Deep Seabed Mining

An urgent wake-up call to protect our oceans

July 2013

GREENPEACE

DEEP SEABED MINING
AN URGENT WAKE-UP CALL TO PROTECT OUR OCEANS

For more information contact: pressdesk.int@greenpeace.org

Written by:
Alicia Craw

Contributors:
David Santillo, Richard Page, Eleanor Partridge, Milko Schvartman, Sofia Tsenikli

Edited by:
Steve Erwood, Isabel Leal

Cover image © Greenpeace / Gavin Newman
Hydrothermal vents at Dom João De Castro.

JN 452
Published July 2013 by
Greenpeace International
Ottho Heldringstraat 5, 1066 AZ Amsterdam, The Netherlands
Tel: +31 20 7182000
greenpeace.org

DEEP SEABED MINING

Deep-sea jelly fish undulating several metres above the seafloor, just south of the IMAX vent at Lost City, Atlantic Ocean, Mid-Atlantic Ridge.

IFE, URI-IAO, UW, Lost City Science Party; NOAA/ OAR/OER; The Lost City 2005 Expedition.

© NOAA/Flickr/CC BY 2.0

An urgent wake-up all to protect our oceans

The deep sea is a place of myth and mystery, filled with weird and wonderful life forms, and vital to the survival of our planet. But now, this mostly unknown world is facing large-scale industrial exploitation – as mining of the deep seabed for minerals fast becomes reality. As land-based minerals become depleted and prices rise, the search for new sources of supply is turning to the sea floor. This emerging industry, facilitated by advances in technology, poses a major threat to our oceans, which are already suffering from a number of pressures including overfishing, pollution, and the effects of climate change.[1]

A growing number of companies and governments[2] – including Canada, Japan, South Korea, China and the UK – are currently rushing to claim rights to explore and exploit minerals found in and on the seabed, such as copper, manganese, cobalt and rare earth metals. There are currently 17 exploration contracts[3] for the seabed that lies beyond national jurisdiction in the deep seas of the Pacific, Atlantic and Indian oceans, compared with only 8 contracts in 2010. Contract holders will be able to apply for licences to carry out commercial mining in the high seas as soon as regulations for exploitation are developed – anticipated as early as 2016.[4] There is also significant exploration interest within national waters, particularly in the Pacific Ocean, and one licence to mine the deep seabed has already been granted in Papua New Guinean waters. However, very little is known about deep-sea habitats, or the impact that mining operations will have on ecosystems and the wider functioning of our oceans. Once thought to be relatively lifeless, scientists now recognise that the deep sea is actually a species-rich environment[5], with many species still to be discovered. Because deep-sea species live in rarely disturbed environments and tend to be slow growing and late maturing, with some unique to their particular habitat types (such as hydrothermal vents) or even specific locations, they are highly vulnerable to disturbance or even extinction.[6]

Deep seabed mining could have serious impacts on the ocean environment and the future livelihoods and wellbeing of coastal communities. Only 3% of the oceans are protected and less than 1% of the high seas[7], making them some of the least protected places on Earth. The emerging threat of seabed mining is an urgent wake-up call: the world's governments must act now to protect the high seas, including by creating a global network of marine reserves[8] that will be crucial sanctuaries at sea for marine life and the ecosystems which we all rely on for our survival. An international, multi-sector approach to management and protection is needed, if we are to ensure the health and sustainable use of our oceans.

The remote deep and open oceans host a major part of the world's biodiversity, and are vital for our survival on Earth.[9] The deep sea plays an important role in regulating planetary processes, including regulation of temperature and greenhouse gases.[10] It supports ocean life by cycling nutrients and providing habitat for a staggering array of species.

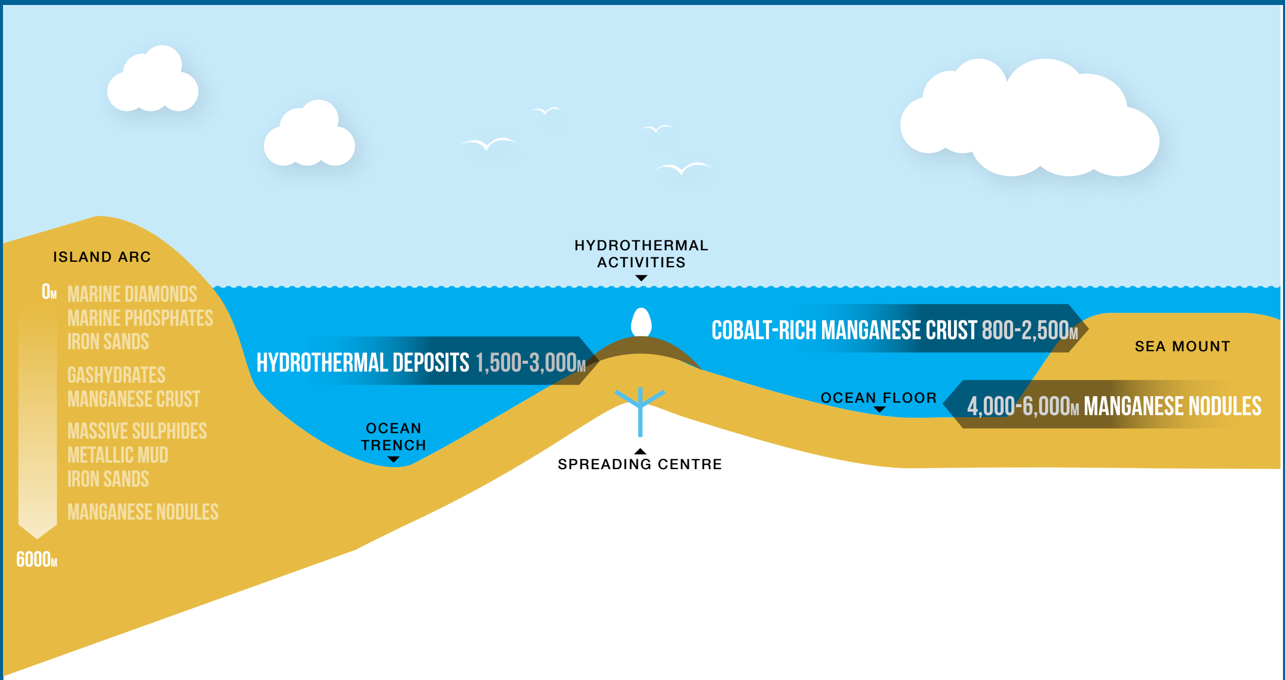
"Different forms of deep-sea mining in different parts of the ocean are likely to impact different types of deep-sea ecosystems, so predicting the impacts of these operations is difficult. This is both because it is difficult to model all of the likely impacts of such operations, and because of the limited scientific knowledge on the biological communities of the deep sea and the species that are found in them."

