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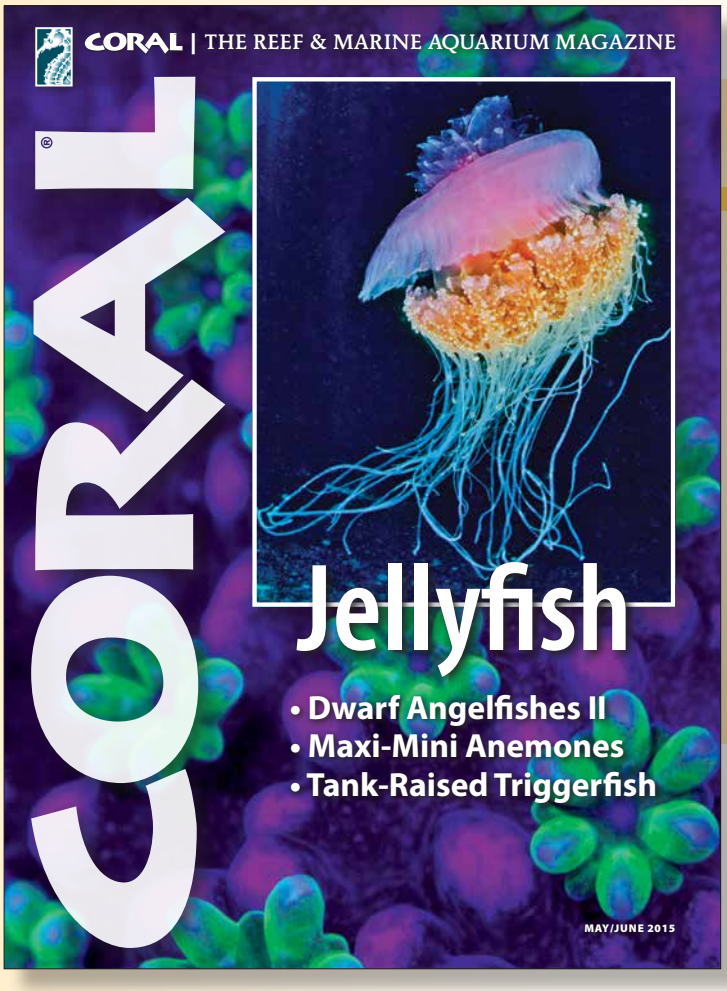

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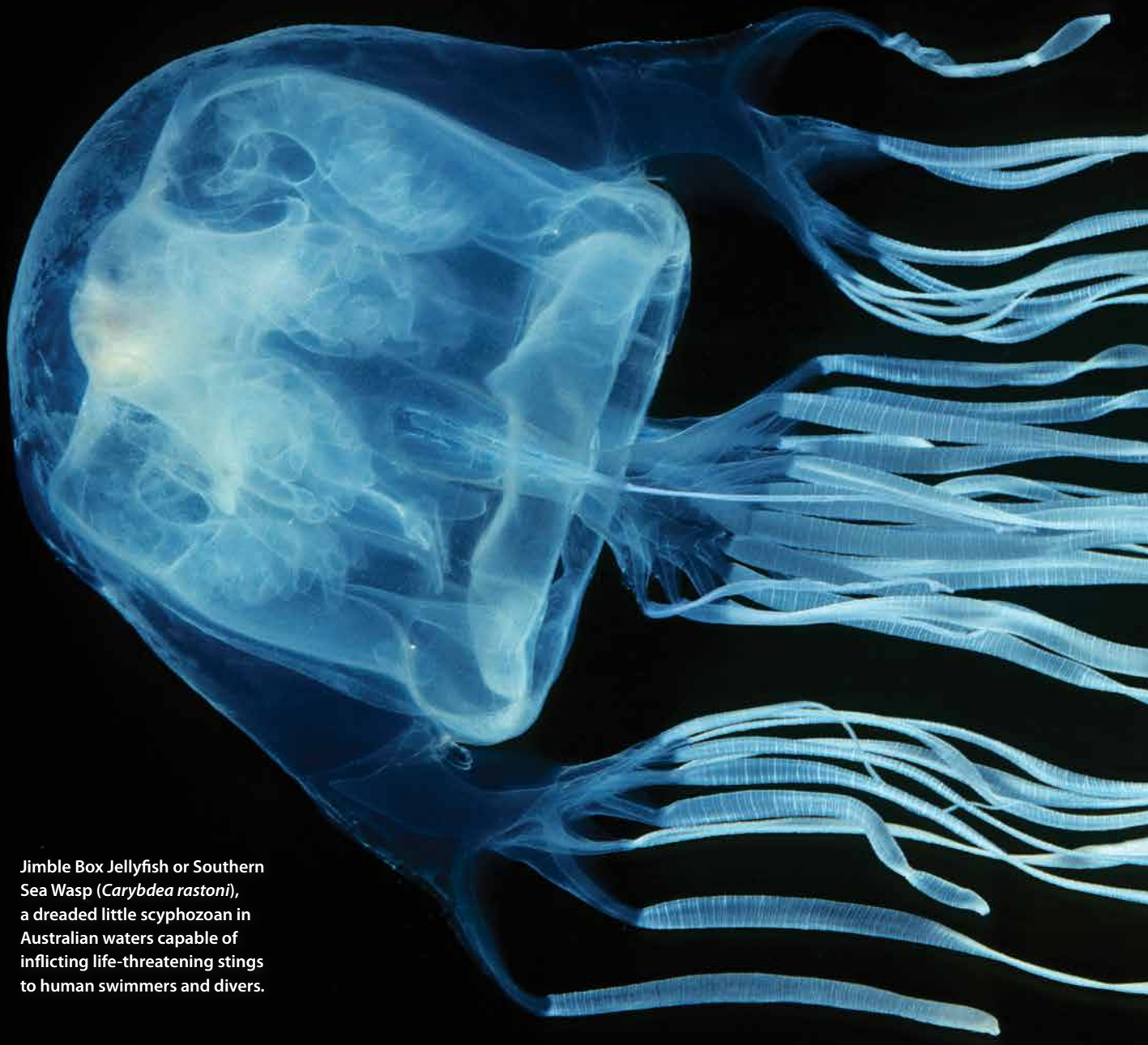
IN THE Scypho-

by **Ronald L. Shimek, Ph.D.**



Jimble Box Jellyfish or Southern Sea Wasp (*Carybdea rastoni*), a dreaded little scyphozoan in Australian waters capable of inflicting life-threatening stings to human swimmers and divers.

Zone

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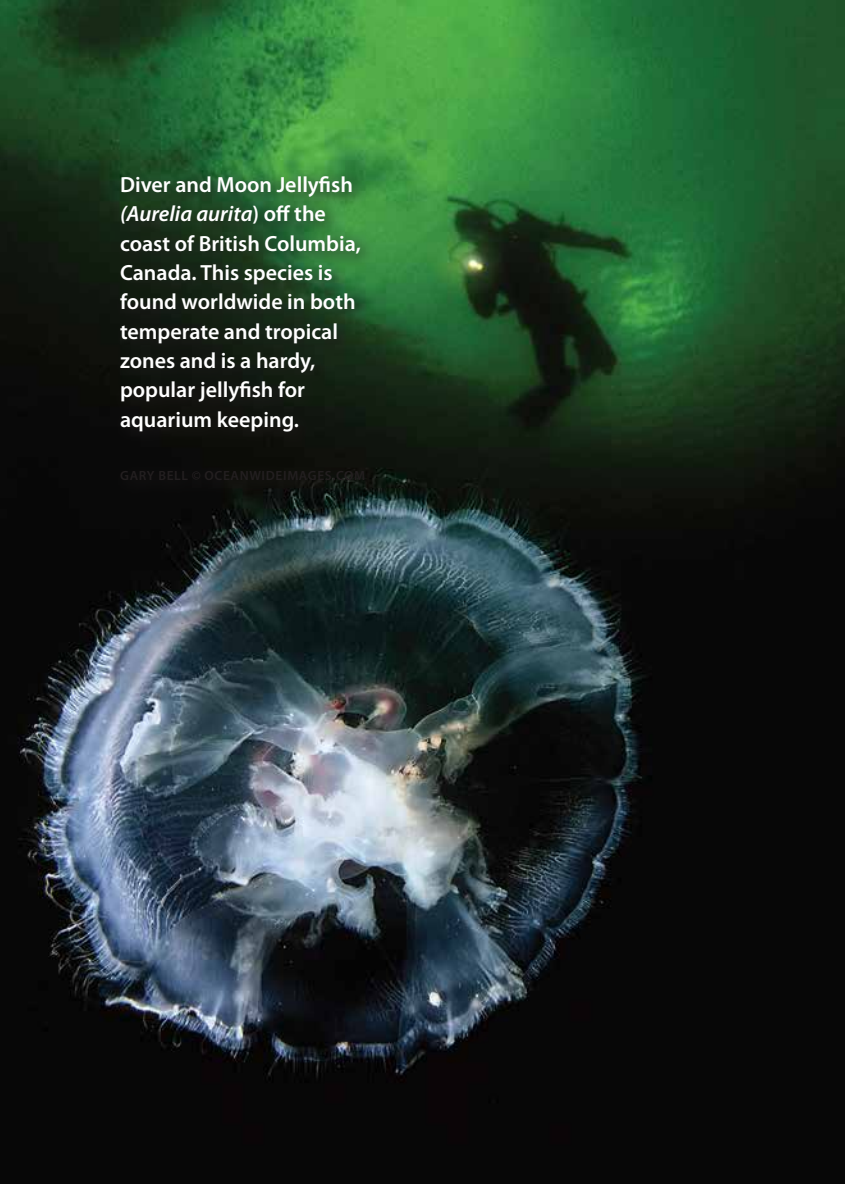
Imagine…

After visiting Walt Disney World in Orlando you decide to extend your Floridian vacation, and as part of the relaxing interlude you take some time off and go to the beach for a dip. Paddling out a short distance from shore, you splash around for a while, then head back in. You're not wearing goggles or a mask, so you don't notice the tiny whitish blob that brushes across your arm. But shortly after reaching shore, the first twinge hits you. Without warning, you feel as if you are being hit repeatedly in the kidneys with a baseball bat; before long you begin to have paralyzing muscle cramps in your arms and legs. It feels like your skin is on fire, and you start projectile vomiting. The vomiting continues for the next 10 to 12 hours, and you begin to have a sense of impending, terrifying doom. Soon the feeling of horror becomes so deep and dark that you start to beg anyone near you to end your suffering. As if all this weren't enough, your heart begins to race, your blood pressure skyrockets, and you lose bladder and bowel control. Unable to walk or even talk coherently, you are taken to a hospital where the emergency room physician, suspecting you have been stung by a jellyfish and remembering that vinegar baths help in some jellyfish stings, wets a cloth in vinegar and rubs it over your arm. This amplifies your pain exponentially to a point where you lose consciousness… which you never regain.

You have just had your first, last, and only experience with what is termed Irukandji syndrome, the result of being stung by one of four small species of box jellyfishes—*Carukia barnesi*, *Malo kingi*, *Alatina alata*, and *Malo maximus*. Other species of box jellies may inflict similar symptoms, but that is uncertain.

Initially discovered off the Northern Australian coast and named for an aboriginal tribe in the region, the Irukandji syndrome species were initially thought to be limited to that area. However, specimens of some of them have now been collected in Britain and Japan and on the east coast of the United States. Fatalities have been recorded in Australia and injuries elsewhere. These tiny jellies, about a cubic centimeter in size—one would fit easily into the space occupied by a sugar cube—are new to science, and because of their small size and fragile nature virtually nothing is known about their behavior. Frankly, given the outcome of an accidental sting, I wouldn't want to get into the water to study their interactions. If the envenomation is not lethal, the symptoms may



Diver and Moon Jellyfish (*Aurelia aurita*) off the coast of British Columbia, Canada. This species is found worldwide in both temperate and tropical zones and is a hardy, popular jellyfish for aquarium keeping.

GARY BELL © OCEANWIDEIMAGES.COM

pass in a couple of months. Victims definitely need to be hospitalized and given treatment—including intravenous morphine and fentanyl for the pain. Although Irukandji syndrome has been uncommon, it is apparently becoming less so. It is part of the new world of jellyfishes that is unfolding in the twenty-first century.

WHATTZZAT?

To put this jolly tale in perspective it is worthwhile to learn a bit about these wonderful animals. We can start by asking: What, exactly, is a jellyfish? As has been pointed out many times, in many places, jellyfishes are neither made of jelly, nor are they fishes. Their shape is unlike that of any other animal. Although they are generally unfamiliar to just about everybody, they are exceedingly abundant in various oceanic environments, and they are very successful animals. They are also well adapted to succeed in "disturbed" environments, making them, in a sense, pre-adapted to exploit habitats that have been trashed by human activities. Scientists call them medusae, a solitary adult jellyfish individual is a medusa, and that is as good a place to start as any.

THE FIRST MEDUSAE

In classic mythology Medusa is one of the three Gorgons, winged demons of the deep and monsters from the underworld. Two of the Gorgons, Stheno and Euryale, were immortal, but their sometimes sinister/sometimes lovely sister, Medusa, was mortal. All three had venomous snakes in place of hair, and it was said that if a person wandering around in ancient Greece gazed upon Medusa's face, he or she would immediately become petrified—turned to stone. Perseus proved that Medusa was mortal by decapitating her and using her head as a weapon. He would hold her head up by her snaky hair, and whoever looked at it would be turned to stone. Some—but not all—medusae live up to this fearsome reputation from mythology.

