1 x 60' 4K

Hacking Evolution:

LIONFISH

The invasive lionfish is a symbol of how one unintentional action can cause unimaginable havoc on the evolutionary process.

Commissioned by PBS Nova

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SUMMARY

FORMAT: 1-hour broadcast television feature, produced for PBS NOVA & Escapade Media

STORY: Human beings have always been on the move. And as we've traveled, we've brought all manner of plants, animals, bugs and diseases with us, accidentally or on purpose, introducing them to places where they aren't native. And it's happening today like never before. The invasive lionfish that was unintentionally introduced by humans along the Atlantic Coast and in the Mediterranean, is a tragic example of how sometimes newly introduced species balloon out of control, dramatically altering and sometimes destroying their new environments. Why is that? Why are complex and well-established ecosystems sometimes so fragile when faced with a single new vine or fish or insect? How does nature respond and recover? And what – if anything – can we do to help? Danni Washington, an engaging science communicator with a background in marine biology, takes us on a journey into the story of the lionfish, and the deeper scientific questions that explore what it means to be invasive, non-native or native from a greater evolutionary perspective.

STORY HIGHLIGHTS

- **Witness the lionfish hunt and examine its distinct traits that make it such a successful predator in its non-native habitats**
- **Follow experts and locals with divergent points of view**
- **Dive 800ft underwater in a submarine to investigate newly observed lionfish behavior**
- **Modern approach to natural history with energetic host**
- **Dive into the unknown, as we explore the outcomes of modern society's impact on the rapidly increasing pace of evolution**
- **Travel from the woodlands of the Pacific Northwest to Caribbean waters as we step back to view the ceaseless process of evolution from wider and deeper perspectives**
- **Question what it really means for a species to be invasive, native or non-native**

STORY BREAKDOWN

SYNOPSIS:

While gliding on a paddle board, marine biologist and science communicator, Danni Washington introduces herself and the story ahead.

Human beings have always been on the move and we have brought all manner of plants, animals, bugs and diseases with us, accidentally or on purpose introducing them into places where they aren't native. And it's happening today like never before. We explore why some introduced nonnative species are harmless, and even beneficial, while others become unstoppable conquerors that devastate regional biodiversity. To tell this story, we examine what many scientists believe to be the most successful species ever – the lionfish.

ACT I

1A: Artificial Reefs & Fish Count

At a massive artificial reef shipwreck site in the Gulf of Mexico, we follow Danni as she dives with fish counters who are keeping track of marine life on artificial reefs in the Gulf.

Danni discovers and observes the lionfish amongst the native fish. The fish counters explain that artificial reefs were created to rehabilitate reef life, but have been overrun by the lionfish that do not belong in these waters. Within only a few decades, they went from population zero to second most abundant fish along the Atlantic coast from Maine to Venezuela, wreaking havoc on the ecosystem and communities.

1B: Invasive Lionfish Origins

In the Florida Keys Danni meets with marine biologist Alli Candelmo, a lead lionfish researcher for REEF (the Reef Environmental Education Foundation).

Alli and Danni discuss the extent of the lionfish invasion and how it began in the first place. Alli shares how aquarium hobbyists in Florida began the invasion in the 1980's by releasing their pet lionfish into the Atlantic ocean. A series of vintage polaroid photographs illustrate the events in a hip 80s apartment (created from a staged reenactment). The seemingly innocuous action of releasing a pet fish created an absolute biological disaster in the Atlantic, and lionfish are now also invading European waters as well.

1C: The Mediterranean Influx

While the lionfish was made invasive along the Atlantic Coast via aquarium releases, it is upending another region of the world, Europe and the Middle East. The Suez Canal merged the Red Sea with the Mediterranean Sea, creating a highway for ships and marine biodiversity to travel back and forth. Without humans' modern engineering the two different bodies of water would never have instantaneously connected, and the mass movement of foreign species into the Mediterranean, called Lessepsian Migration, would never have occurred.

