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Jellyfish Gone Wild — Home

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Jellyfish Gone Wild

HOME
Enviromental Change and Jellyfish Swarms

1. **1/3** of the total weight of all life in Monterey Bay is from gelatinous animals.
2. **3** minutes after a person is stung by a deadly box jellyfish, s/he may be dead.
3. **8** years after fast-reproducing comb jellies invaded in the Black Sea, they dominated it.
4. **20 to 40** people are killed annually from box jellyfish stings in the Philippines alone.
5. **100** foot-long tentacles may dangle from the lion's mane jelly.
6. **400** vast Dead Zones in world oceans are too polluted for almost all life except jellyfish.
7. **1,000+** fist-sized comb jellies filled each cubic meter of water in Black Sea jelly blooms.
8. **45,000** eggs may be released daily by a single jellyfish.
9. **500,000** people are stung by jellyfish in the Chesapeake Bay annually.
10. **500** million refrigerator-sized jellyfish float into the Sea of Japan daily during blooms.

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Introduction

When distributed in reasonable numbers, native jellyfish play important ecological roles. But when jellyfish populations run wild, they may jam hundreds and perhaps even thousands of square miles with their pulsating, gelatinous bodies.

In recent years, massive blooms of stinging jellyfish and jellyfish-like creatures have overrun some of the world's most important fisheries and tourist destinations--even transforming large swaths of them into veritable jellytoriums. The result: injuries (sometimes serious) to water enthusiasts and even occasional deaths.

Jellyfish swarms have also damaged fisheries, fish farms, seabed mining operations, desalination plants and large ships. And proving that jellyfish can be political animals, knots of jellyfish have done the work of anti-nuclear activists: they have disabled nuclear power plants by clogging intake pipes.

In short, since the 1980s, worldwide jellyfish blooms have caused hundreds of millions--or perhaps even billions--of dollars in losses. Worldwide reports of massive jellyfish blooms are triggering speculation that jellyfish swarms are increasing because of human activities. But are they?

This report--which is guaranteed to make your skin crawl--explains the basics of jellyfish biology and what scientists have thus far discovered about the causes and future of jellyfish blooms.

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BIOLOGY OF BLOBS

WHAT IS A JELLYFISH?

To some degree, the definition of a jellyfish depends on who you ask. Beach-goers generally define jellyfish loosely. They use the word "jellyfish" (along with qualifiers such as "ick!") to describe just about any transparent, slumped lump stranded in the sand, and any shapeless, ghost-like creature that lurks in the oceanic murk--whether it is giving swimmers painful stings or just creepily brushing against their skin.

By contrast, scientists define jellyfish narrowly. To be classified as a "true jellyfish" by scientists, an animal must have stingers, have a bell-shaped body as an adult, and belong to the group of animals (phylum) known as Cnidaria. In addition, most true jellyfish have tentacles and eat plankton. Note that jellyfish, which are invertebrates and don't have gills, are not fish.

When scientists categorize animals, they distinguish "true jellyfish" from various types of jellyfish-like animals that look, swarm and squish like jellyfish, but are not jellyfish in the zoological sense.

For example, jellyfish-like animals known as comb jellies--like true jellyfish--have slimy, transparent bodies and tentacles, and populate the world's oceans in large numbers. But comb jellies are not classified as "true jellyfish" because they lack stingers and bell-shaped bodies and have different life cycles than true jellyfish. (Comb jellies are classified as ctenophores).

THE MANY FORMS OF GELATINOUS ANIMALS
The bodies of some gelatinous animals are smaller than contact lenses; others are bigger than truck wheels. Some have tentacles; some don't.

Although jellyfish are famous for their bell-shaped bodies, gelatinous animals come in many shapes. In fact, the longest animals in the world are jellyfish-like animals known as Siphonophores, which live in the open ocean.

Many Siphonophores have long, thin shapes and some reach 130 feet in length, which is about the height of a 13-story building. By comparison, the maximum length of the Blue Whale, the largest mammal on Earth, is about 110 feet. The best known siphonophore is the Portuguese man-of-war, whose giant stinging tentacles may extend dozens of yards.

Caption/Credit:

BEACH BUMMBER
150 million people worldwide are exposed annually to jellyfish. About 200,000 jellyfish stings occur in Florida annually. Credit: Erion Cuko

DEATH BY JELLYCIDE
The comb jelly known as Beroe eats other species of comb jellies. By doing so, it has helped control population explosions of comb jellies in various worldwide locations. Credit: Casey Dunn

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Anatomy

JELLYFISH ANATOMY: A BELL WITH FEW WHISTLES

Jellyfish are the simplest swimming animals on Earth. They are composed of about 95 percent water. (By contrast, humans are about 65 percent water.) The high water content of jellyfish explains why they immediately collapse into defeated, deflated blobs when removed from water.

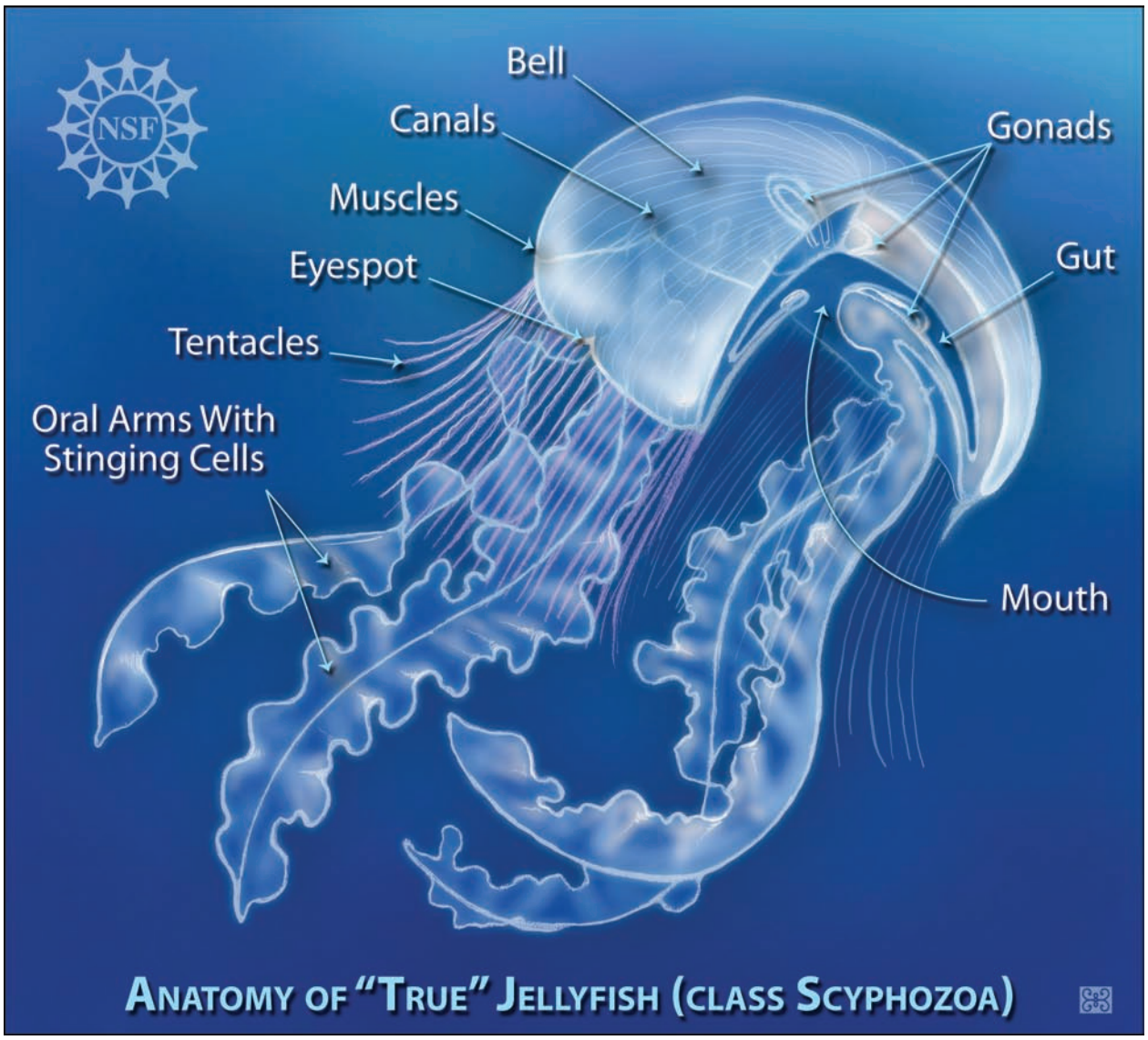
With few exceptions, jellyfish are brainless, bloodless, boneless and heartless, and have only the most elementary nervous systems. So simple, each jellyfish is but a few evolutionary steps beyond being just a stinging bladder of sea water. In fact, jellyfish are so at one with water that they are barely distinguishable from their marine habitats via sophisticated, acoustic surveys.

What's more, the transparent, ghost-like bodies of jellyfish provide excellent camouflage, enabling jellyfish to hide in plain sight from most prey species, and thereby surprise them.

The simplicity of jellyfish and their resulting simpatico with the sea helps explain the adaptability of jellyfish, which have survived on Earth for over 500 million years. Moreover, the ability of these most simple creatures to dominate and essentially rule many diverse ecosystems testifies to the potential power of the lowest common denominator.

Illustration Credit: Zina Deretsky, National Science Foundation

JELLYFISH ANATOMY: A BELL WITH FEW WHISTLES



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Credit: Image - Zina Deretsky, National Science Foundation
Writing - Lily Whiteman, National Science Foundation
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Reproduction

THE HOLY GRAIL TO UNDERSTANDING JELLYFISH BLOOMS

JELLYFISH REPRODUCTION:
Many jellyfish species reproduce extraordinarily quickly. How? By using a peculiar combination of sexual and asexual reproduction involving these steps:

1. Eggs and sperm are released by adult jellyfish--sometimes at incredible rates. For example, jellyfish known as sea nettles that live in the Chesapeake Bay may each shed 40,000 eggs daily.