– Alex Rogers, Professor of Conservation Biology, University of Oxford

Mining methods

There are a variety of proposed methods for seabed mining, all of which will have major potential impacts on the marine environment. The Canadian company Nautilus Minerals Inc. proposes to use large robotic machines to excavate material by removing deep-sea hydrothermal chimneys and then cutting deeper into the sea floor. A suction hood and pipe behind the cutter head of the underwater robot will collect the material, along with anything living on it, which will be pumped up to a ship on the surface as slurry. On board the ship, the slurry mixture would be "dewatered", shifting the solid material into a barge, while the used seawater – containing sediments and heavy metals – would be pumped back down towards the sea floor using pipes.[11] Other companies, including UK Seabed Resources (a British firm owned by US defence giant Lockheed Martin), are investigating the option of vacuuming up manganese nodules that lie on the seabed.[12] Mining of deep-sea phosphates is also imminent, with the granting of a licence for dredging of the Sandpiper Deposit off Walvis Bay, Namibia[13] and other prospects being investigated on the Chatham Rise off New Zealand. The impacts will vary enormously depending on the technology used, which is currently untried.

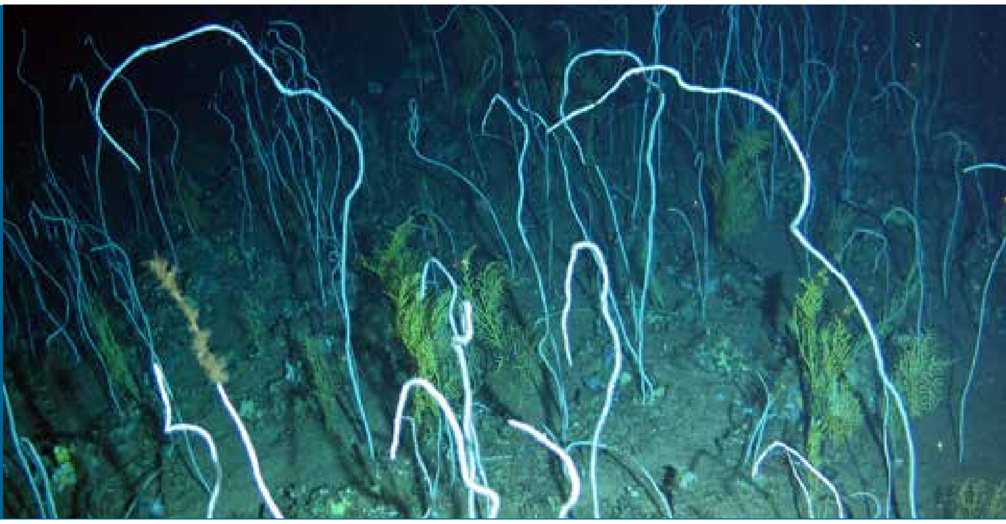
The deep-sea environment has not been extensively studied and some scientists suggest that a major research effort over 10 – 15 years is needed before we begin to understand this ecosystem.[14]



Physical locations of the three main types of deep-sea minerals

Resource	Depth	Key deposits	Key products	Resource size
Sea-floor massive sulphides and metalliferous muds	500-4,000m	East, southeast and northeast Pacific Rise; Red Sea	Copper, zinc, gold, silver	250 known deposits, ranging from 1 million to 100 million tonnes
Cobalt-rich manganese crusts	800-2,500m	South Pacific island states	Cobalt, rare earths, tungsten, tellurium	6.35 million km^2, producing up to 1 billion tonnes of cobalt
Manganese nodules	4,000-6,000m	Clarion-Clipperton zone, Peru Basin, Southern Ocean, North Indian Ocean	Cobalt, copper, nickel, manganese, rare earths	3 to 10 sites with total tonnage of 100 to 600 million tonnes

