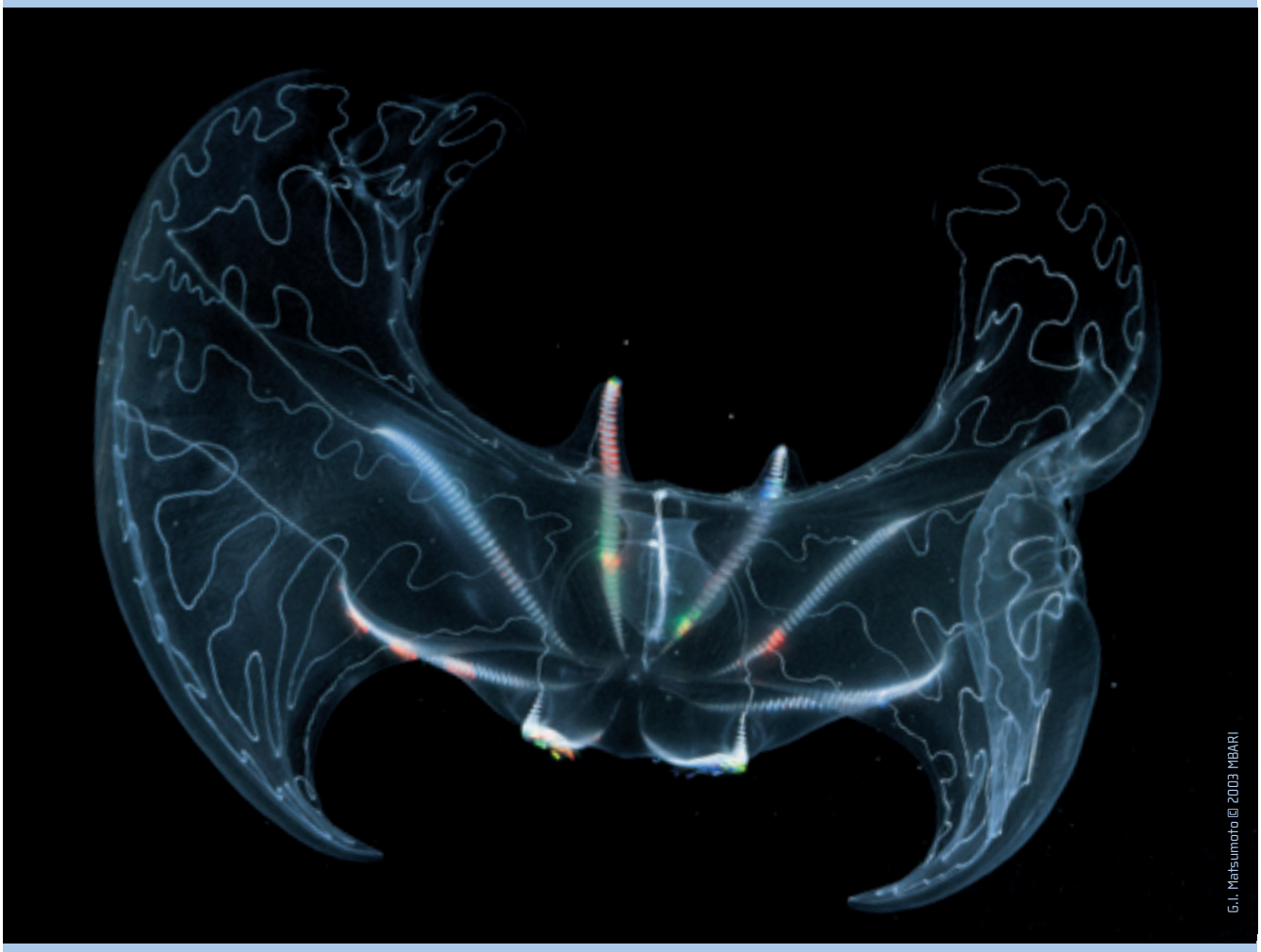

深海奇珍
THE DEEP
11.7 - 12.11.2008

Birth of a passion



In 2001, during the reconnaissance trip for a film on undersea fauna at the Monterey Bay Aquarium in the United States, Claire Nouvian discovered incredible images of creatures with spectacular shapes, with astonishing colors... Unknown animals, some of which had been filmed at 4000 meters depth. Captivated and dazzled, she sought to learn more about them, realizing with perplexity that there was no synthetic document regarding the deep ocean available to the greater public and that its scientific exploration was only at its first steps.

Claire Nouvian embarked assiduously on a precise program:
Between 2002 and 2005, she wrote two documentaries on the deep sea for Arte and The Science Channel. She established Bloom Association, a non-profit organization whose purpose is the protection of the ocean, specifically but not only the deep sea, by means of dissemination of information and images.

In 2006, with the aid of patrons supporting Bloom's actions and its quality approach, her book *The Deep* was published. Translated into six languages (soon more) and reprinted four times already, it was hailed by the critics and has won numerous prizes. The work presents first-ever images of animals of the deep and synthesizes the information collected over twenty years of oceanographic campaigns, thus it represents the first visual encyclopedia of the ocean's depths, revealing the spectacular fauna and the different ecosystems and phenomena that are grouped under the generic term of "deep sea."

