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Census offers glimpse of oceans' smallest lifeforms

By Mark Kinver
Science and environment reporter, BBC News

Modern technology has opened the world of marine microbes to scientists

An unprecedented number of tiny, ocean dwelling organisms have been catalogued by researchers involved in a global survey of the world's oceans.

One of the highlights was the discovery of a vast "microbial mat", covering an area equivalent to the size of Greece.

Microbes are estimated to constitute up to 90% of all marine biomass.

The findings form part of the Census of Marine Life (CoML), a decade-long project that will present its full results in October.

"In no other realm of ocean life has the magnitude of Census discovery been as extensive as in the world of microbes," said Mitch Sogin, leader of the International Census of Marine Microbes (ICoMM).

"It is really only in the last decade that we have had the technology that allowed us to start asking who was out there"

Professor Paul Snelgrove,
Leader of CoML Synthesis Group

In pictures: Oceans' tiniest life

"Scientists are discovering and describing an astonishing new world of marine microbial diversity and abundance."

The ICoMM was one of four of the Census's projects that focused on "hard to see" marine organisms.

The team, involving researchers from the Netherlands and the US, collected samples from more that 1,200 locations, which resulted in the compilation of a dataset containing in excess of 18 million DNA sequences.

CoML researchers suggested that the total number of marine microbes, based on molecular characterisation, could be in the region of one billion species.

They added that the micro-organisms were vital for sustaining life on Earth, as they are responsible for about 95% of respiration in the oceans.

"They play a really critical role in keeping the oceans working," said Paul Snelgrove, leader of CoML's Synthesis Group.

"Certainly, life in the oceans - and then life on Earth - would collapse very quickly without the microbes."

In the 1950s, scientists estimated that about 100,000 microbial cells inhabited in one litre of seawater. However, with the aid of modern technological advances, researchers now suggest that the figure is closer to one billion micro-organisms.

They have also calculated that the estimated total mass of marine microbes is equivalent to 240 billion African elephants.

'Microbial mat' found off S America

As part of the CoML, Chile-based researchers found a "microbial mat" off the south-west coast of South America that covered a vast area, equivalent to the size of Greece.

The mats were found at a depth where "oxygen minimum layers" (OML) occurred. These are regions where there is very little oxygen, or none at all.

However, the researchers found that the communities of microbes thrived on hydrogen sulphide, which is toxic to most lifeforms, and is the product of the breakdown of organic material in an environment where there is no oxygen.

The team - led by Victor Gallardo, vice-chairman of the Census Scientific Steering Committee - said the mats resembled an ecosystem that existed between 2.5bn and 650m years ago.

As well as microbes, scientists working on Census projects also assessed the diversity of zooplankton species; collected samples from abyssal plains, and hydrothermal vents and seeps.

Decade of discovery

Professor Snelgrove said it was thanks to recent technological advances that it was now possible for scientists to study "hard to see" organisms.

The diversity and abundance of "hard to see" species surprised scientists

"In the case of microbes, we could not tell them apart because they were so small and all looked the same," he told BBC News.

"Now we know that things that look identical do very different things in the oceans.

"It is really only in the last decade that we have had the technology that allowed us to start asking who was out there and what exactly were they doing."

He explained that information collected by the various projects will be listed on a open-access database called the Ocean Biogeographic Information System (Obis).

"Everyone who has participated in the Census has agreed to deposit their data into this database," he said.

Currently, Obis - which is accessible via the world wide web - has more than 27 million records covering in excess of 110,000 species.