POTENTIAL IMPACTS

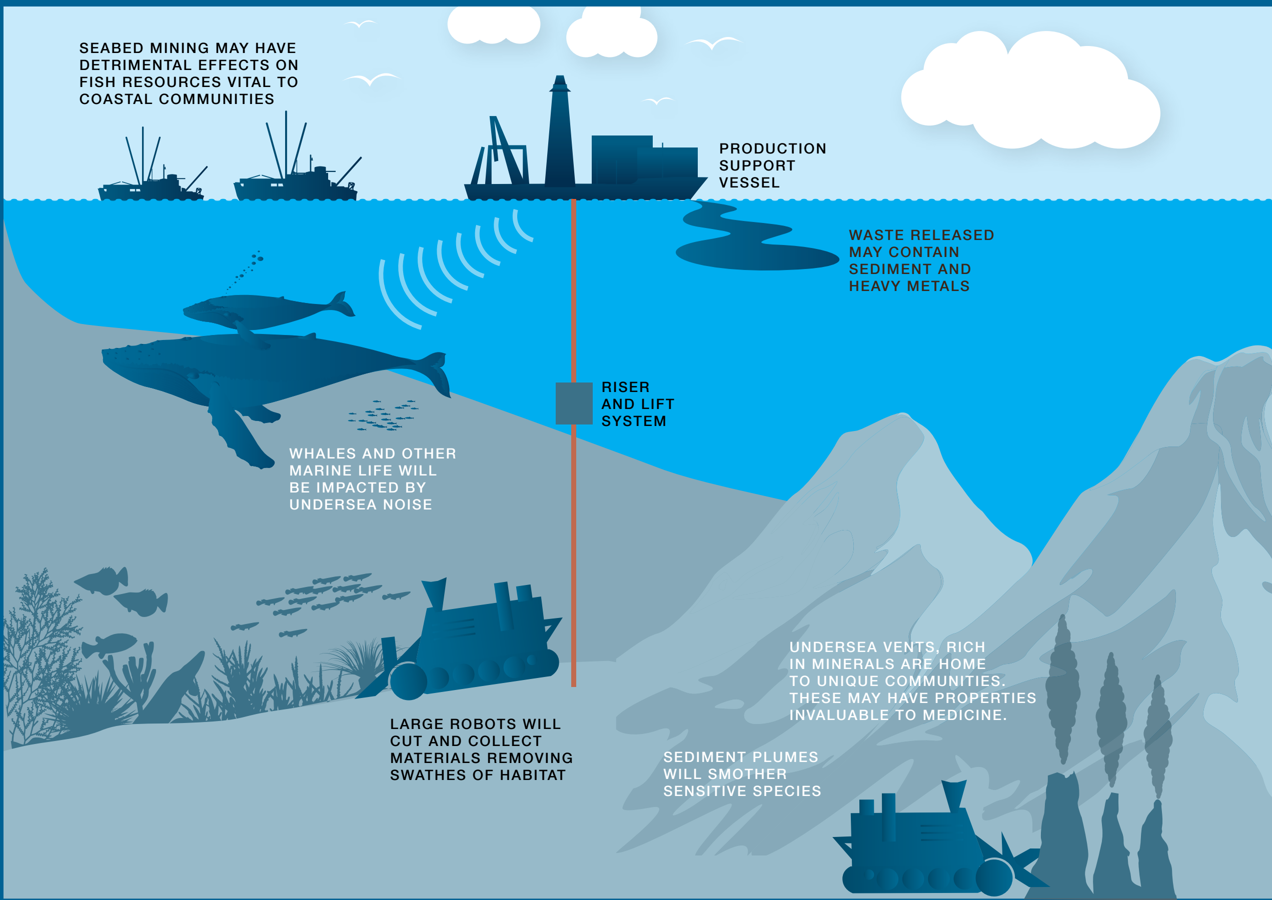


A dense field of whip coral (*Viminella flagellum*) found at 250 -300 metres. Colonies can grow to 3m long. © Greenpeace / Gavin Newman

Seabed mining poses a major threat to our oceans. All types of seabed mining will kill whatever can't escape the mineral extraction operations. Organisms that grow on the seabed will be smothered as a result of sediment disturbance and the discharge of waste. The current lack of scientific knowledge on the deep-sea environment, and the lack of knowledge of the technology employed, limits our ability to predict the environmental impacts of mining operations and to determine whether habitats can ever recover from the disturbance.[15]

We know that deep-sea species from many habitats, such as seamounts and abyssal plains, are particularly vulnerable due to their slow growth rates, their low resilience to changes in their environment, and slow recovery rates after disturbance.[16] Some hydrothermal vent communities may be more resilient to impacts because of the high natural levels of turnover of these ecosystems, although this is dependent on the underlying geology and biogeography of the individual systems.[17]

Mining licences for hydrothermal vents have already been granted to Nautilus Minerals by the Papua New Guinean government to mine for sea floor massive sulphides in national waters 1,500 metres under the sea, despite significant environmental concerns and community opposition. A study at the mining site found 20 new species, with more species likely to be found in the future.[18] The impacts on the actual mining site will be very high, but the resilience of this system is unknown, as are the effectiveness of the proposed efforts to assist natural recovery. The wider impacts of the mining operation on surrounding ecosystems are also unknown.[19]



Some of the environmental impacts of deep seabed mining.

Pollution and contamination

The release of sediment plumes[20], clouds of potentially toxic particles that will smother species and habitats, and could expose seabed communities to heavy metals and acid, is a major concern.[21] Even if they manage to survive the direct mining impact, filter-feeding organisms will have their feeding apparatus clogged by these sediments, causing starvation. Some plumes are likely to be nutrient rich, which could cause algal blooms and reduce oxygen concentrations.[22]

It will be hard to predict how these plumes may spread. It is likely to be impossible to restrict impacts from tailings, or the release of metals to a local area, due to the very nature of ocean currents.[23] Impacts that spread far away from the original site could potentially lead to international disputes. Pollution from dewatering, the removal of water from metals removed from the seabed, may contain heavy metals and other pollutants, which will be re-suspended if discharged into the water column.[24]

Potential contamination of the food chain?

Metals and other contaminants mobilised during mining or processing operations, as well as some processing chemicals themselves, could accumulate in the tissues of marine organisms, including fish. It is not clear how significant any increases above background contamination might be in any one case, and concerns have been raised by scientists and fishing communities in areas targeted for prospecting and mining, regarding the potential for tainting of fish or even the introduction of harmful levels of contaminants into the food chain.[25]

Noise and light pollution

Deep-sea communities live in relative silence, and in the dark. Studies have shown that deep-sea fish communicate at low sound frequencies[26], and are sensitive to acoustic changes to sense food falls – the fall of organic matter that provides an important source of nutrients to the deep sea[27]. Whales rely on sound for communication and navigation, and when encountering increased noise, change their vocalisation patterns and behaviour, and move away to new areas.[28] Studies show that baleen whales experience chronic stress when exposed to increased shipping noise.[29] Low-frequency mining noise could travel far from the mining site, with one estimate suggesting that noise from the Nautilus operation near Papua New Guinea could travel up to 600km from the site.[30] This could have negative impacts on deep diving whales in the area.

