The human community insistently pushes the oceans' limits, seeking to exploit all of its varied resources – fisheries, fuels, minerals and genetic material – now at the centre of the world economy. All of these developments draw oceans closer to the heart of contemporary human societies.

International governance is challenged by the blurring frontier between the mainland and the ocean, constantly redefined by new technologies, scientific discoveries, industrial demands and most recently, by ecological imperatives. No sea escapes these onslaughts.

This volume takes the reader straight to the heart of how human-ocean interactions, work, and identifies contemporary trends, mechanisms and tools that can influence current strategies and choices.

**FEATURES**
- Papers by leading international experts and scholars
- New perspectives through in-depth analyses
- Multiple maps, charts, tables
- A wealth of ideas for specialists and non-specialists alike (policy-makers, administrators, concerned citizens, development professionals, entrepreneurs, journalists, students, and others).
Marine biodiversity offers considerable promise for biotechnology while posing challenges for regulating access and sharing the benefits of bioprospecting. Although some countries, such as Norway and Australia, prove exemplary in their territorial waters, many issues remain unresolved on the high seas.

MARINE GENETIC RESOURCES: THE PATENTABILITY OF LIVING ORGANISMS AND BIODIVERSITY CONSERVATION

In 1919, the Hungarian engineer Karl Ereky coined the term “biotechnology” as a shorthand term to “refer to methods and techniques that allow the production of substances from raw materials with the aid of living organisms” (Sasson 2005). In essence, biotechnology “is based on the search for and discovery of exploitable biology” (Bull et al. 2000). Novel biotechnology is, at its core, intimately connected to biodiversity. The search for and industrial-scale exploitation of natural products and of novel properties of naturally-occurring substances – often referred to by the shorthand term bioprospecting – emerged only in the past fifty years, along with an emphasis on the novel potential of marine biodiversity in particular.

The systematic investigation of the biotechnology potential of the marine environment began in the early 1950s. The first marine bioactive compounds, spongouridine and spongothyridine, were isolated from the Caribbean sponge Cryptotheca crypta and by the mid-1960s were proven to have anti-cancer and anti-viral activity (Leary et al. 2009). Both these drugs were developed from compounds derived from sponges found off the coast of Florida (Foresight Marine Panel 2005). By the 1970s – paralleling rapid developments in biochemistry, biology, ecology, organic chemistry, and pharmacology – the modern marine biotechnology industry began to emerge (Leary et al. 2009), and by the end of the decade, the search for novel biologically active agents was well underway (Cragg et al. 1997).
This chapter considers the links between marine biodiversity and bioprospecting in the marine environment that have led to the development of marine biotechnology. It examines a number of key questions. What is marine biotechnology? How much bioprospecting occurs in the marine environment? Where do companies’ interests lie? What is the scale of commercial activity? Are products developed from marine biodiversity patentable? What is the environmental impact of this activity, and is it being sustainably managed?

CURRENT KNOWLEDGE ON THE DEVELOPMENT OF MARINE BIOTECHNOLOGY

The list of newly-discovered marine natural products grows year by year. For example, in the most recent published survey of literature, Blunt et al. note that in 2008, 371 scientific articles describing some 1065 new compounds were published (Blunt et al. 2010). Recent reviews of patent data (discussed below) also highlight this trend. Marine flora and fauna provide a vast source of novel lead compounds for the development of pharmaceuticals in particular, with more than 52% of those leads coming from sponges (Blunt et al. 2010).

A recent detailed study of bioprospecting suggests that the development of natural-product marine biotechnology covers several broad categories, including medical research on substances with an anti-cancer and anti-tumour function; substances for treating HIV-AIDS; applications against other infectious diseases, such as fungal infections and malaria; and other medical applications such as anticoagulants (Leary et al. 2009). Other areas of research include the development of new DNA polymerases for use in research and diagnostics; development of novel enzymes for use in industrial and manufacturing processes; treatment of waste and industrial effluents; bioremediation, biomining and bioleaching, to name but a few (Leary 2007). Other forms also involve the production of novel products from marine raw materials, including chitin and related compounds from shellfish waste; omega-3 and other fatty acids from fish oils; carotenoids, pigments and flavourings; compounds derived from marine algae such as alginates and carageenans, and other nutritional supplements (Leary 2008).