TODAY'S MEDUSAE

The myriad of present-day medusae are discoidal or cylindrical animals possessing not venomous snakes, but venomous tentacles surrounding the edge of the disc or the central mouth. Three obvious characteristics allow you to determine whether what you see is a jellyfish medusa or some other form of marine protoplasm, or even a bit of translucent drifting flotsam.

Firstly, a jellyfish has a unique body shape. The shape of most medusae is similar to that of a bell, umbrella, or toadstool: it is basically discoidal, but convex on the aboral side (usually the top) and concave on the oral side (usually the bottom). The mouth is located on a stalk extending from the center of the oral side. Tentacles are typically located either all the way around the outer edge or at some discrete regions on that edge, as well as on tissue flaps near the mouth. The tentacles may be very short, as in the Moon Jellyfish, *Aurelia aurita*, and related species, or may exceed 66 feet (20 m) in length, as in the Lion's Mane Jellyfish, *Cyanea capillata*, one of the largest shallow-water medusae.

Secondly, jellyfishes capture food in a unique way. The feeding process is fairly complicated at the microscopic level, and most of the "action" is just too small to be seen by an observer. What an observer will see, however, is that prey animals (typically far smaller than the jellyfish) that inadvertently touch the tentacles first become agitated and then appear to be in great distress, making random, undirected movement, often followed by convulsions and paralysis. Then they are pulled into the mouth by the tentacles and eaten.

Thirdly, jellyfishes move in a characteristic and unique manner. The major locomotory muscles are the circumferential muscles located around the edge of the

bell. When they contract, they pull the edges of the bell together. This closes the cavity on the underside of the bell by decreasing the area of its opening and the volume of the cavity, expelling water from it. The muscular action is opposed by the "jelly" of the "fish," which has a finite volume of water-filled gel and cannot be compressed. As soon as the muscles cease to contract, the jelly pushes the bell back into its original shape. Simultaneously, radially oriented muscles contract and get shorter and fatter, compressing the jelly between them and counteracting the action of the circular musculature. These movements are casually termed "belling" or "pulsing" by many jellyfish observers, and all of the mature jellyfishes or medusae move with this peculiar pulsation pattern; no other kind of animal does that.

A Lion's Mane Jellyfish (*Cyanea capillata*) with juvenile pelagic fishes sheltering around its tentacles. This species is regarded by some as the world's largest jellyfish, and it can reach an enormous size.

GARY BELL©OCEANWIDEIMAGES.COM

JELLYFISH EXTREMES

A common scyphozoan jellyfish that is found in the northern reaches of the Atlantic and Pacific Oceans, as well as the Arctic Ocean, is known as *Cyanea arctica* or *Cyanea capillata arctica* or simply *Cyanea capillata*. Most people call it the Lion's Mane Jellyfish. Specimens of this species or variety—take your pick, nobody has done genetic examination of them, so any guess is as good as any other—have been documented to reach more than 7 feet (2 m) in diameter, which is reported to be the largest size for a scyphozoan medusa, or any single cnidarian animal, for that matter. To put this in perspective, such an animal is one of the largest predators on Earth.

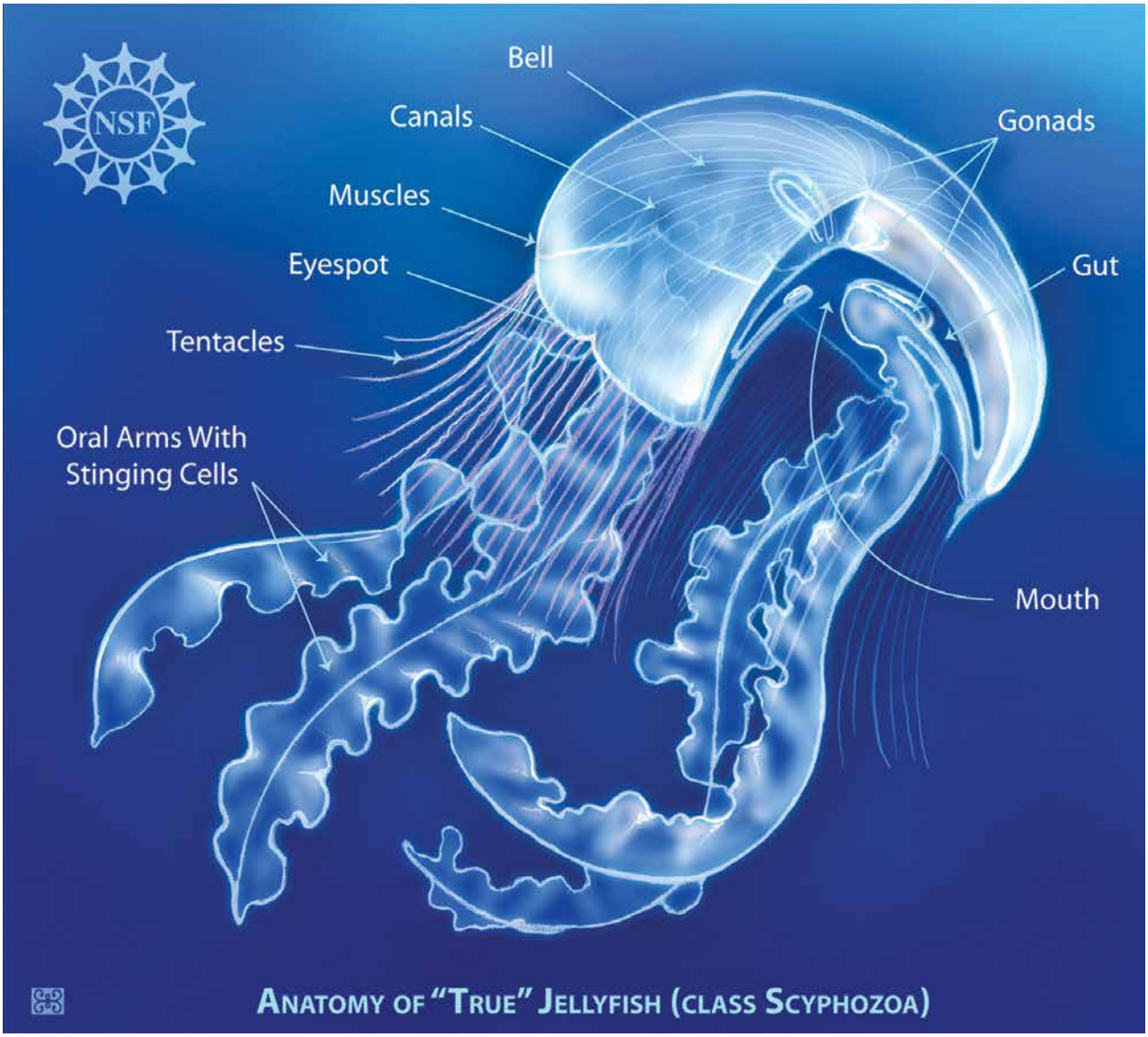
A *Cyanea arctica* individual with a diameter between 7 and 10 feet (2–3 m) will have tentacles that can extend an estimated 100 to 130 feet (30–40 m). The question might arise as to what such large predators eat, and the answer would, quite obviously and quite reasonably, be "Anything they want." People might question that answer, but as Dr. Lisa-ann Gershwin has pointed out, most of the larger medusae do eat anything they can catch. Given that fact, these jellyfish, weighing in excess of a ton and having very virulent nematocysts, will immobilize and catch anything dumb or careless enough to find its way into the killing volume of the tentacular maze beneath the animal. When the tentacles from such a huge creature are fully extended they are so thin and difficult to see that they create an essentially invisible network under and around the animal—a three-dimensional meshwork of fine, threadlike, nematocyst-covered tentacles that may extend for 50 to 100 feet (15–30 m) in all directions. Any animal swimming into such a volume soon becomes painfully disoriented and unable find its way out. Paralysis and capture soon follows. The tentacles then contract, and the dying victim is brought home to the predator.

On the 19th of June, 1981, on a research dive in Saanich Inlet on the east side of Vancouver Island, a ways north of Victoria, BC, my dive partner and I were swimming back toward our anchored boat. We were at a depth of about 60 feet (18 m), about 30 feet (9 m) above the

bottom, and maybe 100 feet (30 m) from the boat. We were swimming toward the anchor chain, barely visible as a vertical shadow in the greenish murk ahead of us, but if we looked up toward the surface we could see no detail, but just a green haze. Suddenly, all around us in the water there were pale white, orange, red, and brown threads. We had entered the tentacle field of a *Cyanea* medusa some distance above us.

Uh-oh…

I was fortunate: my dry suit hood, plus my moustache and beard, protected my face. My clean-shaven diving partner wasn't so lucky. He had several tentacles wrap around his face, especially around his lips, which, of course, were exposed around his regulator's mouthpiece, and the skin under his mask. Being an excellent scientist, he stopped, noted the time on a writing slate, and for the next several hours kept track of the results of encountering these *Cyanea* tentacles; we had seen several such medusae from the surface and assumed we had encountered one of them. He said it was a very unpleasant situation for about an hour; by about six hours later most of the sensations were gone, but it took about 12 hours



JELLYFISH ANATOMY: Jellyfishes are often dismissed as "spineless, eyeless, and brainless" bags of water. The latter is true, as their bodies are up to 98 percent water, but they do have some remarkable sensory abilities and microscopic weaponry. The rim of the bell, or umbrella, in a typical Moon Jelly such as this is ringed with tentacles that are covered in countless nematocysts, microscopic organelles that discharge with explosive force from cnidocytes and are capable of killing and snaring prey items—or, in some species, of paralyzing large animals, including humans. A nerve network in the epidermis serves to detect stimuli, and some species of box and cube jellyfishes have primitive sensory organs that can detect light and movement. Digestion takes place in the gastrovascular cavity served by a common mouth/anus at the center of the oral base of the bell. For a detailed discussion of Scyphozoan anatomy, see: http://www.reef2rainforest.com/in-the-scypho-zone/.

ZINA DERETSKY, NATIONAL SCIENCE FOUNDATION

A Moon Jellyfish, *Aurelia aurita*. Note the tentacles fringing the edge of the bell, all bearing stinging nematocysts. This species is generally harmless to humans.

for all of the stinging results to disappear completely. He had reddish welts on his face and small, bright red lesions in lines where the tentacles had touched his skin. Not a fun experience by any stretch of the imagination.

When *Cyanea* tentacles are fully extended they are as thin as hairs and invisible at anything other than very short distances. Nonetheless, if encountered, they are immediately noticeable by their effect on a diver's bare skin, and also presumably by any other animal not wearing a rubber suit or thick fur. Data for small *Cyanea*, those less than a foot or so in diameter, indicate they eat small crustaceans, small fishes, and smaller medusae, particularly small Moon Jellies (in the Northeast Pacific, the species of Moon Jelly is *Aurelia labiata*).

Verifiable dietary data for the really large *Cyanea* are so sparse as to be non-existent, although there are a lot of anecdotal data. For example, when I was teaching at the University of Alaska, Anchorage, in the late 1970s, an Alaskan Native in one of my classes described a large jellyfish, probably an individual of a *Cyanea* species, stranded on the Arctic Ocean shore on the Alaskan North Slope. The body of this dead mass of colored goo contained a few relatively large Arctic char or other similar salmonid fishes, along with a dead seal. Upon hearing this, my supposition was that the medusa caught and killed the char; the seal approached, saw the struggling or dead fishes, went into the oral tentacle mass to grab a fish, and got massively stung, dying either directly from the medusa's nematocyst venom or from anaphylactic shock induced by the massive amount of venom suddenly in its body. On top of this ability to get large, mobile animal food, all medusae are capable of feeding on all sizes of food along the complete range until, at the other end of the food scale, they can ingest dissolved materials in the water by using pinocytosis, or cellular ingestion by their gastrodermal cells.