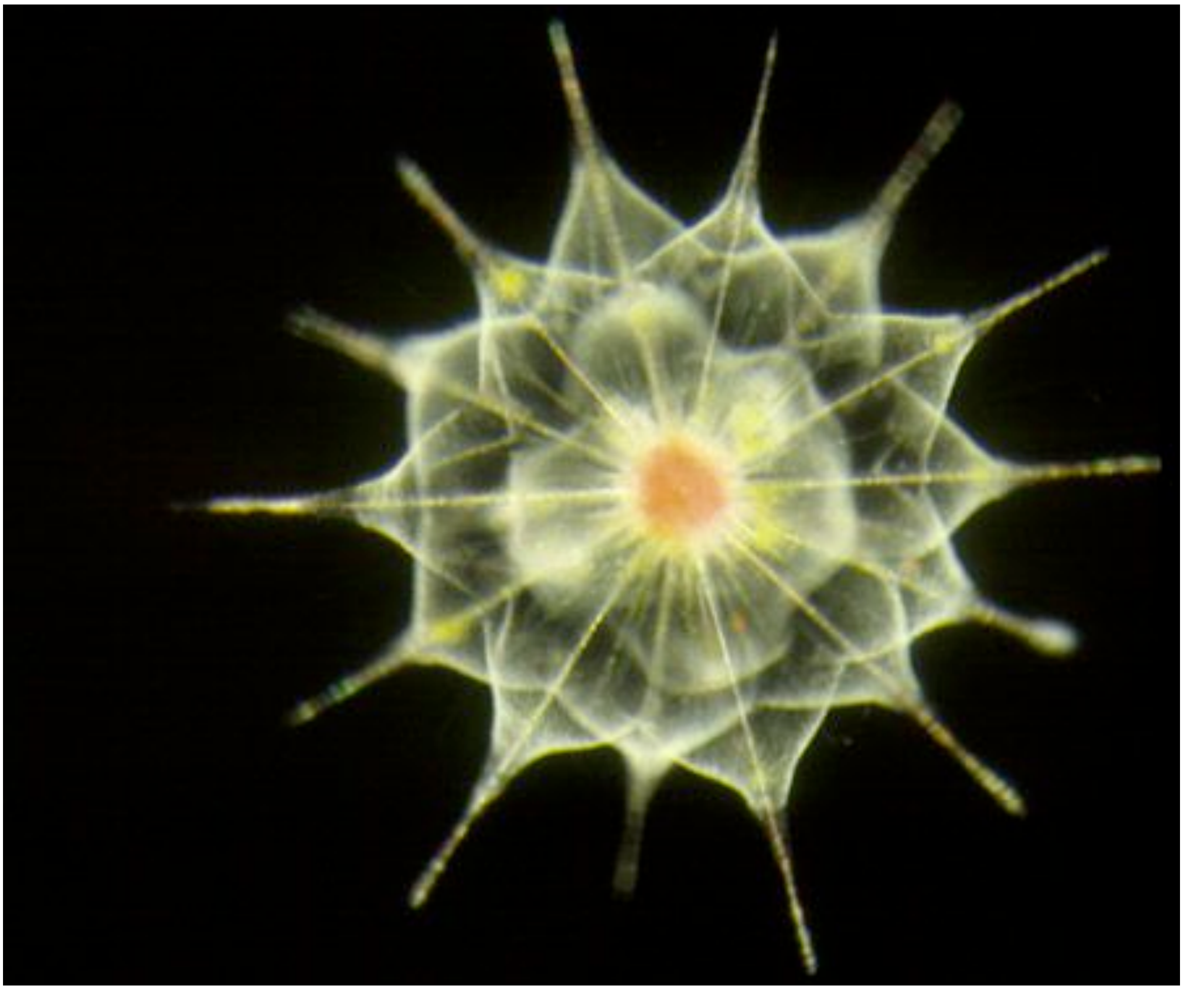
It contains a wide range of information, including details of a species; where it was recorded, and at what depth.

"This has led to the building up of this global ocean biodiversity dataset," Professor Snelgrove observed.

"This is already allowing people to test predictions about where life is in the oceans, where are the biodiversity hotspots and lowspots?

"I think it is going to be an extremely rich dataset to mine well into the future."