Alarmingly, they are spreading through the Mediterranean just like in the Atlantic, and there are no known predators to manage their population growth. The effects of the lionfish's Mediterranean invasion are yet to be known, but the recipe is there for it to be just as dire as the Atlantic.

With our world becoming increasingly globalized, humans are changing the face of the earth as we know it.

Here in the Mediterranean, lionfish, along with countless other species, are changing the mechanics of this ecosystem that they have not evolved within.

(animated map shows the range of lionfish: from the northern US through the Caribbean and all the way down to Venezuela. At the same time we see the spread in the Mediterranean going outward from the Suez Canal.

What is that makes the lionfish so successful in these new environments?

1D: Characteristics and Evolution

In response to Danni's question, Alli outlines the lionfish's incredible characteristics that make it an outstanding predator in an environment where they have not coevolved with the native species. A black and white blueprint animation corresponds to Alli's outline of the fish's extraordinary characteristics, anatomy and evolved behaviors.

Voracious eaters, lionfish eat almost anything that fits in their mouth. They can consume up to 90% of their body weight in one day and their stomachs can expand up to 30 times its normal volume. As they are built for ambush, the jagged teeth like structures within their stomach prevent a still wiggling fish from escaping. Because they do not swim particularly fast, they have evolved to have 13 venomous spines that are used not to stun prey, but as a protective mechanism against threatening predators. Danni, in awe of these characteristics, remembers how hypnotic the lionfish were on the reef. B-roll of her dives in the Gulf of Mexico allow us to take a closer look at how their slow movements and camouflage striped bodies allow them to sneak up on prey without them noticing.

Lionfish populations in the Pacific are kept in check by parasites, diseases, predators, and other factors that coevolved with it. For instance, Pacific giant grouper eats lionfish, but the nearly identical Atlantic giant grouper does not. Why is this? To understand we take a closer look at coevolution.

ACT II

2A: The Asian Giant Hornet and the Honey Bee

On the North West corner of the United States, Dorothy McFall tends to her bee hives in Custer, Washington. Dorothy describes how one morning in 2020, she discovered 60,000 of her bees....decapitated. She was bewildered. What could do this and how? The mysterious question transformed into a nightmarish realization: the bee hives were destroyed by the invasion of the Asian giant hornet, a.k.a. the murder hornet.

This discovery is of existential concern and could change the face of North America as we know it. Honey bees are responsible for one in every three bites of food we take. The North American agricultural system is inextricably tied to the welfare of honey bees. We follow Dorothy and fellow beekeepers set traps for the newly introduced hornets as they, along with thousands of citizen activists in Washington state, strive to protect the honey bee population. Ironically, the honey bee was once non-native and first introduced by European colonists in the 1600s. But from most peoples' perspectives, unlike the Asian giant hornet, the honey bee provides value to the ecosystem – pound for pound, there is no other species that pollinates as well as they do in North America.

While walking through the forest with her beekeeping club, Dorothy explains how Asian giant hornets attack. Asian giant hornet nests have scouts that roam around the forest looking for bee hives. When located, the scout injects a pheromone onto the outside of the hive that signals to fellow hornets that this colony is a target. This is like a searchlight, a beacon, a pin marked on a gps. The scout returns to its nest to rally the others, and now as a group they follow the pheromone back to the beehive. When the hunting party arrives, there's no hope for the bees, they're completely defenseless.

But these Asian giant hornets have been in Japan for a long time and it's not like their ecosystem has collapsed. Why are they less destructive in their native habitat? Over time successful Asian honey bees have genetically passed down traits that can defeat one Asian giant hornet. The hive's survival is dependent on killing the scout. If you kill the messenger, the message never arrives. When a scout hornet approaches an Asian honey bee hive, the bees lure the hornet inside the hive, allowing the bees



to then swarm and ball up around the scout hornet. Once in a compact ball, the bees quiver and flex their muscles to create heat, eventually cooking the threat to death. If they've been tagged by the scout hornet's pheromone, they do everything possible to cover the scent with sap, dung, and mud.