2. A jellyfish egg unites with a jellyfish sperm to produce a larva.

3. Each larva attaches to a hard surface, such as a rock or an artificial structure like a drilling rig, at the ocean bottom.

4. The larva lives as a stationary polyp at the ocean bottom. Although much about polyps -- which have only rarely been found in the wild--remains mysterious, scientists suspect that they may simultaneously blanket large expanses of ocean floor. They also suspect that polyps may opportunistically extend their polyp phase from days to even years or decades until conditions, such as temperature and food, are favorable to their survival as adults.

5. Once conditions become favorable, each polyp elongates and then buds off and releases many young jellyfish. A single polyp may thereby, by itself, reproduce large numbers of jellyfish.

What's more, individual polyps probably don't churn out young jellyfish in isolation. Rather, fields of polyps probably simultaneously transform into veritable jellyfish factories, mass producing tens of thousands of jellyfish at a time. Swarms of young jellyfish may thereby quickly form when their survival prospects are best.

6. Each young jellyfish rapidly develops into an adult jellyfish, and the cycle repeats.

Desperately Seeking Polyps: Because of the importance of polyps to the formation of jellyfish swarms, scientists are currently working feverishly to find polyps in the wild. "To understand jellyfish blooms, we must find those polyps," affirms Lorenzo Ciannelli of Oregon State University.

But searching for tiny, transparent polyps on the ocean floor is like searching for the proverbial needle in the haystack. So researchers are currently using computers to simulate the drifting of young jellyfish from suspected locations of polyp colonies in the Bering Sea--a jellyfish hot spot where polyps have never been observed--to areas in the Bering Sea where adult jellyfish are known to swarm. Such analyses are designed to help identify the probable locations of polyp colonies, which may eventually be searched via remotely operated robots.

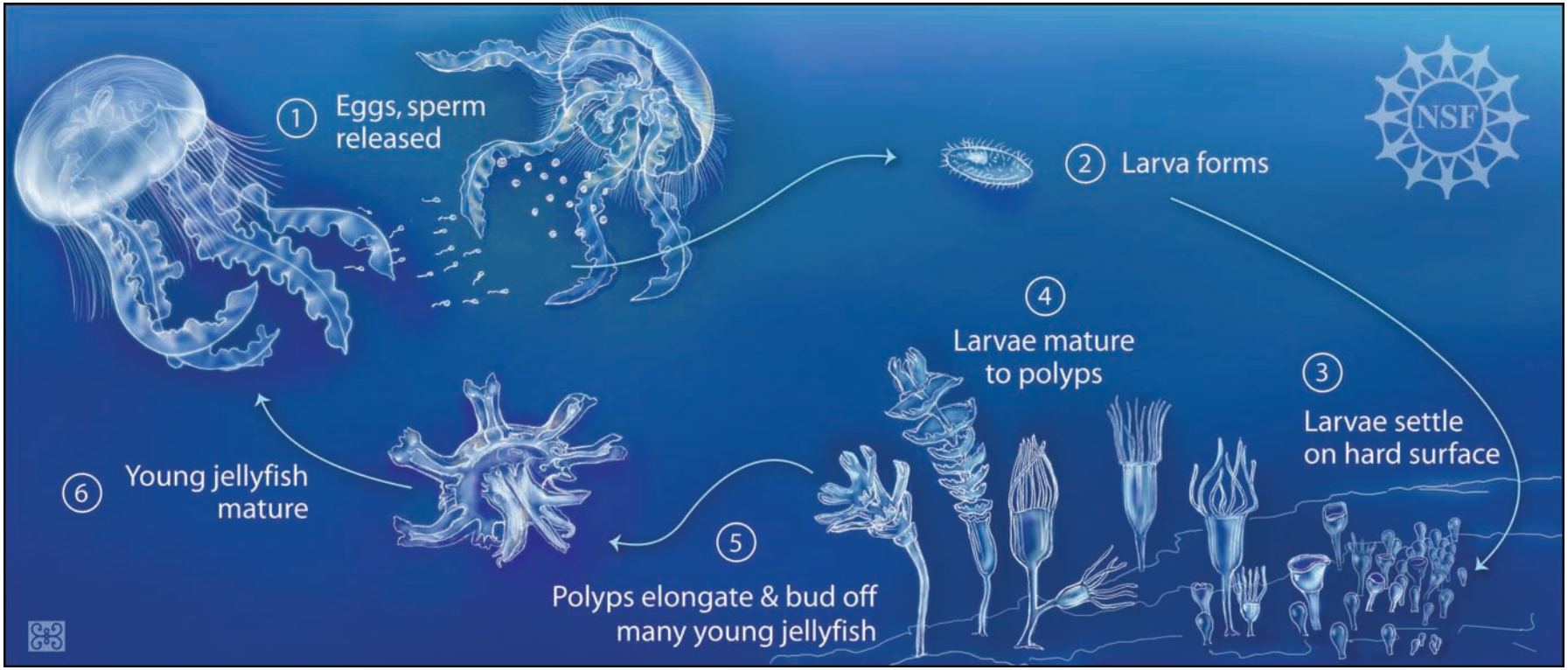
COMB JELLY REPRODUCTION:
Comb jellies--jellyfish-like creatures that are not true jellyfish but behave like jellyfish--also reproduce quickly. But they have a different reproductive cycle than jellyfish.

Each comb jelly is a self-fertilizing hermaphrodite that releases both eggs and sperms. An egg and sperm unite to form a fertilized egg that becomes an adult comb jelly without a polyp stage.

Some species of comb jellies, such as the widely distributed Mnemiopsis, reproduce quickly because: 1) individuals may start reproducing within days of being born; and 2) an adult may release 8,000 eggs and sperm per day.

Illustration Credit: Zina Deretsky, National Science Foundation

JELLYFISH REPRODUCTION: The Holy Grail to Understanding Jellyfish Blooms



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Credit: Image - Zina Deretsky, National Science Foundation
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Sting

Most species of jellyfish and jellyfish-like animals are not harmful to people. But all true jellyfish and some species of jellyfish-like creatures sting; a single stinging tentacle may be studded with thousands of stingers. Stinging gelatinous creatures cause various reactions in people, ranging from no noticeable sensation to rashes, and in relatively rare cases, death.

Beware: Gelatinous creatures that are harmful to people live in every ocean. Common harmful species include:

· THE PORTUGUESE MAN-OF-WAR: The pain of this creature's sting has been compared to that caused by being struck by lightning.

· THE LION'S MANE: Clumping into giant formations resembling horrifying hairballs, the tentacles of the Lion's Mane jellyfish--which may each reach 100 feet in length--are lined with toxic stingers.

· *PELAGIA NOCTILUCA* OR THE MAUVE STINGER: After being stung by *Pelagia* in the Mediterranean, one swimmer described the experience as "feeling like 1,000 needles were simultaneously sunk into my skin."

HOW THE STINGER WORKS
Most species of jellyfish cannot target or stalk prey. Instead, these brainless, spineless creatures--lacking malice--passively wait for prey to brush against their stingers, which automatically fire when touched. Even dead jellyfish, beached jellyfish and detached tentacles can keep stinging.

Wound like a tightly coiled harpoon, the jellyfish's stinger sinks poison into prey with about as much pressure as a gun fires a bullet. The discharge of the jellyfish's stinger is one of the quickest movements in nature.

BOX JELLYFISH
Box jellyfish--named for their squarish bells--are among the most feared types of jellyfish. Thus far, about 30 species of box jellyfish have been identified; some are more deadly and painful than others.

The Medical Journal of Australia reports that lethal or potentially lethal box jellyfish "occur worldwide, around every major land mass in the tropical and some subtropical oceans," and that deaths and serious injuries from them "are more common than previously believed."

Twenty to 40 people die from stings from box jellyfish annually in the Philippines alone. But because death certificates are not required in many countries within the range of box jellyfish, worldwide fatalities from box jellyfish may be seriously underestimated.

The box jellyfish known as *Chironex fleckeri* is the world's most venomous animal. A *Chironex fleckeri* can kill a person in under three minutes--a world's record. On average, this animal kills one person per year in Australia.

Other species of box jellyfish cause Irukandji syndrome: a suite of agonizing symptoms that may include heart failure. There are two confirmed deaths from Irukandji syndrome on record--both occurred in Australia. But scientists suspect that additional deaths from this hard-to-diagnose syndrome, which may be caused by as many as 10 jellyfish species, have been wrongly attributed to heart attacks and other causes.

Irukandji syndrome is most common in Australia. But Irukandji syndrome, or an Irukandji-like syndrome, has been reported in tropical waters around the world, including Hawaii, Florida and other U.S. locations.

Caption/Credit:

A HUMDINGER OF A STINGER
In Australia, about 10,000 people are stung annually by the Portuguese man-of-war. This animal’s sting is famous for its excruciating pain. Credit: Laurence Madin, Woods Hole Oceanographic Institution

GIANT, STINGING TENTACLES
The tentacles of the lion’s mane jellyfish can grow longer than a 100-foot blue whale, the largest animal on Earth. The largest lion's manes live in Arctic waters. Credit: Kip Evans, NOAA

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How They Swim

JELLYFISH: SWIMMING TO EAT

GOING NOWHERE FAST
Jellyfish are captives of the currents, travelling wherever they are carried--sometimes over thousands of miles.

While carried by currents, jellyfish continue to swim and pulsate their bells. But most jellyfish can only move up and down in the water column without making significant horizontal headway against currents. Therefore, the locations of jellyfish swarms are more determined by currents than by jellyfish themselves, which are unable to chart their own courses.

Why are jellyfish such weak swimmers? Because, according to Jack Costello of Providence College, jellyfish muscles are only one-cell thick--hardly the hulk needed to generate Olympic swimming records. In addition, the disk shape of jellyfish bells is probably "one of the least effective shapes for forward progress that we can imagine," says Costello.