While natural products remain at the forefront of developments in biotechnology, the past decade has seen a paradigm shift in biological research and development, with greater use of “genomics” i.e. approaching the biology of organisms through their genetic blueprints, and new research methodologies (Bull et al. 2000). Previously, the methodology of so-called “traditional biology” prevailed, involving a search strategy based on collecting individual specimens and experimenting on each in the laboratory. More recently, such research increasingly draws on the newer methodology of bioinformatics. Bioinformatics is a computer-driven search strategy that examines data from a large volume of samples, which it screens and evaluates in order to identify a few promising substances for closer examination (Bull et al. 2000).

The wholesale screening of large collections of microorganisms is now a widespread research and development strategy in the biotechnology industry, with many
companies establishing collections of microorganisms and other biota from a variety of sources, including marine ones (Ferrer et al. 2005). These are then screened, and candidates selected for their abilities to synthesize pharmacologically active metabolites, along with a range of other uses (Ferrer et al. 2005).

THE COMMERCIAL SCALE OF INTEREST IN THE MARINE ENVIRONMENT
While there is clearly significant commercial interest in marine biotechnology, to date it has been very difficult to quantify this in dollar terms due to a lack of clear global data on the market value of marine biotechnology (Leary et al. 2009). There have been a number of studies of the commercial value of marine biotechnology, but it is difficult to arrive at accurate figures, since assessment methodologies vary considerably. Some studies have attempted to give a global view of the marine biotechnology industry. For example, one recent study estimated that in 2004, marine biotechnology globally was valued at €2.2 billion, excluding aquaculture, seaweed and processing-related industries (European Commission 2005). Other studies have focused on specific market values of industries commonly using marine genetic resources, and on approximate annual sales of selected marine-based products (Leary et al. 2009). For example, one cancer-fighting agent alone derived from marine sources had annual sales of US$1 billion in 2005 (Leary et al. 2009).

Regardless of its true commercial value, marine biotechnology is certainly a substantial market. Examples of specific products in the pharmaceuticals sector shed some light on this value. For example, in 2005 sales of a herpes remedy derived from a sea sponge were estimated at between US$50-$100 million per annum (Leary et al. 2009). More spectacularly, anti-cancer fighting agents developed from marine sources were estimated at more than US$1 billion in 2005 (Leary et al. 2009). But the lack of clear data on the market value of marine biotechnology suggests a need for an authoritative valuation of marine genetic resources and their commercial use (Pisupati et al. 2008).

One should not forget, however, that the path from sample collection to profitable drug or other product can take many years and involve the expenditure of vast sums of money, often in the range of hundreds millions of dollars, with no guarantee that a successful product will result. As one researcher in the field has commented:

[Marine biotechnology] is only truly successful when someone manages to profitably sell a finished product to a customer. To successfully develop a product it takes a lot more than just good research. There has to be a market for the product and the market has to be willing to pay a price for the product that allows a profitable return on the research, development, production, transport, marketing and sales costs of the product... Most products fail, so a company based on a single technology is also likely to fail (McKenzie 2003, 50).

The process of product development starts with the selection of appropriate biological materials, followed by screening for a desired attribute; this leads to the selection
of the best option from among a short list of positive hits, and culminates with the
development of a commercial product or process (Bull et al. 2000). But there are
many points along the way where product development can grind to a halt. As Firn
(2003) has suggested, the process of developing a new drug beyond screening raises
many questions. These include:
- “Will the drug be safe to use? (e.g. are there adverse side effects due to the chemical
  having more than one effect?)
- Is the drug clinically useful? (e.g. does the effect found in the test tube translate
  into a positive outcome for the patient?)
- Can the chemical be extracted, synthesized or produced by fermentation on an
  industrial scale economically?
- Can the drug and its derivatives be adequately protected by patents?
- Is the market big enough to repay the typical $500 million development costs for
  the drug?” (Firn 2003, 209)

Despite these obstacles, there are now many companies active in research, devel-
opment and commercialisation of marine biotechnology. Table 1 below (based on
descriptions of these companies drawn from their own marketing material) gives
some examples of the diverse range of companies involved.

THE KEY ISSUES CURRENTLY UNDER DEBATE
The status of marine-derived biotechnology is emerging as a significant issue of
international debate. In terms of international law, the debate centres on who has
the right to control access to marine biodiversity for the purposes of developing
biotechnology, and who has the right to share in any profits that may ultimately
arise. This is often referred to as the debate over “access and benefits sharing.”