A final synthesis report will be published at the beginning of October to mark the end of the decade-long project involving in excess of 2,000 scientists from more than 80 nations.



Acantharian

This amoeba grow fragile, crystal shells of strontium sulphate. They're found almost everywhere across the world's oceans and lead their adult lives within 300 metres of the surface. During reproduction stages, the amoeba walls itself in and forms a cyst. This cyst falls like a microscopic snowflake towards the seabed and have been found as deep as 2000 metres.

Within the sinking shell, the amoeba divides several times so that when the strontium sulphate dissolves, daughter cells can feast on sinking dead phytoplankton.

Acantharians form cysts at any time of year, but the rate is highest in spring, possibly coinciding with the abundance of dead phytoplankton from algal blooms.

(Image: Dr. Linda Amaral Zettler)

Bacteriastrum

This phytoplankton lives on the surface of the ocean. The image clearly shows its spidery setae: long hair-like structures that radiate out from the central, silicate-walled cell. Rather than the familiar green chloroplasts of plants, its photosynthetic material is yellow-brown. This cylindrical microbe links up with neighbours to form filaments.

This specimen was captured off Martha's Vinyard in Massachusetts, part of the thriving *Bacteriastrum* community among the surface phytoplankton species there.

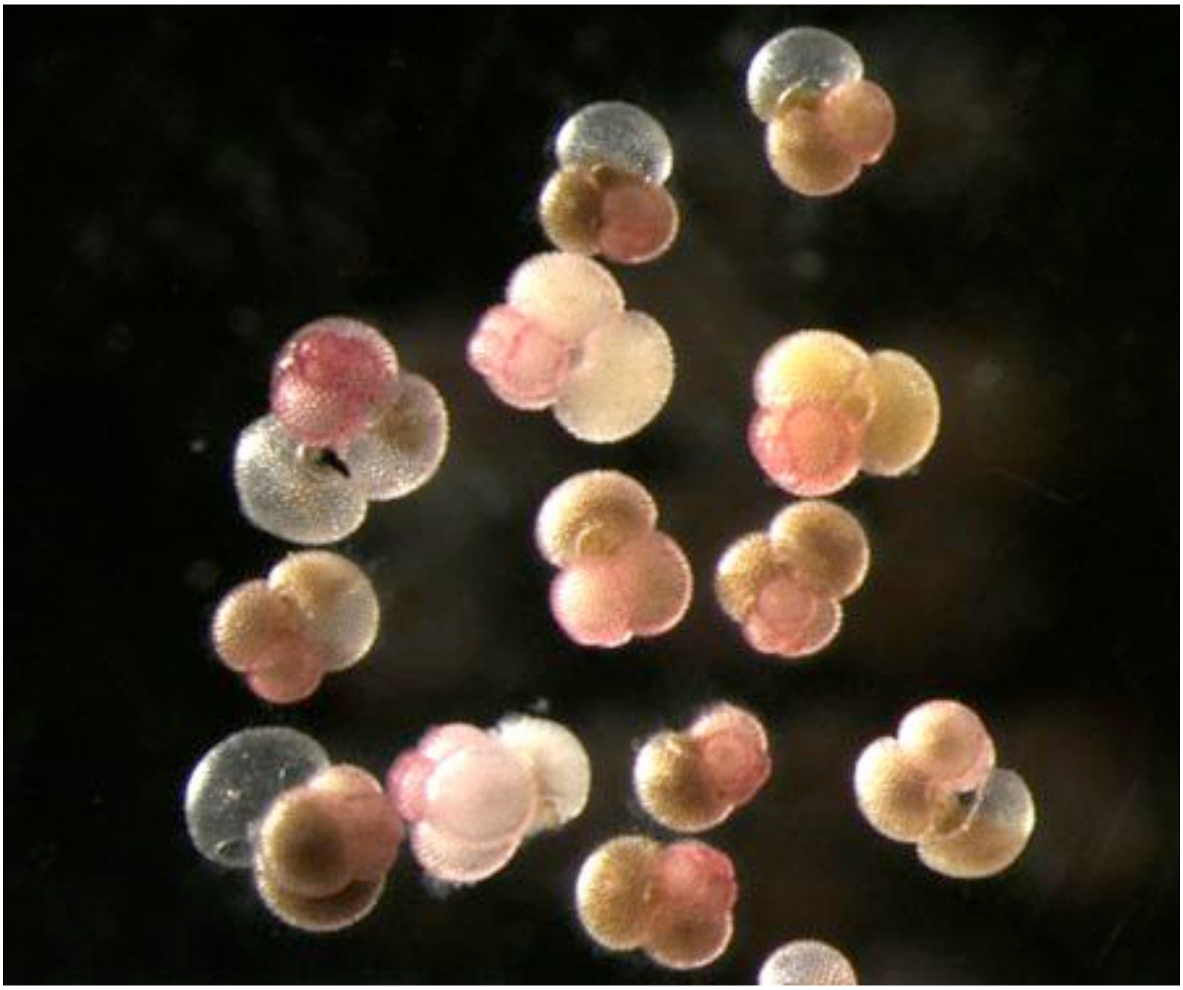
(Image: J. Cole)