The European honeybee in North America has no instinct to defend itself when the Asian giant scout hornet locates their hive. They are absolutely clueless to this new threat, and therefore pose the risk of easy eating for the Asian giant hornet in this new land. An abundance of food resources with no competitors or predators in turn creates explosive population growth and spread – just like the lionfish in the 80's and 90's.

2B: Eradicated vs. Established

In her lab, Washington state pest biologist, Telissa Wilson, processes DNA from Asian giant hornet fecal pellets found in an eradicated hornet nest. Telissa shares that Washington state has been keeping track of the Asian giant hornet spread through their DNA. When and if a new queen hornet emerges, they can test their DNA and figure out which hive they came from. Telissa discusses questions revolving around differences between the evolution of the Asian honey bee vs. the European honey bee. If humans are able to stop the spread of the Asian giant hornet, could the European honey bee adapt to defend itself against murder hornets like the Asian honey bee?

Danni reflects on how the Asian giant hornet's accidental arrival was similar to the arrival of the lionfish in the 1980's, but the difference between the two invasive species is that we actually have a shot at eradicating the Asian giant hornet because we're taking immediate action. The lionfish is an established invasive meaning, there they are now considered permanent residents of the Atlantic and Mediterranean. They can never be eradicated, but they can be managed.

Why do we want to lessen the impact of invasive species? Is it up to us? Evolution is always taking its course. Do we, as humans, have a responsibility to manage invasive species that we introduce?

ACT III

3A: Citizen Activism and Microeconomics

Two fishers, José Colón and Jean Paul Polo, dive and spear lionfish off the coast of Curaçao. After spearing the fish, José will gut it upon his ascent and leave the entrails in the water for endangered sharks to eat. Back on the boat, they discuss how their community has been hit hard by the lionfish invasion and how it has dramatically shifted the biodiversity in the past couple of decades. Their parents' generation all fished and have seen nothing like this.

Once they are back on shore, José prepares a local dish using lionfish. He gestures to the lionfish's venomous spines, which can still sting you even if the lionfish is dead. José and JP describe the intense painful feeling of being stung by a lionfish, like having a hammer hitting your hand over and over nonstop. The increase in hunted lionfish has also led to a development of a new product ripe for selling and elevating the local economy. While enjoying the dish, they discuss how they are encouraging local restaurants to put lionfish on their menus to create an economic demand for the fish.

Will the Atlantic ocean ecosystems ever evolve to manage lionfish without human intervention? We interfered with nature once, so must we now indefinitely interfere with nature again to keep it the way we want it?

3B: Lionfish Management

Danni and Alli walk along a dock in Key Largo as diving teams get ready to compete in the lionfish derby. According to scientists, since lionfish can never be fully eradicated as they are now far too widespread, we turn our focus to managing their population. As dynamic footage shows spearfishers diving and spearing lionfish, we learn that the most effective tactic of managing lionfish along the Atlantic Coast has been to spearfish them and data shows lionfish derbies are highly effective.

Back on land, a derby winner is announced. The creation of commerce initiatives could reduce the lionfish population. Many countries have recently banned the possession and breeding of high-risk invasive species. In Florida, ground zero for the lionfish invasion, the legislature recently voted to ban the possession and breeding of 16 high-risk invasive species. The state also pays bounties of $50 per catch of 8 lionfish, and this has created an incentive economy for lionfish hunters.