This debate pivots on the interaction of two key international treaties: the 1992
Convention on Biological Diversity (the “CBD”) and the 1982 United Nations
main objectives: the conservation of biological diversity, the sustainable use of
its components, and the fair and equitable sharing of the benefits arising from
the utilisation of biodiversity, genetic resources in particular. It is a framework
treaty that sets out several obligations aimed at implementing these objectives.
UNCLOS is the main treaty dealing with the oceans and divides the ocean space
into a number of discrete jurisdictional zones. Under the provisions of UNCLOS,
the coastal state has clearly defined jurisdiction over ocean space, including the
twelve-nautical-mile territorial sea (which is regarded as sovereign territory),
and the 200- nautical-mile exclusive economic zone (“EEZ”) (where states posses
certain sovereign rights, including the right to regulate access to marine biodiver-

Within the territorial sea and the EEZ (and to a limited extent on the continental
shelf, at least with respect to sedentary species), access and benefit sharing issues
are regulated by the provisions of the CBD, which recognises the rights of the coastal
state to regulate within national jurisdiction (CBD 1992, Article 4).
## TABLE 1. EXAMPLES OF MARINE BIOTECHNOLOGY COMPANIES

<table>
<thead>
<tr>
<th>Company</th>
<th>Products(s) and areas of research and development interest related to marine biotechnology</th>
<th>Location, Country</th>
<th>Web address</th>
</tr>
</thead>
<tbody>
<tr>
<td>A/F Protein Inc &amp; A/F Protein Canada Inc.</td>
<td>Develops antifreeze proteins from Arctic and Antarctic fish species for the control of cold-induced damage in medical, food, and cosmetic products.</td>
<td>USA and Canada.</td>
<td><a href="http://www.afprotein.com">www.afprotein.com</a></td>
</tr>
<tr>
<td>Aquapharm-Biodiscovery</td>
<td>This company has a substantial collection of unique marine bacteria and fungi isolated from diverse and extreme marine habitats, including the Arctic and the deep sea, and uses these to develop new biologically active natural products for pharmaceutical, nutraceutical and industrial applications. Its core product areas are: anti-infectives (new antibiotic and antifungal development), carotenoid pigments (novel high yield fermentation), new enzymes (bio-transformations), and functional molecules. In addition, it also makes its library of marine bacteria and fungi available to third parties for research and development purposes.</td>
<td>Based in Scotland (United Kingdom)</td>
<td><a href="http://www.aquapharm.co.uk">www.aquapharm.co.uk</a></td>
</tr>
<tr>
<td>Biotec Pharmacon ASA</td>
<td>Biotec Pharmacon develops, manufactures, and markets immune modulating compounds and molecular biology grade enzymes, based on its own research in immunology and marine biotechnology.</td>
<td>Norway</td>
<td><a href="http://www.biotec.no">www.biotec.no</a></td>
</tr>
<tr>
<td>Magellan Bioscience Group Inc.</td>
<td>Main field of operation is in microbial extracts for drug discovery, agrochemical, enzyme, and specialty chemical research. Magellan has a collection of over 13,000 unique marine microbes and 60,000 diverse fungal strains sourced from the Arctic and Antarctica as well as from shallow reefs, marine caves, deep (&gt;1000M) ocean sediments, and tropical and temperate waters.</td>
<td>USA.</td>
<td><a href="http://www.magellan-bioscience.com">www.magellan-bioscience.com</a></td>
</tr>
<tr>
<td>New England Biolabs.</td>
<td>Enzymes and polymerases, including those isolated from deep sea hydrothermal vent ecosystems.</td>
<td>USA</td>
<td><a href="http://www.neb.com">www.neb.com</a></td>
</tr>
<tr>
<td>Pharma Mar</td>
<td>PharmaMar is a biopharmaceutical company founded in Spain in 1986, and its main business focus is on exploiting the potential of the oceans as a source of novel medicines for improved cancer treatment. The company has a unique marine organism library containing over 85,000 specimens. PharmaMar’s Research, Development, and Innovation Department has discovered 700 new chemical entities and identified 30 new families of compounds. As a result of this work, PharmaMar has over 1800 patents that either have been awarded or are in the processing stage. Yondelis®, developed by PharmaMar and initially approved by the European Commission in 2007 for the treatment of soft tissue sarcoma, and in 2009 for the treatment of relapsed ovarian cancer, is the first in a new generation of anti-tumour drugs developed from marine compounds. Since that time, Yondelis® has been approved in 21 countries of Asia, Central and South America, as well as in Switzerland and Russia. PharmaMar’s other pipeline compounds, Aplidin®, Irvalec®, Zalypsis®, and PM01183 are in different phases of clinical evaluation.</td>
<td>Spain and USA</td>
<td><a href="http://www.phar%C5%82amar.com">www.pharłamar.com</a></td>
</tr>
<tr>
<td>Pronova Biopharma (previously known as Pronova Biocare)</td>
<td>Pronova BioPharma develops and manufactures marine-originated, omega-3-derived pharmaceutical products, especially focusing on treatments for cardiovascular diseases.</td>
<td>Norway and Denmark</td>
<td><a href="http://www.pronova.com/">www.pronova.com/</a></td>
</tr>
<tr>
<td>Unilever</td>
<td>This company is a large food manufacturer that has developed antifreeze proteins derived from Arctic eel pout for use in making ice cream.</td>
<td>Company has world-wide operations.</td>
<td><a href="http://www.unilever.com/">www.unilever.com/</a></td>
</tr>
<tr>
<td>Verenium Corporation (previously known as Diversa Inc.)</td>
<td>Verenium Corporation develops cellulosic biofuels and enzymes. Verenium has a broad library of unique enzymes for commercial development sourced from extreme environments including the Arctic, Antarctica, volcanoes, rain forests and deep sea hydrothermal vent microorganisms. Verenium is also involved in anti-biotic and other drug research.</td>
<td>Company has operations world-wide.</td>
<td><a href="http://www.verenium.com">www.verenium.com</a></td>
</tr>
<tr>
<td>Zymetech ehf.</td>
<td>Zymetech concentrates on research in the field of enzymes and their use in the development and production of pharmaceuticals and cosmetics. The company is primarily involved in development, production and marketing of marine enzymes and products derived from such enzymes. Products marketed by this company include PENZIM, a product containing purified enzymes that purportedly brings relief to people suffering from a variety of skin conditions, rheumatic or arthritic diseases, swelling, and muscle pains, among other problems.</td>
<td>Iceland</td>
<td><a href="http://www.zymetech.is">www.zymetech.is</a></td>
</tr>
</tbody>
</table>