Mining will also introduce bright light into an environment that, but for bioluminescence, is constantly dark, impacting species that are adapted to these conditions, such as deep-sea vent shrimp, which have been shown to be blinded by the lights used by researchers.[31]

> "In order to assess the level of risk that human and ecological communities will face from DSM operations, it is essential to know the oceanographic characteristics of any particular site and the properties of the metals that will be dispersed there. Of particular concern is whether upwelling and currents could carry pollutants up out of the deep sea or from spills and leakages into marine food chains. In addition, we know virtually nothing about the chemical forms of the metals that will be released by DSM operations and the extent to which they will find their way into marine species and the seafood eaten by local communities."
>
> *– Dr Helen Rosenbaum, Co-ordinator of Deep Sea Mining Campaign*[32]

Rainbow deep-sea hydrothermal vent field, close to the Azores. © Missão Seahma, 2002 (FCT, Portugal PDCTM 1999MAR15281) w/ IFREMER

Undiscovered life at risk on deep-sea hydrothermal vents

The seabed and deep sea is the last frontier on Earth, the vast majority of it unexplored by humans. We have more detailed maps of Mars than we have of the seafloor. Some deep-sea communities, such as those found on and around hydrothermal vents, are barely understood. First discovered in 1977, these hydrothermal vents are like underwater hot springs, spouting out clouds of metal sulphides from within the Earth. As the hot clouds cool and solidify, they create towering chimneys, known as "black smokers". The organisms that live there are like nothing else on Earth, as they draw their energy not from the sun but from the chemicals gushing from the vents. These thriving communities live in an extreme environment – one that is dark, deep (up to 5,000m depth), hot (up to 400°C), and usually strongly acidic, yet hosts an extraordinary array of life.[33] Over 700 vent species have been discovered, and due to factors such as geographical isolation, many are unique to their particular regions or even locations. Species include giant tube worms, crabs, shrimps and fish.[34] On average, two new species were discovered every month for the 25 years up to 2002[35], and we've still barely scratched the surface.

The deep sea is also the largest reservoir of marine genetic resources, and is of major interest to pharmaceutical companies, a number of which already hold patents for products discovered in the deep.[36] Enzymes from hydrothermal vent species are estimated to have an annual commercial value of $150m US dollars.[37] Despite their intrinsic ecological and scientific value and their potential benefit to humankind, deep seabed mining could destroy these genetic resources before they are fully understood or even discovered[38] – resources that could, for example, hold cures for diseases such as cancer.

Boy fishing with a harpoon in Papua New Guinea.
© Markus Mauthe / Greenpeace

Impacts on fish populations

The impacts of seabed mining are expected to change species diversity and density in the mined area, resulting in changes to the food web, with potential impacts on ecosystems and fish populations of unknown duration. The extraction of minerals from the seabed will destroy seabed habitat, and depending on the location and the mining technique used, leave a flatter, compressed surface that could be unsuitable for recolonisation and habitat recovery, or smother habitat in mining tailings. On seamounts, mining will cause the destruction of centuries-old coral and sponge communities and change complex seabed topography into a flattened and rubble and sediment strewn sea floor.

Seabed mining could cause fish mortality, due to habitat loss and a decline in food sources. For example, phosphate extraction proposed in shallow water near Namibia is expected to impact fish populations through habitat and food source removal, with mining operations set to take place within migratory routes and spawning grounds.[39]

Similarly, within the deep sea, mineral deposits often occur in habitats that support important and diverse fish populations. For example, cobalt-rich crusts are often located on the flanks and summits of seamounts, underwater mountains that host a great abundance of species. These include slow-growing fish species such as orange roughy, grenadiers and redfish, the status of which – in the cases where data exist – is generally considered already overexploited or depleted by deep-sea fishing.[40] In cases where seamounts have been severely destroyed by bottom trawling, there has been no sign of recovery of large bottom-dwelling fauna five years after trawling stopped, highlighting the vulnerability of these communities.[41] Research suggests that it will take many decades or more for seamount communities to recover from such trawling.[42] Greenpeace has been calling for a ban on deep-sea bottom trawling to stop the potentially irreversible impacts of this destructive fishing practice on sensitive deep-sea habitats and species. The impacts of mining in these areas would be even more devastating to the already threatened fragile ecosystems of the deep ocean.

Boys in a boat, Papua New Guinea. Several communities have expressed their concerns about the environmental and socio-economic impacts of deep sea mining, including the Pacific Conference of Churches (PCC), representing 6.25 million Pacific people. © Markus Mauthe / Greenpeace

Manganese nodules in the eastern Pacific

Twelve contractors currently own exploration mining contracts issued by the International Seabed Authority (ISA) for the extraction of manganese nodules in the Clarion Clipperton Fracture Zone (CCFZ) between Mexico and Hawaii in the eastern central Pacific. The eastern Pacific supports an abundance and diversity of pelagic fish and lies on a major trans-Pacific pathway for tuna migration. It also contains key migration corridors for leatherback turtles across the Pacific from New Guinea, and from nesting beaches in California and Mexico to feeding grounds. It is also important for loggerhead turtles, blackfooted albatross and northern elephant seals.[43] Organisms including worms, crustacean larvae, sponges and molluscs, live within and on top of manganese nodules, as they provide one of the only hard substrates on the deep sea floor. The nodules are covered with single-celled organisms, and only a few studies have been carried out on these communities due to their delicate nature and the depth at which they live.[44] Nodules can take many millions of years to form, some growing by only 1 – 2 mm every million years[45], with nodules in the CCFZ growing at 10 – 50 mm every million years.[46] Their extraction would remove crucial habitat and cause local extinction of nodule fauna.[47]

The ISA has designated nine Areas of Particular Environmental Interest in the CCFZ. Mining is prohibited in these areas in order to protect biodiversity. However, areas licensed for mining were deliberately avoided in the placement of these protected areas. In other words, the protected areas were designed around the proposed mining sites, in part to protect the interests of mining claim holders, therefore inevitably compromising conservation goals. This approach highlights the perilous situation of ocean ecosystems, and reinforces the urgent need for a global network of marine reserves to be designated, both to protect the marine environment from multiple threats and to ensure sustainable use of our oceans into the future.