Karenia brevis

Unassuming as this lonely specimen may appear, this single-celled alga is the cause of so-called "red tides" in the Gulf of Mexico, forming typically between August and February. During this period the multitude of *Karenia brevis* gives the water a reddish tinge. The algae secrete a neurotoxin that paralyses and kills fish by halting respiration, leaving many dead fish to wash onto the shore.

The flagella of *K. brevis* cause it to move in a spinning motion, and it can be photosynthetic.

(Image: Bob Andersen and D. J. Patterson)



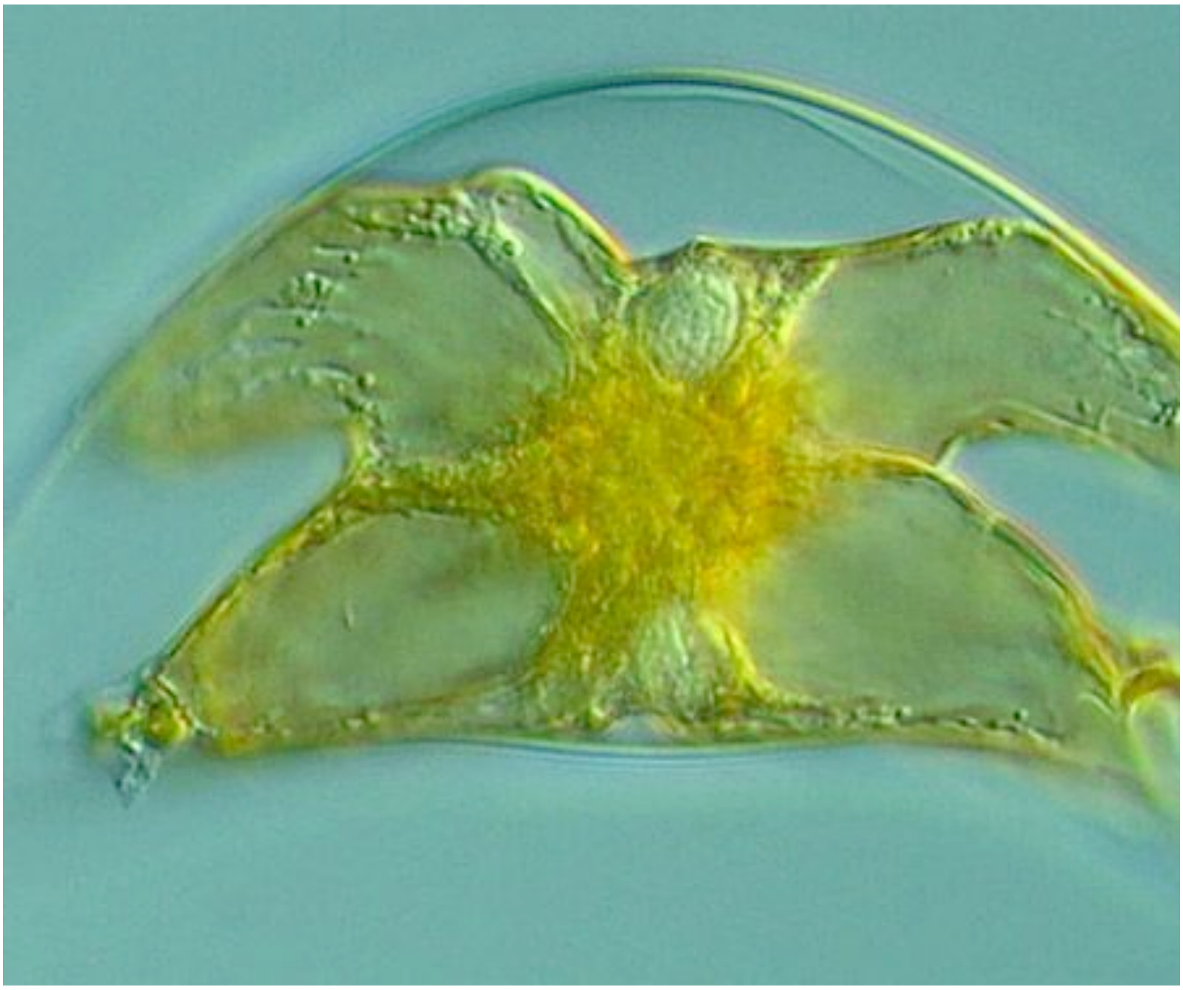
Foraminifera

These examples, found in the Sargasso Sea, build bubble-like defences of calcium carbonate or silicates. Within them live single-celled jelly-like plankton.

Living in the deepest parts of the ocean, they constantly "rain" dead plankton onto the sea floor. Their carbonate bubbles fossilise well, resulting in one of the most complete fossil records dating back to the mid-Jurassic period.

Their fossils are particularly valuable for dating nearby rocks and for historical climate science, because their bubble composition reflects the materials available at the time. In addition, geographical patterns in Foraminifera fossils can reveal ancient ocean currents.

(Image: Colomban de Vargas, EPPO/SBRoscoff)



Pyrocystis

The chloroplasts of this bioluminescent dinoflagellate follow the sun across the cell. This individual is dividing – the separated nuclei are visible above and below the central knot of photosynthetic material

