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POINT & CLICK ON BOLD LINKS



Equipment

Edited by Rosemary 'Roz' E. Lunn



New Yacht Toy

When it comes to purchasing your own private submarine, there is quite a choice. U-Boat Worx has just unveiled their latest contribution; the Super Yacht Sub 3. This is capable of taking you, plus two friends to a maximum of 300m / 984f. As you would expect it comes complete with luxury leather seating and an air-conditioned environment. U-Boat Worx state the six powerful thrusters can handle strong currents, and you can get quite decent bottom times. The 42kWh lithium-ion batteries have a burn time of 12 hours. Prices start from €1,750,000. UboatWorx.com

Heptastar

The Green Force Heptastar 2000 DPM light head has seven LED's generating 2,000 Lumens. This anodized aluminum light head is incredibly mean when it comes to power consumption, a mere 21 Watts, which translates into good burn times. The Heptastar 2000 DPM runs on batteries ranging from six to 18 Volts, hence the burn time depends on the battery you screw this light head into. The 'DPM' in the name refers to 'Dynamic Power Management'. In other words the light automatically adjusts the level of illumination according to the amount of light that is required. Close up objects do not require huge illumination, whilst objects in the distance, or during an emergency, require full illumination. It appears to be a very sturdy product and in fact Green Force states it is almost indestructible. Green-force.com



J2

Fourth Element has augmented their thermal underwear range with the launch of the J2 collection. These garments were specifically designed for the 2013 deep caving expedition to the Mexican Cheve Cave system, hence the name. The team spent several days underground, therefore they needed base layers that could stand long repetitive wear without the risk of skin infections developing. One way of reducing this risk is to keep the skin dry. The fabric has a unique knit that minimises contact with the skin, allowing air to circulate, whilst having enough fibres to wick away sweat. In addition the fabric is bacteriostatic and anti-fungal, thanks to anti-microbial silver ions embedded within the fibres of the fabric. The result is a lightweight compact base layer than can be worn for extended periods beneath a drysuit. FourthElement.com



Beach Bag

Sometimes you just fancy a simple day snorkelling or playing on the beach, and want an easy solution for carrying your kit, and keeping your wallet and keys safe. This brightly coloured and highly functional beach bag from Subgear has a discrete zipped pocket at the front for goodies you don't want to get wet. Fins are securely stored in a separate pocket, with the mask and snorkel stashed in another compartment. (All kit is easily accessed via elongated zips). The heavy-duty nylon bag benefits from a number of integrated mesh panels that allow excess water to drain away, and there are two options for carrying it—a padded single shoulder strap or a side handle. Subgear.com

Connector

When the European Standard for oxygen connection came into force in August 2008, it was supposed to help make diving safer. Cylinders containing a mix were meant to have a different thread to help prompt the diver to consider what they were breathing. Instead it has been a source of major frustration and, where possible, ignored by the community. But what do you do when you want to get a tank filled that has an M26 valve fitted and the air station only has M25 whips? Alternatively if you have a M26 first stage and need to dive a M25 valved tank, what is the solution? AP Diving has a range of relevant adaptors that you can simply screw in place. APDiving.com



Checking out the bottom

Aqua-Vu's Micro Series is a complete underwater camera system no bigger than a smart phone. Yet it is an economical underwater viewing system featuring full-blown features at a fraction of the price. Playing live color underwater video on a 3.5-inch LCD, the Micro II includes 50 feet of camera cable wrapped on the integrated viewscreen. Micro camera is the size of a bottle cap, includes auto IR lighting and enters the underwater world with an amazing stealth that won't spook fish. aquavu.com



Pelican ProGear Elite

Renowned hard case manufacturer, Pelican, has launched a new product line called the ProGear Elite series. The collection includes a 22-inch Carry-On (shown), a 27-inch Weekender and a 30-inch Vacationer. All models are available with an optional enhanced travel system that includes a lid organizer, a toiletry kit, and a zipped shoe sack. Each case benefits from an integrated TSA-approved combination lock, a smooth fabric interior for simple clean up and custom-designed solid-hub wheels for easy maneuverability. Pelican states the 'Press & Pull' latches ensure the luggage will remain secure under the stress of rough baggage handling and the demands of travel. Pelican.com



Britannic

Otter has announced that divers now have the option of colour accents on the MK2 Britannic drysuit. This trilaminate/shell suit was originally developed in 1987 by the British manufacturer for Kevin Gurr's expedition to HMHS *Britannic*. Over the years this suit has been 'the suit of choice' for many expeditions diving the iconic wreck. In 2013, Otter launched the MK2 version. Fans of Otter find this suit lighter than its parent. Otter has developed a flexible armour skin that is malleable, strong and does not weigh much. The MK2 Britannic benefits from a telescoping torso, choice of pockets and valves (Sitech or Apeks), big double knee pads and a neoprene neck warmer as standard. Optional extras include a choice boot; either a dry neoprene sock/rock boot combo, or a traditional drysuit boot; dry glove systems, replacement silicone neck and wrist seals. Drysuits.co.uk



Sidekick

The KISS Sidekick is a streamlined, lightweight rebreather system that has been designed specifically for side-mount diving applications. Due to its compact size and mounting position, it can also be carried as a bailout rebreather (BOB) system. It is a mechanical rebreather, so there are no electronics controlling the gas addition to the system. Both the head and scrubber is placed inside a large single counterlung, which in turn is housed within and protected by a cylindrical shaped stainless frame, making for a small and lightweight rebreather with fewer parts and less complexity than diving a fully closed circuit rebreather. By shunting a portion of each exhaled breath back into the loop, this device will extend the duration of a given gas supply by a factor of three. The benefits of this type of gas-extension provide advantages for both recreational and technical diving. Note that proper training outside the level 1 GEM Sidekick course is required prior to doing any technical diving. KissRebreathers.com

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A diver explores a rich coral reef

A closer look at

Biodiversity

— At the Heart of the Coral Triangle

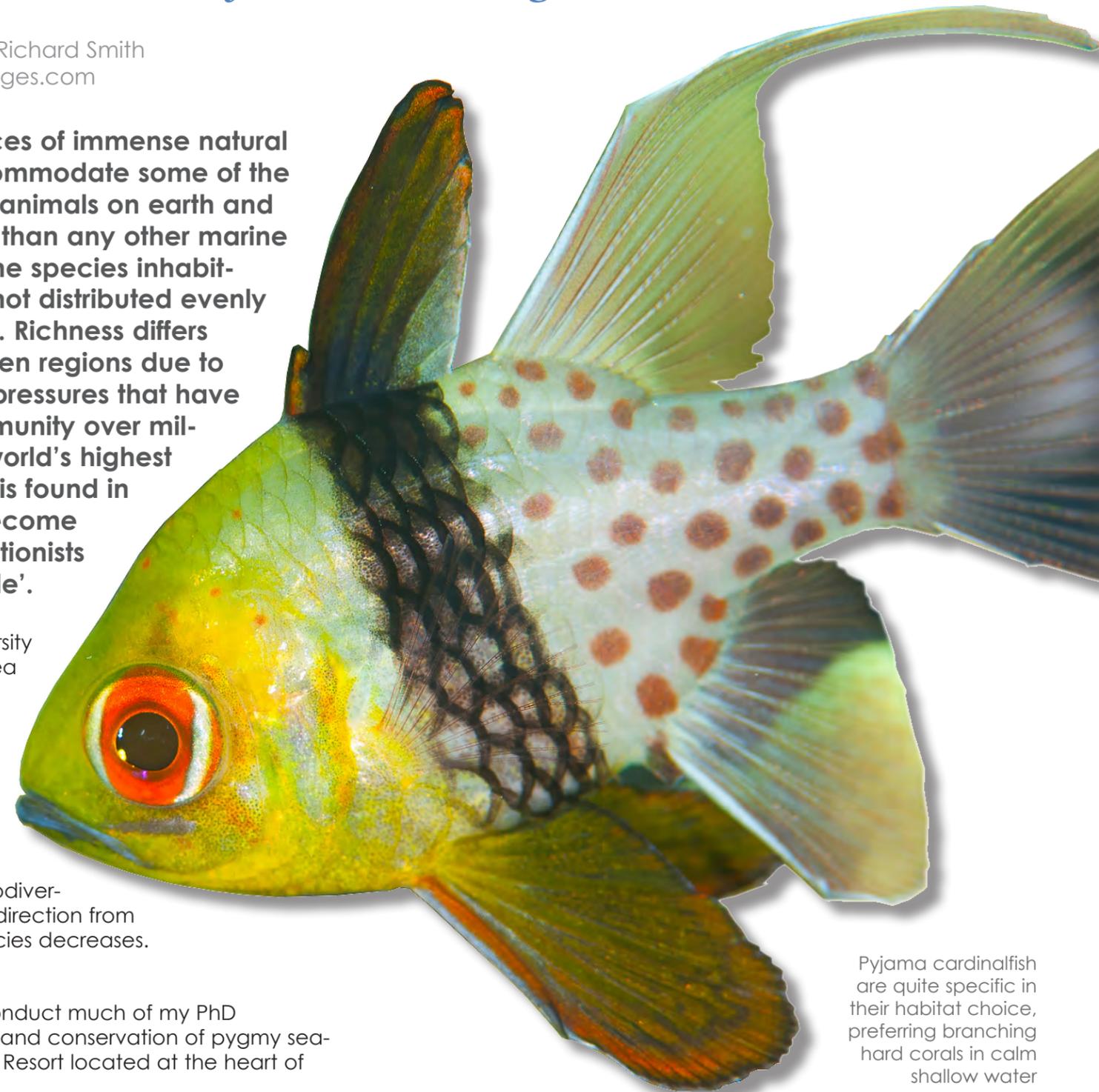
Text and photos by Dr Richard Smith
www.OceanRealmImages.com