"We are deeply concerned and call for an immediate moratorium. The people of the Pacific have a right to determine for themselves what they want done on the ocean floor and they must be allowed to speak. The Pacific Conference of Churches were unequivocal that no further action should be taken by regional governments until there is empirical evidence on the effect that deep sea mining and exploration will have."

– PCC General Secretary Reverend Francois Pihaatae

Oily tar balls washing up on the shoreline.
© Rich Williamson / Greenpeace

Potential for accidents

Seabed mining projects could cause further environmental damage if accidents occur. The loss of an ore barge or ship would risk thousands of tons of toxic ore, fuel and other hazardous material being released into the open sea or the near-shore environment.[48] Accidents could also occur on the seabed, such as oil or hydraulic fluid leaks from machinery.

Cumulative impacts of a seabed mining rush

No proposed mining operations consider the cumulative impacts of their extraction in their assessments. It may be impossible to predict the cumulative impacts without more scientific understanding of direct impacts in the first place.[49] There is no strategy in place to assess cumulative impacts of deep-sea mining and other activities such as deep-sea fishing; and there is a lack of governance to manage and conserve the environments under exploitation.[50]

Alternatives to seabed mining

As the production of electrical products has increased, so has the volume of waste electronic and electrical equipment (e-waste), which is now considered the fastest growing waste stream in the world.[51] With land-based resources of certain metals becoming scarce, and seabed mining posing such a significant environmental risk, it is crucial that e-waste is recycled responsibly, to extract valuable materials from discarded products such as mobile phones and laptops rather than disposing of them in landfills.[52] For example, a mobile phone at the end of its lifespan can be responsibly recycled in order to recover materials – such as gold, copper and silver – that were used to build it.

Responsible e-waste recycling can be a more efficient way to source metal than mining virgin ore, and can provide larger volumes of metal than virgin stocks.[53] Some experts claim that electronic waste now contains precious metal "deposits" 40 to 50 times richer than ores mined from the ground.[54] The responsible recycling of minerals would also create jobs and business opportunities.[55]

Rather than turning to the seabed for future sources of minerals, end-user industries should invest in designing products that minimise the use of these minerals and have a longer life, as well as take responsibility for reusing and recycling initiatives, including effective take-back schemes for their own products.

THE URGENT NEED FOR HIGH SEAS PROTECTION

Basalt ridge with crinoids, corals, and sponges, New England seamount chain.

IFE, URI-IAO, UW, Lost City Science Party; NOAA/OAR/OER; The Lost City 2005 Expedition.
© NOAA/Flickr?CC BY 2.0

The current way of managing the high seas puts corporate interests before the long-term health of our oceans. If states or corporations want to fish, drill or mine the high seas, there are organisations and processes that enable them to do so. In the case of seabed mining, the International Seabed Authority was set up to control all mineral-related activities, including deep-sea mineral exploration and extraction. However, there is still no agreed global process to identify and create multi-sector protected areas and marine reserves on the high seas, let alone monitor and control them. Currently only a tiny fraction - less than 1% of the high seas - is protected, despite political commitments to protect 10% of the word's ocean by 2020 and scientists recommending 20-50% protection.[56] There is also no global requirement for the industry to undertake environmental impact assessments that take into account the cumulative impacts of human activities, before extractive and potentially damaging activities were allowed to take place on the high seas.

This is why **Greenpeace is demanding a high seas biodiversity agreement under the UN Convention on the Law of the Sea (UNCLOS), to protect marine life in areas beyond national jurisdiction**. This agreement would enable the establishment, monitoring and enforcement of marine protected areas and marine reserves, and mandate a requirement for robust environmental impacts assessments for high seas activities. The large majority of countries support a global agreement to protect the high seas, but a small number continue to slow progress. **At the Rio+20 summit that took place in June 2012**, governments committed to take a decision on the development of **a global agreement under UNCLOS by the end of 2014**, at the UN General Assembly, where issues can be taken to a vote.[57] **Nations must now take this forward with urgency and determination**.

Sea urchin on a cold-water reef, Inner Hebrides, North Atlantic.

© Greenpeace / Gavin Newman

Marine reserves: sanctuaries at sea

Marine reserves are proven and effective tools to conserve and protect marine biodiversity, fish populations and vulnerable marine ecosystems. Within the deep sea context, marine reserves also provide a mechanism for protecting not just what is known at present to be important, but what may turn out to be important in the future.

Deep seabed habitats – including hydrothermal vents, seamounts and cold-water corals – form particularly vulnerable and unstudied ecosystems that require robust protection regimes. According to the UN, it is estimated that conserving 20% to 30% of the oceans through a global network of marine protected areas could create a million jobs and sustain a fish catch worth $70-80bn US dollars a year.[58]

GREENPEACE'S POSITION

The spiral tube worm, *Sabella Spallanzanii*, lives in membranous tubes, often reinforced by the inclusion of mud particles, and has a feathery, filter-feeding crown that can be quickly withdrawn into the tube when danger threatens.

© Greenpeace / Gavin Newman

Given the experimental nature of seabed mining, the fragile, highly valuable, and often undiscovered environments at risk, and the potential impact on human communities, the rush to mine the oceans before ecosystems are protected provides yet another example of states putting short-term financial interests above long-term benefits.

Unless the institutional framework is in place to ensure that the global commons are effectively protected Greenpeace believes that the carving up of the sea floor for mining by states and corporations must be stopped. **Greenpeace demands that no seabed mining applications are granted, and that no exploration or exploitation takes place,[59] unless and until the full range of marine habitats, biodiversity and ecosystem functions are adequately protected**, including:

- a high seas biodiversity agreement adopted under UNCLOS that provides the global framework for the conservation and sustainable use of marine biodiversity in areas beyond national jurisdiction;
- establishment of a global network of marine reserves, covering 40% of the world's oceans, where all extractive activities are prohibited; and
- rules to ensure that the environmental and cumulative impacts of seabed mining, as well as potential impacts on alternative uses and livelihoods, have been thoroughly assessed and properly addressed in advance.