3C: Invasive Lionfish Mystery

Back in Curaçao, marine biologists, Carole Baldwin and Luke Tornabene, prepare to take a submersible 1,000 feet underwater. Something unusual is happening with lionfish in the Atlantic. While lionfish in the South Pacific have been recorded at depths of 250 feet, they have been seen in Caribbean waters at far deeper depths that reach up to 980 feet. Carole and Luke hope to find out why lionfish are going deeper. How are they adapting for deeper depths? Is natural selection favoring lionfish genes that innately drive them to deeper water? If so, why? The stakes are high, this is the last piece of the puzzle for managing lionfish. We simply have no good strategy to manage them below 100 feet. We also have little idea of what kind of destruction they're causing down there. So understanding this behavior is key to developing research that can contribute to appropriately managing the lionfish population at these depths.

A crane lowers the submarine into the water and as they descend into darkness, the biodiversity begins to change. They spot a lionfish. Luke maneuvers the submersible and captures it with the submarine's attached spear. Capturing specimens to research their stomach contents will reveal their feeding habits and the depths they are eating at in the water column. The submarine maneuvers and tags a lionfish. Tagging lionfish allows Carole and Luke to track the speed and journey of the fish once it is later found in shallow waters. It is difficult to imagine the lionfish's incredible range and resiliency that allows it to also survive in these depths. As the sub dives below 1000 feet, the scientists become surprised that they are still discovering lionfish.

When lionfish swim deeper than we can dive, how can we continue to manage their population?

ACT IV

4A: The Gittings Trap and Lobster Fishers

Alli Candelmo and Danni stand on a dock and check out the mechanics of the Gittings trap – a new lionfish trap that Alli and her team have modified specifically to catch lionfish below diving range. Alli deploys the trap. It looks like a hula hoop with a hinge that allows it to close like a clam shell. It's covered in netting, and when it's opened on the seafloor, this plastic lattice stands vertically in the middle of the trap, which lionfish cannot resist. It is very effective and has caught up to 24 lionfish on one at a time.

Danni, Alli, and a couple of lobstermen head out to open waters to retrieve a trap they deployed a few days prior. Lobstermen can only legally fish for lobster 4 months out of the year due to lobster conservation purposes. If there's demand for lionfish, trapping them is something they could try and benefit from during the off-season. The new modifications to the trap prove that it no longer catches other fish when deployed, which is very good for the trap's commercial outlook. By making it viable for more fishers to hunt lionfish, Alli and her team are hoping that this will make lionfish a more popular food item and create a snowballing demand.