In November 2007, the exhibition *The Deep* opened at the Natural History Museum in Paris and ran until May 2008. It was a world premiere presenting to the public a large variety of deepwater animals in aquariums as well as a selection of recent -and for some hitherto unreleased- photos and videos.

Introduction

The exhibition *The Deep* comes to life in complete darkness. An introductory zone marks the entrance, then the exhibition unfolds to reveal two themes, a split which corresponds to the differing depths: life in the midwater (the "pelagic" zone) and life on the sea floor (the "benthic" zone).
In order to show these extraordinary creatures – true deep-sea gems because of their rarity and fragility – the design of the exhibition *The Deep* evokes a sense of luxury through its sheer visual quality. The photographs, exclusive to this event, are therefore exhibited in their splendor using the high-end choice for photography display: backlighting and Duratrans printing process. The animals are shown in sober contemporary columns, which resemble jewelers' window displays. Precise, directional lighting will illuminate these "intra-terrestrial" specimens within the dark setting.

Other than the omnipresence of black, the sensation of immersion will be reinforced by an interactive "abyssal" soundtrack.

Overall, the exhibition offers an aesthetic, original and creative design, which guarantees to enhance the reaction of the public on first contact with the deep-sea fauna.

Unfolding

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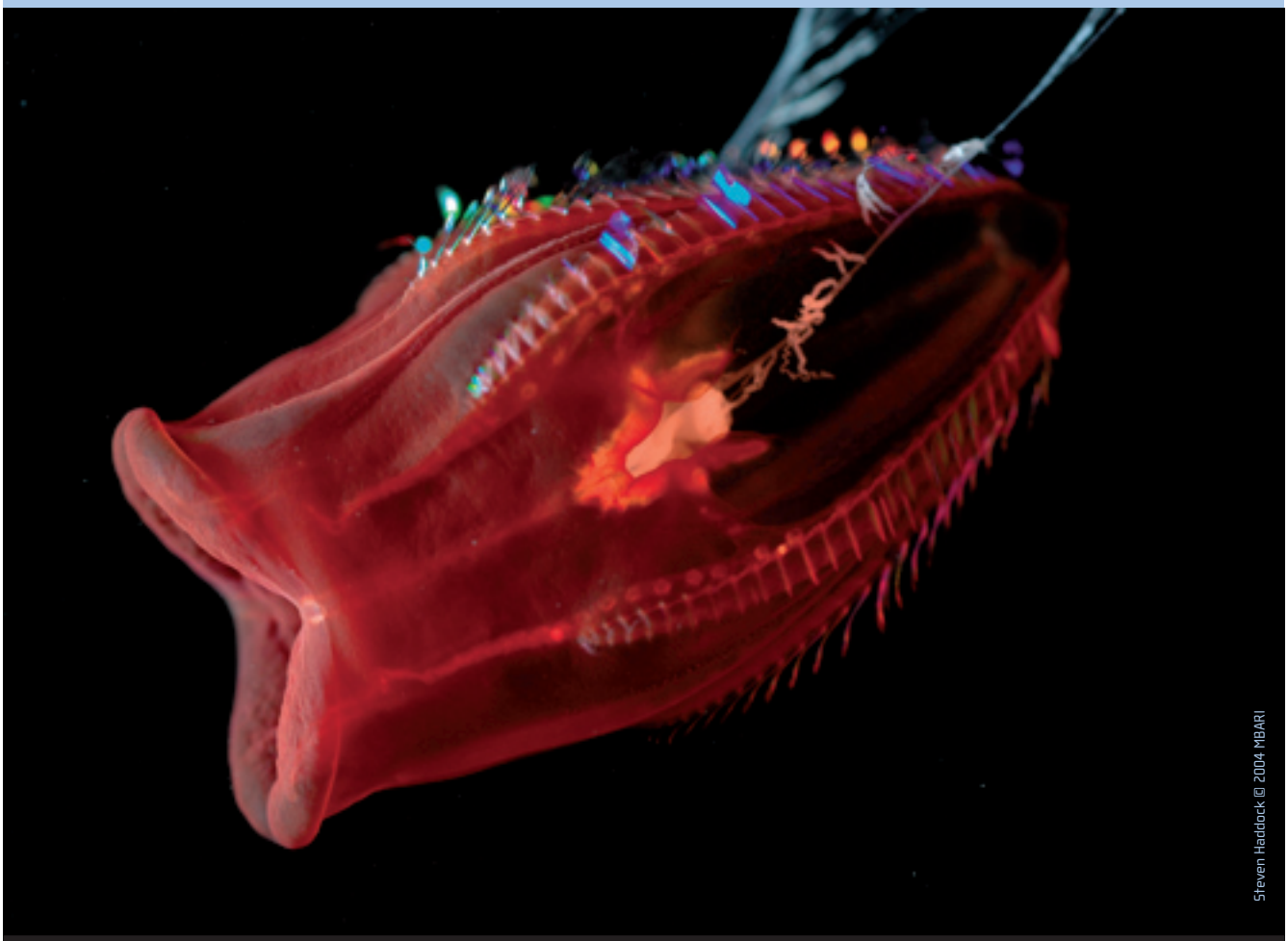