Governments and industries seeking to exploit the oceans must recognise that with rights come responsibilities. Putting sustainability first and adopting a precautionary approach to any seabed mining development is the only way to ensure that the oceans – a vital part of the life support system of our planet – continue to provide essential ecosystem services and resources now and in the future.

The oceans hang in the balance. There is no more time to waste. On top of a number of other existing threats, our oceans could face the potentially devastating impacts of deep seabed mining by 2016. All countries in favour of high seas protection must now join forces and act together for healthy oceans and the millions of people that depend on them.

CALLING FOR A HIGH SEAS BIODIVERSITY AGREEMENT

A high seas biodiversity agreement under UNCLOS is urgently needed to ensure healthy and productive marine ecosystems across the world's oceans. Only a global agreement can provide a coherent and integrated approach for biodiversity in all areas beyond national jurisdiction. The agreement should provide:

- An explicit mandate for the protection, conservation and sustainable use of biodiversity in areas beyond national jurisdiction.
- Implementation tools, such as a mechanism to establish, monitor and control marine reserves; and to undertake environmental impact assessments (EIAs) and strategic impact assessments (SEAs) in areas beyond national jurisdiction.
- Harmonisation and coordination among relevant instruments or regional, international and intergovernmental bodies.
- A mechanism for the access and equitable benefit sharing of the utilisation of marine genetic resources (MGRs).
- A centralised monitoring, control and surveillance system with a register and database of all high seas fishing vessels.

"The dangerous combination of increased industrial pressure, high sensitivity to human disturbance, poor scientific understanding, and virtual absence of protected areas, heralds long-term, even irreversible, environmental destruction in the deep sea. We need an immediate moratorium on all deep sea mineral development until we first have a clear understanding of the risks and impacts, and until we have established large protected areas of the deep ocean permanently free from any commercial development".

– Professor Richard Steiner, 22 May 2013[60]

Endnotes

1 See Greenpeace International (2013). Oceans in the Balance: the crisis facing our waters. 2nd Edition, http://www.greenpeace.org/international/en/publications/Campaign-reports/Oceans-Reports/Oceans-in-the-Balance/

2 ISA exploration contracts as of 12 June 2013, by date of applicants' submissions:
2001: IFREMER/AFERNOD (France); State Enterprise Yuzmorgeologiya (Russia); Deep Ocean Resources Development Company (Japan); China Ocean Mineral Resources Research and Development Association (COMRA) (China); Interocean Metal Joint Organization (IOM) (Bulgaria, Cuba, Czech Republic, Poland, Russian Federation and Slovakia); South Korea.
2002: India
2006: The Federal Institute for Geosciences and Natural Resources of the Federal Republic of Germany (Germany)
2011: Nauru Ocean Resources Ltd (Nauru); Russian Federation; China Ocean Mineral Resources Research and Development Association (COMRA) (China).
2012: Tonga Offshore Mining Ltd (Tonga); South Korea; IFREMER (France); UK Seabed Resources Ltd (UK); Marawa Research and Exploration Ltd (Kiribati); G-Tec Sea Minerals Resources NV (Belgium)

3 According to information on International Seabed Authority website, correct as of July 2012, when last ISA AGM was held.

4 Clark AL, Clark JC & Pintz S (2013). Toward the Development of a Regulatory Framework for Polymetallic Nodule Exploitation in the Area. ISA Technical Study No 11. International Seabed Authority. http://www.isa.org.jm/files/documents/EN/Pubs/TStudy11.pdf

5 Ramirez-Llodra E, Tyler P, Baker M, Bergstad O, Clark M, Escobar E, Levin L, Menot L, Rowden A, Smith C & Van Dover C (2011). Man and the last great wilderness: human impact on the deep sea. PLoS one 6(7).

6 Ibid

7 Spalding et al (2013). Protecting Marine Spaces: Global Targets and Changing Approaches; Ocean Yearbook 27: 213 – 248

8 Areas free from all industrial activities, including mining and fishing.

9 Koslow T (2007). The Silent Deep: The Discovery, Ecology and Conservation of the Deep Sea.

10 Armstrong CW, Foley N, Tinch R & Van den Hove S (2010). Ecosystem goods and services of the deep sea. Deliverable D6.2 HERMIONE Project (p. 68); and
Armstrong CW, Foley NS, Tinch R & Van den Hove S (2012). Services from the deep: Steps towards valuation of deep sea goods and services. Ecosystem Services, 2, 2-13.

11 Nautilus Minerals (2008). Environmental Impact Statement.
http://www.cares.nautilusminerals.com/Assets/Documents/Main%20Document%20Text.pdf [Accessed 13 May 2013].

12 BBC News (2013) UK Seabed Resources joins deep-ocean mineral mining rush. [online]
http://www.bbc.co.uk/news/science-environment-21774447 [Accessed: 15 May 2013].

13 http://www.unionresources.com.au/?page=25

14 Wilson C (2012). Environmental Uncertainties Halt PNG Deep Sea Mining. 21 December 2012, Jakarta Globe.
http://www.thejakartaglobe.com/international/environmental-uncertainties-halt-png-deep-sea-mining/562974 [Accessed 17 January 2013].

15 The impacts outlined in this report represents information gathered for Greenpeace from modelling studies, benthic disturbance experiments, scientific information and observations by companies involved in mining operation development. Extensive deep-sea data is needed to predict impacts, but this is currently lacking. Allsopp M, Miller C, Atkins R, Rocliffe S, Tabor I, Santillo D & Johnston P (2013). A Review of the Current State of Development and the Potential for Environmental Impacts of Seabed Mining Operations. Greenpeace Research Laboratories Technical Report (Review) 03-2013: 50pp.

16 Rodrigues N, Sharma R & Nagender Nath B (2001). Impact of benthic disturbance on megafauna in Central Indian Basin. Deep-Sea Research II 48:3411-3426;
Rosenbaum H (2011). Out of our depth: mining the ocean floor in Papua New Guinea. MiningWatch Canada, CELCOR PNG and Oxfam Australia.
http://www.deepseaminingoutofourdepth.org [Accessed 4 January 2013]

17 Personal communication. A Rogers, deep-sea biologist, Professor of Conservation Biology, University of Oxford. 29 May 2013.