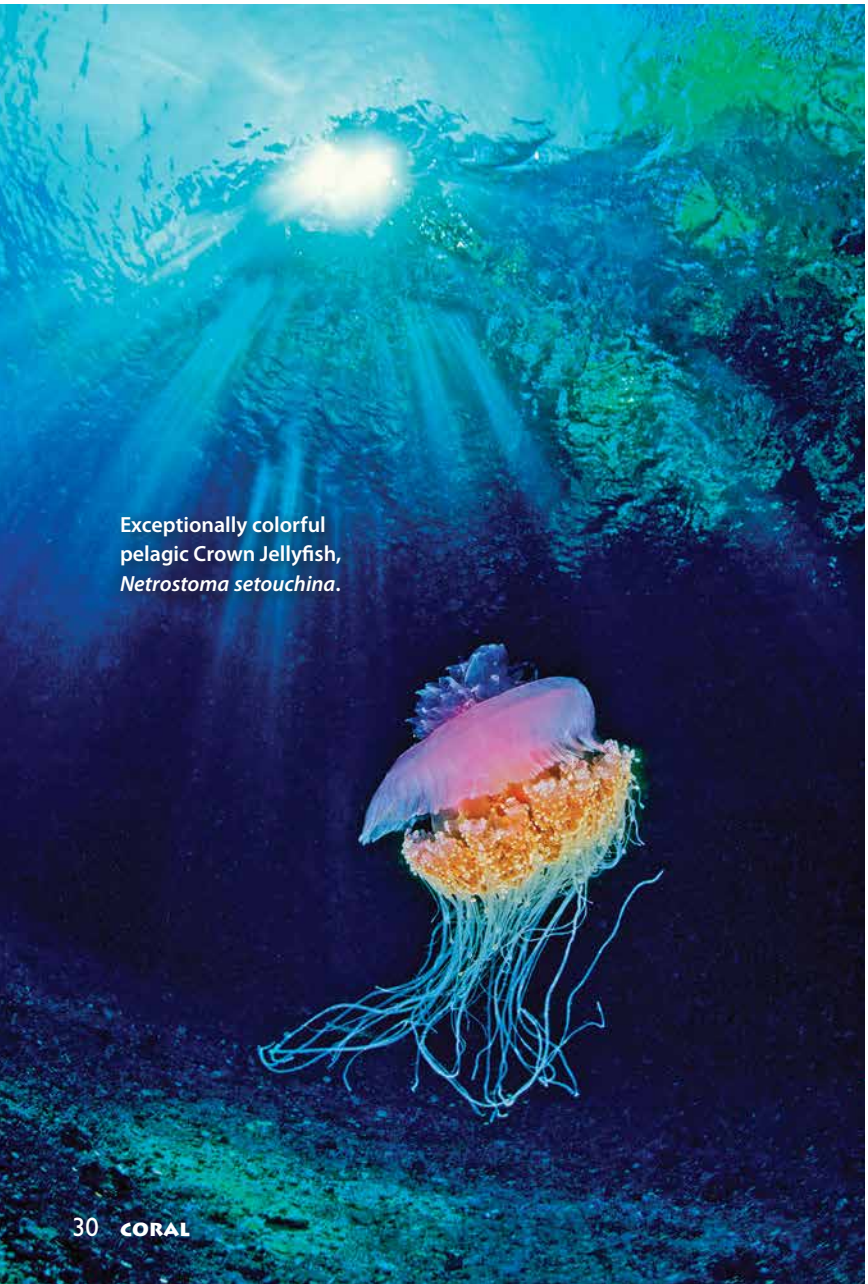
IN EXTREMIS...MINOR

Although most discussions are about large medusae, as with other classes of animals, most individuals of all species are not the big ones. Even those animals that have large adults start out small. Most species of medusae, particularly within the hydrozoa, have a relatively tiny adult size and they generally are pretty safe to handle; however, it is worth remembering that there are many scyphozoans and cubozoans, as well, whose adults are quite tiny. This is particularly the case with those cubozoans that constitute the group known as the "Irukandji jellyfishes." In these species, the small adult sizes camouflage the fact that they are some of most murderously

dangerous animals on the planet.

Hydromedusae, sometimes known as "water medusae," are taxonomically and visually distinctive from the cubo- and scyphomedusae. They are typically smaller than most scyphomedusae, and their bells are usually clear; scyphomedusae and cubomedusae typically have colored or translucent bells. Hydromedusae are seldom more than 4 inches (10 cm) across, and unlike most scyphomedusae, they are often brilliantly bioluminescent. During the night, if one of them is touched or bumped, they often flash with a relatively brilliant light that is often a particularly pretty shade of bluish-green.

This fact was noticed early in the study of marine animals, and, starting in the 1960s and continuing for many years thereafter, Professor Osamu Shimomura, his colleagues, and many hired student minions visited the University of Washington's Marine Labs at Friday Harbor, Washington, and spent the summer collecting, by walking back and forth along the dock floats and netting individuals of one specific jellyfish species one by one. Over a summer the crew would collect many hundreds of thousands of individuals of the very common, exceptionally beautiful large hydromedusan *Aequorea victoria*. Over a period of more than 20 years they collected in total several million jellyfishes, killed them, and processed their bodies to obtain, each year, no more than a few grams of the chemical, initially called "Aequorin," that caused the jellyfishes' bioluminescence. Considering the cost of paying wages, travel, housing, and such for the collecters and processors, this chemical had to be, on a per-gram basis, one of the most expensive materials known at that time, being worth several thousand times as much as gold. As time passed and techniques improved, the material's name was changed to "green fluorescent protein," and the researchers discovered its structure and how to make it. In 2008, the Nobel Prize in Chemistry was awarded jointly to Osamu Shimomura, Martin Chalfie, and Roger Y. Tsien "for the discovery and development of the green fluorescent protein, GFP" which is now used in all sorts of research venues.



Exceptionally colorful pelagic Crown Jellyfish, *Netrostoma setouchina*.

Reaching 4–5 inches (10–12 cm) across, *Aequorea victoria* is large for a hydromedusan, most of which are less than a centimeter in diameter. They are budded from a polyp, and their structure is similar to that of scyphomedusans, although they lack oral arms and possess a shell around the underside of the bell called a velum. Hydromedusans, by and large, are predators on an array of small crustaceans and other planktonic animals. Essentially, their diet consists of anything they may be able to catch, subdue, and stuff in their mouths, from protozoans to larvae, to small copepods, to other hydromedusans. For a while at Friday Harbor, there was a pea cannery operating across the bay from the laboratory where Shimomura et al. collected their medusae, and during much of the day each *Aequorea* was quite visible in the water because of the single pea each individual held in its gut. Although a few hydromedusae have been found with phytoplankton in their guts, it is presumed by most researchers that such food is really so minor as to be immaterial.

The only freshwater jellyfishes are hydromedusans that are about the size of a nickel. There are a couple of species worldwide, but only one species, *Craspedacusta sowerbii*, originally from China, is found in North America. They have been reported from most of the United States, but they are not consistently found anywhere.

Small hydromedusans, typically common in coastal waters, are often found in

The Crown Jellyfish, *Cephea cephea*, a highly variable species, in the Andaman Sea, Thailand.

huge numbers, they are essentially harmless, and as positive benefit can provide part of the bioluminescent light show seen by anybody who goes swimming off a summer beach after dark, as well as being an intermediate link in many marine food webs. Speaking of dark...

ON THE DARK SIDE

Small individual jellyfishes that are neither scyphomedusans nor hydromedusans, but rather small cubomedusans, are truly on the dark side of the jellyfish force. Cubomedusans are, as the name implies, cubical in shape. Their tentacles arise in tufts from each of the four lower corners, or sometimes just from two diagonally opposed corners on the oral side. The largest cubomedusans reach about a foot (30 cm) in diameter, but most are smaller. Superficially they may remind one of hydromedusans, but don't make that mistake and consider them to be, as most hydromedusans are, essentially harmless to humans. If you do, it may be the last mistake you ever make.

Most medusae are sit-and-wait or, more correctly, float-and-wait predators. Even though they don't chase their prey, make no mistake—they are predators and they may be very important predators in their particular ecosystem, but most of them don't chase down their prey. They spread their tentacles as wide as they can and let their prey catch themselves, much as lobbyists catch congresscritters—only the reward is different. Jellyfish prey get eaten, congresscritters get rich, and for the rest of us there is no justice.

Cubomedusan behavior has been watched underwater by researchers wearing specifically designed wet or dry suits. The suits have to be carefully cleaned to make sure that no cubomedusan tentacles or fragments are adhering to the suits when they are entered or removed. That having been noted, most observations of cubomedusan behavior have been made either from the surface in shallow water using glass bottomed buckets or other similar viewing devices, or by observing them in aquariums.

Unlike the simple photoreceptors found on other medusae, the photoreceptors possessed by some cubomedusae are very sophisticated camera eyes having lenses—sometimes two or more—corneas, and retinas. In fact, they basically look quite similar to human eyes, except that some of them have two irises. Although these eyes create excellent images, as deduced from their optical properties, their owners simply don't have brains that can process such complex images. Nonetheless, even though the cubomedusan nervous system is quite rudimentary, it is sophisticated enough that it can be used to ensure the jellyfish can use the images to chase down prey. Generally, most researchers hypothesize that the images are excellent shadow and motion detectors and work with a series of complex and sophisticated reflexes to provide the animal with a way to chase down its prey.

The overall functional unit in this case, of course, is a predator with sophisticated eyes, a sophisticated reflexive nervous system, strong musculature, and a hydrodynamic design that maximizes the velocity produced during swimming effort. Even some tiny species are quite capable

of swimming faster than a human. Often found congregating in areas around mangrove roots, they use their eyes to avoid entanglement and also to chase down prey such as fishes or shrimps. And, interestingly enough, if they are found in mangroves adjacent to a beach where humans are swimming, they also seem to chase down human swimmers. As if this were not enough, the nematocysts in these animals are armed with an array of venoms that make the jellyfishes absolutely marvelous in their functionality. Additionally, although these venoms seem to stop most prey and other critters in their tracks, the jellyfishes seem to be eaten without harm by some fishes and turtles.

JELLIED PERSPECTIVES

Other than those people with a death wish who go swimming in areas where cubomedusans are common, why should anybody care about those drifting or occasionally swimming blobs of goo called jellyfishes? Until fairly recently, nobody did. Or at least, nobody other than the occasional, and somewhat peculiar, scientist cared much about jellyfishes.

Well, that's not quite true. There is, and has been for several centuries, a small Asian fishery for jellyfishes as food. Of course, both the fishermen and their customers care about the jellies. Those individuals with an urge to learn new things could always learn new, useful, and technically demonstrative terms by accompanying net-using fishermen into an area experiencing a jellyfish bloom. Ridding the fine-meshed nets of the tons of jellyfishes that clog them after attempting to fish during such a bloom is said to be both exceedingly unpleasant and painful, resulting in the frequent use of some rather technically precise and admirably descriptive language that is, however, of limited applicability. But virtually nobody else cared.

Still, a few people spent enough time learning about them to notice that over the last century or so, their populations appeared to be increasing. Blooms were becoming more frequent and larger, but it didn't seem like a big whoop to most of the public. However, during the late 1970s, a period that will probably be known in the future as the beginning of the end of humanity's youthful free ride from nature, particularly in the oceans, conditions seemed to reverse and abnormal occurrences started to seem like the norm. Many news stories started to appear describing utterly bizarre occurrences, such as huge numbers of jellyfishes literally filling bays, resulting in clogged intakes for power plants, problems with ships, and hundreds of people at swimming beaches getting stung by jellyfishes.

As the lyrics of a popular song noted, "The times, they [were] a changing...." Or were they? Perhaps people were just becoming more aware of events. Lisa-ann Gershwin, in her book *Stung!: On Jellyfish Blooms and the Future of the Ocean*, published in 2014, cites a short report published in 1880 by the eminent zoologist Karl Möbius, one of the pioneers in the field of marine ecology, describing a jellyfish bloom in Kiel Bay in Germany, where Moon Jellyfish, probably *Aurelia aurita*, were so dense that an oar pushed—PUSHED!!!—into the water remained upright without sinking. Jellyfishes have always bloomed, it seems. Gershwin also described a flagstone quarry in Wisconsin that has several bedding

A Moon Jellyfish in the Andaman Sea off Thailand. This female is displaying pink masses of embryos developing within the oral arms prior to being released as planula larvae.

BULLETPROOF MOON JELLIES

Aurelia aurita are hardy animals tolerant of many extreme conditions that would kill reef animals. Maintaining *Aurelia* polyps appears to be relatively easy, and if the polyps are kept in good health they will regularly produce small medusae that will rapidly grow to a sellable size. These jellies prefer cold to cool water. They do well at room temperatures that would turn most corals into driveway gravel. Like all aquarium creatures, they can be overfed; this does not hurt the medusae so much as encourage bacterial growth, which causes the oxygen level in the tank to drop too low. If they are well fed, the medusae should eventually start to produce gametes. The animals are sexually mature when they reach a diameter of 1–2 inches (30–50 mm). The tissues around the gastric pouches, the gastrodermis, start to become thick and especially noticeable. If the animal is a male, the tissue turns a vibrant white; in females the color is more subdued and ranges from beige to tan to orange, yellow, or bright pink. The eggs are yolky and the color of the yolk colors the eggs and gonads.

If spawning occurs, the male's gonads, which are just pouches full of sperm, empty—usually during the night. If there is a receptive female in the tank she ingests or eats the sperm and transports them internally to her collection of eggs, where fertilization occurs. After a short time the eggs start to develop as embryos and move down to the oral arms, where they are kept in small aggregations. Then the embryos develop into swimming larvae called planulae, which are released from the female. Males that have spawned are reported to die after a few weeks. Females may live a month or longer than males. It may be possible to keep the spawned individuals alive, but that has not been noted in the literature.

The planulae can settle and develop into polyps within a few hours to a few days if the substrate is acceptable. If the polyps are well fed they may grow and strobilate, producing ephyrae in as little as 10 weeks, but it may also take years, depending on the conditions. These scyphopolyps are perennial and can live many years, growing and dividing to produce large masses of polyps. If they are well fed, the ephyrae develop rapidly, being recognizable medusae within a few days, and reach sexual maturity within six weeks.

planes showing stranded jellyfish blooms fossilized from a stranding of jellyfishes in the Cambrian period, about 500 million years ago. As Gershwin notes, when jellyfishes are abundant they form blooms, and if they are in bays, they get stranded; and they have always done so.

Nevertheless, people are probably becoming more aware of jellyfish blooms. And given the degradation of the oceans, there are probably a lot more jellyfish blooms than there used to be. Jellyfishes have become more abundant due to two factors. The first factor is the removal of the top predators in marine ecosystems. These top predators are fishes, and by golly, humans have pretty much fished all fishable fishes to commercial and, in many places, ecological extinction. Several different researchers, using different methodologies, have come to the same conclusion: sometime between 2030 and 2050, the oceans will be effectively fished out.

With the removal of these larger fishes—think sharks, or fishes you can no longer find at a market, such as Newfoundland Cod—an "ecological" vacuum is created. The animals that most efficiently fill that vacuum are medusae, mostly scyphozoans. The kicker is, though, even if we'uns, we humans, that is, quit fishing, in most areas the fishes won't come back. The jellyfish blooms won't let them come back. The medusae eat not only the food of the

juvenile and smaller fishes, they also eat those few juveniles and smaller fishes that do exist—or will exist for a few moments of evolutionary time. In a very real sense these jellyfish blooms appear to be forever.