DIFFERENT STROKES FOR DIFFERENT GELATINOUS FOLKS
There are two major types of jellyfish strokes:

Small Jellyfish -- The Jet-Set: Most species of small jellyfish (usually too small to be noticed by people) are thimble-shaped with narrow bells. They swim by jetting motions that involve expanding their bells to collect water and then contracting their bells to expel it. The force created by the expelled water propels the jellyfish forward in the opposite direction (modest though this distance may be).

Why do jellyfish jet about? Possibly to escape predators or to reach better feeding areas. Between jetting spurts, small jellyfish remain passively suspended in the water, waiting for prey to touch their killing tentacles, similar to the way that spiders passively wait for prey to stumble into their webs.

Large Jellyfish -- Power Rowers: Most species of large jellyfish have relatively wide, flattened, bells and cannot jet about like small jellyfish. Why not? Because large jellyfish--limited by the one-celled thickness of their muscles--would be unable to muster the strength needed to squeeze out the large quantities of water that would be collected by whole-bell contractions.

So instead of jetting, large jellyfish swim by contracting only the rims of their bells into subtle rowing motions. By doing so, large jellyfish displace manageable volumes of water. They also create small vortices and currents that draw water, and more importantly, entrained prey into their tentacles.

Because the vortices and currents created by pulsating jellyfish bells are relatively subtle and imperceptible to many prey species and because the diaphanous bodies of jellyfish blend practically seamlessly with the water, jellyfish can hide in plain sight from their prey. Most prey are unable to detect even large nearby jellyfish, and so do not flee them.

Therefore, even though brainless jellyfish cannot intentionally target and stalk prey as can brainier animals, they have evolved a stealthily effective hunting method. Indeed, under some circumstances, swarms of large jellyfish--continuously rowing in order to capture enough food to sustain their large bodies--strip fish, fish eggs and plankton from the water almost as completely as plagues of locusts strip vegetation from land.

Caption/Credit:

THE PURPOSE OF THE PULSE
With every pulse of its bell, a jellyfish draws water and entrained prey to its tentacles. A lion’s mane appears here. Credit: Sean Colin, Roger Williams University, and John Costello, Providence College

LIGHTS! CAMERA! JELLYFISH!
Dye is used to outline the wake of a moon jellyfish swimming in a marine lake on the island of Mjlet, Croatia. Credit: Sean Colin, Roger Williams University, and John Costello, Providence College

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TRANSCRIPT

Here in the northern Gulf of Mexico, I think it's pretty typical everywhere, at least in coastal environments, is that when you get a good, you know, well-established bloom of jellyfish and they start accumulating in these aggregations close to shore, and you know, it depends a little bit on the species, but if we're flying over on an airplane, you can go the entire coastline and see repeated, you know, just pink aggregation after aggregation of, you know, just thick jellyfish. So, they can go for miles and miles, you know, hundred miles long. In the thickest packs, it's – there's more jellyfish than there is water so, you know, you can, you know, as many jellyfish as you can squeeze into a cubic meter, that's what the density is so it's easily in the 50 to 100 animals in a cubic meter of water when they're at their thickest.

Here in our waters we've got anything from old bridge rubble, when a bridge is taken down, they'll take the bridge out and dump it or we sink whole ships. Recently they sunk an aircraft carrier off of Pensacola. We have fields of World War II era army tanks and it used to be that pretty much anybody could take anything they wanted, as long as they made sure it was, and had it permitted, that it was drained of oil and gas or anything else that might leak into the environment, but they can take anything out and put it into a specific area, but dropping it so we have barges of shopping carts and newspaper – old newspaper vending machines and, you know, people would take their old cars off, you know, just dump all this stuff out there so it's this haven for fish, but we've done this without really appreciating what we might have done to the environment in terms of bringing in habitat for things that otherwise wouldn't be there. So, and within this community of things that otherwise might not be there might be whole suites of jellyfish polyps and other things that otherwise wouldn't have a home to reside.

Part of their life history is always to be numerous at times if we're talking about medusaes, to be numerous at times. So, these blooms, they're not really oddities but what happens when you start adding more nutrients or you start removing too many fish or you start adding too much structure in the ocean, or you do all these things or even, you know, increasing the temperature of the water, you do all these little things, each one by themselves seems to be able to nudge jellyfish to being more abundant. You add all of them together and they'll do a very good job of bringing jellyfish numbers up and so we can see that jellies are kind of sitting on this, you know, on this threshold of ecosystems that if ecosystems are, you know, healthy, then jellies will sort of do their normal thing. They'll go about the --- make blooms, they'll go about their happy jellyfish lives, but if you nudge the system towards the more perturbed side, the jellyfish will take off and so we do sort of think of jellies as being that, you know, that canary, that bellwether of change, and I think it's an appropriate comparison.

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ECOLOGICAL ROLES OF JELLYFISH

Plying the world's oceans for over 500 million years, gelatinous creatures have influenced marine communities almost as long as marine communities have existed.

As prey, gelatinous creatures are eaten by seabirds, pink salmon, sun fish, turtles and other gelatinous creatures. (Animals that eat jellyfish are not impacted by their stings.) As predators, gelatinous creatures eat fish eggs and larvae, invertebrates, small, floating creatures called zooplankton and other gelatinous creatures.

Scientists are continuing to identify new ecological services provided by jellyfish. For example, recent studies show that the tentacles dangling from the Bering Sea's large jellyfish provide hiding places for young pollock that are pursued by other predators but have grown too big for the jellyfish to eat.

IMPACTS OF RUNAWAY POPULATIONS

When populations of gelatinous animals explode, various types of ecological changes may result. For example:

- During the 1990s, a voracious, invasive jellyfish-like creature known as the comb jelly was introduced into the Black, Azov and Caspian Seas. Uncontrolled by natural predators, comb jelly populations quickly ran wild. The rise of the comb jelly contributed to crashes in the populations of anchovies in the Black and Azov seas and to crashes of a small commercial fish known as kilka in the Caspian Sea.

How did the comb jelly damage the populations of these commercial fish? By eating their eggs and larvae and by eating the same zooplankton prey they eat. The resulting reductions of anchovy and kilka catches in the Black, Azov and Caspian Seas have cost area fishermen hundreds of millions of dollars.

The impacts of the rise of the comb jelly in the Black, Azov and Caspian Seas have cascaded up the food chain. For example, seals of the Caspian Sea have suffered from the virtual decimation of populations of their kilka prey by comb jellies.

Increases in comb jellies can help cause massive algae blooms. Here's why: when populations of comb jellies increase, populations of their zooplankton prey decrease. The result: controls on algae populations that are otherwise provided by zooplankton are reduced or eliminated. Lacking controls, algae populations may explode.

Caption/Credit:

FEWER TURTLES; MORE JELLYFISH
All seven species of sea turtles eat jellyfish and all seven species are endangered. Their survival is threatened by fishing lines that trap them, pollution, beach development, climate change and sales of turtles and turtle parts. Credit: Mito Paz

IN THE BELLY OF A JELLY
A fish was recently captured by this freshly caught box jellyfish *Carybdea alata* in Honolulu, Hawaii. Credit: Dr. Angel Yanagihara, PBRC, University of Hawaii

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Evolution

Plying the world's oceans for more than 500 million years, jellyfish and jellyfish-like animals were among the first animals to inhabit the Earth. They were also probably among the first animals to break the shackles of a stationary lifestyle and swim freely through the primordial seas.

Jellyfish and other jellyfish-like animals evolved along entirely different evolutionary pathways from one another. This evolutionary redundancy reflects the adaptability and success of the transparent, gelatinous body form.

Caption/Credit:

OLDER THAN DIRT
This jellyfish fossil is more than 500 million years old, the oldest jellyfish in the fossil record to date. Fossils like this one and genetic studies indicate that jellyfish and jellyfish-like creatures have exerted important influences on marine ecosystems for millions of years.
Credit: J. Hendricks and B. Lieberman, University of Kansas

NO BONES ABOUT IT
Fossils of boneless jellyfish are rare, but do exist. This jellyfish fossil is from the middle Cambrian.
Credit: J. Hendricks and B. Lieberman, University of Kansas

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Where They Live

THE LONG TENTACLES OF GELATINOUS ANIMALS WRAP AROUND THE GLOBE

JELLYFISH LIVE ALL OVER THE WORLD

Jellyfish and other gelatinous animals live in every ocean, from the Caribbean to the Arctic. They also inhabit every depth of water, from shallow waters to the darkest, deepest abysses. No marine environment is too hostile for jellyfish and other gelatinous animals.

For example, scientists studying the floor of the Pacific Ocean near Costa Rica recently discovered colonies of a bell-shaped, hot-pink jellyfish living on volcanic vents located 8,500 below the ocean's surface. Emitting iron-darkened water, these scalding, deep-sea vents present one of the harshest environments on Earth.

Jellyfish are also found in a limited number of inland seas and freshwater lakes.

NUMBERS OF SPECIES

The official count of the total number of species of true jellyfish is currently at about 200. But this figure is rapidly increasing and may ultimately reach about 2000. Why? Because scientists are continually identifying new jellyfish species as they:

- Explore more marine environments.
- Use ultra-sensitive DNA analyses to distinguish new species that were indistinguishable by relatively crude comparisons of body shapes and other physical characteristics traditionally used to identify jellyfish species.

WHO LIVES WHERE

Some species of gelatinous animals have narrow geographic ranges; others have broad ranges. Environmental conditions that help determine the geographic ranges of gelatinous animals and the timing of their blooms include the following factors:

- **Food:** During, the summer availability of prey that are eaten by gelatinous animals tends to increase.
- **Water salinity:** Water salinity varies from water body to water body. Water salinity may be impacted locally by currents and by changes in the flow of freshwater rivers into coastal areas that are caused by variations in climate and weather and by dams.