18 Referred to in Steiner R (2009). Independent review of the environmental impact statement for the proposed Nautilus Minerals Solwara 1 seabed mining project, Papua New Guinea. Bismarck-Solomon Indigenous Peoples Council.
http://www.deepseaminingoutofourdepth.org/wp-content/uploads/Steiner-Independent-review-DSM1.pdf [Accessed 10 May 2013]

19 Deep Sea Mining (2011), Catalyst Program, Australian Broadcasting Commission, 9 June;
Personal communication, A Rogers op cit.

20 Sediment plumes will be caused by the mining operation on the seabed and by the dewatering of the mined slurry, which will be pumped back into the ocean.

21 Van Dover C (2010). Mining seafloor massive sulphides and biodiversity: what is at risk. ICES Journal of Marine Science 68:341-348.

22 Rosenbaum H (2011), op cit.

23 For example, tailings disposal from Lihir gold mine in Papua New Guinea spread over an area of 60km^2 from the outfall pipe due to subsurface currents: Shimmield TM, Black K, Howe J, Highes D & Sherwin T (2010). Final Report: Independent Evaluation of Deep-Sea Tailings Placement (STP) in PNG. Project Number 8.ACP.PNG.18-B/15, Scottish Association of Marine Sciences Research Services Limited.

24 Nautilus Minerals (2008), op cit.

25 Luick J (2012). Physical oceanographic assessment of the Nautilus EIS for the Solwara 1 project.
http://www.deepseaminingoutofourdepth.org/wp-content/uploads/EIS-Review-FINAL-low-res.pdf [Accessed 10 May 2013] and; Steiner R (2009), op cit.

26 Rountree R, Juanes F, Goudey C & Ekstrom K (2011). Is biological sound production important in the deep sea? In: Popper A & Hawkins A (Eds). The effects of Noise on Aquatic Life. Advances in Experimental Medicine and Biology vol 730. Springer, Pp.695.

27 Stocker M (2002). Fish, mollusks and other sea animals' use of sound, and the impact of anthropogenic noise in the marine acoustic environment. Journal of the Acoustical Society of America 112:2431-2457.

28 Nowacek D, Thorne L, Johnston D & Tyack P (2007). Responses of cetaceans to anthropogenic noise. Mammal Review 37:81-115.

29 Rolland R, Parks S, Hunt K, Castellote M, Corkeron P, Nowacek D, Wasser S & Kraus S (2012). Evidence that ship noise increases stress in right whales. Proceedings of the Royal Society B: doi:10.1098/rspb.2011.2429 published online.

30 Steiner R (2009), op cit.

31 Herring P, Gaten E & Shelton P (1998). Are vent shrimps blinded by science? Nature 398:116.

32 http://www.deepseaminingoutofourdepth.org

33 Ramirez-Llodra E et al (2011), op cit.

34 Desbruyères D, Segonzac M & Bright M (Eds) (2006). Handbook of the deep sea hydrothermal vent fauna. Land Oberösterreich, Biologiezentrum der Oberösterreichische Landesmuseen, Pp.544

35 Van Dover C, German C, Speer K, Parson L & Vrijenhoek R (2002). Evolution and biogeography of deep-sea vent and seep invertebrates. Science 295:1253–1257.

36 Armstrong CW et al (2012), op cit.

37 United Nations University (2007). An Update on Marine Genetic Resources: Scientific Research, Commercial Uses and a Database on Marine Bioprospecting. http://www.ias.unu.edu/resource_centre/Marine%20Genetic%20Resources%20UNU-IAS%20Report.pdf [Accessed 6 February 2013].

38 UNEP (2012). Green economy in a blue world. UNEP, FAO, IMO, UNDP, IUCN, WorldFish Center, GRIDArendal. http://www.unep.org/greeneconomy [accessed 2 June 2013].

39 Midgley J (2012). Environmental impact assessment report for the marine component - Sandpiper project. Pp.17 http://www.envirod.com/draft_environmental_impact_report2.html [Accessed 20 January 2013].

40 Norse EA, Brooke S, Cheung WWL, Clark MR et al (2011). Sustainability of deep-sea fisheries. Marine Policy 36(2): 307-320.

41 Althaus F, Williams A, Schlacher T, Kloser R, Green M, Barker B, Bax N, Brodie P & Schlacher-Hoenlinger M (2009). Impacts of bottom trawling on deep-coral ecosystems of seamounts are long-lasting. Marine Ecology Progress Series 397:279-294.

42 Ibid.

43 Roberts CM, Mason L, Hawkins JP et al (2006). Roadmap to Recovery: A global network of marine reserves; Environment Department, University of York.

44 Veillette J, Sarrazin J, Gooday A, Galéron J, Caprais J, Vangriesheim A, Étoubleau J, Christian J & Kim Juniper S (2007). Ferromanganese nodule fauna in the Tropical North Pacific Ocean: Species richness, faunal cover and spatial distribution. Deep-Sea Research I 54:1912-1935.

45 Ghosh A & Mukhopadhyay R (2000). Mineral Wealth of the Ocean: a treatise on distribution, origin, exploration, mining, and management of sea floor non-living resource. Taylor & Francis Pp.200.

46 Dymond J, Lyle M, Finney B, Piper DZ, Murphy K, Conard R & Pisias N (1984). Ferromanganese nodules from MANOP Sites H,S, and R—control of mineralogical and chemical composition by multiple accretionary processes. Geochim. Cosmochim. Acta, 48:931-950, in Schulz H & Zabel M (2006). Marine Geochemistry 2nd Edition.

47 Glover A & Smith C (2003). The deep-sea floor ecosystem: current status and prospects of anthropogenic change by the year 2025. Environmental Conservation 30:219-241

48 As noted in Steiner R (2009), op cit.

49 Rosenbaum H (2011), op cit.

50 Van Dover C, Smith C, Ardron J, Dunn D, Gjerde K, Levin L, Smith S & The Dinard Workshop Contributors (2012). Designating networks of chemosynthetic ecosystem reserves in the deep sea. Marine Policy 36:378-381.