4B: Tissue Analysis

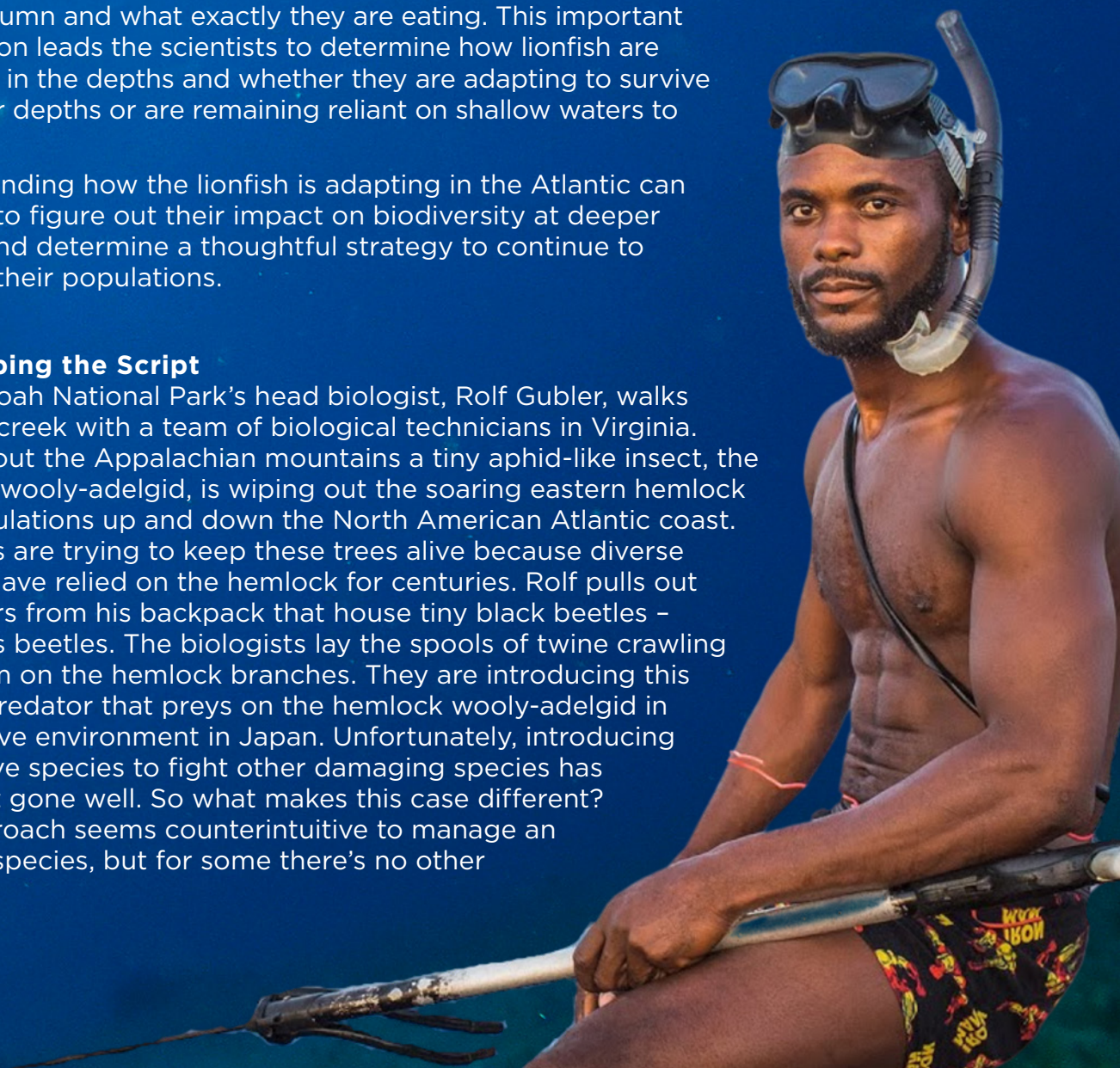
Back at his lab at the University of Washington, Luke and grad student Megan Ewing examine the lionfish samples Luke and Carole caught during the submarine dive. Through analyzing the fish's isotopes and sequencing the DNA of their stomach contents, they can understand how far the lionfish is traveling up and down the water column and what exactly they are eating. This important information leads the scientists to determine how lionfish are behaving in the depths and whether they are adapting to survive at deeper depths or are remaining reliant on shallow waters to feed.

Understanding how the lionfish is adapting in the Atlantic can allow us to figure out their impact on biodiversity at deeper depths and determine a thoughtful strategy to continue to manage their populations.

ACT V

5A: Flipping the Script

Shenandoah National Park's head biologist, Rolf Gubler, walks across a creek with a team of biological technicians in Virginia. Throughout the Appalachian mountains a tiny aphid-like insect, the hemlock wooly-adelgid, is wiping out the soaring eastern hemlock tree populations up and down the North American Atlantic coast. Scientists are trying to keep these trees alive because diverse species have relied on the hemlock for centuries. Rolf pulls out containers from his backpack that house tiny black beetles – laricobius beetles. The biologists lay the spools of twine crawling with them on the hemlock branches. They are introducing this natural predator that preys on the hemlock wooly-adelgid in their native environment in Japan. Unfortunately, introducing non-native species to fight other damaging species has often not gone well. So what makes this case different? This approach seems counterintuitive to manage an invasive species, but for some there's no other way.