Some species of gelatinous animals prefer water with relatively high salinity; others prefer water with relatively low salinity; and others, like the comb jellies that live along the East Coast of the United States and in several European seas, can thrive in low or high salinity waters.

- **Currents:** Currents can sweep gelatinous animals together into swarms and carry them thousands of miles. For example, currents sometimes carry the Portuguese Man-of-War, which may travel in mobs of 1,000 or more, from Florida as far north as Cape Cod.

In addition, currents may transport gelatinous animals into non-native habitats. If invasive species of gelatinous animals are swept into non-native habitats, where they encounter few or no predators and where their environmental needs are met, they may colonize them. A case in point: The Gulf of Mexico has been colonized by various species of invasive jellyfish--some of which may have been swept there from the Caribbean by currents.

- **Temperature:** Increases in temperature increase the rates of growth and reproduction of many jellyfish species.

Caption/Credit:

JELLYFISH UNDER THE ICE
A diver extends his fingers towards the tentacles of a jellyfish in Antarctica's McMurdo Sound, where water temperatures are below 30 F.
Credit: Henry Kaiser, National Science Foundation

JELLYFISH ON VOLCANIC VENTS
The pink jellyfish and spiky tubeworm casings that festoon recently discovered volcanic vents near Costa Rica are like "the serpent-haired Medusa of Greek myth," said expedition leader Emily Klein. Credit: Emily M. Klein, Duke University

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The Ecological Clout of Jellyfish

Even when jellyfish and other gelatinous creatures are not gathering in swarms, they account for large proportions of the life in some marine ecosystems and even dominate some ecosystems.

JELLYFISH ARE IMPORTANT PLAYERS

Evidence of the abundance of jellyfish includes ongoing surveys of Monterey Bay led by Bruce Robison of the Monterey Bay Aquarium Research Institute; these surveys involve using remotely operated cameras to film animals living throughout the water column--from the ocean's surface to its floor.

Robison says that his studies indicate that "jellyfish and other gelatinous animals currently account for at least one-third of the biomass (total weight of all living creatures) in the water column in Monterey Bay."

In addition, a recent study led by Cynthia Suchman of the Virginia Institute of Marine Science and the National Science Foundation showed that jellyfish are even more abundant than fish in a fish-rich region off the coast of Cape Blanco, Ore. Because this study confirms the results of similar studies of the area that were conducted in the 1980s, it suggests that the current abundance of jellyfish in this area is not an abnormal or unusual phenomenon.

The longevity, adaptability and global abundance of jellyfish suggests that the saying, "there will always be another fish in the sea" might be more appropriately phrased, "there will always be another jellyfish in the sea."

DO JELLYFISH GET ENOUGH RESPECT?

Despite the importance of jellyfish to marine ecosystems, these sea creatures have traditionally been underappreciated by the scientific community. In fact, most marine scientists have historically regarded jellyfish as interesting oddities (at best) and usually as only undesirable, unavoidable bycatch that interferes with studies of fish--long considered the true stars of marine ecosystems.

As a result, when marine ecologists pulled up research nets laden with jellyfish, they often simply ignored or discarded their gelatinous hauls. "But the truth is," says Jack Costello of Providence College, "that researchers were pulling up jellyfish--not because they are unimportant--but because they are important, influential members of marine communities, and always have been."

In addition to suffering from unwarranted biases, research of jellyfish (many of which have painful stings) has been hampered by a bevy of practical obstacles. For example, jellyfish are extremely fragile and are frequently damaged by nets. Therefore, it is difficult to collect jellyfish. In addition, it is difficult to raise jellyfish in captivity and to preserve their bodies. As a result, we generally know more about fish than jellyfish and much of our understanding of jellyfish is the result of recent research.

Caption/Credit:

BIG RED
Sporting a meter-wide bed and up to seven fleshy arms, "Big Red" was discovered in California's coastal waters by scientists in 2003. It lives at depths of 2,000 to 4,800 feet off the west coast of North America, Hawaii and Japan.
Credit: © 2002 MBARI

JELLYFISH PATROL
A remotely operated vehicle (ROV) collects gelatinous animals from the depths of Monterey Bay in California. As scientists explore more marine environments, they are discovering new species of gelatinous animals. Credit: © 2005 MBARI

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WHERE SOME REAL SLIMEBALLS GATHER

WHY SWARMS FORM
A swarm is a dense, rapidly-formed cluster of animals. Jellyfish swarms are a naturally occurring, world-wide phenomenon. Scientists believe that jellyfish swarms--even huge ones--have occurred for millions of years and would continue to occur in some locations even without environmental damage from people.

For example, scientists have observed dense summer swarms of sea salps--a three-inch long, tube-shaped gelatinous creature--covering up to 38,600 square miles in the North Atlantic. Such swarms are believed to be natural occurrences that are not influenced by human activities.

Scientists believe that gelatinous creatures swarm when ecological conditions align to favor their survival. These conditions include the concentration of predators and competitors, food availability, currents as well as the temperature, salinity, and oxygen content of the water.

DAMAGE FROM LARGE SWARMS
Natural and unnatural swarms cause various types of problems by:

· Discouraging tourism: Summer blooms of stinging jellyfish keep bathers out of the water in prime tourist destinations from Maryland to the Mediterranean. Various species of box jellyfish, which are among the world's most toxic creatures, regularly swarm in tropical waters around the world, including Hawaii and Australia.

· Damaging fishing operations: Jellyfish have interfered with fishing operations in world-class fisheries, including the Gulf of Mexico, the Black Sea and the Bering Sea by: 1) busting fishing nets; 2) poisoning and crushing captured fish; 3) consuming fish eggs and young fish; and 4) clogging the engines of fishing boats.

· Crippling industrial operations: Jellyfish have recently disrupted the operations of marine diamond mining facilities in Namibia, desalination plants in Iran and various large ships around the world by clogging intake pipes carrying sea water.

Jellyfish swarms have also forced a number of nuclear power plants around the world to interrupt output or temporarily shut down. In fact, enough jellyfish to fill 50 trucks clogged the intake pipes of a power plant in the Philippines in 1999, and thereby plunged 40 million people into darkness and started rumors of a coup d'etat. (Such freak events prove that jellyfish can be political animals.)

Caption/Credit:

STRENGTH IN NUMBERS
Because jellyfish reproduce quickly, are hardy and face few competitors or predators in many degraded waters, they can quickly overrun and dominate ecosystems. Credit: Dr. Jamie Seymour, James Cook University

A HEART-BREAKING HAUL
Jamming boat engines, breaking nets with their weight, poisoning and crushing caught fish, jellyfish blooms intermittently shut down the Gulf of Mexico's $60 million-per-year shrimp industry. Credit: Dauphin Island Sea Lab

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The Sea Stings Back

THE SEA STINGS BACK: ARE PEOPLE CAUSING GLOBAL INCREASES IN JELLYFISH?

HOW PEOPLE PROMOTE JELLYFISH SWARMS
"We don't worry about the normal swarms; you just learn to live with them or avoid them," says William Hamner of the University of California at Los Angeles. "We worry about the plagues of jellyfish that really take over an area. A jellyfish swarm is considered abnormal if it is bigger or denser or occurs more frequently than normal swarms," says Hamner.

"I'm often asked whether a single, overarching condition is triggering jellyfish swarms in diverse locations," says Monty Graham of the Dauphin Island Sea Lab. In response, Graham usually explains that he regards abnormally large, dense or frequent jellyfish swarms as "a symptom of an ecosystem that has been tipped off balance by environmental stresses."

"The exact nature of such balance-tipping environmental stresses may vary from place to place and usually involve unique interactions with local ecology," Graham explains. "But such stresses are often caused by people."

So, just as a weakened person is particularly vulnerable to opportunistic diseases, stressed ecosystems are particularly vulnerable to infestations of opportunistic jellyfish. Nevertheless, some stressed waters do remain free of jellyfish blooms.

DEFINING HUMAN IMPACTS
"There is clear, clean evidence that certain types of human-caused environmental stresses are triggering jellyfish swarms in some locations," says Hamner. These types of environmental stresses include:

· The introduction of jellyfish species into non-native habitats by ships;

· The formation of ultra-polluted areas, known as Dead Zones, where jellyfish face few predators and competitors;

· Increases in water temperatures, which accelerate the growth and reproduction of many jellyfish species;

Nevertheless, various constraints often complicate efforts to define human impacts on jellyfish populations in areas that are simultaneously experiencing multiple stresses, such as rising temperatures and pollution. In addition, many areas lack long-term historical records of the sizes and frequencies of jellyfish blooms and the species involved in them. Such data gaps often make it difficult to identify deviations from normal, baseline jellyfish conditions.

To address these and other constraints on jellyfish research, scientists are currently developing many new tools.These tools include: 1) computer models that are helping to identify the individual impacts of overlapping environmental stresses; and 2) DNA analyses that may help reveal the history and global movements of jellyfish species.

CAN WE EVER UN-RING THAT (JELLYFISH) BELL?
When jellyfish populations run wild, they eat large volumes of fish eggs and larvae and thereby limit the ability of fish populations to rebound. Therefore, once jellyfish dominate a stressed ecosystem, they may continue to control or influence it indefinitely.

Because of this principle, the comb jelly--a voracious, rapidly-reproducing jellyfish-like creature -- will probably maintain its tentacled-grip on Narragansett Bay indefinitely. Likewise, the comb jelly is probably now a permanent influential resident of the Black Sea--a highly stressed water body where comb jellies exploded from 0 pounds to about one billion pounds in less than 10 years during the 1980s.