Source: Adapted and updated from Leary (2008) and companies’ websites.
Since the negotiation of the CBD, many states have developed domestic laws and policy regulating access and benefit sharing, some of which have extended to bioprospecting in the marine environment. For example, in Australia, the six State and the Northern Territory governments have jurisdiction over access and benefit sharing from the coast to three nautical miles out, while the area beyond that mark to the outer edge of Australia’s EEZ is regulated under the provisions of the Commonwealth’s Environment Protection and Biodiversity Act 1999 (Australia EPDA 1999) and associated regulations. Under this regime, permits are required for taking native species’ biological resources for research and development on their genetic resources or biochemical compounds. The Australian government has subsequently developed model access and benefit sharing agreements under this regime, which provide the basis for most arrangements where Australian Federal law applies. This regime applies in the marine environment as a whole, although permits for specific locations, such as the Great Barrier Reef Marine Park and Australia’s Antarctic Territory, are handled by separate authorities.

Like Australia, Norway has also recently adopted domestic legislation with provisions that specifically regulate access and benefit sharing. The Marine Resources Act (Act of 6 June 2008 no. 37 relating to the management of wild living marine resources) aims to “ensure sustainable and economically profitable management of wild living marine resources and genetic material derived from them, and to promote employment and settlement in coastal communities” (Section 1) and recognises that “wild living marine resources belong to Norwegian society as a whole” (Norway MRA 2008, Section 2). As the Norwegian Research Council has observed:

The new legislation is seminal in that it establishes the legal right of the [Norwegian] State to claim financial or other compensation when Norwegian marine genetic materials are commercially exploited (Norwegian Research Council 2010).

Moves by countries such as Australia and Norway to regulate access and benefit sharing within their areas of national jurisdiction provoke little controversy, because they are perfectly consistent with these countries’ rights under the CBD and UNCLOS.