Coral reefs are places of immense natural diversity. They accommodate some of the highest densities of animals on earth and have more species than any other marine habitat. However, the species inhabiting coral reefs are not distributed evenly through the oceans. Richness differs dramatically between regions due to the many different pressures that have molded each community over millions of years. The world's highest marine biodiversity is found in an area that has become known by conservationists as the 'Coral Triangle'.

This region of mega-diversity is a roughly triangular area extending from central Indonesia to Papua New Guinea and the Solomon Islands, and northwards to the Philippines. This relatively small area, on a global scale, boasts the world's richest marine biodiversity. As you travel in any direction from there the number of species decreases.

The richest reefs

I was lucky enough to conduct much of my PhD research, on the biology and conservation of pygmy seahorses, at Wakatobi Dive Resort located at the heart of



Pyjama cardinalfish are quite specific in their habitat choice, preferring branching hard corals in calm shallow water

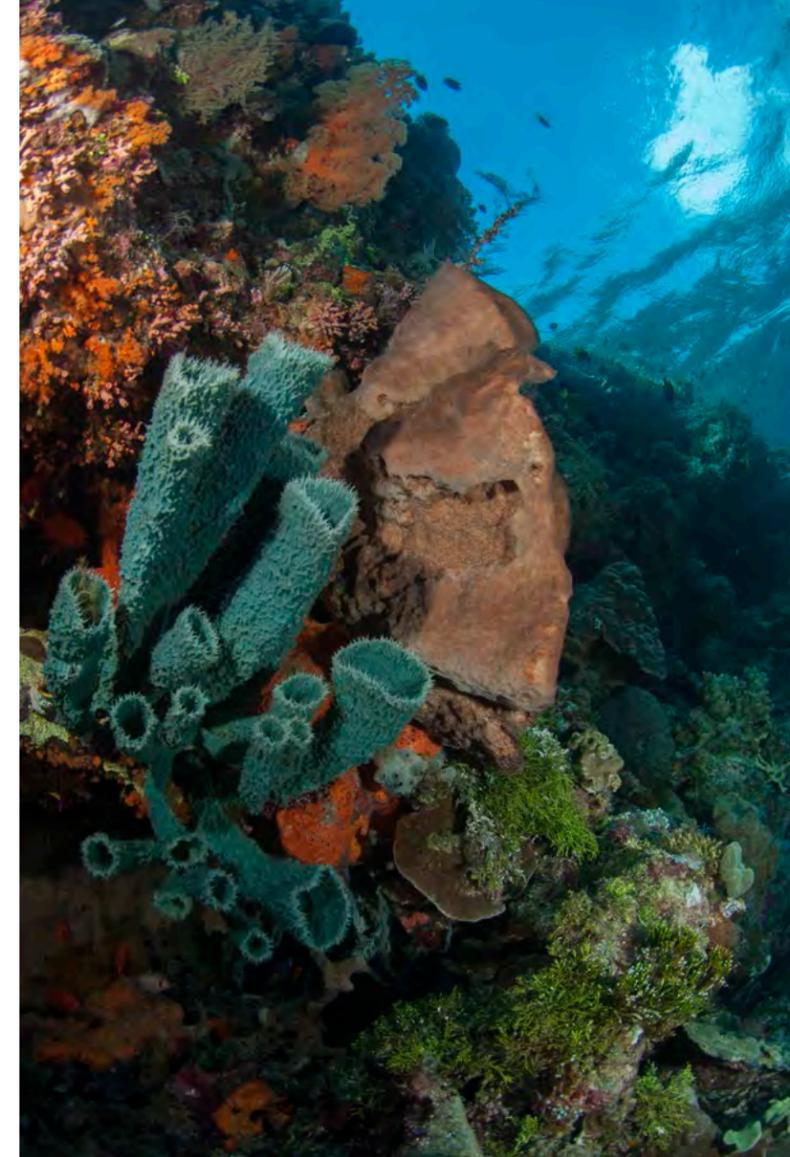




Coral reefs are the world's most biodiverse marine ecosystem



Seagrass meadows harbor a unique assemblage of marine life. Robust ghost pipefish are common in this habitat but hard to find due to their uncanny mimicry of dead seagrass fronds



A shot showing a diverse reef of sponges, halimeda algae, hard and soft corals in the Tukangbesi archipelago



Rough-snout ghost pipefish are rare inhabitants of muck dive sites, preferring the protected sand or rubble slopes to coral reefs

the Coral Triangle. For more than six months, over a three-year period, I dived the reefs and really got chance to appreciate the amazingly high biodiversity of this region. Due to the nature of my work, I spent hundreds of hours in one specific location on the reef and as a result got to know the area like the back of my hand, and the local residents like family.

Over the years I had the opportunity to appreciate the change, or lack thereof, on the reef. Astoundingly over the three years, there was almost no perceptible change in the size of sponges, whips and soft corals in my small

overhang on the Wakatobi House Reef. I was constantly amazed that, even after six months, I would still encounter something new almost daily. One day I found a tiny beige frogfish half the size of my little finger nail, the next a nudibranch I had never seen before crawling across my path and the following evening a bright orange shrimp crept from beneath a sponge. Such is the Coral Triangle, the world's most biodiverse marine habitat.

Today's diversity

Today, the two main areas of reef diversity centre on the Caribbean

and Indo-West Pacific. The biodiversity in these two areas, however, is quite different: the species richness in the Indo-West Pacific vastly surpasses that of the Caribbean. The Indo-West Pacific supports at least 600 species of coral and 4,000 fish, compared to 62 and 1,400 species respectively in the Caribbean. The species count for either fish or corals in one Indonesian bay can exceed the number of species found in the entire West Atlantic. In fact, for the majority of reef organisms there are 10-30% as many species in the West Atlantic as Asia, and no reef-associated fish species are shared



Pontoh's pygmy seahorses attain a maximum length of less than 2cm

between the two bodies of water. Whilst the number of species in the Caribbean appears low, they are in fact entirely different to those of the Pacific due to millions of years of separation.

There is some debate over the explanation for such high Asiatic diversity. One theory is that the area is a hotbed for evolutionary change and species are created here, with some eventually spreading to other regions of the Pacific. Another possibility is that the ranges of many species from the Indian and Pacific Oceans overlap in the Asian archipelago, causing higher diversity where they coexist. In addition, the geology of the region has origins in many areas, each with their own fauna. The Australian and continental Asian land fragments

each contribute their own unique assemblage of organisms.

Whilst the true explanation is probably a combination of these factors, the most simple and palatable reason for high diversity is the huge diversity of habitat types in the Coral Triangle. The profusion of different habitats equals a correspondingly high diversity of organisms to inhabit them: sheltered inner shore habitats have their own set of species, whilst exposed atolls have another. Beneficially, the Coral Triangle has also avoided the mass extinctions that have blighted other areas over the millennia. Instead, the Coral Triangle has been blessed with long periods of warm, stable conditions fostering the persistence of species.

Fish doctors without borders

Last year I had the opportunity to join Wakatobi's liveaboard, Pelagian on an itinerary that ventured beyond the resort's reach and explored other islands in the chain. Whilst the resort has a profusion of different habitats including steep walls, pinnacles, ridges and bays, I had often heard about the muck dives found on Buton island, close to the Sulawesi mainland. Muck dives are interesting as they host a diverse set of species you are unlikely to see in other habitats, due to their distinct set of environmental conditions. Ghost pipefish, seahorses, frogfish and countless other oddities make this their home. It is a perfect example of the influence habitat diversity can have on overall species richness. The mangrove



A small soft coral cowrie feeding on a Dendronephthya coral



Nudibranchs reach their highest diversity in the Coral Triangle, Nembrotha lineolata





Even the infamous Crown of Thorns seastar serves a role on a healthy coral reef. Only when humans disrupt the ecosystem do they reach plague proportions



A huge cuttlefish rests next to a huge gorgonian coral



A rare crab found only on nocturnal feather stars



An experience without equal



"After 20 years of diving around the world, we are speechless for the first time. Whoever thinks that he knows what diving is about does not know Wakatobi. For sure this is the last paradise on Earth!"