Steven Haddock © 2004 MBARI

An opening introductory area

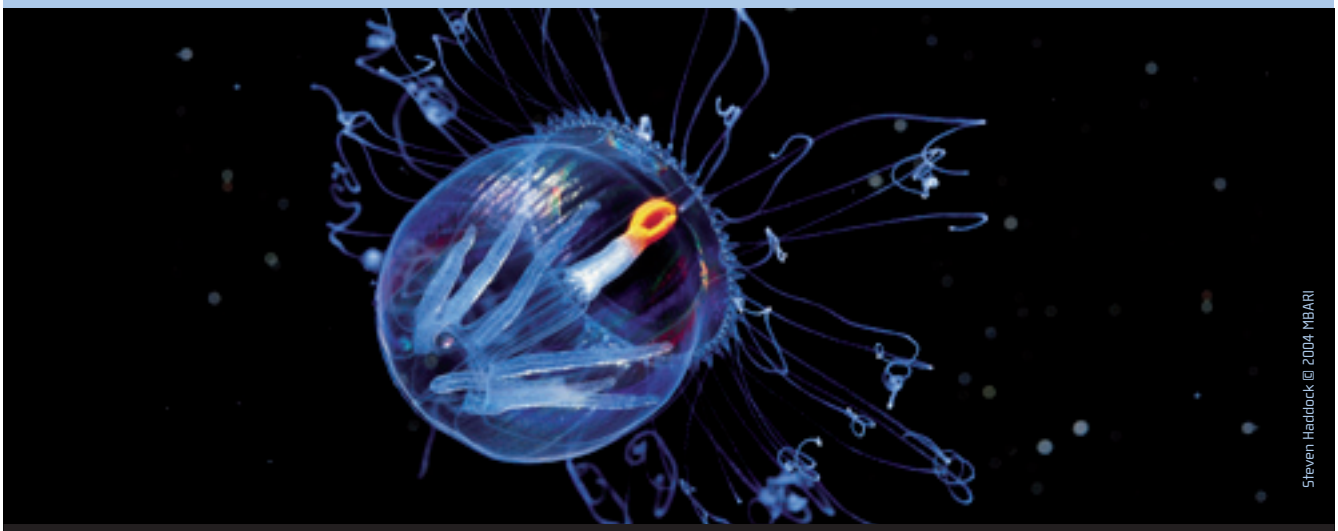
The exhibition *The Deep* begins in a totally black room, with only a backlit image of a fantastic creature: the alien-looking squid from the cover of the book *The Deep*, a short introduction text to explain the unfolding of the exhibition to visitors
This minimalist, sober space will serve to set the ambiance and create an impressive, enticing entrance.

This section displays a chronology of deep-sea exploration and an outline of the oceanic ecosystems (cross-section of the oceans)

The chronology will be composed of a graphic string of images and videos, with a timeline above and text beneath the visual string. A few inspiring quotations will branch off from the timeline.

These milestones remind us that the first direct observations of the deep sea are recent.
Traditionally, the inception of deep-sea oceanography is considered to be 1872, start of Sir Charles Wyville Thomson's four-year journey around the globe on board of the Challenger, during which he explored the seabed using modern sounding leads for the first time. In the 1930's, explorers William Beebe and Otis Barton immersed themselves for the first time in the abyss. They reached the record depth of 922 meters with their bathysphere connected to a vessel by a cable, and observed, in situ, marine life in the deep sea. However, Auguste Piccard and his bathyscaph invented in the 1950's and allowing free navigation (without cable), opened the way to deep-sea exploration. In 1960, one of the submersibles he developed the "Trieste" went down to 10,916 meters in the Mariana Trench, the deepest part of the world's oceans, located in the Pacific Ocean. This record of the deepest dive remains unbroken to date. The technological prowess allowed us to leave the era of the chase for records and to enter the era of true scientific exploration of the deep ocean.

Unfolding



Steven Haddock © 2004 MBARI

The midwater

After the introductory zone, the visitor discovers the world of direct immersion through colorful pictures taken in situ. Deep-sea dives in the midwater (or pelagic zone) have only taken place in recent years. We can roughly date them to the mid 1980's, when two American oceanographic institutions (Harbor Branch Oceanographic Institution, HBOI, and the Monterey Bay Aquarium Research Institute, MBARI) started developing submersibles and ROVs with specific midwater navigation capabilities. These research centers were the first ones to dedicate their research to the understanding of the pelagic zone, which had previously been considered devoid of life and therefore of little interest.

Diving into the water column, the visitor discovers that this environment is actually teeming with magnificent organisms. These creatures are often gelatinous, sometimes giant in size.

The visitor also learns that the water column is actually an organized body with its own rules and phenomena and that the distribution of the fauna obeys invisible frontiers: whether it be the concentration of salt or oxygen, the temperature, and the most important barrier, the availability of light. As far as the light penetrates (down to a depth of 1000 m), no matter how feeble the rays are, the creatures can still detect it. Beneath 1000 m, it is total darkness. This imposes new constraints on the fauna, but can also present new advantages.

From 200 to 1 000 meters: the twilight of the oceans

In the first stage of the exhibition, the visitor experiences a world which to the human eye appears totally dark, but in which the animals are still able to detect light. It creates a great theater of Chinese shadows. It is a highly dangerous zone, but one in which food is more abundant than further down, and therefore inhabiting it is worth the risk.