Caption/Credit:

MARVELING AT MASTIGIAS JELLYFISH
A marine lake in Palau. Credit: Dr. Jamie Seymour, James Cook University

LIVING IN THE DEAD ZONE
Draining the U.S.'s heartland, the Mississippi River dumps huge volumes of pollutants into the Gulf of Mexico. This process triggers the formation of an ultra-polluted, oxygen-starved Dead Zone in the Gulf's bottom layers every summer. Unlike almost all other types of animals, jellyfish thrive in the Dead Zone. Every fall, seasonal storms mix oxygen-poor waters with oxygen-rich surface waters bringing a reprieve until spring. Credit: Robert Simmon, NASA

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JELLYFISH INSTANTLY FORM SWARMS OUT OF THE BLUE

It's the stuff of horror movies: a beach that seems to be free of jellyfish one day swarms with jellyfish the next day. The amazing ability of jellyfish to quickly form large, dense swarms begs the question: How do they do that?

Jellyfish populations can quickly explode because jellyfish:

·Grow fast: When food is abundant and other conditions are right, a jellyfish may double its weight in a single day…and then double it again the next day …and so on. Moreover, some types of gelatinous creatures can start reproducing within days of being born

· Reproduce quickly: Although rabbits are the international symbol of fertility, their reproduction rates pale in comparison to those of the humble jellyfish.

Jellyfish can reproduce quickly because: 1) a single female jellyfish can release tens of thousands of eggs per day; and 2) the fertilization of an egg and a sperm produces a bottom dwelling polyp that can use a unique form of reproduction to, by itself, bud off massive numbers of juvenile jellyfish. (See Reproduction.)

The comb jelly--a jellyfish-like creature that is a self-fertilizing hermaphrodite--can release 8,000 eggs into the water per day. At least in theory, a single comb jelly transported into an ecologically friendly environment could, by itself, start a new population.

· Live in Dead Zones: Dead Zones are huge swaths of deep ocean that are ultra-polluted and oxygen starved. Unable to breathe in Dead Zones, most sea creatures, such as fish and shellfish, either flee or die. But jellyfish thrive in Dead Zones. How? By playing unique metabolic tricks.

For example, jellyfish can dissolve oxygen in their watery tissues, and thereby carry built-in, life-sustaining oxygen supplies into Dead Zones. (Jellyfish are 95 percent water; humans are 65 percent water.)

Moreover, jellyfish in Dead Zones face few predators and competitors that would otherwise control their numbers. Feasting on ubiquitous plankton, jellyfish not only survive but actually dominate many Dead Zones.

The Earth currently has more than 400 Dead Zones--some of which cover tens of thousands of square miles. Many Dead Zones are so jellified that they could rightly be renamed Jellyfish Zones. The U.S. has Dead Zones in the Gulf of Mexico, the Chesapeake Bay, Narragansett Bay, Long Island Sound and the Pacific Ocean off the Oregon coast.

· Survive on modest means: Because jellyfish are mostly water, their nutritional demands are relatively humble. And when food supplies decrease, jellyfish can shrink their bodies, and thereby reduce their food demands. Some comb jelly species can survive for weeks without any food.

· Avoid being eaten as adults, under some conditions: "A few birds and fish will eat the jellies in their larval or juvenile stages," says Richard D. Brodeur of the National Oceanic and Atmospheric Administration, while discussing jellyfish that swarm in the Bering Sea, whose bells reach several feet in diameter. "But once the medusae (jellyfish) reach a certain size, not much eats them."

JELL HELL
Blooms of moon jellyfish may cover hundreds of square miles of the degraded waters of the Gulf of Mexico during the summer. Credit: Dauphin Island Sea Lab
A NATURAL GATHERING Millions of jellyfish gather in a marine lake in Palau in the Pacific. Scientists believe that Palau’s gatherings are not caused by human activities. Credit: Michael Dawson, University of California, Merced

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STRESSED OUT SEAS:
ENVIRONMENTAL STRESSES THAT MAY PROMOTE JELLYFISH SWARMS

Jellyfish represent an ecological "perfect storm" -- able to prosper from various types of environmental stresses that are currently proliferating in many parts of the world.

TYPE OF ENVIRONMENTAL STRESS
Invasions of non-native jellyfish

HOW ENVIRONMENTAL STRESS MAY INCREASE JELLYFISH POPULATIONS
Ships transport jellyfish around the world in two ways:

1. Juvenile jellyfish (called polyps) cling to ship hulls and therefore travel with ships.

2. Ships take on ballast water, needed for stability, in originating harbors. In destination harbors, ships may dump their ballast water along with accompanying organisms, including jellyfish. (Billions of gallons of ballast water are transported around the world annually.)

Jellyfish that are released into non-native habitats may colonize them--particularly if they face few or no predators in these habitats.

Underscoring the importance of shipping to global jellyfish movements is a recent study of moon jellyfish, which currently live in many worldwide locations. Conducted by Michael Dawson of the University of California at Merced and others, the study incorporates computer simulations of the global distributions of populations of moon jellyfish over the last 7,000 years, based on ocean currents and other factors.

Results show that "it is very unlikely that the current global distribution of moon jellyfish is natural," says Dawson. "Shipping is the most viable mechanism responsible for the current global distribution of jellyfish."

EXAMPLE LOCATIONS
Black Sea
Gulf of Mexico
Hawaii

TYPE OF ENVIRONMENTAL STRESS
Pollution

HOW ENVIRONMENTAL STRESS MAY INCREASE JELLYFISH POPULATIONS
Jellyfish are among the only creatures that can adapt to utra-polluted, oxygen starved waters known as Dead Zones. Lacking competitors and predators in Dead Zones, jellyfish tend to thrive in such waters.

From 2004 to 2006 alone, the number of global Dead Zones--which each coverto 45,000 square miles--increased from 150 to 200.

EXAMPLE LOCATIONS
Gulf of Mexico
Chesapeake Bay

TYPE OF ENVIRONMENTAL STRESS
Climate Change

HOW ENVIRONMENTAL STRESS MAY INCREASE JELLYFISH POPULATIONS
Increasing water temperatures may expand the geographic and seasonal ranges of jellyfish.

When droughts reduce river flows into coastal waters, coastal waters become saltier. Under such conditions, coastal waters may provide habitat to jellyfish that usually avoid coastal waters in favor of saltier waters.

EXAMPLE LOCATIONS
Narragansett Bay
Bering Sea
Australia

TYPE OF ENVIRONMENTAL STRESS
Over-harvesting of fish

HOW ENVIRONMENTAL STRESS MAY INCREASE JELLYFISH POPULATIONS
The over-harvesting of fish removes jellyfish predators and fish that eat the same food as jellyfish. Fewer predators and more food for jellyfish means more jellyfish.

EXAMPLE LOCATIONS
Black Sea
Namibia

TYPE OF ENVIRONMENTAL STRESS
Dams

HOW ENVIRONMENTAL STRESS MAY INCREASE JELLYFISH POPULATIONS
By reducing the flow of fresh water and nutrients into coastal waters, dams may--together with other environmental stresses and under some circumstances-promote conditions favoring jellyfish.

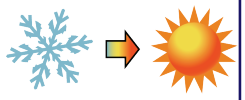
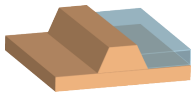
Scientists suspect that swarms of giant jellyfish that drift into the Sea of Japan originate in China’s coastal waters, which have been impacted by the gigantic Three Gorges Dam and many other environmental stresses.

Dams on the Danube River may have been one of many factors that set the stage for population explosions of comb jellies in the Black Sea.

EXAMPLE LOCATIONS
China
Black Sea

STRESSED OUT SEAS: Environmental stresses that may promote jellyfish swarms

Jellyfish represent an ecological "perfect storm" —able to prosper from various types of environmental stresses that are currently proliferating in many parts of the world.

Type of Environmental Stress	How Environmental Stress May Increase Jellyfish Populations	Example Locations
Invasions of non-native jellyfish 	Ships transport jellyfish around the world in two ways: 1. Juvenile jellyfish (called polyps) cling to ship hulls and therefore travel with ships. 2. Ships take on ballast water, needed for stability, in originating harbors. In destination harbors, ships may dump their ballast water along with accompanying organisms, including jellyfish. (Billions of gallons of ballast water are transported around the world annually.) Jellyfish that are released into non-native habitats may colonize them—particularly if they face few or no predators in these habitats. Underscoring the importance of shipping to global jellyfish movements is a recent study of moon jellyfish, which currently live in many worldwide locations. Conducted by Michael Dawson of the University of California at Merced and others, the study incorporates computer simulations of the global distributions of populations of moon jellyfish over the last 7,000 years, based on ocean currents and other factors. Results show that "it is very unlikely that the current global distribution of moon jellyfish is natural," says Dawson. "Shipping is the most viable mechanism responsible for the current global distribution of jellyfish."	• The Black Sea • The Gulf of Mexico • Hawaii • The Mediterranean
Pollution 	Jellyfish are among the only creatures that can adapt to ultra-polluted, oxygen starved waters known as Dead. Lacking competitors and predators in Dead Zones, jellyfish may thrive in such waters. The Earth currently has more than 400 Dead Zones affecting a total area of more than 245,000 square kilometers. The worldwide count of Dead Zones has doubled every 10 years since the 1960s.	• The Gulf of Mexico • The Chesapeake Bay
Climate Change 	• Increasing water temperatures may expand the geographic and seasonal ranges of jellyfish. • When droughts reduce river flows into coastal waters, coastal waters become saltier. Under such conditions, coastal waters may provide habitat to jellyfish that usually avoid coastal waters in favor of saltier waters.	• Narragansett Bay • The Bering Sea • Australia • The Gulf of Mexico • The Mediterranean
The Over-harvesting of fish 	The over-harvesting of fish removes jellyfish predators and fish that eat the same food as jellyfish. Fewer predators and more food for jellyfish means more jellyfish.	• The Black Sea • The Gulf of Mexico • Namibia • The Mediterranean
Oil rigs, harbor structures, docks and other artificial structures	Oil rigs, harbor structures, docks and other artificial structures Artificial structures create habitat for young jellyfish that live as immobile polyps attached to hard surfaces.	• The Gulf of Mexico • Harbors
Dams 	By reducing the flow of fresh water and nutrients into coastal waters, dams may—together with other environmental stresses and under some circumstances-promote conditions favoring jellyfish.	• Scientists suspect that swarms of giant jellyfish that drift into the Sea of Japan originate in China's coastal waters, which have been impacted by the gigantic Three Gorges Dam and many other environmental stresses. • Dams on the Danube River may have been one of many factors that set the stage for population explosions of comb jellies in the Black Sea.