Marties and Wolfgang Liebau, November 2013



www.wakatobi.com

forests, shallow seagrass beds and even the open ocean are just a few of the other habitats that contribute their own collection of unique species to the Coral Triangle.

During our tour of the Tukangbesi archipelago, in which Wakatobi Resort lies, I also came across, for only the second time, a pair of Denise's pygmy seahorses living on a whip coral colony. Unusual associations and biological quirks such as this seem quite commonplace in the Coral Triangle. With the Coral Triangle as a production line for new species, it might be that these pygmy seahorses, or their offspring, are better adapted to life on a whip coral. In many generations time it might be

that these pygmies split off to become a new, distinct species.

Endemism: riding the wave

As well as accommodating the highest number of species in the Indo-Pacific, South East Asia also has the greatest number of endemic or indigenous species (species that occur nowhere else). Certain areas of the ocean are more prone to high levels of these restricted range species: Hawaii has 86 species of endemic reef fish, the Red Sea 41, New Caledonia 43 and the Great Barrier Reef 33. The Coral Triangle vastly outshines all these areas, with over ten percent of its almost two and a half thousand species found only there.

In 2007, when I was first at Wakatobi conducting my pygmy seahorse observations, one of the guides found a tiny pipefish-like fish. It was distinct in several ways: it's miniature stature of less than 3cm in length, strange swimming method resembling a sea dragon and red wisp-like filament on the head all indicated to me this was something new. Later that year the pygmy pipehorse, *Kyonemichyths rumengani*, was scientifically described. Known initially only from Sulawesi in Indonesia, this tiny fish is now also recorded from Halmahera and Raja Ampat and seemingly making it another Coral Triangle endemic.

Currents play a major role in the movement of organisms around the

ocean, and reef communities can become isolated from others depending on local current systems. The East Australian Current, for example, flows from tropical equatorial waters towards the much cooler waters of southern Australia and Tasmania. This effectively backs the reef organisms up against uninhabitable cold waters, isolating the organisms from other populations and fuelling their evolution into distinct species.

Certain species are especially susceptible to such conditions and form a higher than average proportion of the endemics. Those species whose juvenile forms spend long periods drifting in the ocean as miniscule larvae tend not



A small dottyback emerges from inside a protective tunicate

to become isolated as they are able to reach distant reefs during this period, increasing their range. Other species, such as anemonefish and dottybacks, have well-developed young that settle very quickly on the local reef. The young, therefore, do not get chance to move far from their place of birth before settling, and thus have a propensity towards endemism.

Human impact

Patterns of marine biodiversity around the globe are historically quite stable and species evolve to fill a specific role within their own community. Man's technological advances have had unexpected affects on marine organisms, as they can now reach areas that were once physically well beyond their reach. The Suez and Panama



canals link bodies of water, and their inhabitants, in ways that would never meet naturally. For example, blacktip reef sharks have been found for the first time in the Mediterranean having originated in the Red Sea. Pacific nudibranchs are also arriving in the ballast water of ships in the Caribbean and Indo-Pacific Lionfish have invaded the Caribbean thanks to released aquarium subjects. These illegal aliens have the potential to severely disrupt their new home and the diversity that has evolved without them.

I was very pleased to see the energy that Wakatobi put into protecting their reefs. Great effort is made to educate and work with local communities to prevent destructive

practices such as dynamic or cyanide fishing on local reefs. In fact, much of the revenue from guests visiting the resort goes directly into local villages in payment for a strict no-fishing policy on fif-

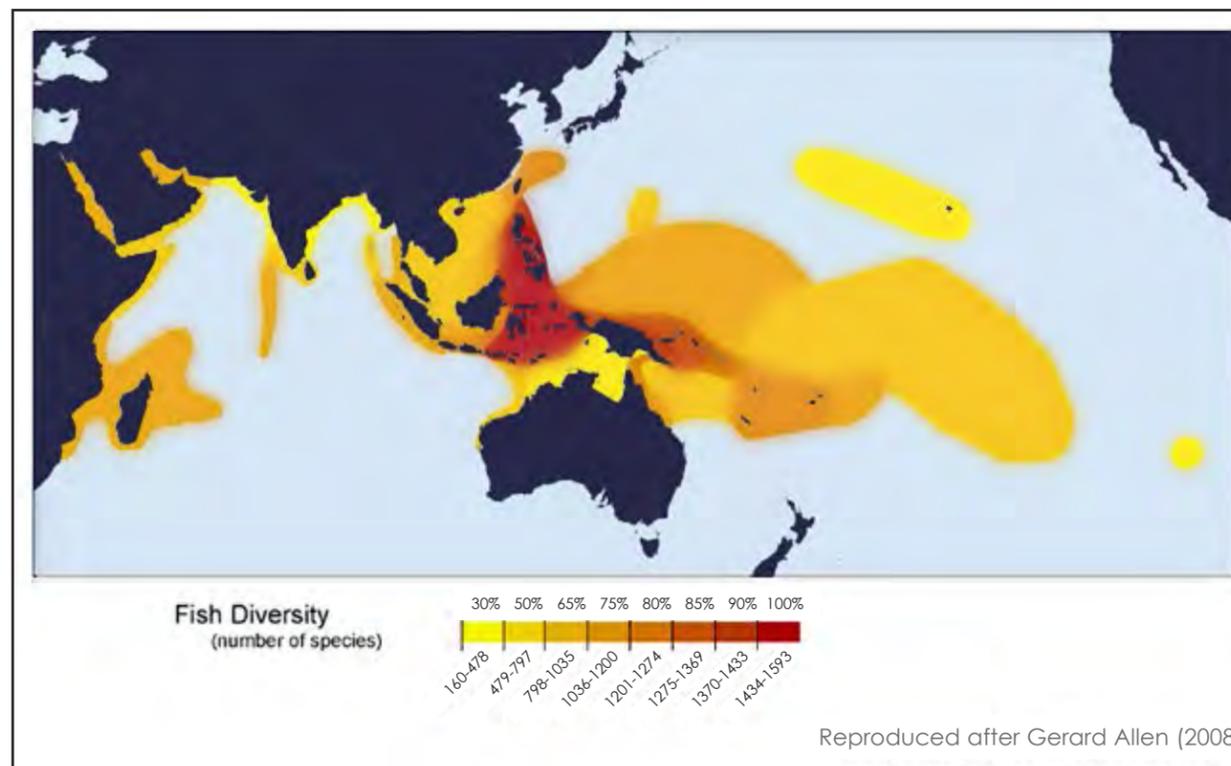
teen miles of reef surrounding the resort. The extremely remote location, extraordinarily high biodiversity and conservation efforts in the area make this a safe haven for many species that are suffering

throughout the Coral Triangle. With very limited resources available to conservation efforts, the identification of regions that contain high species diversity or many endemic organisms may help pinpoint areas of conservation priority. Scientific data indicates that the protection of South East Asian reefs will preserve the most species; however, there are also many other areas deserving of a conservation focus.

Richard Smith is a British marine biologist and photojournalist. As well as writing for many publications internationally, he leads marine life expeditions where the aim is for participants to get more from their diving and photography by learning about the marine environment: www.OceanRealmImages.com

Biodiversity

Crinoid clingfish (left) are a small species found in small groups at the centre of feather stars. Small, cryptic species play a large role in the accumulation of the Coral Triangle's biodiversity; Scientifically described in 2007, *Kyonemichthys rumengani* (left center), is found only in the Coral Triangle





Detail of a magnificent anemone mantle

ABOUT WAKATOBI

The area commonly known as Wakatobi lies within the Tukang Besi island group, in Indonesia's Southeastern Sulawesi region. It is one of the most remote regions of Indonesia, and until recently, travel to this area required more than 24 hours from Bali by a com-

bination of small aircraft, overland and boat travel.

The title Wakatobi is an acronym derived from the first two letters in the names of the group's four major islands: Wangi Wangi, Kaledupa, Tomia and Binongko. These islands encompass some of the planet's most productive and

pristine reefs and coastal shallows.

Much of the island group lies within the Wakatobi National Park, which is the second largest in Indonesia. In 2012 this area was designated a UNESCO Marine Biosphere Reserve. In addition, a 20-kilometer section of reef is under the protection of the Wakatobi Marine Reserve, which is a private program administered through the Wakatobi Collaborative Reef Conservation Program.

This initiative was developed by the founders of Wakatobi Dive Resort to provide a proactive means of protecting the reefs and marine resources. Established in

1996, Wakatobi Dive Resort was the first operator to offer services for diving and snorkeling in this region. A portion of revenue generated from resort activity funds a lease system that pays area villagers and fishermen to honor a no-take policy on specific reef tracts. Since the program's implementation in 1998, environmentally damaging fishing practices have ceased, and the reefs have remained in near-pristine condition, with some showing marked improvement.