The second factor that promotes jellyfishes to the top of the heap is environmental degradation. Once humanity starts to do its other oceanic things, other than fishing, that is, vast areas of the ocean become unsuitable for fishes. Any fishes. The huge dead zones that cover large portions of the Gulf of Mexico, or similar but somewhat smaller zones off the mouths of river systems where agricultural and industrial waste has killed the ocean bottom life, have become a common feature of shorelines in the developed world (see http://en.wikipedia.org/wiki/Dead_zone_%28ecology%29#/media/File:Aquatic_Dead_Zones.jpgand https://nofishleft.wordpress.com/tag/marine-dead-zones/). Such areas are lacking in most fishes—not because of overfishing, although that may be a factor as well, but because many of the smaller animals that the fishes would feed upon are absent because of the truly horrible physical conditions. Interestingly enough, jellyfishes can often survive in such areas because they can harvest and eat just about anything that floats, wiggles, or drifts in the water column, as long as it is smaller than they are.

One of the more interesting things that happens in the oceans when fishes are removed is that the biological or ecological energy flow becomes truncated. Ecologically useful energy (food in one state or another) continues to enter the ocean. Generally, it enters as sugars and organic materials produced by phytoplankton fueled by sunlight. While it seems relatively easy for humans to remove fishes from the world's oceans, it is a lot harder to remove phytoplankton and the tiny animals, the zooplankton, that eat those phytoplankton. And these small critters can be prime jellyfish food. Even the huge *Cyanea* can persist or thrive in areas where the fishes it normally eats are absent. In those areas, these big jellies eat medium-sized jellies, which eat smaller jellies, which eat...well, I think you can get the drift.

Pretty much the only resilient and stable system left is dominated by medusae. In a very real sense, the oceans have reverted back to a state seen in very, very, very ancient times, such as the Cambrian seas, when fossilizable life first became abundant. During those periods, the largest and most successful mid-water predators were jellyfishes of one sort or another. There were no fishes to contest the territory with the jellies. The same thing is happening today.

So are jellyfish blooms important? Yes and no; yes, they are indicators of oceanic changes that are going to affect us all very soon, and no, by their very presence they indicate that systems have changed so drastically that reversion to a "healthy" ecosystem is essentially impossible.

DO YOU WANT TO SEE JELLYFISHES IN CAPTIVITY?

Over the past couple of decades, technology has developed that allows the maintenance of jellyfishes in small to quite large

aquariums. Basically, all that is needed is a tank designed so that the medusae do not hit or get hung up on the aquarium walls. These are the ultimate in fragile animals, and if that is allowed for, and designed for, they may be kept relatively easily, as the recent marketing of *Aurelia aurita* jellyfish aquariums is showing. The primary problem with maintaining medusae in perpetuity is having a successful stock of medusa-producing polyps. The methodology for keeping *Aurelia* has been mastered. Maintaining the polyps appears to be relatively easy, and if the polyps are kept in good health they will regularly produce small medusae that will rapidly grow to be a sellable size. There are quite a number of species that have an adult size similar to *Aurelia*, and some of these are quite striking in their morphology.

One promising species, *Periphylla periphylla*, the Helmet or Santa's Hat Jelly, is normally found in very deep water, but is occurring in plague numbers in a couple of Norwegian fjords. It has no polyp stage, passing directly from egg to juvenile to adult. Reaching about a foot long, the body is a striking red and looks quite a bit like the hat of a garden gnome with a fringe of thick red tentacles.

Some other jellies that may have promise are hydromedusans such as *Aequorea victoria*, the species from which GFP, green fluorescent protein, was derived. The ultimate problem is maintaining the polyp, but if that can be mastered it would be quite possible to maintain a tank of beautiful and brilliantly bioluminescent medusae about 4 inches (10 cm) in diameter. This species has the added advantage of being absolutely harmless to humans.

In large, brightly illuminated tanks containing a sand substrate, it is possible to keep *Cassiopeia* species, the upside-down jellyfishes. There are several species in this genus, found in different oceans. The animals get much of their nutrition from the symbiotic algae maintained in their tissues. They reach the size of dinner plates and pack an irritating sting. They are fairly common in shallow-water sandy lagoons throughout the tropics, where they used to provide a major food source for turtles. However, with the demise of most turtle populations the upside-down jellies are becoming a minor ecological plague in some areas. *Cassiopeia* will not do well in the normal Kreisel tanks that other jellies thrive in. They produce copious amounts of mucus, and the mechanical filtration necessary, as well as their large size, makes them unsuitable for home Kreisels, although with the proper design and forethought one should be able to keep them in a dedicated DSB aquarium.

Another jellyfish that might be good for either a home or commercial aquarium is one of the several almost identical subspecies of *Mastigias papua* found in "jellyfish" lakes in the Palau, Indonesia, New Guinea region. Derived from the rhizostomous medusae found in the open ocean of this area, they have mild nematocysts, generally harmless to humans. They eat small zooplankton found in their lakes, but only get about 30 percent of their nutrients from food. They absorb a lot of nutrients from the lake water and get the remainder from their symbionts. They get about 4 inches in diameter.

CONCLUSION

Why should we care about these pulsating blobs of jelly? They are beautiful animals and surprisingly abundant near the seashore, but that isn't the only place they are found. In fact, a couple of the small hydromedusan jellyfishes are found in fresh water throughout the world. One of these species, *Craspedacusta sowerbii*, is found sporadically throughout most of the United States.

However, marine jellyfishes are the ones making the news. Over the last 20 years or so, we've been hearing about massive jellyfish swarms appearing at beaches. Mostly they have just inconvenienced swimmers, but Cubozoan jellies, also known as sea wasps or box jellies, have occasionally killed a swimmer.

However, these swarms on beaches really hide bigger problems. In certain

A snorkeler encounters masses of Moon Jellies off Exmouth in Western Australia. With fish stocks dwindling in many places, jellyfishes are proliferating with fewer predators to keep their numbers under control.

areas around Japan there have been occasional swarms of the giant Nomura's jellyfish, *Nemopilema nomurai*. These jellies are spectacular, reaching about 6.5 feet (2 m) in diameter, making them, along with the Lion's Mane, *Cyanea capillata*, some of the world's largest known cnidarians. Not coincidentally, these swarms occur when the local fishermen are out trying to harvest their catch. The headline reads, "Japanese fishing trawler sunk by giant jellyfish"; it seems that our heroes of the moment, the three-man crew of the 11-ton trawler *Diasan Shinsho-maru*, tried to haul in a net full of the jellies, each of which weigh up to 450 pounds (200 kg). As might be expected, the little trawler capsized, undoubtedly rendering the fishermen infamous among their peers. This tale of woe could continue with more examples, but the real question is, "Why, all of a sudden, do jellyfishes appear to be taking over the ocean?"

Probably the two most commonly proposed reasons for jellyfish blooms are related to human alteration of marine ecosystems. Most fisheries throughout the world are overfished, and this opens up all sorts of ecological niches for jellyfishes to expand into. Many near-shore oceanic habitats have also been severely altered, and these alterations allow spectacular blooms in the asexual stages of jellyfishes, which, in turn, allow equally spectacular blooms in their pelagic sexual stages. So we humans, in our typical blundering manner, have given the jellyfishes a significant leg (or tentacle) up in both of their critical habitats. It is likely that global climatic change is significantly favoring these animals by increasing the abundance of the planktonic foods that the jellies eat.

Our easy access to digital media promote over-reporting and under-analyzing. Although it might seem that in a few years we will be able to walk across the water in any oceanic embayment because the surface will be solid jellyfishes, this is not the case. There do appear to be a lot more jellyfish blooms now than there have been in the past, but it is quite possible that numerous jellyfish blooms have occurred in the past but were not reported. Given the ephemeral nature of the jellyfish corpus, even huge blooms leave no permanent record. Still, an awful lot of jellyfishes are being sucked into the cooling systems of power plants and showing up on beaches.

As a species, we are very likely to blame for the jellyfish events that are now occurring throughout the world, including the spread of deadly box jelly species. We may have no idea what "the" problem is, because the damage to marine ecosystems is so severe that there is no single cause. You name it, we've done it: overfishing, pollution, global climate change, and plastic trash so voluminous that it will make markers in the geological record and provide a new substrate, a rock called "plastigomerate," for the polyps to thrive on.

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DOUG PERRINE/SEAPIX.COM

Not-quite-two-years old, Audrey Pedersen adjusts the LED lighting in her family's six-gallon Jellyfish Art tank, which houses three Moon Jellyfish (*Aurelia aurita*).

MATT PEDERSEN

by **Matt Pedersen** *with* **Dr. Toshihiro Yoshida**

My First Jellyfish

A seasoned marine aquarist goes back to husbandry school

"Fisch…Fisk…Light…Touch…Blue…." Such are the musings of my 22-month-old daughter Audrey as she gazes into our recently established desktop jellyfish aquarium. She is enthralled and enraptured, yet completely confused. What are these pulsing translucent objects? I am truly amazed that something so alien can elicit such a strong positive response in a child. Frankly, however, these reactions are not unlike those of an experienced reef aquarist who gives in to temptation and sets up his or her first Scyphozoan tank.

I have recently been experimenting with the brainless bags of water that have been piquing many marine aquarists' curiosity of late. Historically, jellyfishes in the home aquarium have never caught on, the notable exception being the benthic Upside-Down Jellies (*Cassiopeia* spp.), which often rest on the bottom and tolerate relatively rough contact with solid objects. But things have been changing, so it seems like a good time to take a fresh look. I ordered a trio of free-swimming Moon Jellyfish, and as I waited for them I thought about the rumors I'd heard: jellies are incredibly sensitive, must be kept in expensive tanks, and are difficult to care for.

RUMORS OF SENSITIVITY

It is true that jellyfishes are sensitive; they are gelatinous creatures that are easily torn or punctured. If you think an anemone being sucked through a powerhead turns out bad, it's far worse for a jellyfish. Because of a jellyfish's inherent soft makeup, combined with its typical pelagic existence, where there is no physical boundary or barrier, physical contact can be terribly problematic. Even something as benign as a small air bubble trapped under the bell of this creature can literally "drill through" the soft tissue, so capture with a net can cause damage and exposure to air must be strongly avoided. For this reason jellyfishes are moved with cups and shipped with

no air space in the bag. That said, my own experience with Moon Jellyfish has proven that healthy individuals are also incredibly resilient. I have seen them endure tears, holes, and even the loss of oral feeding arms and fully heal.

RUMORS OF EXPENSIVE EQUIPMENT

Given the sensitive physical makeup of jellyfishes, aquariums that cater to their needs are necessary. At first, such systems were custom-built, scaled-down versions of public aquarium technology; they were expensive 10 years ago. But since keeping jellyfishes has become more popular, smaller aquariums with more affordable prices have arrived on the market. You can now choose from a variety of jellyfish aquariums, from elegantly simple air-driven kreisels to eye-catching showpiece aquariums, and custom commercial jellyfish installations are becoming routine for some aquarium service companies. All these systems use gentle, gyre-based circular currents to keep jellyfishes adrift in the water column and steer them away from filtration intakes.

RUMORS OF DIFFICULT HUSBANDRY

The husbandry of jellyfishes is rumored to be for experts only, but most of the difficulty stems from the suggestion that live foods are required. "Live food" most often means baby brine shrimp (*Artemia* nauplii), at least when dealing with hobbyist-suitable jellyfish species. Hatching and collecting brine shrimp is fundamentally very easy: you add the cysts to salt water, wait 24–30 hours, harvest, feed what's needed, and store the rest in the refrigerator.

That said, all the species suitable for home culture will also feed on frozen brine shrimp nauplii, so if hatching is simply "too much work," this prepared option is available to you. Still, live brine shrimp has the advantage that it does not sink to the bottom, so there is less risk that it will become food waste. To varying degrees, the jellyfish suitable for home culture will also consume prepared coral/jellyfish foods, which are helpful supplements that will make up for the nutritional shortcomings of baby brine shrimp. The Moon Jellyfish (*Aurelia aurita*) I'm currently maintaining are thought to be unique in their ability to subsist on prepared jellyfish feeds as their sole diet.

General recommendations for jellyfish care suggest small, frequent feedings rather than large, haphazard ones. Short periods without food probably are not problematic for jellyfishes; in fact, their size can generally be controlled by the amount of feeding.

Beyond feeding, jellyfish husbandry is very basic. Weekly water changes are a no-brainer with small desktop tanks that hold under 10 gallons. Water changes of 15–25 percent per week, maybe only 1–2 gallons, work very well with moderate stocking levels. The biggest difficulty in performing water changes is making sure you don't accidentally suck up a jellyfish! You must also be careful not to introduce bubbles into the tank, and if any bubbles do become trapped in the bell of a jellyfish, you should carefully turn the creature over to allow the trapped air to escape. When cleaning tank surfaces, move slowly so you do not tear the jellyfishes.

Tankmates for jellyfishes are generally considered a bad idea; either the jellyfish or the tankmates are bound to have issues. I've seeded my aquarium with a few micro brittle stars from my reef aquarium and some small amphipods, but these benign creatures are meant to live in the filtration area and consume uneaten food. Mixing jellyfish species is also to be avoided; maintain them only in species aquariums.

JELLYFISHES OF TODAY

As a veteran aquarist, I find that my desktop jellyfish aquarium is the easiest, most undemanding aquarium in my care. Certainly, if a jellyfish aquarium is your first aquarium you have much to learn, but establishing a jellyfish aquarium is no more complicated than setting up a 10-gallon aquarium to house a pair of clownfish.