At his lab at Virginia Polytechnic Institute and State University, Biologist Scott Salom and his team mass rear the laricobius beetles. Before introducing the new species, they tested them rigorously against other native species to make sure that they will only affect the targeted species – in this case, the hemlock wooly-adelgid. In a quarantine facility, lab technicians Holly Gatton and Aryanna James isolate a new non-native fly, which they hope will be another species that can help target the damaging species. In this setting they introduce the non-native species to native species and observe what happens. For instance, will it eat it or compete against it for resources? The scientists are working to remove the unknown outcome when a nonnative species enters a new ecosystem. In doing that, it may be their best chance with saving the beloved hemlock while not creating a whole different problem with the intentionally introduced species.

What would the laricobius beetles eat here if hypothetically all the hemlock wooly-adelgid insects are eaten up? Would it die out or find another aphid to chew?

5B: Prepping the Next Generation of Reefs

In a boat in the middle of the Gulf of Mexico, Danni and underwater archeologist, Melissa Price, witness a tugboat being sunk. Artificial reef production would be paused if it encouraged lionfish to further decimate reef populations. But this is not the case. Fishers, activists and scientists in the Panhandle, in addition to the artificial reef program organizers, are cautiously optimistic about the future. They've learned to somewhat manage the lionfish. Since lionfish are so attracted to these structures, they actually make for easy and highly effective purging and monitoring of this species.

At a table near the ocean, the dive team that opened up the documentary are reviewing their fish count data. They show Danni some data of fish percentages from years before, and reviews their data from the day's count.

EPILOG

Danni walks along the beach and pushes off into the ocean on the paddle board. She reflects on the story of the lionfish and the bigger questions it has unleashed about evolution.

There's no debating that lionfish have disrupted the current balance of biodiversity along the Atlantic coast. Is it being destructive and wrecking havoc because it's a villain? No, those are human thoughts. The lionfish is just being…a fish. In some cases we've mixed up nature so much it blurs the lines of what is invasive, nonnative, or native. Like our nonnative cherished honey bee. So 400 years from now will people perceive lionfish in the Atlantic as native? Will they become a beloved fish for their beauty and taste? This story may have more surprises to come, because when we disrupt ecosystems so rapidly like our globalized world now allows, we dive headfirst into uncharted waters.

POV & HOST

DANNI WASHINGTON

Marine Biologist, Science Communicator and Activist

Danni Washington is an award winning ocean advocate and science communicator, and first African-American woman to host a weekly science television broadcast program.

Her mission remains clear: inspiring the next generation to connect and understand the natural world's beauty. She has spent the last ten years producing creative ways to convert her passion for the ocean and science into exciting and elevated experiences for young people.

Danni has collaborated on various STEM broadcast programs, including CBS's "Mission Unstoppable", "Xploration Nature Knows Best" on FOX, "Science the $#!* Out Of It," for the popular Facebook Watch vertical, "Untamed Science" for Pearson Publishing, and Ocean GEMS.

Viewers experience the story with Danni as she explores all facets of how invasive populations change ecosystems and discovers the innovative solutions being developed.

Danni will go on case study expeditions and follow breakthroughs in science to learn about the complicated factors involving invasive species.

Watch Danni's Reel at: tinyurl.com/DanniReel

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PRODUCTION COMPANY:

Orange Frame is a highly specialized nonfiction production company that formed in 2015.

Our company's roots lead back to a partnership producing content around the world for National Geographic. Over the past 6 years we've built a sustainable company out of producing relevant, cinematic, and impactful stories for tv, theaters, and museums.

The company's expertise is in interpreting science, history, and natural history subject matter for an inclusive audience. The Orange Frame team has produced tv documentaries and immersive media exhibits for National Geographic, Smithsonian, PBS, National Park Service, NASA, and other renowned organizations.

Many of our projects require complex production logistics in remote areas while at the same time translating equally complex subject matter into engaging and relatable tv. We have proven results in delivering large scale film projects from concept to airdate, and have built our success around sticking to producing content we genuinely find compelling.