Underwater environment

The islands of Wakatobi are typically flanked by fringing barrier



Rare Denise's pygmy seahorse living in association with a whip coral colony

Divers investigate a rich coral reef in the Wakatobi region

reefs that drop to depths of 40 meters or more at distances of less than 100 meters from shore. There are also a number of offshore reef plateaus and sea mounds in the region that rise from the depths to create isolated areas of shallow habitat.

What sets Wakatobi apart from other venues in the region is the unmatched access divers, snorkelers and photographers have to the most promising sites, most of which begin in very shallow water. Additionally, finding many elusive, well-hidden creatures such as the pygmy seahorse, is made easier by Wakatobi's dive guides, aka dive experience managers, who are experts at locating most species in their natural environment.

The islands of Eastern Indonesia are surrounded by some of the most bio-diverse coral reefs on the planet. This region, known as the "coral triangle," is home to more than 450 varieties of hard and soft corals, 3,000-plus species of fish and several thousand more types of invertebrate animals. With literally thousands of species living in close quarters on Wakatobi's reefs and shallows, there is no one single animal that could be said to be the signature attraction for underwater identification and viewing. That said there are some

Biodiversity



that never fail to entertain or provide unique opportunities for fish watchers and photographers. A few of the interesting denizens of the reefs at Wakatobi include:

Sea turtles. Thanks in part to Wakatobi's turtle nursery program and other conservation efforts, area reefs and shallows hold extremely healthy populations of sea turtles such as the green turtle and hawksbill turtle.

Pygmy seahorses. Wakatobi provides an ideal environment for pygmy seahorses to thrive, and it was only recently that this group of tiny creatures became known to science; most significantly, four of the seven known species are regularly seen in Wakatobi, and were discovered nearby in the past decade. According to marine biologist Dr Richard Smith,



An uncommon nudibranch, *Noumea crocea*, on the reefs of Wakatobi

"Anyone who has the pleasure of watching one of these animals should consider themselves privileged, because they are seeing something that few humans will ever see. And when it comes to finding pygmies, there is no better place than Wakatobi to begin the hunt." Unlike their larger cousins, the pygmy seahorses live only on coral reefs, and in many cases on a single species of gorgonian sea fans, which are found in abundance on the reefs at Wakatobi.

Cuttlefish. With eight arms growing out of their heads, and three hearts pumping blue blood through their gelatinous bodies, cuttlefish may seem like creatures from another planet, but they actually thrive in abundant numbers on the reefs of Wakatobi. In particular, the broadclub cuttlefish is a very common sighting, and groups of sometimes a half dozen can be seen hunting in pack formation, with their mantles pulsing and flashing as they send visual messages back and forth.

Humphead parrotfish. One of the larger members of the parrotfish family, the humphead can be readily identified by the crest-shaped growth on its forehead. They are seen often at Wakatobi trave-

ling in large groups. Like other parrotfish, the humphead uses powerful incisors and pharyngeal teeth to grind up coral and algae-covered rocks; the organic matter is digested while the remaining inorganic material is excreted. While this may sound destructive, it is this processed "coral poop" that washes ashore to form beaches. A school of parrotfish can add tons of soft sand to a beach each year. These fish often travel in shoals of 50 or more, and can live to be 40 years old.

Mandarinfish. Normally shy, these brightly colored members of the dragonet family lose their inhibitions as the sun goes down. At dusk, the males leave the cover of the rocky shallows they typically inhabit to perform intricate courtship displays that highlight their brilliant coloration. When a male attracts the attention of a female, they pair up belly-to-belly and begin a spiraling dance upward in the water column, releasing egg and sperm simultaneously at the apex of their ascent.

Mantis shrimp. Growing up to 30cm in length and able to deliver a smashing blow with their raptorial claws that can shatter a crustacean's shell, the mantis

What is biodiversity ... really?

Text and photos by Peter Symes

Diversity is about numbers, so the more species present in a habitat, the greater the biodiversity, right? Not quite.

Diversity in a biological context is often confused with **richness**, which is a simple measure that quantifies how many species are present without taking their abundance into account.

Biodiversity is a more comprehensive measure that takes into account both the number of species and their relative abundance and distribution. As such it is both a

quantitative and qualitative measure consisting of two components: **species richness** and **species evenness**.

To use a more familiar example, consider the barley field shown below. It is essentially a mono-culture and the patchy presence of a few wild flowers does not make it a rich and varied habitat. Including the boundary with all the many different flowers does not quite make it either because the distribution remains very uneven (there is still so much more barley than flowers).

The same notions apply to the marine environment and what we as divers would like to encounter. Say, if we want to go look for mandarin fish, pygmy seahorses, rhinopias and other photogenic or exciting species, they not only need to be present at the location to which we are headed, but they also need to be not so exceedingly few and far apart that we have little chance to find them.

Measures and maths

So how does one go about an objective measure to biodiversity? A number of math-

ematical indices have been formulated, which in various ways gives weight to the proportional abundance of observed species. In its simplest form, species diversity can be calculated by taking the inverse of the weighted average of species proportional abundance.

A number of indices that put emphasis on different aspects of the diversity have, over time, been proposed and put to use. The Shannon index, which is derived from information theory formulated in the late 1940s, is probably the most popular. □



A barley field (left) has low biodiversity as the presence of a few other species of flower does not significantly alter the fact that the field is a mono-culture.

is one shrimp that deserves respect. The mantis are solitary borrowers, constructing elaborate tunnels into the rubble or sand strata of the sea floor. One of these animals' most distinctive features are the iridescent eyes, which not only move independently to provide 360-degree binocular vision, but also see in a wider spectrum of light than any other creature in nature, including UV and polarized light.

Frogfish. There are more than 15 spe-

cies of frogfish native to Wakatobi, and though they don't reveal themselves to the casual observer, divers and snorkelers who look closely may realize that what they first thought was a lump of rubble or a clump of sponge is actually a stealthy predator, lying in wait.

Crocodilefish. It is the distinctive snout and head that give the crocodile flatfish its moniker, but perhaps the most unusual feature of this ambush predator are the frilly iris lappets, which protrude over the

black pupils of their eyes to break up the one remaining pattern that might alert unwary prey. Like the namesake reptile, this fish will lay motionless for long periods of time, waiting patiently for the right moment to strike out.

There are many, many other marine creatures readily found on Wakatobi's reefs. Learn more by visiting Wakatobi's blog, Wakatobi Flow, at blog.wakatobi.com. □ SOURCE: WAKATOBI MEDIA INFORMATION

Stability and resilience in ecosystems

Text by Peter Symes

The transfer of food energy from the source in plants through herbivores to carnivores is commonly referred to as the **food chain**. The **trophic level** of an organism is the position it occupies in a food chain. Food chains start at trophic level 1 with primary producers such as plants such as phytoplankton, kelp or seagrasses, move to herbivores at level 2, predators at level 3 and typically finish with carnivores or apex predators at level 4 or 5. The path along the chain can form either a one-way flow or a **food web**.

The classification of organisms by trophic levels is one of function and not of species as such, and a given species may occupy more than one trophic level i.e. when they go through stages of development. Size has a big effect on the organization of food chains; Animals on successive trophic levels tend to get larger i.e. the shark, which is the top predator, is larger than the seal which is a carnivore that largely feeds on fish and marine invertebrates.

So, in a way, it seems like foodwebs tend to organize themselves into a pyramid-like structure with few and big individuals at the top, while there are myriads of both species and individuals on the lower trophic levels forming the base.

And the question is...

Ecological communities with higher biodiversity form more complex trophic paths, but does complex mean more stable societies? And what limits the size and complexity?



How much plankton is needed to make a shark... or two?

Energy sets limits

In food chains the energy moves from one trophic level to the next in what is called an **energy pyramid**. At the bottom of this pyramid, we have the 'primary producers', which largely are the photosynthesisers, plants and other organisms that convert the energy in sunlight to chemical energy that can later be released to fuel the organisms' activities. On the next levels, we typically subsequently have herbivores, carnivores and top predators.