Today, the basic rules for keeping jellyfishes are well understood, and the Moon Jellyfish is generally considered the easiest species to maintain. They are usually thought of as temperate creatures, and their aquarium doesn't even require a heater. To say they are tough little animals is an understatement; our Moon Jellies were delayed in shipping, and when they arrived after 48 hours in transit the water was probably between 40 and 45°F (4.4–7.2°C). We expected the worst, yet they are still alive and well a couple of months later.

At first glance, it would seem that the only species suitable for the home aquarium is the Moon Jellyfish; they are ubiquitous, and are shown in almost every tank being discussed and marketed. This left me asking, "What else is there?"

JELLYFISH OPTIONS FOR THE AQUARIST

I put that question to Dr. Toshihiro (Toshi) Yoshida of Exotic Aquaculture, based in Hong Kong, which cultures multiple species of jellyfish for the aquarium trade. (Dr. Yoshida is also a cofounder of Cubic Aquarium Systems Ltd.) He shared his short list of five species suitable for the average home aquarist, including all relevant information and insider tips. He started with the Moon Jellyfish, but then mentioned a few surprising species, most of which have a lifespan of about a year. With these animals you're not looking at a long-term commitment. A naturally short lifespan is also good for ensuring the long-term viability of commercial propagation. Additionally, all of these species will accept prepared jellyfish foods as supplements to their primary diet of live or frozen brine shrimp nauplii.

All of the species selected by Dr. Yoshida are generally considered to have "low toxicity" and, according to Exotic Aquaculture, are "not harmful to humans." This does

Blue Blubbers, *Catostylus mosaicus*

Flame Jellies, *Rhopilema esculentum*

Spotted Lagoon Jellyfish, *Mastigas papua*

not mean that they cannot sting you, so prevention is better than finding out the hard way that you're the one person who has a negative reaction to contact with one of these more or less benign animals. As a precaution, you should consider donning protective gloves before putting your hands into a jellyfish tank.

DR. YOSHIDA'S TOP 5 JELLYFISH PICKS

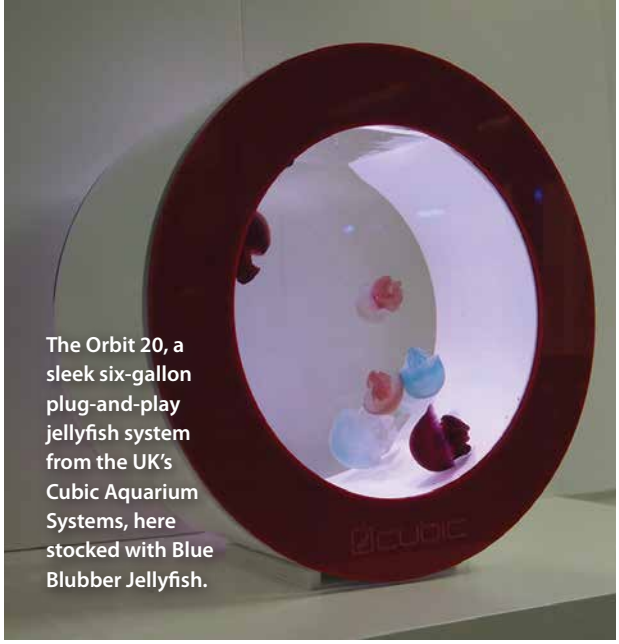
Moon Jellyfish (*Aurelia aurita*). This is an easy-to-care-for species, distributed globally. Most strains in the trade are from cold-water or temperate sources, but can tolerate a range of temperatures from 59 to 77°F (15–25°C). Some tropical strains can tolerate temperatures up to 82°F (27.7°C). Moon Jellies are routinely captive-cultured now, and have a natural life span of about one year. They can reach a diameter of up to 12 inches (30 cm), but as noted earlier, size can be controlled through feeding. Moon Jellies are considered the easiest of all the jellies to feed, accepting live and frozen *Artemia*, copepods, *Mysis*, and some prepared powdered feeds. Dr. Yoshida noted that Moon Jellies require better water quality than the other species listed. This intriguing observation suggests to me that if you can maintain water good enough for a Moon Jellyfish, all the other species will do well under your care!

Blue Blubber (*Catostylus mosaicus*). Native to Southeast Asia and most frequently collected and exported from the Philippines, the Blue Blubber is easy to keep in captivity. It is tropical, requiring a temperature range of 73–83°F (23–28°C). It is smaller than a Moon Jelly, reaching only 6 inches (15 cm) max, but even 4 inches (10 cm) is large. Blue Blubbers are active, and therefore require good, routine feeding to reduce shrinkage. They are one of the only species on this list that are not currently being cultured, as their reproductive habits are not yet known. They also have the shortest anticipated lifespan; six months in captivity is considered normal for a wild-collected animal. For the aquarist wanting a less monotonous display, Blue Blubbers occur in multiple hues ranging from white to blue to purple to brown. Dr. Yoshida notes that contact with this species causes a rash or welts in some people.

Flame Jellyfish/Edible Jellyfish/Bizen Jellyfish (*Rhopilema esculentum*). The Flame Jellyfish is another undemanding species. They start out transparent but develop a striking coloration as they mature. This is a temperate species with a suggested temperature range of 60-79°F (15.5–26°C). While they can reach a large size of 20 inches (51 cm), Dr. Yoshida states that they do not grow over 6 inches (15 cm) in captivity. This is one of the species that is commonly dried and eaten in Asia, and they are available as cultured animals. Like the Blue Blubber, this species may cause rashes or welts in some people, so it is best to avoid contact with skin. The Flame Jellyfish is more suceptible to shipping stress than others on the list, so larger water volumes per individual animal are used to compensate.

Spotted Lagoon Jellyfish (*Mastigias papua*). The Spotted Lagoon Jellyfish is another tropical species, preferring a temperature of 73–83°F (23–28°C). It can get up to 8 inches (20 cm) long. This South Pacific native is being bred in captivity and is considered easy to keep, but it adds another wrinkle to jellyfish husbandry: the

ALL COURTESY DR. TOSHIHIRO YOSHIDA / EXOTIC AQUACULTURE, HONG KONG



The Orbit 20, a sleek six-gallon plug-and-play jellyfish system from the UK's Cubic Aquarium Systems, here stocked with Blue Blubber Jellyfish.

species hosts symbiotic algae that require full-spectrum, more intense lighting than the subdued ambient light required by all the aforementioned species. These algae are also thought to be the reason for the diversity of color forms within the species. Despite being photosynthetic, this jellyfish still requires daily feedings to meet its energy requirements.

Australian Spotted Jellyfish (*Phyllorhiza punctata*). Dr. Yoshida says this species requires a bit more care than the others, calling its care level "medium." Like the Flame Jellyfish, it can reach sizes of up to 20 inches (51 cm), but 6 inches (15 cm) is the norm. Like the Spotted Lagoon Jellyfish, this species hosts symbiotic algae and requires full-spectrum, higher intensity lighting for optimal care, but is said to do adequately without it. In either light setting, it requires daily feedings. Originally from Australia and the Western Pacific, it has spread to Hawaii, the Mediterranean, and more recently the Gulf of Mexico. It is also cultured in captivity. It is suggested that budding polyps of this species may attach to ships and thus spread into other areas where it is non-native, and in some cases it is considered invasive.

IS THERE A JELLYFISH FOR YOU?

I'm only a few months in, but my experience suggests that jellies are not the mysterious, difficult, and expensive creatures they once were. The "one size fits all" Moon Jellyfish, which has single-handedly propelled the last 10 years of interest and growth in jellyfish-keeping, may soon be joined by a number of intriguing species.

There most certainly is a jellyfish for most tastes. Don't worry about boredom...each year, you can try a different species in the same tank! Given how much enjoyment my children get from our current trio of Moon Jellies, I just might have to try all of Toshi Yoshida's species suggestions over the next five years.

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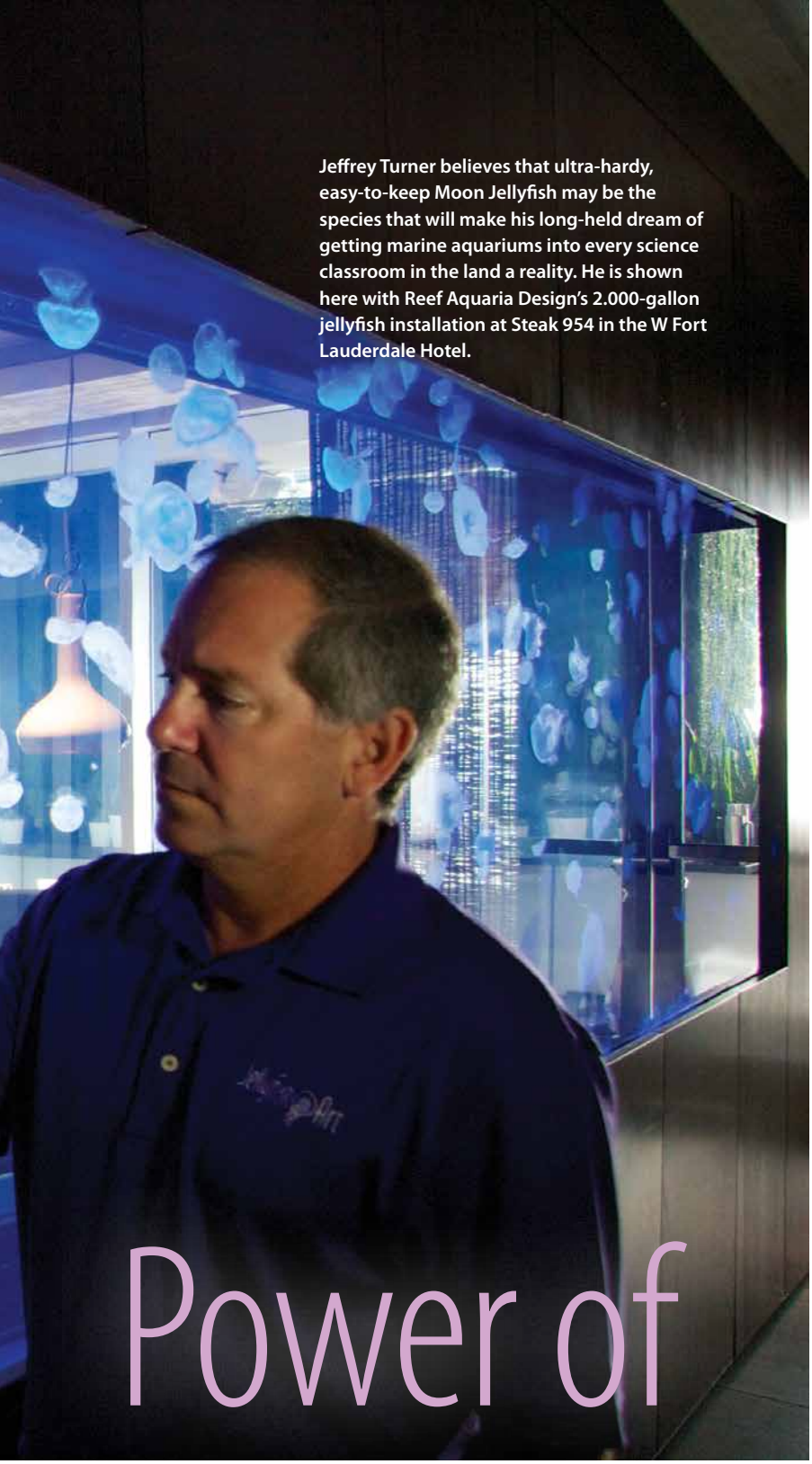


Jeffrey Turner believes that ultra-hardy, easy-to-keep Moon Jellyfish may be the species that will make his long-held dream of getting marine aquariums into every science classroom in the land a reality. He is shown here with Reef Aquaria Design's 2.000-gallon jellyfish installation at Steak 954 in the W Fort Lauderdale Hotel.

PAY APANTE

Power of

In the classic 1920s song "Let's Fall in Love" Cole Porter claims jellyfishes are both lazy and lovestruck, but neither is true, according to Jeff Turner, the president of Jellyfish Art. "When it comes right down to it," Turner told me, "they're spineless and brainless."

Although Turner's comment sounds flip, he's very serious about jellies and the real good he believes they can do—from influencing the aesthetics of aquarium-keeping to providing a perfect way to introduce marine aquariums into classrooms across the country. It strikes me that keeping jellyfish could even transform the saltwater aquarium trade at a time when comprehensive reform is so desperately needed.

Turner's resume makes it abundantly clear that his professional life is synonymous with the aquarium trade in Florida, if not nationwide. In addition to Jellyfish Art, which he purchased in 2013, Turner is the president and founder of Reef Aquaria Design and CEO of Boyd Enterprises. He holds a license from the state of Florida to collect marine life for the aquarium trade and has helped lead the Florida Marine Life Association for years. Turner's family is steeped in the industry: his father was a pioneer in the aquarium trade both in South Florida and nationally, and his son, Joe Turner, is now general manager of Jellyfish Art.

I wanted to interview Turner to learn more about Jellyfish Art, so we went to lunch at Steak 954 on the ground floor of the beachfront W Fort Lauderdale Hotel, where he designed and built his first big jellyfish aquarium. The tank served as a starting point for a chapter in Turner's professional life but also, perhaps, in the aquarium trade at large. Are we entering an age of jellies, or is this just a fad—a sideshow to a hobby and trade based predominantly on fishes?