51 UNEP (2011) Manual 3: WEEE / E-waste "Take Back System.

52 Reck BK & Graedel TE (2012). Challenges in Metal Recycling. Science, 337(6095), p.690–695. http://www.sciencemag.org/content/337/6095/690 [Accessed 14 January 2013].

53 UNEP (2011), op cit.

54 United Nations University (2012) E-waste: Annual Gold, Silver "Deposits" in New High-Tech Goods Worth $21 Billion+; Less Than 15% Recovered. [press release] 6 July 2012. http://unu.edu/news/releases/step-news-release-6-july-2012-e-waste-precious-metals-recovery.html

55 Coalition for American Electronics Recycling,(2011). Supporting the responsible electronics act.

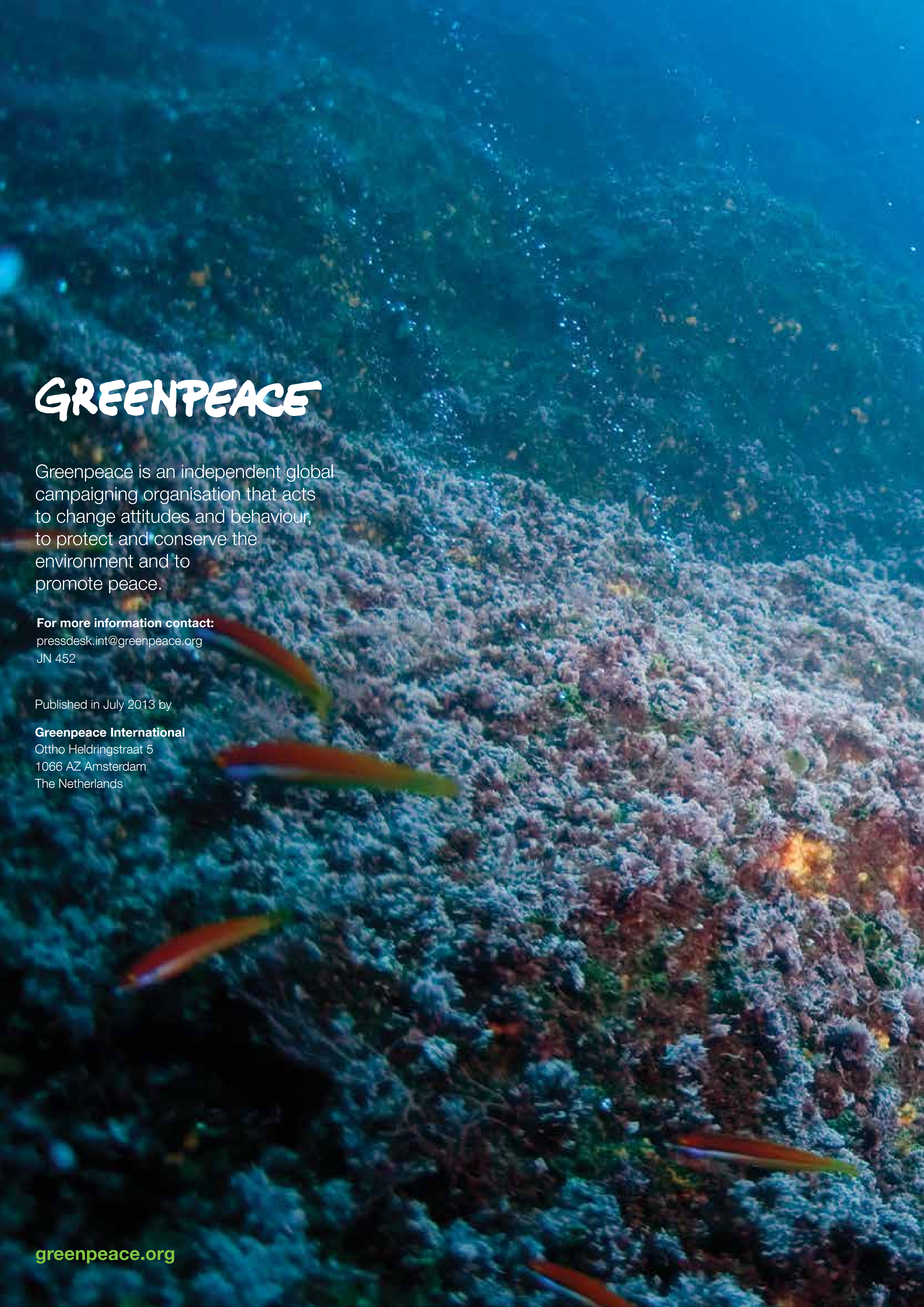
56 Roberts CM & Hawkins JP (2000). Fully-protected marine reserves: a guide. WWF Endangered Seas Campaign, 1250 24th Street, NW, Washington,DC 20037,USA and Environment Department, University of York,York,YO10 5DD,UK. ISBN: 2-88085-239-0. This review found that the majority of nearly 40 studies concluded that between 20% and 50% of the oceans should be protected to achieve the conservation of viable populations, support fisheries management, secure ecosystem functions and assure sufficient connectivity between marine reserves in networks.

57 United Nations (2012) Outcome document of the United Nations Conference on Sustainable Development, entitled "The future we want", adopted by UNGA Resolution A/RES/66/288*.

58 Secretariat of the Convention on Biological Diversity (2009). Biodiversity, Development and Poverty Alleviation: Recognizing the Role of Biodiversity for Human Well-being.

59 Whether within coastal areas, on continental shelves or in areas beyond national jurisdiction.

60 Professor Richard Steiner, personal communication, 22 May 2013.



GREENPEACE

Greenpeace is an independent global campaigning organisation that acts to change attitudes and behaviour, to protect and conserve the environment and to promote peace.

For more information contact:
pressdesk.int@greenpeace.org

JN 452

Published in July 2013 by

Greenpeace International
Ottho Heldringstraat 5
1066 AZ Amsterdam
The Netherlands

greenpeace.org