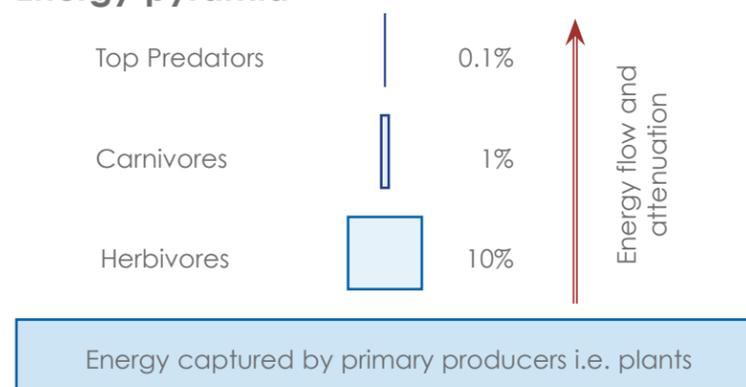
The 10% limit

The efficiency with which energy or biomass is transferred from one

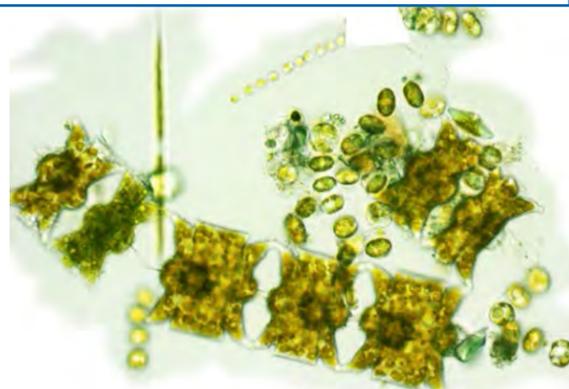
trophic level to the next is called the **ecological efficiency** and is no better than about ten percent on average. In other words, consumers on each level only convert about one tenth of the chemical energy in their food to their own organic tissue. This is also known as the 'ten percent law'. Since energy drops off so quickly by passing through the levels, it follows that food chains rarely extend for more than five or six levels before energy is depleted.

Since plants only convert about one percent of the sunlight they receive into chemical energy in the first place, of the total energy originally present in the incident sunlight that is finally embodied in a tertiary consumer, say a shark in the ocean, is about 0.001%.

Energy pyramid



Simplified energy pyramid with four trophic levels showing the conversion and throughput of energy between levels. The energy can somewhat be correlated to biomass.



Stability does not follow complexity

Stability is a dynamic concept that refers to the ability of a system to bounce back from disturbances (a subject we previously treated in more detail in X-RAY MAG #17, p. 71, "Why and how ecosystems change").

For starters, the intuitive argument that increased stability follows increased community complexity in the food web was already countered in the 1970s when it was demonstrated that *complexity actually reduced stability in mathematical models*.

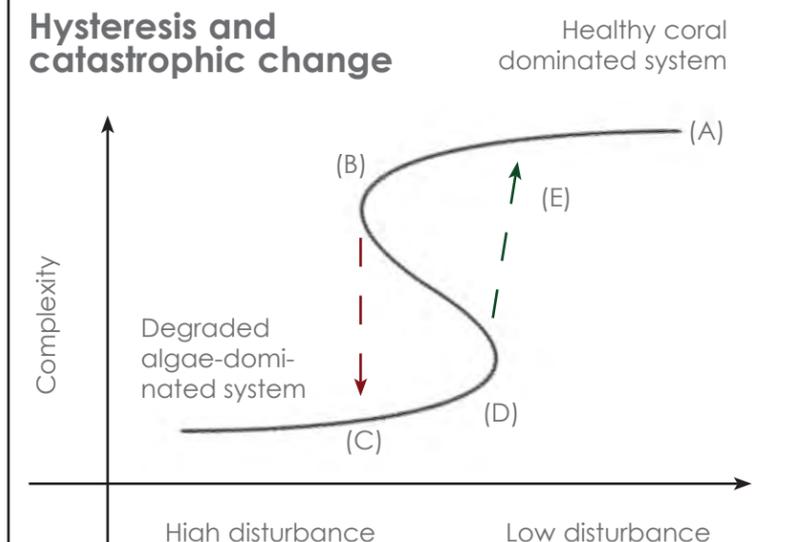
Where diversity does create stability or steady state scenarios in ecosystems, it follows from the establishment of enough equilibrium and buffer mechanisms in the assemblage of interacting species, which may or may not happen through non-random mechanisms.

Stability in complex systems is not a given. In fact, some systems are inherently unstable or chaotic and prone to crash, after which they will cease to exist and only the stable systems will prevail. Whether such systems are resilient to perturbations or fragile is another question.

Resilience

Resilience is a measure of the ability of the system to persist in the presence of perturbations arising from

Hysteresis and catastrophic change



When a healthy complex system such as a varied coral reef is subject to a disturbance, it will move along the gradient from (A) to a point (B) where a dramatic or catastrophic change occurs and the system collapses into one of lower complexity dropping down to point (C).

Reversing the collapse, or restoring the reef, however, takes a different path and often 'uphill' against some gradient or energy requirement. One has to, along with other restorative measures, also lower the disturbances, or cause, to at least level (D) after which it will eventually evolve back up to point (E). This curve also shows how different states can exist under the same conditions—when disturbance levels lie in the range between (B) and (D).

physical or chemical factors, climate or human activities such as fishing or pollution. Regulations on fisheries, for example, where outtake or harvest is limited is all about keeping the perturbations within 'sustainable limits'. Take only so much, and the resource will grow back. Take out too much, and the ecosystem may suffer a major collapse during which its overall structure and composition gets dramatically altered in a manner that is often impossible or very difficult to reverse.

Hysteresis

In an ecological context, hysteresis refers to the existence of different stable

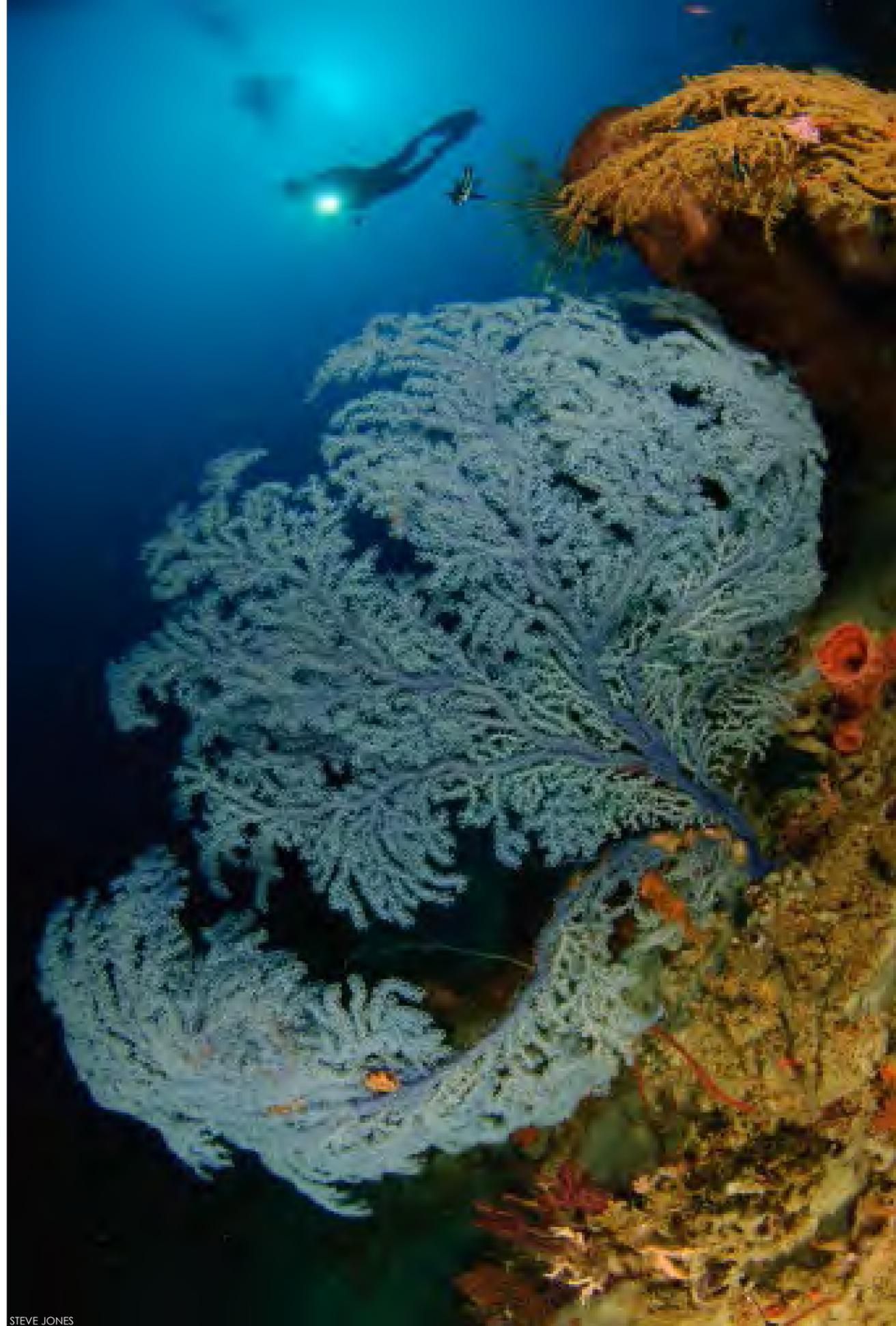
states under the same variables or parameters.