MEZMERIZING THE MASSES

Jellies—the preferred common name for cnidarians from the group of animals called Medusozoa or Scyphozoa—were already a popular public aquarium fixture by 2009, when Steak 954 opened. Displaying jellies was popular in Japan long before it became popular in the U.S. It was not until the 1980s that aquarium-goers in the U.S. saw their first jelly exhibit. The Monterey Bay Aquarium in California has led the way: since 1985 it has mounted five jellyfish exhibits that have drawn throngs of awestruck people of all ages.

"When we opened the "Living Treasures of the Pacific" exhibit in 1989, we had three jelly exhibits," said Ken Peterson, communication director for the Monterey Bay Aquarium. He said visitors flocked to the aquarium to see the drifting, primitive invertebrates: "We realized we had a hit here."

"Planet of the Jellies" opened in 1992. It was the first time, according to Peterson, that anyone had a display of just jellies. "People would say things like 'I walk into the

Inventor Alex Andon with an early Jellyfish Art tank model.

Under new ownership led by Jeff and Joleen Turner of Reef Aquaria Design, Jellyfish Art is now culturing its own supply of Moon Jellies in this facility.

room and my heart beats slower,'" he recalled, trying to put his finger on exactly what the attraction to jellies is. "It's both an aesthetic and a spiritual experience." Since 1996, jellies have been part of the permanent exhibit galleries and the focus of several rotating exhibits, including the wildly popular "Jellies Experience," which opened in 2012 and is slated to close later this year.

The success of jellyfish exhibits at Monterey proves that, while Cole Porter may have underestimated jellyfish energy levels, people clearly love these mezmerizing creatures—so it's not surprising that some adventurous amateurs would want to keep them in their homes. Up until Jellyfish Art arrived on the scene, however, keeping jellies wasn't really possible for the average home aquarist. As the Jellyfish Art website explains, "Jellyfish cannot go in a regular fish tank because they will get stuck in corners and sucked into filtration intakes." In order to successfully keep jellies, a special tank called a kreisel is necessary. The kreisel aquarium creates a flow pattern that replicates the open ocean currents on which jellies depend in the wild. All mechanical impediments to the smooth drifting of vulnerable animals in the gyre of water must be removed; the kreisel has no edges, corners, nooks, or obstructions. While these tanks provided a solution for keeping jellies in captivity, their design and construction were complex and expensive—well beyond the reach of most home aquarists.

KREISEL INGENUITY

Enter Alex Andon, a 2005 Duke graduate living in San Francisco who saw a void and sought to fill it by launching Jellyfish Art in 2007. "When I started out," Andon told me in a phone interview, "jellyfish aquariums had become really big in public aquariums." Although he didn't specifically mention the "Jellies Living Art" exhibit that was ongoing at Monterey at the time, elevating jellies to art was a concept not alien to the general population and helped pave the way for Jellyfish Art's success. Andon told me that some companies were trying to make commercially available home aquariums for jellies at the time, but they were all on the public aquarium scale. "The minimum price was something ridiculous, like five grand," he said. "I basically figured out a way to do it much, much cheaper." But that took a while.

Andon started with a simple website, the premise that "jellyfish are quickly becoming the latest trend in exotic aquatic displays," and $100 spent on promoting web traffic with Google Adwords. Before he had spent that first $100, Andon made his first sale and, more convinced than ever that he was onto something, started doing custom jellyfish aquarium installations. Quickly, though, he learned that while people love jellies, the number of clients willing to shell out $25,000 for a custom aquarium featuring jellies was relatively small, and servicing those clients was beyond his means. He found that an existing Los Angeles company, Jim Stime's Jelliquarium in Thousand Oaks, was already serving the high-end custom jellyfish tank market. That's when Andon began thinking about making an affordable desktop jelly aquarium.

He began working on the concept and got his big break when the fledgling company was profiled in a 2009 *New York Times* article on entrepreneurs. Unfortunately,

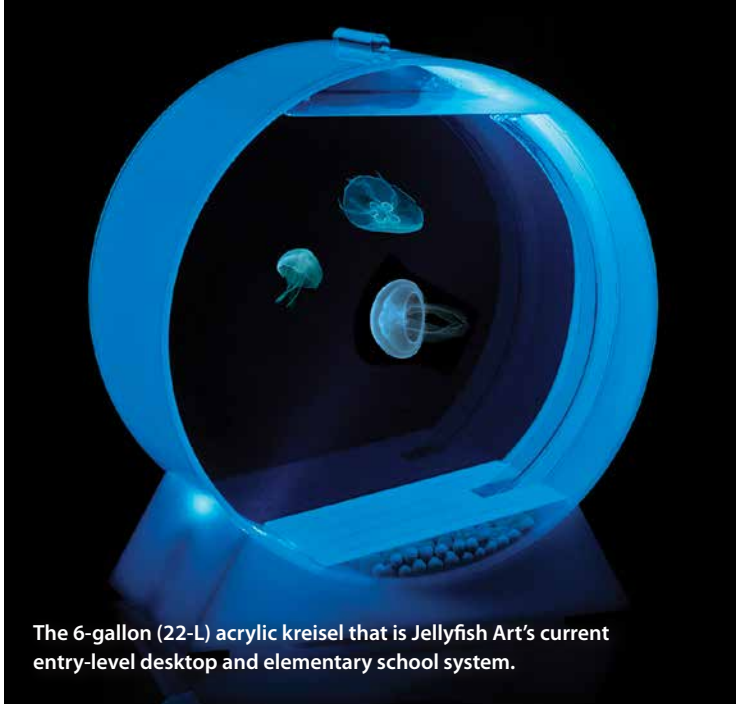
the desktop jellyfish aquarium was still just a concept, so the media attention didn't yield direct sales—but it did make Andon "the Jellyfish Entrepreneur," as the *Times* put it, so when he came out with his first product, a retrofitted cylindrical aquarium priced at about $500, he had a ready market. The business started to take off.

Because Jellyfish Art's first jelly tank was not purpose-built from the ground up for keeping jellies, it was relatively expensive to source it and labor intensive to convert it. There were other challenges for the young company—most notably securing a reliable supply of jellies to meet the demand—but the aquarium itself was limiting growth. So Andon sat down and hammered out a design that looked similar to the 5-gallon desktop jellyfish aquarium that Jellyfish Art sells today. With the first prototypes in hand, he was off to the 2011 Global Pet Expo, the pet industry's largest trade show, where the Jellyfish Art Desktop Aquarium won the Best New Product of the Year award. Andon now had a customer base, a reputation as "the Jellyfish Guy," and an award-winning product...or at least the prototype of that product. What he didn't have was the product itself.

Andon got help in the form of a Chinese manufacturer, a small business loan, and a hugely successful Kickstarter campaign launched in the late summer of 2011. The crowd-sourced fundraising initiative was so successful that it received almost as much attention from the media as the award-winning aquarium. In just a month Andon raised close to $163,000—roughly $160,000 over his initial goal (thanks in large part to a Tweet by rap artist Jermaine). It seems like a lot of money, but what Andon was trying to do was no small feat. At the time he entered what the *Times* called "the jellyfish pet space," if somebody wanted to keep jellies at home, he or she probably had to lay out at least $10,000—the actual figure could be more than twice that amount. Andon wanted to change that.

"I want anyone to be able to have their own pet jellyfish," wrote Andon as the lead to his Kickstarter campaign. With "the first affordable aquarium designed specifically for jellyfish" ready for production, he promised customers that "it's as easy to maintain as a regular fish tank." Nearly 450 people pledged at least $350, receiving their own aquariums as rewards.

Spurred on by Jellyfish Art's success, Andon appealed to a tech startup incubator and investment firm, suggesting that he could leverage the burgeoning jellyfish business into "the Amazon for pets." But as many in the aquarium industry have learned, scaling up to ship a large volume of live animals is a tough business; margins are generally poor and risk is high. He decided to stick with jellies, but the big question was, "How many people who can afford a $500 aquarium will actually buy one?"



The 6-gallon (22-L) acrylic kreisel that is Jellyfish Art's current entry-level desktop and elementary school system.

As sales slowed, Andon became convinced that a $500 aquarium was still too expensive; it was a niche product. To take the business to the next level, he felt the price needed to be reduced; that might induce the big box retailers to get involved. While he knew he could build, market, and sell a less expensive aquarium, there was another major challenge—finding a steady, reliable supply of live jellyfish. It was increasingly clear to Andon that Jellyfish Art would have to culture its own jellies.

Ken Pedersen of Monterey Bay Aquarium also talked with me about the importance of culturing jellies at the

The Coconut Creek, Florida, Jellyfish Art team, left to right: Jon-Michael Degidio, in charge of jellyfish culture; Paola Espitia, education director; and Joe Turner, general manager.

BELOW: MATTHEW WITTENIRCH. LEFT: PAY A PANTE. RIGHHT: RET TALBOT.

public aquarium level. "We really wanted to have them aquacultured," he said, "and not just be collecting them." For much of Jellyfish Art's early efforts, Andon relied on wild-harvested jellies, which posed some real problems. Jellyfish populations are seasonal and they move with ocean currents. While there are zero concerns about sustainable harvest—jellyfish populations are increasing worldwide and even achieving nuisance status in many places—cost-effective, reliable harvest is another issue altogether. Andon tells the story of one of his best suppliers, who reliably collected jellies from the same spot time and again, only to go back one day and find none. Whether they are for public aquariums like Monterey or for home aquariums, it's obvious that culturing jellies is a prerequisite for successfully displaying them, and Jeff Turner took that concept to heart when he bought Jellyfish Art from Alex Andon.

Jon-Michael Degidio checks a group of captive-bred *Aurelia aurita* prior to shipment.

THE JELLYFISH BRAND

Steak 954 is the very definition of a restaurant at the intersection of hip and swank, and the massive jelly aquarium Turner designed and built there defines the space. We were seated at a table next to the aquarium, and throughout lunch I watched people gaze at the hypnotic dance of the jellies. They pointed, asked questions, and took selfies. Many were restaurant patrons, but it was plain that some had come just to see the aquarium.

Unveiled to the public nearly six years ago, the aquarium didn't start out as a jelly project. Turner explained

that when the restaurant designer approached him, the plans called for a 20-foot aquarium. “It was certainly my intent to build them the largest reef aquarium in a restaurant in the country,” he said. But the restaurant designer, who was French, had another idea. “He had seen jellyfishes in a public aquarium in Europe,” Turner explained, “and he was fascinated with these undulating sea creatures.”

By the time Reef Aquaria Design got the contract to build the tank, the building was already under construction. “We had to move quickly to integrate our changes into the blueprints,” Turner said. The hotel and restaurant opened in 2009, and from day one the aquarium was its defining feature. It’s hard to imagine a reef tank in the space today. While it would have been be a stunning display, I think that bright, reef-ready lighting would have overpowered the space. Instead, the mellow, translucent jellies, bathed in blue hues, are a piece of kinetic art that grounds the restaurant and expands the ambience into something surreal.

The general manager later told me how important the jellyfish tank is to the restaurant: “It’s part of our identity—our brand,” he said. “It’s more important than the food in terms of our social media reach.” Sure enough, a Google image search yields just as many pictures of the jellies as it does of the food, and hashtag Steak 954 is all about jellyfish aquarium selfies.

The opening of Steak 954’s jaw-dropping aquarium paved the way for more large custom jelly installations by Reef Aquaria Design. Like Andon, Turner found there was a demand for $25,000 jellyfish aquariums installed in restaurants and private homes. Unlike Andon, Turner already had a well-established, extremely successful aquarium installation and maintenance company that could meet that demand. This was still years before Turner bought Jellyfish Art, but the seeds for Jellyfish Art’s next chapter had most certainly been planted.

CULTURING JELLIES

As Andon learned, culturing one’s own jellies is a path to success for anyone wanting to offer a jelly experience to the masses. If jellies were to become “the new goldfish,” as Josie Garthwaite dubbed them in her Fetish column in *Wired*, it would be essential to be able to meet demand. It’s one thing to put relatively inexpensive desktop jellyfish aquariums into people’s homes, but it’s quite another to provide three jellies for each of those tanks, as well as replacement animals every eight months to two years.

When Turner bought Jellyfish Art he put together a team that could take the company to the next level. A groundbreaking educational initiative and savvy market plan were central to his vision for the next iteration of the company, but few aspects of the business were more important to him than supply and customer service.

Jon-Michael Degidio is Jellyfish Art’s Director of Aquaculture and Production. Having grown up in Rhode

Island (the "Ocean State"), he has always been drawn to the sea. Years of fishing and diving eventually led him to pursue a B.Sc. in marine biology and aquaculture at Florida Institute of Technology. He completed his M.Sc. in fisheries and aquatic sciences at the University of Florida while working on the aquaculture of marine ornamental fishes at the Tropical Aquaculture Lab. His thesis work focused on the Milletseed or Lemon Butterflyfish (*Chaetodon miliaris*).

Degidio now works out of a lab several buildings away from Jellyfish Art's main office. The lab is small but well appointed and sufficient to meet current demand. Although he doesn't give an exact number, Degidio told me he is producing hundreds of Moon Jellies a month and is prepared to scale that up to meet the growing demand the company expects. As it is in most aquaculture endeavors, food is a critical part of the equation. The polyp stage jellies in the lab and the Ephyra (jellyfish larvae) are both fed newly hatched *Artemia* (brine shrimp). For the free-swimming jellies, Degidio is using a mix of live *Artemia* and Jellyfish Art's proprietary dry food. Not surprisingly, he's found that increased feeding results in increased growth. In the lab, jellies are fed throughout the day. "I don't have a strict protocol for feeding," said Degidio. "It is more like tailoring the feeding to what I want from the jellies at a given point." Home aquarists are advised to feed their jellies twice a day using Jellyfish Art's proprietary dry, pelleted food.