However, in areas beyond national jurisdiction, controversy has recently emerged concerning the status of marine biodiversity subject to bioprospecting. UNCLOS and the CBD do not clearly regulate bioprospecting in those waters. A hotly contested debate has arisen over the extent to which existing international organizations, such as the International Seabed Authority (ISA), should regulate bioprospecting both on the sea floor and in the water column or high seas above. The ISA already has a role to play in managing minerals extraction in the deep sea beyond national jurisdiction, or the “Area” to use the UNCLOS definition. The “Group of 77” countries (i.e. developing countries such as Argentina, India, South Africa, Indonesia and China), supported by a number of their academic commentators (see e.g. Armas Pfirter 2006), have argued in recent years that access and benefit sharing should be brought within its mandate. This position rests on a questionable interpretation.
of international law, one that extends the concept of the “common heritage of mankind”\(^1\) to marine genetic resources in the Area beyond the ISA’s existing clearly defined minerals mandate. The debate in the current context is whether the “common heritage of mankind” concept (and all of the legal consequences and structures under UNCLOS tied up in that term mentioned above) should be applied to marine genetic resources or not. The UN General Assembly has set up a process to consider a resolution of this question (and other issues associated with marine biodiversity in areas beyond national jurisdiction), the Ad Hoc Open-ended Informal Working Group: its mission is to study a range of issues relating to the conservation and sustainable use of marine biological diversity beyond areas of national jurisdiction.

This issue has also been debated extensively in the recent meetings of the United Nations Informal Consultative Process on the Law of the Sea (for a detailed overview of this process, see Ridgeway [2009]). These issues are canvassed elsewhere in this book and so will not be examined in this chapter. But as debate in this forum and others has shown, resolving the status of these resources may be some way off. Simply put, there is no international agreement on whether or not the common heritage concept has any bearing on this issue, and whether in future the ISA should play any role in regulating access and benefit sharing in the oceans beyond national jurisdiction.

**LINKAGES WITH INTELLECTUAL PROPERTY RIGHTS**

A fundamental flaw in the “common heritage” argument is that it ignores the crucial role that patents play in biotechnology development. As noted above, biotechnology research and development is a very expensive and time-consuming process with limited likelihood of success. Patents are granted as a monopoly on exploitation of an invention in exchange for its disclosure; they reward the inventor for the time, effort and expense entailed in developing the new invention.

Under the provisions of Article 27(1) of the international treaty known as the Agreement on Trade-Related Aspects of Intellectual Property Rights (the “TRIPS Agreement”), “a patent may be granted for any invention, whether product or process, in any field of technology, provided that it is new, involves an inventive step, and has industrial application” (WTO 1994). Under Article 27(2) of the TRIPS Agreement, “States may exclude inventions from patentability on the grounds of ordre public or morality (including to protect human, animal or plant life or health, or to avoid serious prejudice to the environment), provided that such exclusion is not made merely because the exploitation is prohibited by their law.”

---

1. The term “common heritage of mankind” is used here rather than the equivalent gender-neutral “common heritage of humankind” because it denotes a specific concept defined by international law, established before gender neutrality was a concern. As reflected in UNCLOS, it has three core elements (1) non appropriation of the deep seabed beyond national jurisdiction by States; (2) common management of the mineral resources of the deep seabed beyond national jurisdiction by the ISA and (3) benefit sharing in relation to any profits that may come from the exploitation of deep sea minerals.
The granting of patents for products derived from marine biodiversity has proven controversial. As Salpin and Germani (2009) have recently observed:

There is an ongoing public debate about whether naturally occurring organisms and substances isolated from their natural surroundings are inventions or discoveries; whether they meet the criteria of being capable of industrial application; whether the extension of patent protection to genetic material is justifiable on ethical grounds; and on the impacts of permitting patent claims that are very broad in scope (Salpin and Germani 2009, 18).

Despite this controversy, many such patents have been granted around the world, and for the time being the patentability of such inventions seems beyond doubt. A number of recent surveys have highlighted this increasing trend. For example, in a 2007 study, the present author signalled at least 37 patents granted for inventions isolated from species associated with deep sea ecosystems (such as hydrothermal vents). These range across a diverse series of applications, including biological sciences research, medicine and diagnostics (Leary 2007). In a similar vein, Arico and Salpin (2005) note that patents have been granted for a number of applications (including pharmacology, agrichemistry and cosmetics) where the active ingredient has been sourced from a range of marine organisms, e.g. “bacteria, fungi, algae, sponges, cnidaria, echinoderms, molluscs and tunicates” (Salpin et al. 2009 citing Arico et al. 2007). More recently, another study identified at least 135 patents granted from 1973 to 2007, derived from marine biodiversity with applications in chemistry, pharmacology, cosmetics, food and agriculture (Leary et al. 2009). Table 2, drawn from data contained in that study, provides some examples of those patents.