A real-world example is helpful to illustrate the concept. Coral reef systems can dramatically shift from pristine coral-dominated systems to degraded algae-dominated systems when populations grazing on algae decline. While the shift in one direction takes one path, reversing the process will follow a different path often requiring a significant input of the driving force to facilitate the change.

In this case the disturbance or causing agent has to be reduced to a level much lower than it was when the dramatic shift occurred. □



Diver with very rare blue sea fan, *Acanthogorgia* sp., found below 45 metres depth, Gorontalo, Sulawesi, Indonesia



STEVE JONES

Scuba Confidential

What if Diving was New?

Text by Simon Pridmore
Photos by Steve Jones
Millionfish.com

Imagine scuba diving is a brand new sport. You hear about it for the first time when one of your friends tells you about a scuba experience she had recently on holiday and you think this sounds incredibly exciting.

After thinking about it for a long time, you decide you want to learn. You take lessons to improve your swimming and then you look online for a dive instructor. There are no dive centres in your town. You have never actually seen a dive centre. You will have to travel to a nearby island to learn.

You are the first person you know who has signed up for a scuba diving course. For the people of your parents' generation, even if they were aware that scuba diving existed, they would

never have considered it even remotely possible that they could learn to dive. Diving was something that navy personnel did. It was a professional activity, not a sport.

Now they know that you are going to become a diver, your friends are envious and your family are worried about you. You feel like you are embarking on an adventure that will change your life.

The first scuba divers

In the 1950s and 1960s this must have been how it was for the first sport divers in Europe and the United States where scuba diving as a leisure activity began. The baby boomers born in the States and Europe in the aftermath of the Second World War were the first people ever to go under water for fun. Before, everyone who had dived was doing a job and had

no time or inclination to take any notice of what was happening around him. Nor, before Cousteau and Gagnan

came up with the idea of the aqua-lung, did anyone have the opportunity to move around very far, tethered as they were to the surface.

Several free magazines have been published, featuring movie stars and pop idols as diving role models. The gurus and industry leaders here are in their 20's or 30's.

But in Indonesia, where we are fortunate to live, this is what is happening right now! People have been diving in Indonesia for decades but only recently have Indonesians themselves been diving here, other than as professional dive-masters and guides. For the first time, a generation of Indonesians has the economic security and free time to dive for fun.

Scuba is COOL!

The wonders of Indonesia's underwater world are now constantly featured in newspapers, magazines and television documentaries. Several free magazines have been published, featuring movie stars and pop idols as diving role models. The gurus and industry leaders here are in their 20's or 30's. Scuba is COOL!

My dive buddy and I visited a hotel on the Sunda coast a few months ago and were sitting by the pool in the

For the first time, a generation of Indonesians has the economic security and free time to dive for fun.





evening while a film unit was shooting scenes for one of Indonesia's most popular television soap operas.

One of the crew came over and asked what we were doing there and when we explained we were scuba divers, filming came to an abrupt halt and all the cast members, actors and actresses famous throughout the country, immediately surrounded us, asking questions about diving and saying how they were all planning to do courses. We felt like we were the stars!

World class diving — on your doorstep

How wonderful must it be to start diving and then discover that some of the best diving in the world is there right

on your doorstep? The vast majority of Indonesia's 170,000 plus islands lie in the coral triangle where two massive oceans, the Pacific and the Indian, join.

Places that people spend tens of thousands of dollars to visit for just a few days a year are easily accessible to you pretty much any time you want to go there. Do you fancy a long weekend in Komodo? You could leave work in Jakarta on Friday evening and be diving off Cannibal Rock the next morning. How about Christmas in Raja Ampat? Why wait until Christmas? There are overnight flights to Sorong from Jakarta every night of the week.

...it is wonderful to witness a whole society that is discovering the joys of dipping their heads below the surface of the sea for the first time.

Positive benefits

On a serious note the environmental and conservation consequences of so many Indonesians learning to dive can only be positive. The country has an appalling conservation record on land and sea, with plenty of well-meaning laws protecting the environment but very little implementation or enforcement. A new generation of divers could well be a powerful force in turning the situation around.

Living in Indonesia and seeing scuba diving through the eyes of newcomers to the sport is refreshing. Coming from a part of the world where scuba diving is well established and it is taken for granted that almost anyone can dive if they want to, it is wonderful to witness a whole society that is discovering the joys of dipping their heads below the surface of the sea for the first time.

Comedian Dave Barry once wrote, "When you finally see what goes on underwater, you realize that you've been missing the whole point of the ocean. Staying on the surface all the time is like going to the circus and staring at the outside of the tent."

Welcome to the circus, Indonesia! □

Simon Pridmore has been part of the scuba diving scene in Asia, Europe and the United States (well, Guam) for the past 20 years or so. His latest book, also called Scuba Confidential, is available in paperback and e-Book on Amazon.

Diver and grand sea whip (right) and porcelain crab on anemone (below) in Gorontalo, Indonesia



STEVE JONES

STEVE JONES

Evie Dudas

For a West Chester woman, sunken ships meant treasure—and tragedy.

—The following is an article entitled “Sea Fever” previously published in AquaCorps Magazine, No. 1 February-March 1990.

Text by Cathie Cush
Photos courtesy of AquaCorps

As Evelyn Bartram Dudas’s Nikonos III made its way toward the bottom of the Atlantic Ocean one day not too long ago, she did the only thing that made sense to her at the time. She dove after it, retrieving the camera just before it was lost amidst the twisted remains of a shipwreck on the sea floor. Her rapid descent cost her a broken eardrum. It wasn’t the first time this veteran West Chester, Pennsylvania, diver, dive shop owner, and mother of four had suffered at the hands of the sea.

Evie Bartram learned to dive in 1964, while a student at the University of Buffalo. She thought it would give her and her boyfriend an activity to pursue together. The relationship didn’t work out. Heartbroken, Evie left school and

returned home. But she had found a new love.

After a short stint doing piecework in a machine shop and a summer back in Buffalo spent climbing mountains and diving instead of studying, Evie set sail on

a new course. When an opening arose at Aqua Terra, a Coatesville wetsuit company, she made scuba her business.

“They made very fine wetsuits, but they only made four sizes,” recalls the slender, energetic 44-year-old. “They didn’t fit

me, because I was about 5 feet 8-1/2 inches and skinny as a rail. I figured if I went to work for a manufacturer, I could learn to make myself a wetsuit that fits.”

Soon she was customizing suits for other divers—on the boss’s time—and saving for a Corvette. She and her colleague beau were racing to see who would be first to buy one of the flashy sports cars. He eventually was killed in his.

In the meantime, Evie joined Main Line Divers Club. She made her first ocean dive with them off Sea Isle City, New Jersey, in 1965.

“I was petrified to touch



the bottom. I didn’t know what starfish were; I didn’t know if they could hurt you,” she recounts.

She quickly overcame her apprehensions. By her third ocean dive, she was exploring the *Stolt Dagali*, a tanker that had been sheared in two in a collision the year before. The ship’s stern rests in 130 feet of water, rising to within 70 feet of the surface. In the gallery, Evie recovered several stainless steel pots, then discovered that her buddy was no longer with her. He had run out of air. She followed him to the surface, when he was apparently in the process of drowning.

“I had to drop all my goodies and tow him back to the boat,” she says. “At that point I decided that buddy-diving left a little to be desired. If you’re going to do any hardcore diving, you have to be self-sufficient.”

On another visit to the *Stolt*, Evie Bartram met John Dudas, a dive equipment manufacturer’s representative who became

her dive buddy for the next 17 years. Together they pioneered East Coast wreck diving, exploring the waters from New York to Maryland, and identifying the remains of several vessels that had sunk to the bottom years before. Today Evie’s home is full of artifacts she and John recovered from these virgin wrecks. Often they hitched rides on fishing charter boats, paying their fare with lobster they’d grab from the bottom. They taught scuba classes. She made wetsuits on her own now, and he repaired regulators. (She left Aqua Terra when they began making rainwear for use by troops in Vietnam).

In 1967, during a lecture to the Philadelphia Lion’s Club, Evie boasted that she would be the first woman to dive the Italian luxury liner *Andrea Doria*. Her prediction came true that summer, when she and Dudas joined an expedition to explore the celebrated shipwreck, which rests in 73 metres (240 feet) of water approximately 110 miles east of Long Island, New York. They returned with





the *Virginia*. It lay in deep water—50 metres (165 feet)—so a short dive was planned. After ten minutes the divers surfaced and swam to the ship's anchor line, down

which they would descend to three metres (10 feet) to recompress—a technique that was common at the time. As Evie pulled herself down the line, her hands lost their strength and went numb. She was bent.