"Culturing jellies is a whole lot different than marine ornamental fish," Degidio said as he packed jellies for the afternoon FedEx pickup. While raising jellies may be easier than raising captive-bred Milletseed Butterflyfish, Degidio said that culturing Moon Jellies presents more than enough challenges to keep him engaged. Getting the daily protocols wired is his primary focus now, but he's interested in working with other species in the future. He sees the potential for exciting new work and even publication, as there is relatively sparse information out there regarding the successful culture of jellies.

Beyond the difficulty of producing a reliable and consistent supply of jellies to support the sales of the Desktop Jellyfish Aquarium, Degidio, like all the company's principals, is looking at the big picture. "I think jellyfish can transform the world of aquarium-keeping," he said. "I think that jellyfish, like the nano tank, are transforming what the value of a small tank can be by both the simplicity of the tank and the beauty of the jellies. Jellyfish have the potential to change the mindset of aquarists, both old and new, and push the traditional boundaries of aquarium-keeping for dedicated hobbyists."

THE CLASSROOM JELLYFISH TANK

Late in the day, I sat in Turner's office talking with Degidio, Joe Turner, and director of education Paola Espitia. Having seen the building blocks of the company and its day-to-day operations, I was curious about their newfound passion for jellyfish and how they see the big picture. Where could Jellyfish Art be in five years, and what role will keeping jellies play

within the broader context of the aquarium hobby and trade? Could jellies have a transformative effect on the aesthetics of aquarium-keeping? Might they prove central to putting aquariums in classrooms as educational tools? Could an affordable plug-and-play jellyfish setup boost the success rate of thousands of novice aquarists who enter the hobby each year, only to give it up in under two years?

While there are many possibilities on the horizon for both Jellyfish Art and jellies in general, the education front is advancing most rapidly. Espitia came to Jellyfish Art with a B.Sc. in wildlife conservation and photography from the University of Delaware and an M.Sc. in marine biology and coastal zone management from the Nova Southeastern University Oceanographic Center in Fort Lauderdale. She has worked at public aquariums including the Monterey Bay Aquarium, the National Aquarium in Baltimore, and the Downtown Aquarium in Denver, where she was a jellyfish aquarist.

Perhaps actively engaging in science as a researcher—her thesis research was on coral restoration in South Florida—and seeing how the public interacts with science in the public aquarium context has made Espitia uniquely qualified to lead Jellyfish Art's education program. She said there is "a significant gap in communication between scientists and the public. Jellies can help bridge that gap in a really powerful way." Inspiring and educating people about the importance of being ocean-minded has never been more important, and she's hoping jellies in schools can do just that.

"The overall idea," Degidio added, "is to steward marine science within the classroom—to create a product around which teachers can build affordable lesson plans, create a curriculum, and pass the inspiration of everyone who has been around the ocean on to those who don't have access to the ocean and those who think it's 'gross and yucky.' We want everyone to be able to take part and see that there's more going on than you see on the surface—more than going to the beach and getting stung by a jellyfish."

In the first full academic year of the Jellyfish Art education program, the team aspires to have 1,000 educators around the country actively engaged with jellies in their classrooms. Espitia will play point on collaboration with educators using innovative tools like Skype in the Classroom. She plans to present professional development workshops to educators across the country. While much of the education is currently science-based, she envisions jellies being used in other subjects ranging from English to the arts.

Enrolling 1,000 educators in the program is an ambitious goal, but Espitia said she is encouraged by the initial response. She recently went to the 2015 National Science Teacher Association Conference, attended by an estimated 12,000 people. "We were talking all day with science teachers, and the response was great," she said. "We had 1,200 people sign up for our email list." In June, Espitia will attend the National Marine Educators Association meeting in Rhode Island so she can interact directly with more teachers. Initiatives to put marine aquariums into classrooms all too often end poorly, but the Jellyfish Art team believes that Moon Jellyfish are the perfect education tool, even for primary school students. "They are relatively inexpensive and easy for students to maintain with little support from the teacher," Espitia explained. The rewards, on the other hand, are tremendous, and the problem of what to do with the aquarium at the end of the school year is much easier to address. "A student could easily take it home and care for it," she said. Turner told me the company is prepared to take jellies back if a school can't place them at the end of the year.

JELLY FUTURES

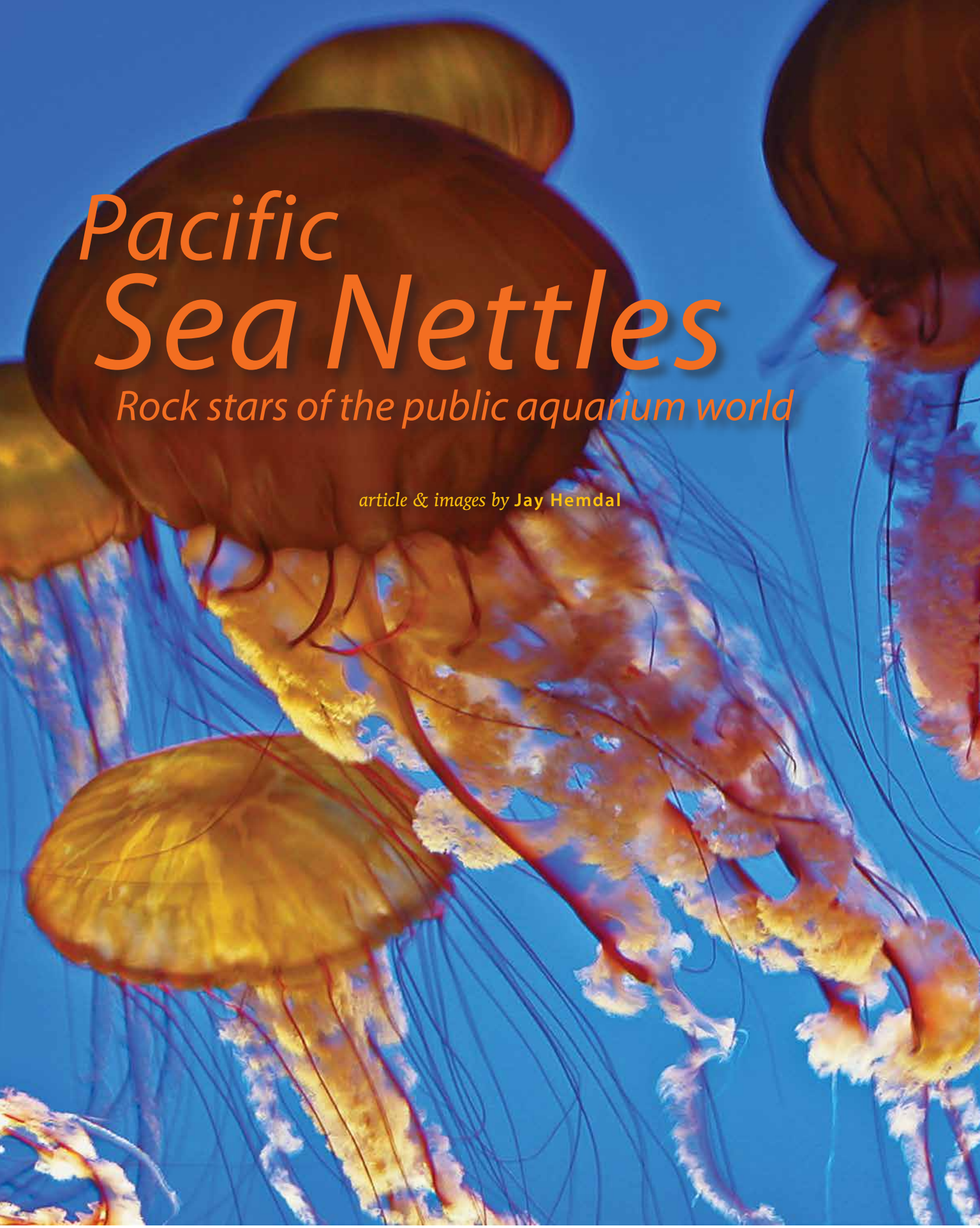
Time will tell how popular desktop jellyfish aquariums will become and how deeply they will penetrate the aquarium hobby and trade. Thanks largely to

Andon's early work with the company, Jellyfish Art has helped pave the way with an affordable kreisel design, and competition is starting to grow. James Bruce's UK–based Cubic Aquarium Systems Ltd. offers several home-scale Orbit jellyfish systems that are distributed in North America by Polyp Lab in Montreal. Cubic is also working with Toshihiro Yoshida's Exotic Aquaculture to supply several species of cultured aquarium jellyfishes. Jellyfish Art and Cubic offer basic systems in the $250 to $400 price, and as competition grows the prices of entry-level tanks are likely to drop. (At the same time, larger, higher-end systems are sure to appear as amateur jellyfish-keeping attracts serious enthusiasts.)

Jellyfish Art is building a strategy to make its systems affordable and irresistible to the education marketplace. Educators who intend to use jellies in the classroom get a significant discount, said Joe Turner, admitting that the pricing for a tank and livestock must be kept as low as possible for budget-minded teachers. He said the company is working on that challenge.

As I left sunny Florida for snowbound Maine, I imagined a future I don't think anyone at Jellyfish Art currently envisions. Flying—the glint of sun off the wing and the expanse of blue sky—always makes me think big. The team at Jellyfish Art seems bound to succeed, based on their solid business plan and hard work, but I was wondering how jellies could help the marine aquarium trade as a whole. In 2016, the sequel to *Finding Nemo* will be released. It features Dory, the Pacific Blue Tang. Following the release of *Finding Nemo*, clownfish sales increased dramatically. Unlike Blue Tang, clownfishes are aquacultured in large numbers, are relatively easy to keep, and don't require a huge amount of space. The Pacific Blue Tang, on the other hand, is not aquacultured, is more difficult to keep, and needs a much larger aquarium, despite the fact that it's commonly available at quarter-size in local fish stores. If millions of kids and marine aquarium newbies suddenly start buying and trying to keep Blue Tangs, it might not be a pretty picture.

What if, instead of difficult-to-keep marine fishes, people started with ultra-hardy jellyfishes that are forgiving of less-than-perfect husbandry? What if every big-box pet store offered a jellyfish aquarium setup for under $150? Could jelly-keeping lower the large number of novice aquarists who get into the hobby, struggle, and get out? Keeping bulletproof jellies would cover the basics of aquarium-keeping—maintaining consistency in salinity and temperature, adopting an appropriate feeding regimen, and performing regular water changes. After a year, those who succeeded and enjoyed the hobby would be more likely to do well with a fish-only or reef tank, while those who found they weren't really committed would still have a relatively easy-to-care-for and incredibly cool piece of kinetic art.



Pacific Sea Nettles

Rock stars of the public aquarium world

article & images by **Jay Hemdal**

West Coast Sea Nettles (*Chrysaora fuscescens*) in an exhibit at the Monterey Bay Aquarium—an inspiration for the author and other public aquarium curators worldwide.

For most people, face-to-face encounters with live jellyfishes have happened in public aquariums, where Schyphozoan exhibits enjoy soaring popularity, enthralling crowds and sending visitors away with never-to-be-forgotten memories of mesmerizing, slowly drifting swarms of "really weird" or "really beautiful" animals.

At the Toledo Zoo Aquarium, opened in 1939 as a freshwater-only facility, we added marine exhibits slowly over the years, including a small exhibit of Moon Jellies (*Aurelia aurita*) in 1993. Age and the corrosive effects of salt water had taken a heavy toll on the building's infrastructure, and we started making plans to renovate and preserve the historic Works Projects Administration (WPA)–era building. The old aquarium was decommissioned in the fall of 2012 and, after $25.5 million in renovations and upgrades, the new aquarium opened to the public in March 2015. Among the exciting new features is a display of Pacific Sea Nettles (*Chrysaora pacifica*) in a special "infinite blue" aquarium that makes them look as if they are floating in the open ocean.

I will give credit where it is due: any public aquarist who has viewed the awesome "Jellies Experience" exhibit at the Monterey Bay Aquarium in California wants to reproduce it at his or her own facility. At the Toledo Zoo, we knew that in addition to a new 800-gallon (3,000-L) Moon Jelly cylinder exhibit (with user-changeable LED lighting) we wanted a display of sea nettles in our new aquarium. Pacific Sea Nettles have a reputation for being hardy and good subjects for captive systems, growing to a maximum diameter of about 6 inches (15 cm) and being relatively easy to obtain from Japanese livestock sources or public aquariums that have surplus captive-bred jellies.

The Monterey Bay Aquarium makes its exhibit construction techniques available to others, and early on in the project we contracted with a manufacturer of fiberglass aquariums to construct a "pseudo-kreisel" exhibit that included systems designed by our life-support engineers and curatorial staff.

A donor for the project came forward. A longtime loyal Toledo Zoo supporter, Mary Ellen Pisanelli, and her daughters, Eleni and Lia, chose to sponsor the Pacific Sea Nettle tank because they were impressed by the animals' graceful movements and color and knew that their beauty and soothing motion would delight visitors and encourage them to pause at the tank and reflect on the wonders of the sea.

Once the exhibit was designed, the funding

Just unveiled to the public: The Toledo Zoo Aquarium's new 1,000-gallon Pacific Sea Nettle exhibit with young specimens from Japan. Initial planning for the rejuvenation of the whole aquarium began six years ago and included visitor surveys to help plan potential exhibits and bench-testing of a wide variety of aquarium equipment options, such as LED lighting, Hydrowizard pumps, and drum filters. Eighty percent of the funding for the project came from a 2006 Lucas County (Ohio) tax levy, and the remainder from public and private donations (including all zoo staff and board members).