Credit: Images - Zina Deretsky, National Science Foundation
Writing - Lily Whiteman, National Science Foundation
For more information on Jellyfish see:
http://nsf.gov/news/special_reports/jellyfish/index.jsp

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http://www.nsf.gov
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TRANSCRIPT

Cynthia Suchman: I think jellyfish are important to study because they can play a really important role in the overall food web of a given ecosystem in the marine world. So, if we just don't pay attention to all the components, especially, you know, one that's as large as the jellies can be, then we're missing the big picture and if the goal is the understand the way the system works, we've got to understand all the parts.

John Costello: We have to deal with the sea the way that the animal affects the water, and we have to be able to measure that, and the way that we see it starts off with a really very common visualization technique which is to use dye and water and to record how the swimming motions of the animal affect the water around. We do that in the laboratory and in the field. The laboratory is great because it can be quite controlled, but the problem is, in the laboratory, it's hard to have animals swim naturally, place the dye where you need to, and not have all kinds of effects from the tank and the walls and your hand messing it up, so really, our most instructive work has come from working in the environment with the animal where they live.

Cynthia Suchman: I've spent a lot of time in the laboratory dissecting their gastric pouches. They don't have a stomach like a fish has a stomach.

Cynthia Suchman: So, when we try to get a sense over a regional scale of what's going on with jellyfish populations, one of the resources we have is to look at what's gone on with fish catches. There are various sampling programs that trawl nets, not necessarily to catch fish to eat them, but to try and determine how many are there. The fisheries agencies would do that, and those nets often catch large jellies as well. So, in the event that those data sets will include counts of jellyfish, which would be caught incidentally while they're trying to catch the fish to determine how big those populations are, that's a really valuable resource when we try and start asking questions and answering questions about changes in jellyfish populations.

Cynthia Suchman: I mean, it's hard to understand jellyfish ecology in full if we don't even know the source of the polyps or how many there are. We can work in the laboratory with specimens to find out what sorts of things trigger the release of the baby jellyfish and people are starting to do that and have some interesting information on that, but it's hard to get an overall sense of either jellyfish blooms or changes in jellyfish populations without a full understanding of the whole life cycle.

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From Australia's swarms of potentially deadly, fingernail-sized jellyfish to Japan's swarms of 450-pounders, each region's jellyfish swarms are distinct--varying in species composition, timing, size and consequences. Why these differences?

From Australia's swarms of potentially deadly, fingernail-sized jellyfish to Japan's swarms of 450-pounders, each region's jellyfish swarms are distinct--varying in species composition, timing, size and consequences. Why these differences? Because each region's jellyfish populations reflect local ecology and, in many cases, local environmental stresses.

But, despite regional differences among jellyfish populations, the global influence of jellyfish on marine ecology warns all of us: Ask not for whom the jellyfish's bell tolls; it tolls for thee…

At any particular time, large jellyfish populations may be found in any number of worldwide locations. This map flags areas where scientists and/or the press have recently reported major increases in jellyfish populations.

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Australia

THE EXPANDING RANGE OF POTENTIALLY DEADLY BOX JELLYFISH

They say that "everything in Australia either bites or stings." But Australia's reputation as an epicenter of freak animal assaults is currently being promoted particularly aggressively by various species of box jellyfish whose ultra-venomous stings cause Irukandji syndrome.

Irukandji syndrome includes a range of agonizing symptoms, including racking body pain, vomiting, skyrocketing blood pressure, high heart rate and sometimes even heart failure. On a 1-to-10 pain scale, Irukandji syndrome rates a "40," says Jamie Seymour of James Cook University in Australia, who was stung by Irukandji jellyfish during a research dive.

Since about 2002, Australia has experienced "unprecedented occurrences of Irukandji jellyfish," says Seymour. The result: hundreds of hospitalizations as well as two confirmed deaths.

Six species of box jellyfish are known to cause Irukandji syndrome. Nevertheless, 10 or more jellyfish species are suspected of causing the syndrome, and Irukandji deaths are probably underestimated because the syndrome is difficult to diagnose.

VEXING ENVENIMATORS
Irukandji syndrome presents particularly vexing problems because:

- Irukandji jellyfish are among the world's most venomous creatures.
- Some species of Irukandji jellyfish are tiny and transparent and therefore virtually invisible in the water. These small species are even small enough to slip through nets used to protect beach-goers from a larger and deadlier species of box jellyfish species called *Chironex fleckeri*, which is the most venomous animal on Earth.
- Irukandji jellyfish are unpredictable. These jellyfish can strike in any of the coastal beaches, reefs and islands throughout the northern half of Australia, including the Great Barrier Reef. And, while their stings are most common during the Australian summer, they have occurred during every month of the year.
- Reports of Irukandji syndrome are increasing. This is probably happening for two reasons:
    1. Diagnosis and reporting of Irukandji syndrome increased after the two Irukandji deaths in 2002.
    2. The absolute numbers of Irukandji stings may be increasing. Why? Probably because water temperatures are rising, says Seymour. This warming expands the range of Irukandji's jellyfish into southern waters that used to be too cold for them. It also extends the summer season within Irukandji habitat; a longer summer means a longer Irukandji season.

BIG BOX JELLYFISH AND RISING TEMPERATURES
Chironex fleckeri only live in calm waters that are stilled by offshore reef systems. Therefore, no matter how high water temperatures get, these deadly creatures are unlikely to colonize areas without reef systems, says Seymour.

Nevertheless, *Chironex fleckeri* currently kill an average of one person and dozens of other people throughout the world's tropical waters annually. But because many indigenous people throughout the range of box jellyfish lack access to medical care and because their deaths are not recorded in death certificates, Seymour suspects that worldwide counts of box jellyfish stings may be seriously underestimated. His suspicions are supported by a recent informal survey indicating that most indigenous families in Thailand know of at least one family that has lost a family member to box jellyfish.

Caption/Credit:

CHIRONEX FLECKERI, THE WORLD'S

MOST VENOMOUS ANIMAL
Chironex means "the hand of death" in Latin and *Fleckeri* honors Hugo Fleckeri, a jellyfish researcher. Credit: Courtesy of the Great Barrier Reef Marine Park Authority for and on behalf of the Commonwealth of Australia

STEALTHY STINGER
The tiny *Carukia barnesi* jellyfish causes Irukandji syndrome, a torturous, potentially deadly syndrome. Its transparent, peanut-sized body and threadlike tentacles, which may extend several feet, are virtually invisible in water.
Credit: Dr Jamie Seymour, James Cook University

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Bering Sea

HOME TO "THE SLIME BANK"

Nicknamed "America's Bread Basket," the Bering Sea produces more than fifty percent of the U.S.'s entire catch of fish and shellfish. But now the long tentacles of environmental change are wrapping around this important fishery.

How? By expanding the range and increasing the size of the Bering Sea's jellyfish population. The problem? Jellyfish compete for plankton food with pollock, an important commercial fish, and may consume young Pollock.

THE RISE AND FALL OF BERING SEA JELLYFISH
Starting in the 1990s:

- Bering Sea jellyfish began fanning out north and west from the Alaskan Peninsula. "We began finding thick concentrations of jellyfish in places where we had hardly seen jellyfish before," says Lorenzo Ciannelli of Oregon State University.
- The size of the jellyfish population in the eastern Bering Sea soared by ten-fold, eventually peaking at record levels in about 2000.

During this period, one area north of the southeastern Alaskan Peninsula became so jellified that fishermen nicknamed it "the Slime Bank" and began avoiding it altogether for fear of tangling their nets in wads of tentacles.

After 2000, the Bering Sea's jellyfish population downsized, eventually stabilizing at moderate levels that still exceed the relatively low numbers of the 1980s.

THE CAUSES OF JELLIFICATION
Scientists suspect that many factors are influencing the ups and downs of the Bering Sea's jellyfish population. For example, the annual harvesting of more than one million tons of pollock may increase the availability of plankton food for jellyfish.

In addition, sea temperatures, which have increased since 1990, may be promoting jellyfish reproduction and expanding jellyfish ranges northward. Nevertheless, because temperatures continued to climb as jellyfish populations declined after 2000, scientists believe that--no matter how much temperatures rise--there may be a finite number of jellyfish that the Bering Sea can support.

AN ALL-POINTS-BULLETIN FOR POLYPS
Ciannelli suspects that jellyfish expand their ranges by colonizing new areas as polyps--a developmental phase during which they live as tiny transparent organisms clinging to the ocean floor. But no one knows where the Bering Sea's elusive polyp colonies are located.

Ciannelli's research team is currently attempting to find them via computer simulations that recreate the release and drifting of young jellyfish from suspected polyp habitats. These analyses are designed to help scientists identify the locations of cyber polyp colonies that seed cyber swarms resembling real-life jellyfish swarms. Then, the real-life locations of these cyber polyp colonies can be studied further, perhaps eventually by undersea robots. "To really understand the Bering Sea's jellyfish, we just have to find those polyps," Ciannelli says.

Ciannelli's research team includes Mary Beth Decker of Yale University, Kung-Sik Chan of the University of Iowa and Carol Ladd of the National Oceanic and Atmospheric Administration.

Caption/Credit:

BERING UP Sea nettle populations in the Bering Sea may be increasing and expanding because of climate change. The tentacles of the northern sea nettle extend almost 20 feet. Credit: Photo by Kevin Raskoff

PEAKING POPULATIONS
Jellyfish populations peaked in 2000. They have since moderated at levels that still exceed those of the 1980s. In addition, jellyfish ranges have expanded. Credit: Zina Deretsky, National Science Foundation, after Brodeur et al in "Progress in Oceanography"

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Black Sea

EUROPE'S MOST POLLUTED OCEAN BECOMES THE WORLD'S JELLYFISH CAPITAL

If the world had an official jellyfish capital, it would surely be the Black Sea--a huge inland sea located between Europe and Asia. Why? Because the Black Sea was transformed into a veritable jellytorium during the 1990s by an invasion of *Mnemiopsis*, a voracious, rapidly-reproducing species of comb jelly.