At the surface of the oceans, and while the light still clearly penetrates, the most effective strategy for escaping being eaten is to pass unseen. By having bodies through which light can pass, animals can trick predators by appearing invisible. Transparent tissue is highly prevalent among gelatinous plankton. The fauna residing in the upper water column is often described as the 'glass menagerie': salps, ctenophores, jellyfish, Venus belts, siphonophores, fish larvae, crustaceans...

> *"In the depths of the sea [...] the pelagic population is so present, and so striking from the surface, down to the very bottom that the words « puree », « soup » and « broth » come up time and again in the books of observers."*
>
> *Théodore Monod, Bathyfolages, 1954.*

Unfolding

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Bioluminescence - the most widespread form of communication on Earth

The level of light drops very quickly in the oceans as the water absorbs it, but this is immediately counterbalanced by the light created by deep marine creatures. While bioluminescence is a rare phenomenon on land (only a few click-beetles, glow-worms and fungi produce it), it is prevalent among oceanic fauna: 80-90% of pelagic organisms produce light! Bioluminescence is without a doubt the most widespread form of communication on Earth.
Bioluminescence also exists in different forms: it is found as a sort of headlamp which serves to light up the surrounding water, and is carried not far from the fish's eyes; The photophores can take the form of eyelids that the animals can conceal when they wish; and can be present in the lure (barbel, fishing rod...). Bioluminescent organs often take the form of an eye, to make the animal look bigger than it is (ref. Vampyroteuthis infernalis).
This phenomenon serves several functions: to attract prey (which mistakes the light for the bioluminescent bacteria which often cover organic debris), to communicate with members of the same species, to recognize each other, to signal to a potential mate.
However, it is its role as a defense mechanism that is common to all creatures.

Gelatinous animals: masters of the universe

The great surprise, which met the researchers who carried out the first dives into the midwater, was the discovery of the predominance of gelatinous organisms at this depth. Trawls had always reduced these creatures to unrecognizable slime. Gelatinous animals have adapted to a life without walls, without floors and without any rigid obstacles. They are surrounded by water, and are often made up of it themselves (up to 98% of their composition is water). It transpires that gelatinous organisms make up the most widespread living tissue present in the midwater. In terms of mass, they are the most abundant creatures on earth.

Amongst these are the largest animals on earth! The giant siphonophore Praya dubia can reach 50 m long and Apolemia sp. more than 100 m (personal communication Jean de Vaugelas). We suggest that there is a section dedicated to these incredible predators which, against all expectations, compete with the fishing industry at certain times of the year! In fact, depending on the season, siphonophores are so numerous that they go into direct competition with juvenile fish for resources. (Cf the siphonophores in the Gulf of Maine and the cyclical collapse of fisheries).

Beneath 1000 m - total darkness

The threshold of total darkness lies between 600 and 1000 m below the surface, depending on the number of particles suspended in the water. Below 1000 m it is impossible to detect the slightest photon originating from the sun. The enveloping darkness dictates new behavior and different adaptations, and the animals living below this limit do not migrate to the surface. The residents of this water level have never seen a ray of sunlight. They are, for the most part, static creatures with slow metabolisms, which resort to tricks to find their meals, rather than using force or speed.

• With darkness, the appearance of colors

Contrary to expectations, the deeper down you go in the ocean, the more the animals' skins are pigmented with dark colors: brown, black and dark red. Red is the first wavelength to disappear in the water, so it acts as a black cape, which camouflages the animal from predators. A possible reason as to why so many animals are red in order to appear black, and not simply black, is that it is almost certainly easier to generate red pigment from food than to generate black (therefore it is less "costly" evolutionarily speaking).
Medusae of all types bear vibrant colors (red, pink, burgundy, violet, maroon, black...), which allow them to pass undetected and to hide the potentially bioluminescent prey they may have ingested. The contrast with the creatures that make up the "glass menagerie" of the first few hundred meters of the oceans is striking.

A LIVING FOSSIL

The oxygen level drops progressively as distance from the surface increases and as it is consumed by the great numbers of animals populating the first few hundred meters of water. It reaches its lowest limit between 600 and 1300 m depending on the area. This is called the oxygen minimum layer (it drops to just 5% of the saturation of oxygen in air). The vast majority of animals can only stay very briefly in this zone; cephalopods in particular need concentration levels equivalent to 50% of the saturation of the air. However, there is an extraordinary creature capable of sustaining itself in this environment, and which in fact completes its total life cycle there. The famous vampire squid from hell, Vampyroteuthis infernalis, which is the mascot of the deep seas, and of which photographs are very rare. The vampire is a living fossil whose origins date back more than 200 million years. It shows remarkable adaptations to life in the oxygen minimum layer, taking oxygen from the water using an efficient blood pigment, hemocyanin... Its strategy shelters it from predators.

• Remarkable adaptations

It is neither darkness, reduced oxygen levels, nor the hydrostatic pressure, which ultimately limit development of life in the depths. It is very simply the scarce food supply.
The food passes down through the water column, falling in a fine rain from the surface and finally settling on the seafloor. If we were to eat snow, it would be easier to get it from the ground, where it accumulates, than to try to gulp down enough by following the flakes in the sky. The same goes for the "bathypelagic" fauna (living between 1000 and 4000 m below the surface). Having a limited food supply has forced them to economize on their energy use and conserve muscle reserves. In addition, they do not have large skeletons and often no scales as these would demand great amounts of food to build. Of the vertebrates, most are small in size (as opposed to gelatinous organisms, which do not have to produce bones, and consequently grow very quickly.)