"My hands refused to grip; my feet refused to kick," she says. "I was becoming paralyzed. They rolled me on my back and I thought, 'if this is what it's like to die, this is not bad.' Then I just went unconscious."

John Dudas went at her side and



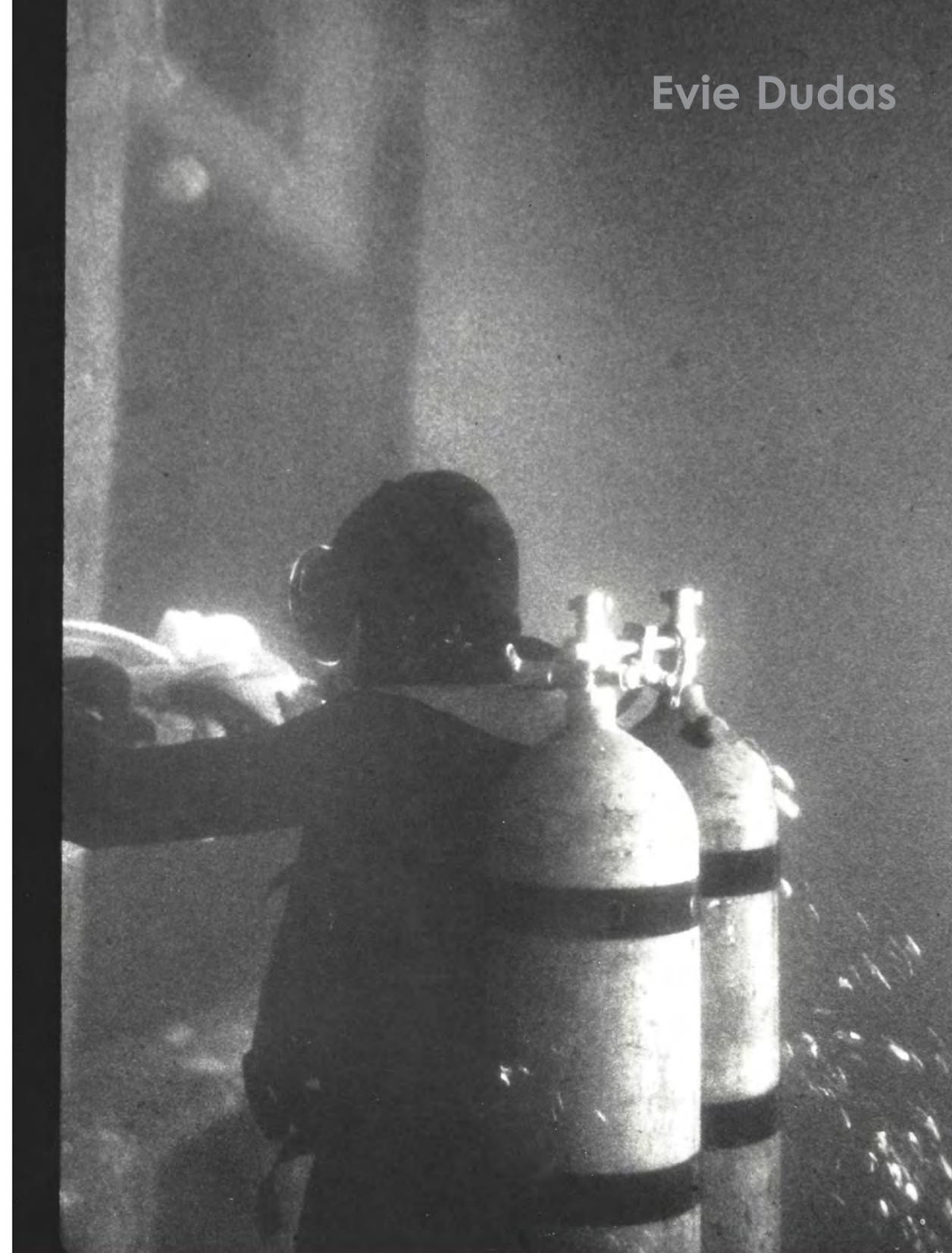
helped drag her back to the boat. Divers and crew fought heavy seas to pull her back on board, finally tying a rope around her waist and hoisting her up like a doll. She recalls lying in the wheelhouse wrapped in a blanket.

"I remember the suction of the mask being pulled off my face," she says. "I had vertigo, and I couldn't talk or see. I tried to scream, and I couldn't. And I remember being cold and hungry. It was a six-hour trip back to port."

That night she was taken to the hyperbaric chamber at Mt. Sinai Hospital, where her decompression sickness could be treated. The next morning, she found Dudas at her side, crying.

"That's when I figured out he cared about me," she adds softly.

After ten days the paralysis was gone, but it took a year and a half before the numbness in her arms and the vertigo left completely. In recent years she has



had post-diving bouts of vertigo and skin bends that last for hours. Still, she continues her 'hard-core' diving and shrugs at the mention of the risks she is taking.

"There's risk involved just driving to the

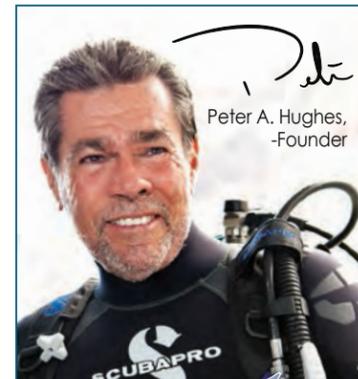
boat," she reminds a visitor pragmatically.

Evelyn Bartrum and John Dudas were married in 1970. They continued to dive together until pregnancy put a damp-

the compass and binnacle cover, a light fixture from over the wheelhouse chart table and a door handle. Dudas also recovered a porthole from the captain's room. Their 60-metre (200-foot) plus dive takes on a new dimension of drama when Evie explains matter-of-factly that the adventure was undertaken with the benefit of gauges to monitor tank air pressure and sans other safety equipment that today's divers take for granted.

In January 1968, tragedy struck when the pair took a Freeport, New York, fishing boat to a wreck known as





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ener on her scuba activities, and shipwrecks took a back sea to a Girl Scout troop, Le Leche League, and other service work. By 1982, Evie was expecting for the fifth time (her firstborn died during childbirth), and she had been out of the water four years.

In July of that year, when Evie was several weeks pregnant, John dove the *Virginia* again. He never surfaced, and was found unconscious on the bottom with only 13 bar / 200 psi in his tanks. He had been on the bottom nearly 30 minutes when he was found, and would have required lengthy decompression before he surfaced. Evie will never

know for sure what happened that day on the sea floor.

If he suddenly realized he didn't have enough air to decompress, he might have panicked, she speculates, even though he had sufficient air to reach the surface. "He saw how badly bent I was after a ten-minute dive, and he did not want to be a vegetable, and I know of times when he passed out from stress."

The *Virginia*, as Evie recalls, was not a very interesting dive.

"I haven't been back," she says slowly, thoughtfully. "I'm not sure

emotionally I could handle it. Still, the curiosity is there."

Sitting in a classroom on the second floor of her dive shop, on a rainy winter day, she talks openly about the accidents and how they affected her life, about the trials of being a single mother, about guilt and misgivings, about plans for the future. When she recounts the events of John's death, it is as if talking about it will help her piece together the puzzle.

When John died, Evie was left with the beginnings of a business that she has nurtured into a successful full-time dive shop. When oth-

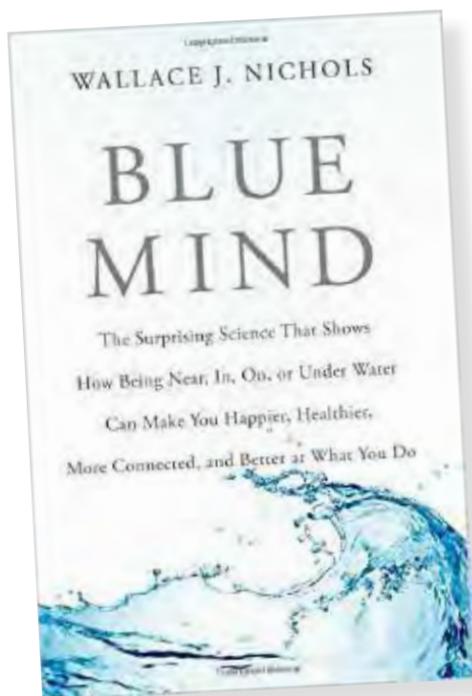
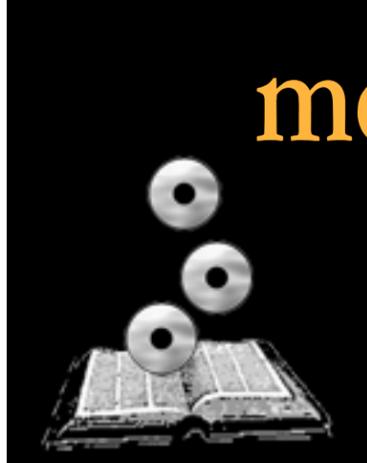
ers might have turned their backs on a pursuit that brought so much pain, Evelyn Bartram Dudas has plunged headlong back into the sea, accepting its risks and reaping its treasures. She does about 100 dives a year, which she says "is not a lot", but as long as they're on shipwrecks, she's happy.