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BUDGET

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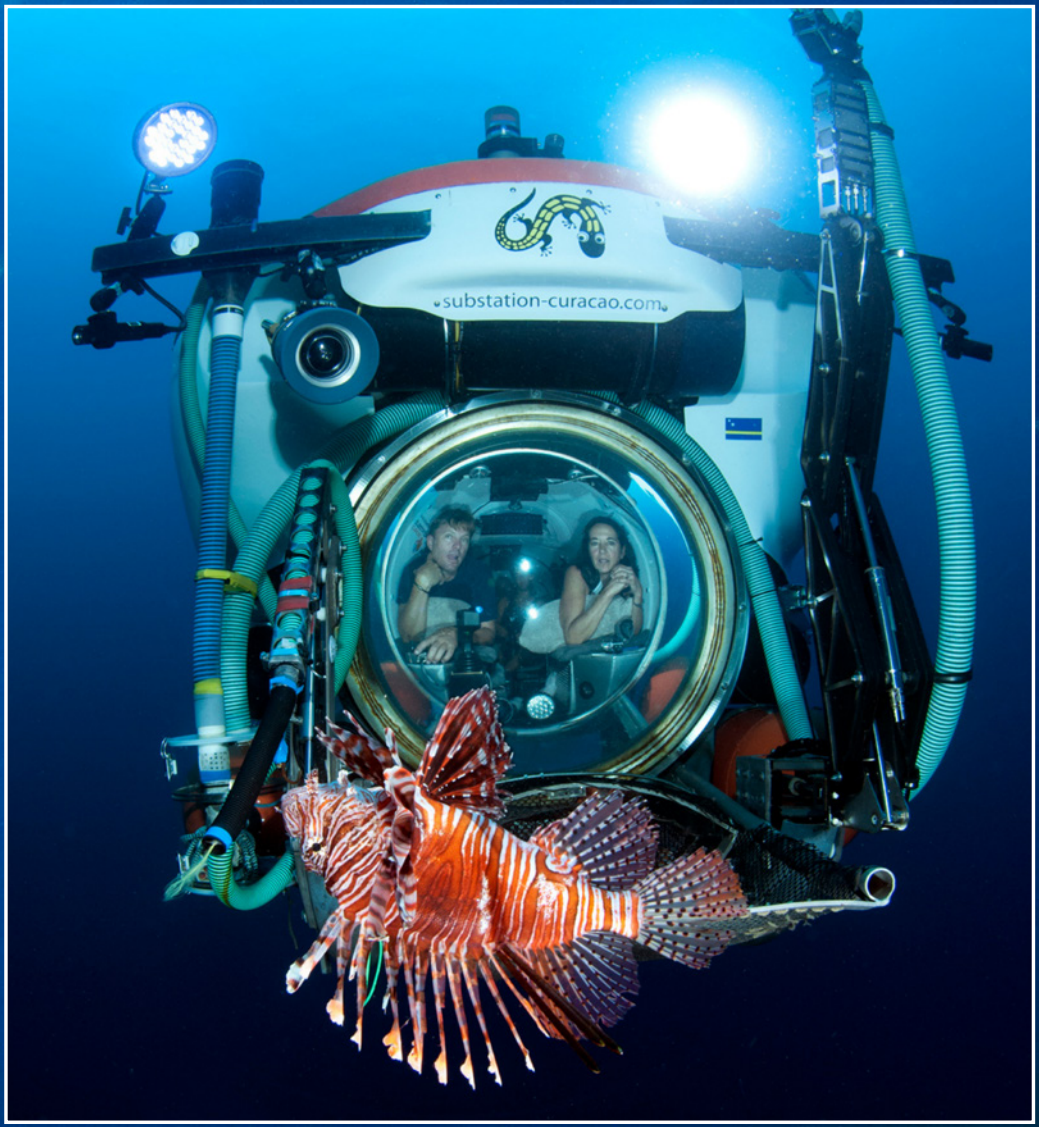

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