With meals being so rare, when prey comes along, missing it is not an option. Some species have been noted to have teeth which are not in proportion with their bodies: the teeth of the viperfish Chauliodus sp. are so big that they do not fit in its mouth. Those of the fangtooth Anoplogaster cornuta are short but sharp. The stomachs of the gulper eel Saccopharynx sp. or of the pelican eel Eurypharynx sp. are extensible, and can swell so as to allow them to swallow prey, which is as big as them (the same principle as for the boa). The gulper eel is a characteristic demonstration of deep-sea adaptations in all aspects: its eyes are extremely small, its jaws are huge, its stomach is expandable and its long tail is said to bear a bioluminescent organ at its very tip.

Life on the ocean floor

The principal message to convey to the public is that the generic term “the deep sea” covers a multitude of environments. There are various ecosystems within the deep, which radically differ from one another. Because of this, it is impossible to answer the broad question “what is a deep-sea dive like?” without having defined the location and the depth of the dive. In the same way, it is unthinkable even to try to represent “the deep-ocean floor” without describing the variety of ecosystems that are found there.

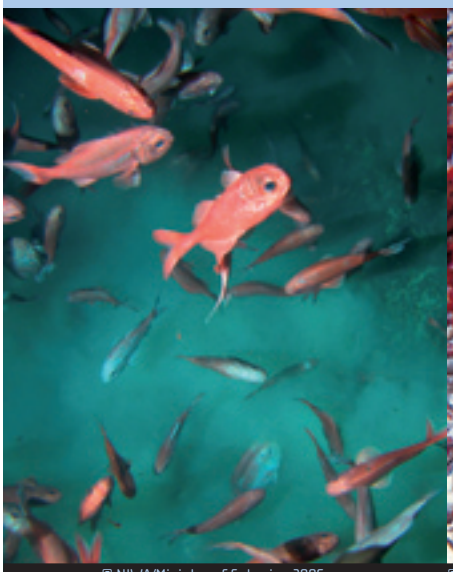
THE ABYSSAL PLAIN

The ocean floor is the final receptacle for all food (the rain of particles), which filters down through the water column. This food settles down at varying speeds according to its location (in the oligotrophic zone, in the center of the oceans, the rate of sedimentation is about 5 mm per 1000 years; in the zones where there is a lot of primary production, the rate reaches up to 10-20 cm per 1000 years). These particles form an organic carpet of which a great variety of creatures can take advantage, but this carpet can by no means support large numbers of animals. A trend becomes clear: biomass is low, but species diversity is high.

It is important to highlight this counter-intuitive notion. In order to put this in perspective, on average there are 5 kg of organisms per square meter in the shallow marine ecosystems, whereas the biomass at great depths does not exceed 1 g/m2.

It is estimated that the benthic layer houses more than 80% of marine species, even though the first 1000 m of water contain the largest biomass on the planet. The diversity in the midwater is less than that on the ocean floor, but the biomass is superior. At the same time, the number of species still to be discovered in the deep sea is without doubt many tens of times higher than the number of species at the surface (estimation 10 million species to be discovered still).

Unfolding 6/6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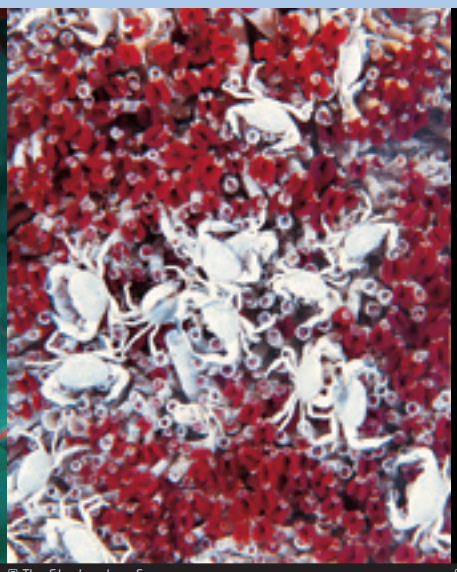
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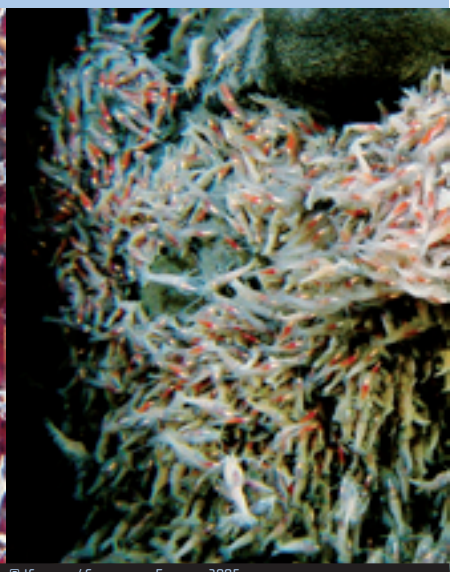
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Particle traps: attracting food... and fishermen

Seamounts and canyons

Habitats where the current is enhanced by the relief (canyons, seamounts) act like "particle traps", therefore there is an increased concentration of life in these areas compared with the abyssal plain. It is here that deep coral reefs develop and, like their cousins in the tropical surface waters, form truly complex ecosystems which are still largely unknown to man. (It is important to define seamounts and explain Taylor's column – the current circulates around a seamount which traps plankton, creating a large food chain from the smallest to the largest creature, and from the top of the seamount to the surface.)