"I've been finding more things," she says of her recent ventures into the sea. She's particularly proud of a brass lantern she discovered on a wreck last summer. Then she adds, "When I dove with John, I was still very much a beginner and he

would find something almost every time he went in the water. This is a man who wore corrective lenses—who was shot in the eye with an arrow when he was a child."

Perhaps this expert sea woman is still trying to be 'as good' a diver as her late husband. There are those in the diving community who say her deep diving practices are an attempt to join him. But maybe Evelyn Bartram-Dudas is only trying to retrieve some small tokens to replace the great treasure the sea has taken from her. □



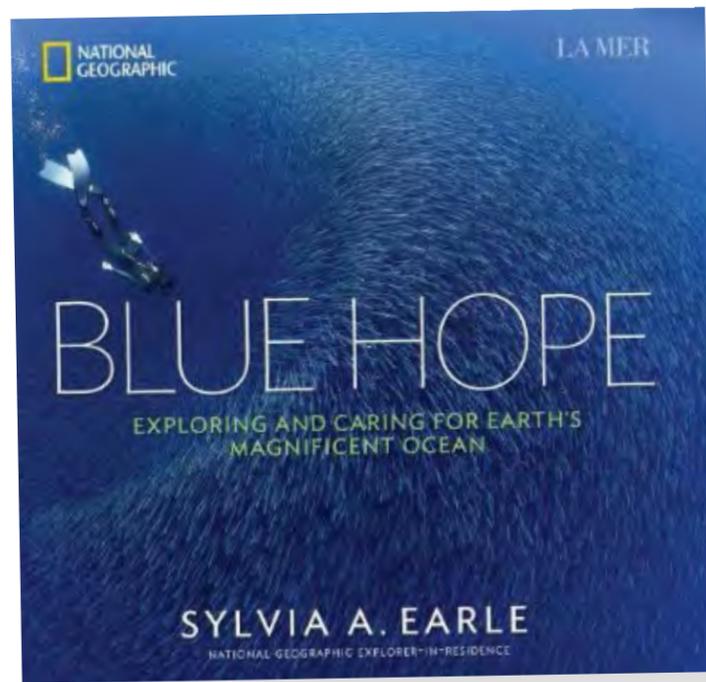


Water & Well-being

Blue Mind: The Surprising Science That Shows How Being Near, In, On, or Under Water Can Make You Happier, Healthier, More Connected, and Better at What You Do, by Wallace J. Nichols. Water is all around us—and within us. The land we stand on is surrounded

by a vast body of water, so much so that our planet appears blue when seen from outer space. The book explores how water can positively boost personal performance and well-being, while easing frayed nerves and anxieties. Written by marine biologist Wallace J Nichols, these claims are supported by cutting-edge scientific data and studies, and are combined with the anecdotal accounts of many individuals, from athletes and artists, to scientists and war veterans. On a larger scale, this book describes the author's philosophy pertaining to our relationship with water, relating it to the universal quest for a better life for all beings on our humble 'water marble'.

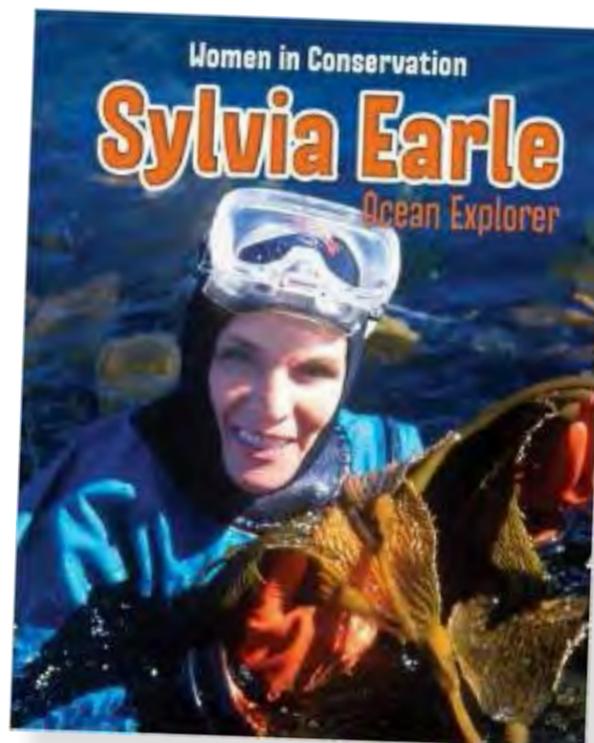
Hardcover: 352 pages
 Publisher: Little, Brown and Company; 1st edition
 Date: 22 July 2014
 ISBN-10: 0316252085
 ISBN-13: 978-0316252089



A Pioneer's Insights

Blue Hope: Exploring and Caring for Earth's Magnificent Ocean, by Sylvia A. Earle. This hardcover book is the latest publication by the acclaimed Dr Sylvia Earle. In 256 pages, it pays tribute to the beauty and magic of our world's oceans, and sheds light on its abundant gifts to the planet. Its seven essays convey the insights and inspirations of Dr Earle and other experts and celebrities, along with supporting facts, maps and stunning photos of beaches, coral reefs and marine life. Throughout the book, one clear and hopeful message resounds: Life depends on the ocean, and to save it, we must love it.

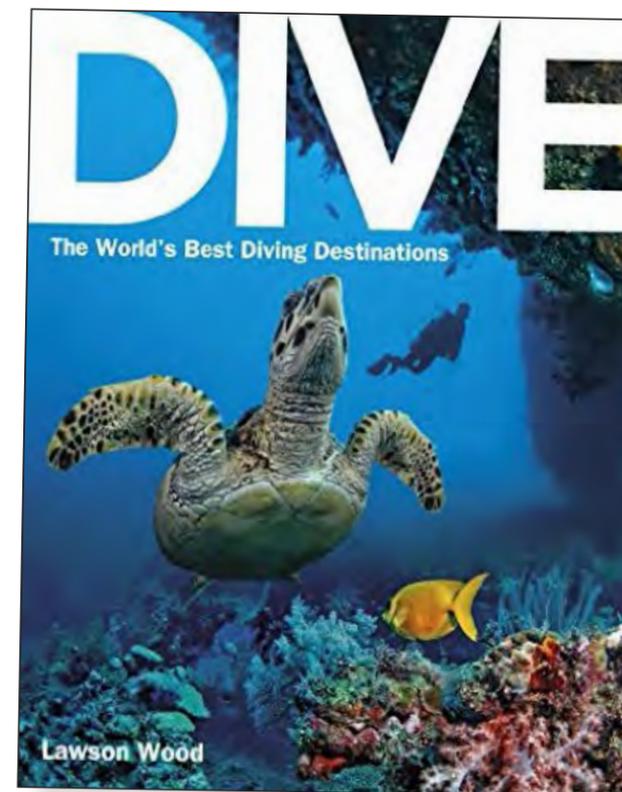
Hardcover: 256 pages
 Publisher: National Geographic Society
 Date: 19 Aug 2014
 ISBN-10: 1426213956
 ISBN-13: 978-1426213953



Her Deepness

Sylvia Earle: Ocean Explorer, by Dennis Fertig. This book is part of Heinemann InfoSearch's *Women in Conservation* series. This particular title features Dr Sylvia Earle and describes her efforts to protect the oceans. It covers her inspirations, discoveries and the impact of her work. At 48 pages, it serves as an introduction to the life of this remarkable lady. The fact that she is featured in this series alongside conservation greats as Jane Goodall, Dian Fossey and Rachel Carson speaks volumes about Dr Earle's achievements.

Hardcover: 48 pages
 Publisher: Raintree
 Date: 14 August 2014
 ISBN-10: 140628338X
 ISBN-13: 978-1406283389



Top Dive Spots

Dive: The World's Best Diving Destinations, by Lawson Wood. The title says it all. Written by a diver with more than 15,000 dives under his weight-belt, this book highlights over 250 of the best dive sites in the world. As a Fellow of the Royal Geographical Society and the co-founder of the Marine Conservation Society, author Lawson Wood had also founded Scotland's first marine reserve. Needless to say, the information contained within the covers comes from his personal experience and knowledge of the dive sites. Flipping through the book—with its photos depicting underwater scenery and wildlife—your wish-list of dive destinations is bound to generate more than a couple of new candidates.

Paperback: 192 pages
 Publisher: Quercus Publishing Plc
 Date: 4 September 2014
 ISBN-10: 1782068562
 ISBN-13: 978-1782068563