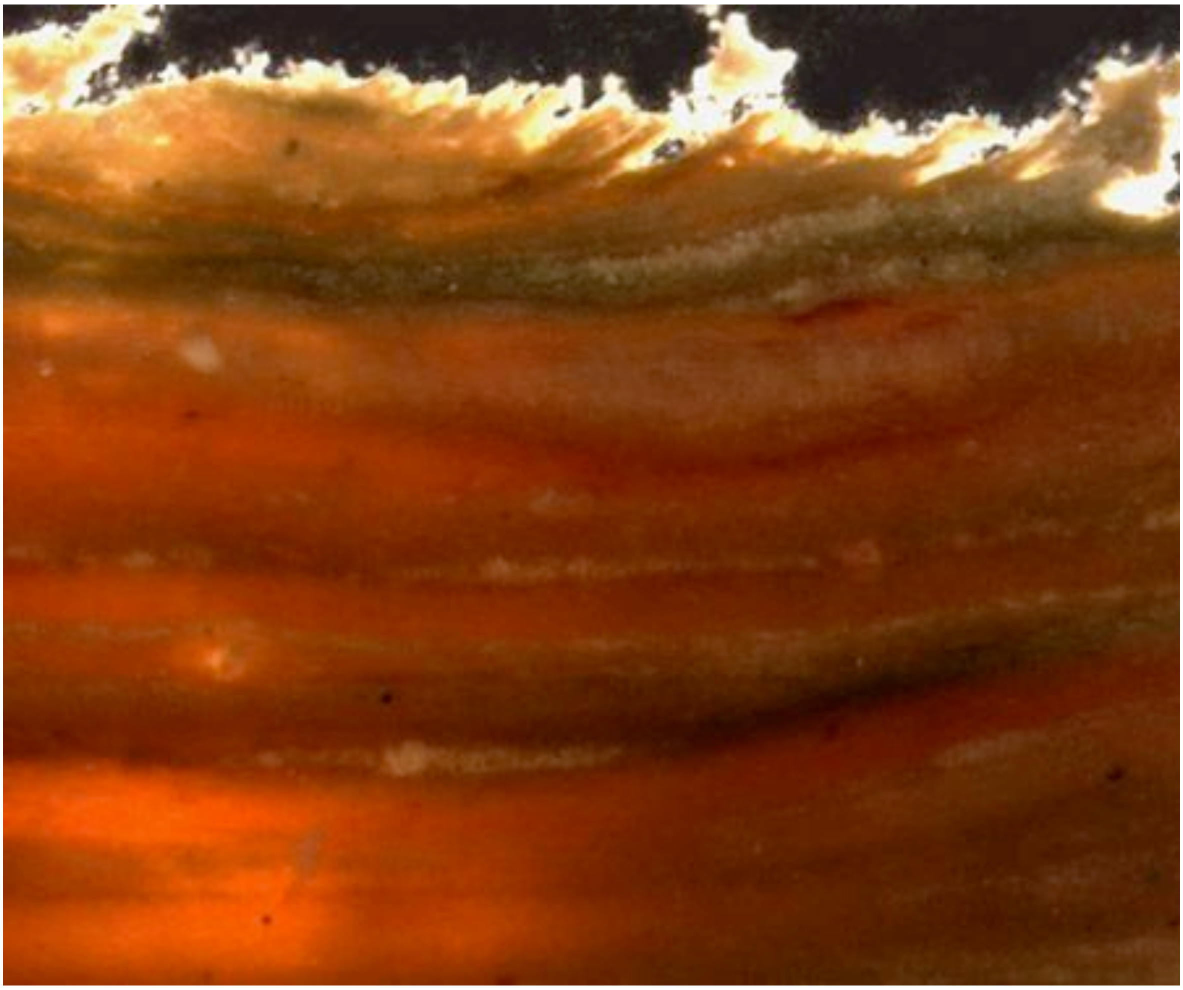
(Image: Bob Andersen and D. J. Patterson)

Pennate diatom

This slender microbe is a pennate, or feather-shaped, diatom. The brown photosynthetic elements are enclosed in a silicate "glasshouse". Made of two mirror-image halves, pennate diatoms developed after their cylindrical cousins.

Fresh water favours pennate diatoms. The porous, silicate shells are so finely marked that they are used to test microscopes' resolution. One such marking is the raphe, a groove often lined with cilia which is thought to be a mechanism that allows pennate diatoms to slowly glide through the water.

(Image: L Amaral-Zettler and D. J. Patterson)



Microbial mat

Microbial mats, thought once to have covered early Earth, are now restricted to regions of extreme conditions where competitors cannot survive: salt marshes, arid temperate deserts, hot springs or Antarctica.

As a layered combination of microbes, these mats form their own mini-ecosystems. Photosynthetic and chemotrophic bacteria live in the mats, with some microbes living off the by-products of others. They can respire both with oxygen, as we do, or without, depending on their depth in the mat.