At its most jellified state during the late 1990s, the Black Sea harbored more than one billion tons of *Mnemiopsis*--which equals more than 10 times the weight of all fish caught throughout the worl----d annually. In some parts of the Black Sea, each cubic meter of water-- a space comparable to the interior of a large garbage bag--teemed with thousands of the golf ball-sized jellies.

The domination of *Mnemiopsis* over the Black Sea started in 1982--probably when a U.S. ship jettisoned into this sea ballast water from the U.S., along with some hitchhiking *Mnemiopsis*. This comb jelly is a hardy ecological squatter that is rapidly spreading along the east coast of the U.S. but had previously never visited the Black Sea.

Nevertheless, the Black Sea, Europe's most polluted ocean, provided a particularly hospitable environment to the *Mnemiopsis* newcomer. Why? Because the Black Sea has no natural predators of *Mnemiopsis* and because its overfished waters offered *Mnemiopsis* only minimal competition from fish. Feasting on copious quantities of plankton and able to shed 8,000 eggs daily, *Mnemiopsis* reproduced with wild abandon.

Swarming from coast to coast, *Mnemiopsis* crowded out almost all fish in the Black Sea. The result: losses of hundreds of millions of dollars to the area's fishing and tourism industries.

The tide only turned on *Mnemiopsis* in 1997, when another invading species of comb jelly, called Beroe, arrived in the Black Sea, probably also via ballast water from the U.S. Because Beroe eats *Mnemiopsis*, it has helped tame the Black Sea's *Mnemiopsis* monster.

Moreover, because Beroe eats nothing but *Mnemiopsis* and disappears as *Mnemiopsis* disappears, it has improved its adopted habitat without causing ecological problems--a rarity for an introduced species.

Nevertheless, *Mnemiopsis* remains a serious problem. Why? Because even though *Mnemiopsis* is controlled in the Black Sea through Beroe-assisted jellycide, it still greatly impacts area ecology. Additionally, *Mnemiopsis* has fanned out from the Black Sea via canals and ships to the Caspian, Azov and Mediterranean Seas. Also, additional waves of U.S.-based *Mnemiopsis* have recently invaded the North Sea and the Baltic Sea.

Just as it did in the Black Sea, *Mnemiopsis* has significantly reduced fish catches in many of these other huge seas. Indeed, *Mnemiopsis* has caused even more damage to fisheries in the Caspian Sea than it did in the Black Sea.

Some European nations have considered intentionally introducing Beroe into their *Mnemiopsis*-infested waters. But so far, they have refrained from doing so for fear of unintended ecological consequences from such introductions. Moreover, it is uncertain whether *Mnemiopsis*-infested waters besides the Black Sea meet Beroe's requirements for salinity, temperature and other environmental conditions.

Caption/Credit:

COMB JELLIES CONQUER EUROPE
The march of the invasive comb jelly (Mnemiopsis), which originated in the U.S.
Credit: Tamara Shiganova

THE COSTLY COMB JELLY
The fishing and tourism industries suffered more than $350 million in losses from the explosion of the comb jelly in the Black Sea. Losses from an ongoing comb jelly explosion in the Caspian Sea are expected to exceed Black Sea losses. Two comb jellies are shown here.
Credit: Jan-Erik Bruun, Finnish Institute of Marine Research

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East Coast

A VORACIOUS PREDATOR TIGHTENS ITS TENTACLED GRIP ON THE EASTERN SEABOARD OF THE U.S.

Populations of the gluttonous, rapidly producing comb jelly called Mnemiopsis are increasing throughout the eastern seaboard. In addition, the northern border of this creature's range recently advanced from Cape Cod to Boston Harbor. These changes are probably at least partly caused by rising temperatures.

Increases in Mnemiopsis populations are disturbing because the belly of this jelly, which feeds continuously, is virtually bottomless. Driven by an insatiable appetite, large swarms of fist-sized Mnemiopsis jellies can almost literally eat a whole in the ocean.

Among the waters that are supporting increasing populations of Mnemiopsis are:

Narragansett Bay:

Since 1971, Narragansett's population of comb jellies has at least doubled; during their annual peaks, comb jellies are now a dominating force on Narragansett's ecology.

Narragansett's comb jelly explosion correlates with an increase of almost two degrees centigrade in average winter temperatures since 1950. This warming enables some comb jelly clusters to, as never before, survive the winter and start breeding and accumulating large populations in the spring. By contrast, comb jellies used to take until mid-summer to do so. A longer comb jelly season means more comb jellies.

In addition, Narragansett's comb jellies used to bloom too late in the summer to exploit blooms of small crustaceans, called copepods, which bloom in the spring; but now that comb jellies also bloom in the spring, they can consume large volumes of copepods. Because copepods are also eaten by fish, whales and sea birds, the impacts of their increased consumption by comb jellies may cascade throughout the food chain.

The Chesapeake Bay:

No one knows how abundant gelatinous creatures were in the Chesapeake Bay before humans began impacting this heavily polluted water body. But the Chesapeake currently harbors large populations of many types of gelatinous creatures, including comb jellies, that are locked in a perpetual power struggle with large populations of comb jelly-eating sea nettles. Ecological dominance in the Chesapeake frequently swings back and forth between these two types of gelatinous creatures.

Currently, comb jellies wield the upper hand (or upper tentacle) in their power struggle with sea nettles. Why? One theory is that ongoing climate change produces conditions that are more favorable to highly adaptable comb jellies than to sea nettles, which have more rigid environmental requirements. Another theory is that the harvesting of the Chesapeake's oysters by the fishing industry has reduced habitat for juvenile sea nettles, which cling to hard surfaces --including oyster shells--and thereby helped reduce the Chesapeake's population of sea nettles. (By contrast, young comb jellies swim freely without clinging to hard surfaces.)

Continued dominance of the Chesapeake by comb jellies may damage its fish populations. Why? Because comb jellies eat more of the same foods that are eaten by fish and eat more fish eggs than do sea nettles.

European SEAS:

Invasive comb jellies, which originated on the East Coast of the United States, are now proliferating in European seas. (See "The Black Sea.")

Caption/Credit:

A JELLIFIED WATER BODY
About 500,000 people are stung by jellyfish annually in the Chesapeake Bay, a degraded water body. Credit: Scott Bauer, USDA

A HEARTLESS PREDATOR
Though humble in appearance, the fist-sized comb jelly (*Mnemiopsis*)--which is heartless, spineless and brainless --is a various predator that dominates many ecosystems during the summer. Credit: Laurence Madin, Woods Hole Oceanographic Institution

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Gulf of Mexico

THE BIGGEST DEAD ZONE IN THE WESTERN HEMISPHERE

The white sands and sparkling emerald waters of the Gulf of Mexico's beaches belie a dirty little (open) secret: a huge Dead Zone that is devoid of almost all life except jellyfish is expanding in the Gulf of Mexico. During the summer of 2008, the Gulf's Dead Zone covered about 8,000 square miles, about the size of Massachusetts. It is expected to soon reach about 10,000 square miles.

CREATION OF THE DEAD ZONE
The Gulf's Dead Zone is produced every summer by tons of fertilizer, sewage and animal wastes that are continuously dumped into coastal waters by the Mississippi and Atchafalaya Rivers. These pollutants do their dirty work by fertilizing huge algae blooms that decay through a process that robs Gulf waters of oxygen. Most sea creatures flee or suffocate to death in the Dead Zone's oxygen-starved waters, leaving highly adaptable jellyfish to proliferate unrestrained by predators and competitors and to gorge on the Gulf's bounty of plankton.

GROWING JELLYFISH POPULATIONS
The most abundant species of jellyfish in the Gulf are the sea nettle and moon jellyfish, which typically swarm over hundreds and perhaps even thousands of square miles each summer. Studies show that these species became significantly more abundant and expanded their ranges during the 1980s and 1990s. Moreover, since 2000, the Gulf has hosted invasions of several non-native jellyfish species, including the Australian jellyfish.

Signs that the Australian jellyfish is satisfied with its adopted Gulf home include its tendency to swell from its usual fist-size to the size of dinner plates in the Gulf. In addition, the Gulf's population of Australian jellyfish is steadily growing and expanding its range; this species recently reached North Carolina.

OTHER JELLYFISH-FRIENDLY FACTORS
Other factors besides the Dead Zone that probably encourage Gulf jellyfish to proliferate include:

- The creation in the Gulf of artificial habitat for young jellyfish (called polyps) that cling to hard surfaces by the presence of about 6,000 oil and gas production platforms and artificial reefs that are designed to support fishing. These artificial reefs are composed of at least one discarded bridge and acres of shopping carts, vehicles and other junk.
- The over-harvesting of fish that compete with jellyfish for food.
- The importation of invasive species of jellyfish into the Gulf by currents from the Caribbean and ships that provide hard surfaces to which young jellyfish cling.

GLOOM FROM BLOOMS
The Gulf's growing Dead Zone intermittently shuts down the Gulf's important shrimp industry: shrimpers do not even dare venture into the Gulf for dozens of days during typical swarm seasons because jellyfish masses would break their nets and clog their engines beyond repair.

Just the invasion of the Australian jellyfish alone cost the shrimp industry about $10 million dollars in 2000--not even counting the indirect costs of the consumption of eggs and larvae of commercial fish by these invading jellyfish.

Caption/Credit:

THE DEAD ZONE
Reds and oranges mark the Dead Zone in the Gulf of Mexico. The Gulf's Dead Zone covered about 8,000 square miles in 2008.