Toledo Zoo Aquarium Pacific Sea Nettle exhibit—by the numbers

- The main tank is 10 feet (3 m) long, 8 feet (2.4 m) tall, and 20 inches (0.5 m) wide.
- The exhibit holds 1,000 gallons (3,785 L) of synthetic sea water and has a 150-gallon (568-L) sump.
- The acrylic viewing window is 6.5 feet (2 m) long and 4 feet (1.2 m) tall.
- The exhibit is lighted from the top and back and has four dimmable LED fixtures on the sides.
- Water leaves the tank through two side skimmers and returns via two spray bars.
- The jellies are moved around two opposing circular "gyres" that meet at the center of the tank.
- The main pump runs at 40 gallons (151 L) per minute.
- There is a biofilter/de-air tower, plus a bag filter to remove uneaten food. Another bag filter in front of the heat exchanger reduces clogging.
- There is a networked alarm to signal high and low water levels in the sump, as well as high and low temperatures.
- There is an ultraviolet sterilizer producing 30 millijoules per square centimeter to reduce bacteria.
- Our sea nettles are fed twice a day with Selco-enriched live *Artemia* nauplii. Every other day, they are fed diced mysid shrimp and chopped *Aurelia* sea jellies. Some aquariums target-feed their jellies to reduce waste, but we haven't found that necessary in our exhibit. Other maintenance for the exhibit includes regular partial water changes, removing algae from the viewing panels, and monitoring water quality parameters. There are three support systems for this exhibit: a 110-gallon (416-L) off-exhibit holding tank for surplus sea nettles, a 50-gallon (189-L) holding tank for "feeder *Aurelia*," and an *Artemia* hatching/enriching station.

secured, and the filtration systems built, the aquarium staff had to prepare the exhibit for the arrival of the jellies. Establishing a biofilter for sea jellies requires a slightly different technique than most home aquarists employ. First, it is advisable to use an inorganic source of ammonia as opposed to using hardy animals to produce the ammonia, as is often done. Second, the classic nitrogen cycle progresses very slowly at the operating temperature at which these jellies typically are held—55°F (12.7°C). Our process was to operate the system at 70°F (21°C) during cycling and then gradually reduce the system temperature after the process had concluded. We inoculated the system with a small amount of bacteria from a previously cycled system, then added 0.05 ounces (1.4 gm) of ammonium chloride and 2.2 ounces (66 ml) of cola per 100 gallons of tank volume every 24 to 48 hours. Yes, you read that correctly—we used soda as an adjunct to the ammonia source. This idea was developed by Barrett Christie, curator of the Dallas Aquarium at Fair Park. He will be writing a paper on the technique, but the basis seems to be that the cola supplies a carbon source (sugar) and phosphorus (as phosphoric acid) in approximately the correct ratio to support the needs of the nitrifying bacteria in a cost-effective manner. We cycled all of our systems using his method, and it allowed us to do it quite a bit faster and produce very stable systems.

NEAR DISASTER

When the exhibit was ready, we acquired our sea nettles from two suppliers in Japan who collect them seasonally. The New England Aquarium in Boston graciously assisted us with the first shipment of 30 animals, and we imported the second shipment of 15 direct from Japan ourselves. Jellies are shipped in plastic bags, just like fishes, but instead of inflating the bags with oxygen, the water is simply charged with oxygen and then sealed off, as any loose bubbles could damage the delicate jellies during shipment.

Prior to the aquarium's opening, the contractors had to test the automatic transfer switch for the building's emergency generators. As you can imagine, a public aquarium of this size requires backup mechanical systems to help maintain suitable water quality at all times, including during extended power outages. I was attending

Behind the scenes, clockwise from above: An LED spotlight illuminates the display tank through a small window; a tall, narrow reserve tank houses replacement jellies; the heart of the life support system plumbing.

the Regional Aquatic Workshop in Monterey when I got the call: during the test, the pump for the sea nettle exhibit had a delayed restart and the tank was filled with air bubbles when it finally did start. As anyone who works with medusae knows, air bubbles are deadly to jellies. They get stuck to the tentacles and rise up into the bell, where they proceed to drill through the jellies' soft tissues.

Since I had 400 of the top public aquarists at my disposal, I asked around at the conference about what we could do about the bubbles. Nobody was very optimistic. Meanwhile, our senior aquarist, Laurie Dixon, took matters into her own hands. She carefully scooped up all of the sea nettles into shallow trays, and the aquarium staff proceeded to invert each of the jellies and tap its bell to dislodge all of the bubbles. This averted the crisis!

One of my most personally gratifying moments during opening week came when I saw a family sitting on the fish-shaped wooden bench in front of the sea nettle exhibit, arms around each other, in silent awe of these beautiful creatures. It is no wonder that many home aquarists have an interest in jelly aquariums. As a specialty aquarium animal, few can surpass the quiet beauty of a sea jelly. But aquarists should consider setting up such an aquarium at home only if they are willing to put in the effort to make the project a success. Those simply looking for "living furniture" to grace their homes may want to avoid this niche type of aquarium—or hire a professional to properly set it up and care for it. Don't purchase medusae on a whim or expect them to thrive in your reef aquarium, as this is doomed to failure.

Common food items of plankton-feeding marine organisms. Typical foods for sea nettles are marked with an asterisk.

ORGANISM	SIZE	SOURCE
Organic molecules (proteins)	~10 nanometers (nm)	Suspended in aquarium water
Bacteria	~5 microns (µm)	Free-living in aquariums
Chlorella/ Nannochloropsis algae	5–10 µm	Culture or preserved
Tetraselmis algae	12 µm	Culture or preserved
Protozoans	25–100 µm	Free-living in aquariums
Copepod nauplii	50–150 µm	Culture (difficult)
Brachionus rotifers	250 µm	Culture (moderate)
* *Artemia* nauplii (stage 1)	440 µm	Culture (very easy)
* *Cyclops* (adult)	800 µm	Frozen (not dried product)
Mysid shrimp larvae	1 mm	Culture (moderate)
* Sea jelly medusa (*Aurelia* sp.)	25–200 mm	Culture (moderate)

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A CLASSROOM JELLY TANK

At 7:30 A.M. sharp, the bell rings and kids trudge from breakfast in the cafeteria to their classrooms. But as they approach my third-grade room, their steps quicken; they push through the door and hurry to witness our 180-gallon (680-L) reef tank waking up. As the lights switch on they look for their favorite fishes, corals, and cleaner shrimps, and another school day is off to a stimulating start.

Recently, the kids have been streaming past the reef tank to behold a new marvel in my classroom—a glowing 6-gallon (23-L) kreisel-type aquarium that holds a trio of translucent Moon Jellyfish, *Aurelia aurita*. There is something magical about the sight of these slowly pulsing or "belling" jellyfish drifting in a slow gyre under the color-changing LED lights. When a new visitor arrives, my students compete to be the resident jelly expert and pepper the newcomer with random facts: "Do you know they don't have brains?" "Some jellies glow in the dark!" "One is called a Pink Meanie!"

At left: Project manager Savanna Olson watches as her friend Florence Lin feeds brine shrimp nauplii to their Moon Jellyfish, one of their daily classroom jobs.

Right: Leah Hernandez and Samaria Keller spot food particles being caught by the jellyfish as they pulse or "bell" around their kreisel tank.

I work very hard to get kids excited by science, and, like all teachers, I live for that *aha!* moment when a child finds his or her own way to an important conclusion. Inspired students are moved to do their best—to feel successful regardless of the outcome. I try to expose my students to things that motivate them to expand their knowledge of the natural world and pass this knowledge on to their peers, but this can be easier said than done.

How can teachers set the stage for moments of awe when they must juggle new curricular standards, budgets for science materials, misbehavior, time constraints, and all the other things that get between kids and learning? What kind of platform or project can support this type of learning, in which students assume authentic respon-

article & images by **Brandon Rutherford**

sibilities and find connectivity among different things they are learning at school?

EASIER THAN REEFKEEPING

To a growing group of innovative teachers, one solution is to create a marine aquarium project in the classroom. Marine aquariums provide ongoing opportunities to study science and teach students learning-process skills, such as measurement and observation, that are needed for many other areas of study. A classroom aquarium provides different degrees of challenge and activity for different grade levels—and is just plain fun to work with.

Cheat Sheet: Tips for keeping jellies

- Do not overfeed your jellyfish, especially when the tank is still cycling. Jellyfish graze on plankton continually, so I try to space the feeding out over the school day. By experimenting with different ways to feed them, my students have discovered that it is helpful to blow uneaten food back into the water column with a food baster or pipette and to syphon it out if overfeeding occurs. Jellyfish may be irritated by targeted feeding, so I try to squirt food into their general area and let them catch it as they bell.
- Jellyfish are sensitive to physical damage. The Jellyfish Art tank is designed to prevent them from becoming stuck or injured, but be sure the bubble channel plate over the biological media is seated flush with the sides of the tank. A jellyfish can get pinched in a tight opening and end up with torn oral arms or other body parts. (Fortunately, they usually heal rapidly.) If a jellyfish does get stuck, gently blow water at its underside with a baster until it's free. Bubbles, even small ones, can also damage tissue. I add water slowly by immersing a small cup held at an angle.
- Moving a cleaning sponge through the water can create a wake that might suck in and injure jellyfish. I am careful to move my hand very slowly when removing algae from the tank.
- This 6-gallon (23-L) Jellyfish Art tank can be transported quickly between classrooms, allowing more students to interact with it. Before moving the tank, I scoop each jelly into its own large yogurt container and then drain about half the water into a bucket. This makes the tank light enough to be carried by an adult.

Setting up a reef tank is an exciting endeavor, but due the expense and level of commitment required, it is not feasible for many teachers. Fortunately, teachers now have more options. I have recently discovered a Florida-based company, Jellyfish Art, that has created an education initiative to provide teachers with low-cost, low-maintenance jellyfish aquariums. Along with it comes a complete curriculum that makes the jellyfish not just classroom pets but part of a fully functional learning tool. My colleagues are naturally very curious, but they frequently ask, "Why jellyfish?"

Foremost, jellyfish offer students a way to observe and study important animals that they might not otherwise see. Cnidarians are typically introduced when students are learning about marine ecosystems, but the anatomy and physiological functioning of jellyfish remain esoteric unless they are studied first hand. Young children and even adults sometimes seem dumbstruck when they view jellyfish for the first time. During parent-teacher conferences this year, I took the tank into the main hallway and listened to the conversations of families who gathered to observe it. Many people thought the jellies were a moving computer image, floating bags, or some kind of bug. It is clear that people's conceptual understanding of biology in all its intricacy is limited by what they've been physically exposed to.

"PB & JELLYFISH"

Jellyfish are also a perfect fit for a classroom because, despite what some people believe, they are very easy to keep. They look delicate but require far less care than marine fishes or even other marine invertebrates. Jellies tolerate a range of water conditions and can easily go without food for a weekend or longer. Jellyfish tanks and consumables are inexpensive compared to other marine aquariums, and keeping the animals healthy requires only simple equipment. The care requirements of jellyfish are appropriate for even elementary school students, and their approximate 9-to-12-month adult lifespan nicely coincides with the school year. When translucent Moon Jellyfish feed, it is very easy to see the consumption and digestion of food as particles move from tentacles to oral arms and into the mouth. Observing and maintaining a jellyfish tank teaches important science-process skills, as students learn to measure water parameters and continually assess the health of their animals.

When I brought jellyfish into my classroom, I immediately found them relevant to much of my science curriculum. I recently used them to teach an important Next Generation Science Standard, requiring students to model how matter moves among organisms in an ecosystem. As my students learned about their Moon Jellyfish and observed them feeding, one boy scrunched up

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his face and asked, "What would eat a jellyfish?" This was a great segue into the role jellyfish play in marine food webs and the concept of trophic levels. As the kids shared their research with friends in neighboring classrooms, new questions came up: "Aren't jellyfish bad for the ocean?" "How do jellyfish sting?" "I heard that some jellyfish can live forever; is this true?" Their interest in the jellyfish made them all want to be experts, and they would jump around in their seats and shout with excitement over anything that was even tangentially connected with jellyfish. Even at lunch, I couldn't escape their enthusiasm for jellies—one boy joked about his "peanut butter and jellyfish sandwich."

MAKING OCEANS REAL

One unexpected outcome of bringing jellyfish into my classroom was that my students became newly interested in environmental activism. My coral reef project aims to make kids more aware of the complexity and fragility of the world's oceans, but most of these concepts remain abstract for children living in the Midwest. However, curiously enough, learning that sea turtles are harmed by eating plastic bags, mistaking them for jellyfish, elicited a visceral reaction in many of the children. Plastic waste is an unfortunate but inevitable byproduct of the school day. Many of my kids didn't realize that a plastic spoon left under the lunch table could eventually make its way to the sea and harm a living thing. With almost no prompting, many of them created informational posters promoting our school's recycling campaign and wrote letters to local businesses asking them to limit their use of plastic bags.

By the time the dismissal bell rings at 2:00 P.M., it's clear that the kids are ready to go home, but they can't resist lingering a few minutes longer by the tank. As I watch them stare at the belling jellyfish, it strikes me that these kids have grown to respect an underappreciated, but important organism. I feel confident that if they can come to care about this strange little planktonic creature and its role in a marine ecosystem, they have the ability to appreciate and protect all parts of the natural world.

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ON THE INTERNET

Jellyfish Art: www.jellyfishart.com/

Live Science—Jellyfish: www.livescience.com/topics/jellyfish/

Jellyfish Biology: http://jellybiologist.com/

Author Brandon Rutherford jokes with his third grade class during a lively lesson about marine food webs on the classroom carpet.