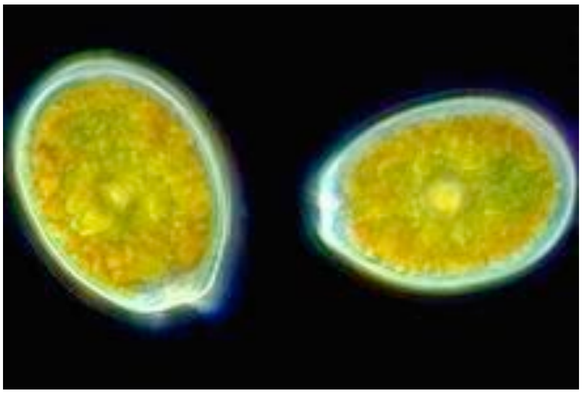
This particular mat cross-section comes from Baja California, a high-salinity area. The different groups of microbes are evident in the layers.

(Image: D. J. Patterson, under license to MBL)

Microbes at darkest depths create carpet size of a nation

By Steve Connor

4:00 AM Tuesday Apr 20, 2010



The Census of Marine Life project discovered organisms that live off hydrogen sulphide and nitrates in a deep layer of seawater. Photo / AP

A vast carpet of underwater microbes that covers an area as big as Greece has been discovered on the seabed off the west coast of South America.
Scientists believe the microbes could be directly descended from some of the earliest life forms to have evolved on Earth.

The discovery is part of a series of astonishing finds made since 2000 as part of the decade-long Census of Marine Life, an international project by more than 2000 scientists from 80 countries to explore the largely unknown life which inhabits the oceans.

The "microbial mat" lives in a deep layer of seawater that is deprived of light and oxygen and seems to have survived by "eating" hydrogen sulphide and "breathing" nitrates.

It could represent a present-day community of organisms descended from primitive microbes which first evolved about 3 billion years ago, when there was no oxygen on the planet.

Scientists said they were taken aback by the spectacle when the first images of the microbial mat appeared on the television screens from video cameras on board a submersible robot, which had been lowered into the deep ocean to explore the continental shelf off the coasts of Chile and Peru.

Article continues below

"It was like a big carpet of white grass with filaments sticking out and waving in the water, said Dr Victor Gallardo, a Chilean scientist on the expedition.

"It looks like a carpet lying on the seabed, separating the underlying sediment from the overlying water."

Initial tests showed the microbial mat is composed of a community of micro-organisms adapted to growing under extreme hypoxia, when there is little or no oxygen.

It is the same kind of conditions that existed before the evolution of the first photosynthetic algae, which were able to convert carbon dioxide into oxygen.

"The microbes in the mat play around with very simple stuff, such as hydrogen sulphide and nitrates. They use nitrates in the water as we would use oxygen and they take the sulphide as their food," Gallardo said.

Scientists estimate the mat extends over vast areas of the seabed in this region of the ocean, covering a territory roughly the size of Greece.

Explorers have found them off the central and northern parts of both Chile and Peru, and they have also been detected in sulphur-rich waters off the Galapagos islands, Ecuador and Panama.

The largest filaments of the mats are about half the width of a human hair and are composed of individual microbial cells organised into long multicellular strands that are white because of a build-up of sulphate salts in the living tissue. The bacteria within the mats are some of the biggest known.

"For most of the time in the history of the world, most of the ocean was anoxic so these species probably dominated the planet for hundreds of millions of years," said Professor Ron O'Dor, chief scientist on the Census of Marine Life and a marine biologist at Dalhousie University in Halifax, Canada.

"The DNA in these micro-organisms has probably been alive for longer than anything else on the planet," he added.

The Census of Marine Life, which publishes its final report in October, has discovered there are many more species of microbe living in the oceans than previously thought - in 2000 there was thought to be about 20,000 species of marine microbe but now the number is nearer to 20 million, O'Dor said.

Marine biologists working on the Census estimated the total weight of marine microbial life is equivalent to 240 billion African elephants - about 35 "elephants" of microbes per person living in the world.

- INDEPENDENT

By Steve Connor | Email Steve