The groups of fish and birds that congregate above seamounts (attracted by the productivity generated by the Taylor's column) have long signaled the existence of this underwater relief to industrial fishermen. Since the 1970s these rich ecosystems, largely unknown to science, have been exploited. The trawlers used are equipped with weights which are sufficiently powerful to completely grind the coral reef on the top of the seamounts (up to 2000 m down). The dragged nets destroy everything in their path, leaving a devastated "lunar" landscape, where only a few hours earlier an architectural coral reef was blooming, which was sometimes up to 10 000 years old. Emphasis will be put on the destruction and conservation of these deep cold-water reefs, as well as the overfishing occurring at the surface.

Chemosynthetic ecosystems: exception to the rules

February 1977: revolutionary discovery.

The American submersible Alvin dives to a depth of 2500 m over the Galápagos Ridge and discovers a profusion of life: strange organisms of spectacular sizes and astonishing forms contrast radically with the desolate basaltic environment of the ridge. This is the very first discovery of hydrothermal vents. In the following years, a flurry of intense research leads to the discovery of hydrothermal chimneys at extremely high temperatures, rising to 15 or 20 m in height. Veritable organic forests surround them, composed of the tangled white tubes of giant worms with red plumes, fields of clams, teeming masses of blind shrimps and invertebrates which live under a constant rain of ashes...

How can such a dense fauna prosper in an environment characterized by toxicity, crushing pressures, and a total absence of light? The answer is chemosynthesis: specialized bacteria use the chemical substances belched forth by the chimneys to synthesize organic matter, and this serves as the basis for the entire hydrothermal food chain. Stated quite simply, bacteria substitute for green plants in this lightless world, and chemistry replaces solar energy. Alongside the well-known photosynthesis, we now must add this other process of primary production.

Other chemosynthetic habitats have since been identified across the oceans: cold methane seeps, frozen gas hydrates and whale carcasses...

Highlights of the exhibition

Animals

Having access to the oceans' depths – whether through the use of submersibles, remotely operated vehicles (ROVs) or trawling – requires exceptional means by definition: less than ten submersibles in the world are capable of reaching depths of more than 1000 meters (m). The specimens presented in the exhibition are extremely rare animals of which very few, if any, exist in good condition elsewhere. These fragile creatures are simply unrecognizable most of the time, as they are so damaged by the nets during trawling. Certain specimens in the exhibition *The Deep* have been captured in situ by the scientific samplers on submersibles or tethered robots. Others have been carefully trawled during oceanographic missions throughout the world. The visitor will thus be able to discover perfectly conserved anglerfishes (the most famous deep-sea fish amongst young children thanks to Finding Nemo) or the only whole colonies of deep-sea radiolarians displayed anywhere for example. The exhibition *The Deep* will bring together the largest collection of deep-sea creatures ever displayed. It will provide a unique opportunity to discover the reality of the deep first-hand, without the distance usually imposed by photographs and films.

Display method

Due to the differences in pressure, temperature, salinity, light and oxygen levels between deep and shallow waters, it is impossible for the deep fauna to survive at the surface. Deep-sea animals can therefore only be exhibited in preserved form. Generally this means conserving them in ethanol, which leads to the gradual loss of pigment, the alteration of their natural color, the dehydration of tissues and changes in their body structure.

As most of the animals have been specifically collected for this exhibition, they are fresh and have never been preserved in ethanol. They will be shown in a fluid environment which will be representative of their natural habitat.

In order to animate the creatures and create a naturalistic effect, invisible threads embedded in resin walls will be used to suspend them within the liquid.