THE THIN LINE BETWEEN LIFE AND DEATH
Turbid Mississippi River water enters the Gulf of Mexico, dumping sediment, plants, fertilizer and other pollutants that promote the expansion of the Gulf of Mexico's Dead Zone, which is hospitable to jellyfish but few other animals. Credit: Nancy N. Rabalais

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Photo Gallery

1. JELLYFISH JAM: In the Gulf of Mexico's densest jellyfish swarms there are more jellyfish than there is water. More than one hundred jellyfish may jam each cubic meter of water. Scientists are currently pouring over records of worldwide marine life that were fastidiously maintained by some early explorers. Such analyses will help scientists better define how and where human activities are promoting jellyfish swarms.

Credit: Monty Graham

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2. IMPACTS CASCADE THROUGHOUT THE FOOD CHAIN: A population explosion of comb jellies in the Caspian Sea is encouraging the growth of huge algae blooms, which appear in green on this satellite photo. The Caspian Sea, which is the world's largest enclosed water body, is located between southeast Europe and western Asia.

Credit: Jeff Schmaltz, MODIS Land Rapid Response Team, NASA GSFC

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3. JELLICIOUS MEALS FOR TURTLES: Because leatherback turtles primarily eat jellyfish, these turtles provide important natural controls on jellyfish populations. However, leatherback turtles are currently critically endangered because of various human activities, including the development of nesting beaches and the dumping of plastics into the ocean; leatherback turtles sometimes mistake floating plastic bags for their jellyfish food, ingest the plastic and then suffocate. The decline of turtle populations may promote jellyfish blooms.

Credit: Suzanne R. Livingstone, IUCN

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4. RINGING THE DINNER BELL: A jellyfish rings the dinner bell by closing its bell on a shrimp. Filtering water to catch prey, a swarm of jellyfish may clear the entire water column of prey many times per day.

Credit: Rebecca J. Waggett, NRC Postdoctoral Research Associate

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5. A FULL MOON: Shown here is a moon jellyfish. Moon jellyfish were probably transported and introduced into many of their current worldwide habitats by ships. Scientists can distinguish native from invasive species via DNA analyses. Native species that have had a long history in a particular ecosystem have had time to genetically mutate. Therefore, they carry more genetic diversity than non-native species that have recently been introduced into ecosystems by humans.

Credit: NOAA

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6. ALIEN INVASIONS: Fifteen to 25 percent of all marine species that are currently found in global sea ports are invasive. Large numbers of species of gelatinous animals have been introduced into non-native habitats by ships. Such invasions have wreaked havoc on many ecosystems, including the Black and Caspian Seas. The economic costs of such invasions have been staggering.

Caption: None Available. Stock image.

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7. STINGING OUTSIDE THE BOX: Large numbers of ultra-venomous box jellyfish (*Carybdea alta)* now regularly visit some beaches in Hawaii. Their numbers substantially increased during the last 30 years.

Credit: Waikiki Aquarium

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8. STINGERS DOWN UNDER: Australia's beaches regulaly host many types of toxic gelatinous animals, including the notorious Portuguese man-of-war and *Chironex fleckeri*, the world's most venomous animal; a *Chironex* can kill a person in under three minutes. In addition, the potentially deadly Irukandji jellyfish, which are currently increasing in number, are small enough to slip through nets that protect Australia's beaches from its larger *Chironex* cousins.

Credit: Dr. Jamie Seymour, James Cook University

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9. JELL HELL: During the summer of 2005, about 500 million *Nomurai* jellyfish--each weighing up to 450 pounds--floated into the Sea of Japan every day. As a result, Japanese fishermen suffered tens of millions of dollars in losses.

Credit: Shin-ichi Uye, Hiroshima University

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10. A GIANT JELLYFISH: Each Nomurai jellyfish weighs up to 450 pounds and sports a bell up to seven feet in diameter. Nomurai have recently increased in the Sea of Japan.

Credit: Shin-ichi Uye, Hiroshima University

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11. AN ALL-POINTS-BULLETIN FOR JELLYFISH POLPS: Baby jellyfish live as fixed-position, stationary polyps before elongating and budding off into free-floating jellyfish. *Nomurai* polyps are shown here. Scientists suspect that huge swarms of *Nomurai* that have recently occurred in the Sea of Japan originated in China's degraded coastal waters, which provide excellent polyp habitat. Much about jellyfish polyps--tiny, deep-dwelling and rarely found in the wild--remains unknown.

Credit: Shin-ichi Uye, Hiroshima University

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12. JELLYFISH IN TECHNICOLOR: *Cotylorhiza tuberculata*, or the fired egg jellyfish, is common to the Mediterranean, Aegean and Adriatic Seas. The diameter of this jellyfish may exceed one foot, but it has only a mild sting, if at all. Unlike many other jellyfish species, this species can cover distances on its own power without relying on currents. This jellyfish is often accompanied by juvenile fish that take shelter in its tentacles.

Credit: Alberto Romeo, romeofotosub team

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13. MAUVES OF THE MEDITERRANEAN: The numbers of mauve stinger jellyfish (centre-right) in the Mediterranean have increased as populations of fish that compete for food with jellyfish have decreased.

Credit: Oceana

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14. AN EVER-INCREASING SPECIES COUNT: As scientists explore new ecosystems, they are identifying more species of jellyfish.

Credit: © Alberto Romeo, romeofotosub team

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15. A FAVORITE FOOD OF JELLYFISH: Copepods are small (microscopic to .25 inches), common crustaceans that collectively provide the biggest source of protein in the oceans. These important creatures are among the favorite foods of jellyfish and jellyfish-like animals.

Credit: Matt Wilson/Jay Clark, NOAA NMFS AFSC

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16. JELLYFISH GEOMETRY: Salps are tube-shaped gelatinous animals that live in every ocean. Increases in the Southern Ocean’s salp population, possibly caused by climate change, may eventually displace some important prey species of penguins and whales.

Credit: Laurence Madin, Woods Hole Oceanographic Institution

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Jellyfish anatomy illustration pdf

Jellyfish life cycle illustration pdf

WEBSITES

NOAA's "Mapping Sea Nettles in the Chesapeake Bay" is a Web site that uses maps to predict where seasonal infestations of jellyfish may occur in the bay:
http://155.206.18.162/seanettles

"Alien Stingers" is an exhibit at the New York Aquarium: http://www.alienstingers.com

The Dive and Discover's "Expedition 10: Antarctica." This expedition, which featured research on jellies, is discussed on these Web sites:
http://divediscover.whoi.edu/expedition10/index.html
http://divediscover.whoi.edu/expedition10/hottopics/salps.html

"Virtual Stowaway on an Oceanographic Cruise": An Interactive Educational Web site: This Web site offers a "virtual" firsthand look at scientific research and exploration aboard a dedicated research vessel on the open ocean:
http://www.sgmeet.com/aslo/orlando2008/viewabstract2.asp?AbstractID=1628.

IMAX MOVIE

The Imax Movie: "Sea Monsters a Prehistoric Adventure":
http://www.nationalgeographic.com/seamonsters/photogallery/jellyfish.html

NSF PRESS RELEASES

Fossil Record Reveals Jellyfish More than 500 Million Years Old:
http://www.nsf.gov/news/news_summ.jsp?cntn_id=110511

Scientists Discover Stinging Truths About Jellyfish Blooms in the Bering Sea:
http://www.nsf.gov/news/news_summ.jsp?cntn_id=111598

New Deep-Sea Hydrothermal Vents, Life Form Discovered:
http://www.nsf.gov/news/news_summ.jsp?cntn_id=108741

MEET THE JELLYOLOGISTS

Jellyfish are studied by a relatively small group of biologists, ecologists, genetics experts, statisticians and other researchers based around the world. Many of these researchers have studied jellyfish with NSF funding, collaborated closely with NSF-funded researchers, used NSF-funded research vessels or have been affiliated in some other way with NSF.

Every few years, jellyfish researchers meet to discuss their research and other jellyfish news. The Web site of the Second International Conference on Jellyfish is http://www.griffith.edu.au/conference/jelly2007.

This report covers research and/or background information provided by the following jellyfish researchers:

Richard Brodeur, Northwest Fisheries Science Center of the National Oceanic and Atmospheric Administration
http://www.nwfsc.noaa.gov/research/staff/display_staffprofile.cfm?staffid=285

Kung-Sik Chan, University of Iowa
http://www.stat.uiowa.edu/~kchan/

Lorenzo Ciannelli, Oregon State University
http://www.coas.oregonstate.edu/index.cfm?fuseaction=content.search&searchtype=people&detail=1&id=756

Sean Colin, Roger Williams University
http://www.rwu.edu/academics/schools/fcas/about/colin.htm

Jack Costello, Providence College
http://www.providence.edu/bio/faculty/costello

Gerald Crow, Waikiki Aquarium
http://www.waquarium.org/email.html

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http://mnd.ucmerced.edu
http://thescyphozoan.ucmerced.edu

Mary Beth Decker, Yale University
http://www.yale.edu/decker

Casey Dunn, Brown University
http://www.brown.edu/Faculty/Dunn_Lab/index.php?subject=People

Dian Gifford, University of Rhode Island
http://www.gso.uri.edu/criticalscales/program/investig/gifford/gifford.html

William Hamner, University of California, Los Angeles
http://www.eeb.ucla.edu/indivfaculty.php?FacultyKey=695

Carol Ladd, National Oceanic and Atmospheric Administration:
http://www.pmel.noaa.gov/people/cladd

William "Monty" Graham, Dauphin Island Sea Lab
http://faculty.disl.org/mgraham.html

Laurence Madin, Woods Hole Oceanographic Institution
http://www.whoi.edu/75th/gallery/week49.html

Anthony Moss, Auburn University
http://www.auburn.edu/cosam/departments/biology/graduate/areas/index.htm

Jennifer Purcell, Shannon Point Marine Center
http://www.ac.wwu.edu/~purcelj3/index.htm

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