaching many types of coral around the equator. This bleaching will cause a collapse of coral reef systems which are habitat for thousands of species.

Toxins & Microplastics

Ocean pollution comes in many forms. Large scale plastic, small scale DDTs, mercury, and CO_2 emissions all are top sources of pollutants.

Every coastal city in America intentionally dumps some form of pollutant into the ocean—whether it's sewage or storm drain runoff or ports that permit cruise ships, oil tankers and cargo ships to operate knowing they exist outside the norms of environmental consideration or policy.

Overfishing & biologic decline

Two billion. That's roughly the number of people who survive on oceanic coastlines around the world. And they survive, many of them, through fishing. But the stark reality is that people, like in the Philippines, China and in India, they've depleted their waters. Not only are they facing the same problems caused by OA, thermal increase, garbage, plastics, and toxins, but they're severely over-fished. As a consequence, fishermen are now having to travel further out from their country of origin to find fish.

Globally, we're facing food decline while the world population continues to increase. Less food to try to feed more people. With declining fish stocks world wide, fishing vessels need to travel farther and often into illegal territories or into sovereign territories to find their catch. Some countries still allow drag netting—which takes everything and lays waste to the habitat.

Habitat Loss

Habitat loss is not just about the coral. Here in Washington State, we have something like a 90% reduction of kelp over the last 20 years. And kelp is having a hard time surviving all over both Atlantic Coast and Pacific Coast. Kelp is a good absorber of carbon, so with less kelp, you're absorbing less carbon, and more carbon is free-floating.

But loss of kelp also represents habitat loss, so there's less area for biology to survive, and consequently less biologic filters. If a variety of shellfish types are not surviving, the ocean soon becomes even more unhealthy because all those shellfish actually act as effective filters. It all leads to an even unhealthier ocean system.

Carbon Sink Loss

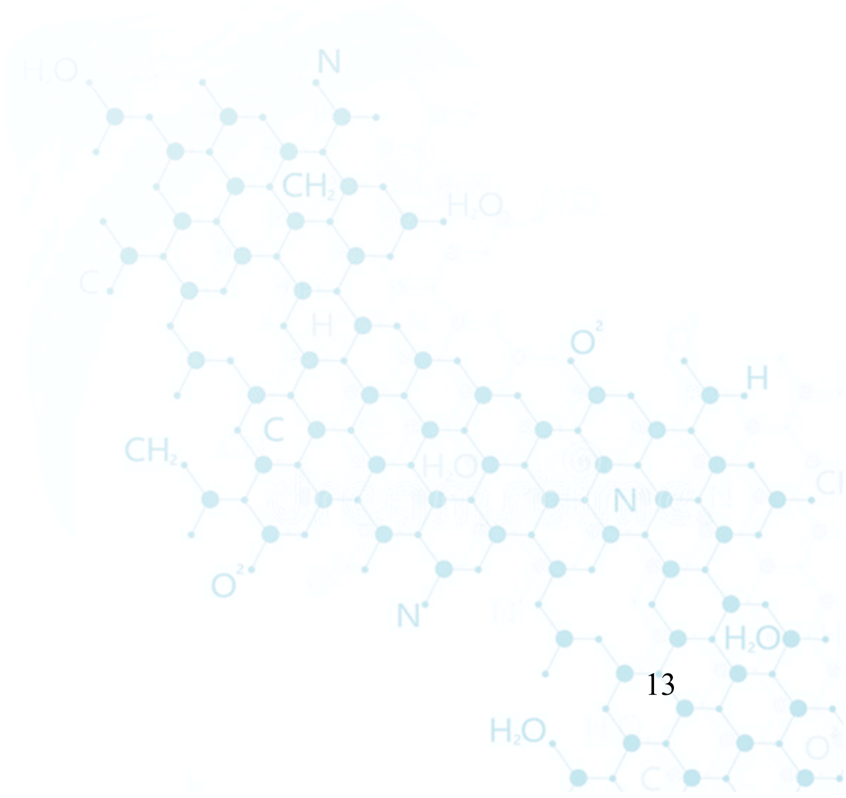
We're pacing ahead of the worst climate models from five years ago. How do you model in the fact that the Amazon jungle is no longer a carbon sink, but is now emitting carbon? How do you model that into your equation of how much carbon is in the atmosphere?

What we can say is this: If you evaluate the health of the ocean, either via fish stocks or biodiversity analysis or any number of things and you look at it, it's all downward trending. And the contributing factors are not getting better—they're getting worse.

Pollution, Nitrites, Agriculture & Urban Run-off into Rivers

A river starts in one state, flows to another, and then to another. When it comes out on the coast, it carries with all manner of agricultural runoff, nitrates, and pollution. Cities add storm water runoff and sewage. It all goes right into the river and it all flows out into the ocean. It's a hypoxic dead zone and a very polluted area.

The other issue that we're gonna have which is unique to the Pacific Northwest is that rivers are becoming too hot in the summer and it's killing the salmon fry. How are we going to cool rivers down to allow the salmon fry to survive and thrive?



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