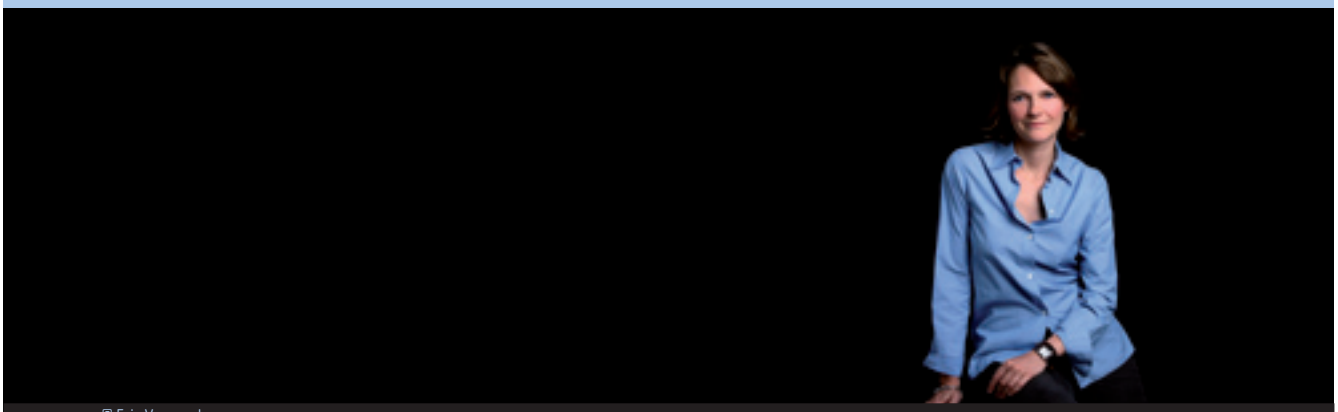
Display in resin

After several years of experimentation, the team behind the exhibition *The Deep* has pioneered a technique that allows the suspension of some of these marine creatures in resin. This shows them in an environment which is as true to life as possible. The transparent resin blocks do not discolor, and the creatures unravel so naturally that children often ask their parents if the animals are alive!

Films

The exhibition benefits from the extended scientific network that Claire Nouvian has consolidated with research institutes throughout the world and thus has access to breathtaking footage. Some of that footage was shot specifically for the exhibition.

Interview of Claire Nouvian, curator 1/2



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How was *The Deep* exhibition project born ?

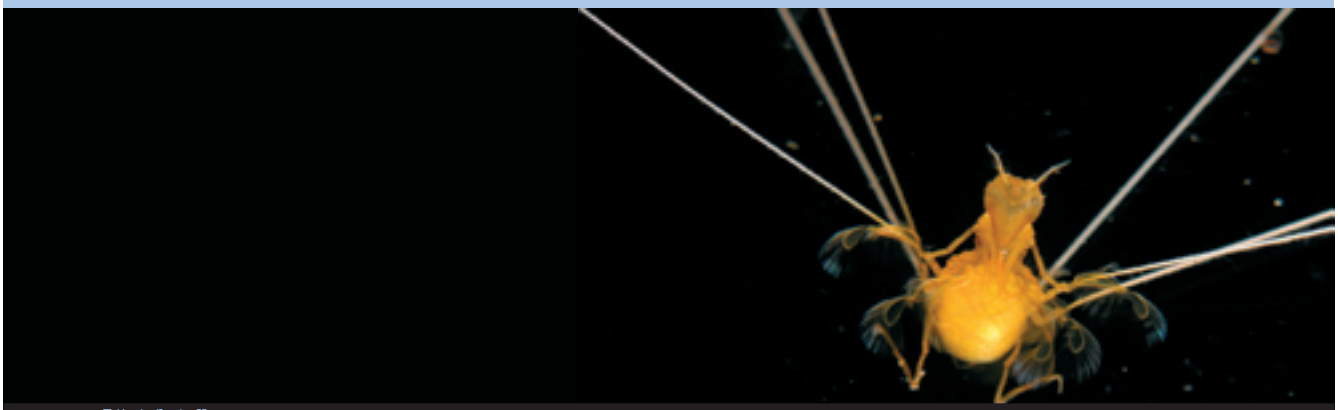
Claire Nouvian : The project was born when I discovered the footage shot in the deep-sea by the Monterey Bay Aquarium Research Institute (MBARI) in California in 2001. I dived with both feet into the abyss, driven by the immediate desire to break the news of these extraordinary discoveries to the largest number of people. In France, at the time, the public had never been informed about the riches of the deep water fauna, besides some creatures living near hydrothermal hot vents thanks to the esteemed rank occupied by our national research institute, Ifremer, in this scientific area. However, we knew nothing about the midwater world. Therefore I decided to get onto this fascinating subject in various ways: by imagining a series of documentaries for television, a book, an exhibition...I started with the documentary films and the book (between 2001 and 2006) and then, I developed the concept of the exhibition over several years with the assistance of architects, graphic artists, aquarium developers and taxidermists, in order to present the deep-sea world in the best possible conditions. Since my « abyssal » crush at the Monterey Bay Aquarium, my scientific knowledge and network became strong enough to create this exceptional event.

How can we say that this exhibition is unique in the world ?

CN : First of all, this exhibition presents an iconography never gathered before. We have capitalized on the massive research I undertook for my book. Therefore, in order to make our selection, we had at our disposal over 7,000 pictures taken in the deep-sea from many varied sources. A great number of them were taken in the course of oceanographic missions: on mid-ocean ridges, above the abyssal plains, near underwater canyons, seamounts, in the water column etc... It is a very rich and unique iconographic resource. I must add that what is true about pictures also applies to video footage: researchers also believe it is high time they shared with the public the sensational recent discoveries from the deep oceans. Research institutes cooperating with us on the project for the last several years -Ifremer in France and American institutes (notably MBARI) – have thus made available video footage of extraordinary quality for us.

Furthermore, this exhibition offers a double worldwide « première » thanks to two aspects:
Firstly, the collection of deep-sea animals gathered here is in all respects, unique, since most of these animals have never been shown to the public before. Having access to an extended scientific network allowed to multiply donations of creatures, whose aspect is at times surrealistic. Consequently, we are able to present a panorama extending from minuscule pelagic fish (living in midwater), to much larger-size specimens, such as ratfish or deep-sea sharks, and including middle-size « monsters », such as our anglers (the deep-sea « monster » in Finding Nemo).
Secondly, the presentation method of these animals has never been used before: thanks to the cooperation with the gifted taxidermist from the Paris Natural History Museum, Christophe Gottini, it is the first time that marine animals are being shown suspended in their aquatic environment, thanks to almost invisible strings fastened to resin inner walls cast on the edges of the aquariums. Everything we can see from these creatures is natural, nothing was altered.

INTERVIEW OF CLAIRE NOUVIAN, CURATOR 2/2



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What are, in your view, the most amazing animals in the exhibition ?

CN : This is a difficult question because each animal shows remarkable adaptations, this is why I insist that visitors should read the comments while watching the creatures. I think the small fish Stylephorus chordatus, with tube-shaped eyes and a huge pelican-like goitre, ending with a minuscule mouth, is probably the palm winner. The disproportion between both organs allows him to create a strong current and inhale its prey, a bit like the way humans gulp down their spaghetti by slurping them. This animal is so rare that I really thought it was just a legend. I burst with joy when the American researcher Tamara Frank gave it to me for the exhibition. We also have a very surprising creature which is as worthy as a masterpiece, considering its rarity: a gulper eel (Saccopharynx sp.) given to me by the biologist Steven Haddock. This fish is in perfect condition and to the best of my knowledge, it is the only specimen in the world caught in situ and shown to the public. This deep-sea eel has a huge jaw and an extensible stomach, allowing it to swallow gigantic preys compared to its size. Besides, the specimen presented here had just swallowed quite a big fish distorting its stomach, before being caught. We X-rayed it to try identify the prey but unfortunately, the result was unreadable because the stage of digestion was too advanced. We also have a couple of deep-sea « dragonfish » (Echiostoma barbatum) offered by the American ichthyologist Tracey Sutton. These are absolutely magnificent animals. All their ventral and lateral bioluminescent organs are untouched, their extremely delicate skin is intact, the photophores below the eyes which they use as torch lights are « as new ». It is the first time I have seen dragons in such good condition.
When you keep in mind the fact that never before has this fish been filmed, because it scuds the lights of submersibles, it is indeed greatly moving to be able to scrutinize it.
These are a few examples only, because the miniature white anglerfish, Haplophryne mollis, with its little horns on the top of its head and its big pimple between its eyes also deserves a look, without mentioning the terrifying Fangtooth Anoplogaster cornuta which seems to be only «skin and bones», or the monster Himantholophus groenlandicus with its huge head and its bioluminescent fishing rod hanging from its forehead as a lure to attract prey...

Deep-sea conservation is current a hot topic, how do you approach the issue ?

CN: First of all, by presenting the biologic diversity of the deep oceans. I am very concerned by the exploitation of deep-sea resources and habitat conservation, but I realized, after the release of my book *The Deep*, that it was difficult to interest the public to these conservation issues without first having shown them what does exist in the deep sea. Most people believe that there is no life at all in the ocean's depths, and a lot of them are actually even still unaware of the existence of hot springs (hydrothermal vents), although their discovery in 1977 was an international newsmaker...
Therefore, it is not surprising that many people have never heard of corals living in 2,000 meter waters, although they are already threatened by deep-se bottom trawling. Consequently, the exhibition aims to present the wealth of this living environment, and then will distil along the visit some striking information: life expectancy of deep-sea fish, age at which they reach sexual maturity etc...It is one way to commit oneself to the conservation of this fragile environment, and specifically address school kids, in order for these actors of the future not to be paralyzed by a counterproductive guilt that should not lie with them. We must continue to make them dream and give them the willingness to fight for whatever still lives on the earth.

Actors

Commissariat général

Claire Nouvian
Association BLOOM
www.bloomassociation.org +logo

Conseillers scientifiques

Peter Batson (Deep Ocean Quest, Australie)
Philippe Bouchet (Muséum national d'Histoire naturelle – MNHN)
Samuel Iglésias (Muséum national d'Histoire naturelle – MNHN)
Matthew Dunn (National Institute of Water and Atmospheric Research - NIWA, Nouvelle-Zélande)
Tamara Frank (Harbor Branch Oceanographic Institution - HBOI, USA)
Steven Haddock (Monterey Bay Aquarium Research Institution - MBARI, USA)
Peter MacMillan (NIWA, Nouvelle-Zélande)
Bertrand Richer-de-Forges (Institut de Recherche pour le Développement - IRD, Nouméa)
Michel Ségonzac (Institut Français de Recherche pour l'Exploitation de la Mer - Ifremer)
Brad Seibel (University of Rhode Island, USA)
Andrey Suntsov (National Oceanic and Atmospheric Administration - NOAA, USA)
Tracey Sutton (Harbor Branch Oceanographic Institution - HBOI, USA)
Marsh Youngbluth (HBOI, USA)
Edith Widder (Ocean Research & Conservation Association - ORCA, USA)
Les Watling (University of Hawaii at Manoa, USA)

Production déléguée	Columbia River Oregon Claire Forest Christophe Hébert
Graphisme	Julien Gaubert
Recherche iconographie & spécimens	Claire Nouvian - Association BLOOM
Assistants	Samantha Bailey Benoît Etienne Elizabeth Flew
Musique originale	Greg Corsaro
Préparation des spécimens	Christophe Gottini - MNHN Allan Gottini Yves-François Séguillon - MNHN

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