Article 28 of the TRIPS Agreement clarifies a patent’s rights of ownership and third-party limitations. In the case of a product, it prevents third parties from making, using, offering for sale or selling, or importing the patented product for those purposes, without the owner’s consent. If the subject of the patent is a process, Article 28 prevents the same acts applied (as a minimum) to the product obtained by that process.

Once the patent is granted, it is irrelevant whether or not access to the original natural product complied with any applicable access and benefits sharing regime. The patent is a stand-alone monopoly, enforceable against the world! There clearly is a major missing regulatory link between the CBD and TRIPS.

**IS BIODIVERSITY CONSERVATION COMPATIBLE WITH THE PATENTABILITY OF LIVING ORGANISMS?**

Quite aside from issues associated with access and benefit sharing and intellectual property rights, developments in marine biotechnology also have a potentially significant environmental impact. Many new products, especially pharmaceuticals, rely upon the availability of sufficient quantities of their originating natural products. In a recent publication, a representative of the leading Spanish company PharmaMar (de la Calle 2009) has highlighted clearly what this can mean in terms of the potential environmental impact of new drug development. He has observed:
A serious obstacle to full development of most marine natural products is the problem of supply. The concentrations of the majority of highly active compounds for marine invertebrates are very often minute, sometimes accounting for less than $10^{-6}$ % of the wet weight. For example, in order to obtain approximately 1 g of the promising anti-cancer agent Yondelis©, close to 1 metric ton (wet weight) of the ascidian tunicate *Ecteinascidia turbinate* must be harvested and extracted. In other cases, such as halichondrin B, a powerful cryostatic polyketide of sponge origin, the ratio of biomass to final product is even less favourable. In order to obtain as little as 300 mg of a mixture of two halichondrin analogues, 1 metric ton of the sponge *Lissodendoryx sp.* must be collected and extracted. Other anti-cancer compounds, such as the dolastatins, have been isolated from the sea hare *D. Auriculata*, where the concentration of pure compounds is less than 1 mg per 1 kg (wet weight). A large number of similar cases can be found in the literature (de la Calle 2009, 214).

<table>
<thead>
<tr>
<th>SECTOR</th>
<th>PATENT NUMBER</th>
<th>DESCRIPTION AND APPLICATION</th>
</tr>
</thead>
<tbody>
<tr>
<td>Chemistry</td>
<td>WO2006127823</td>
<td>Describes the use of a <em>Silibacter</em> sp. for the genetic transformation of marine algae and production of antibiotic agents.</td>
</tr>
<tr>
<td></td>
<td>US5089481</td>
<td>Polysaccharides extracted from marine algae and an antiviral drug containing active polysaccharides extracted from seaweeds.</td>
</tr>
<tr>
<td></td>
<td>JP10120563</td>
<td>Describes culturing a type of marine bacteria to produce cyclopodioligins for a new immunosuppressant, apoptosis-inducing agent and treating agent for leukaemia.</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Pharmacology</td>
<td>JP2000080024</td>
<td>An anti-inflammatory composition from an extract of marine algae.</td>
</tr>
<tr>
<td></td>
<td>JP2000229977</td>
<td>A novel compound with proliferation-inhibitory action against cancer cells.</td>
</tr>
<tr>
<td></td>
<td>US2006234920</td>
<td>Anti-cancer drug Kahalalide F, isolated from a sea slug in Hawaii, is currently in Phase II clinical trials in hepatocellular carcinoma, non-small cell lung cancer and melanoma.</td>
</tr>
<tr>
<td>Food</td>
<td>JP2004065152</td>
<td>Describes a starch-based food product or a flour-based food product obtained from Antarctic krill.</td>
</tr>
<tr>
<td></td>
<td>US7041788</td>
<td>Anti-freeze protein isolated from Antarctic eel pout, which can be used in food preservation.</td>
</tr>
<tr>
<td></td>
<td>JP10084988</td>
<td>Describes the use of a lipase from <em>Candida antarctica</em> to obtain a (S)-3(2H)-furanone compound with a sweet fruity fragrance; useful as a food perfume.</td>
</tr>
<tr>
<td>Agriculture</td>
<td>WO03081199</td>
<td>Describes a halogenated tryptophane residue derivative with antifouling effects.</td>
</tr>
<tr>
<td></td>
<td>JP2005145923</td>
<td>Shows how to obtain an antibacterial agent from adhesive marine bacteria that has excellent sustained antibacterial power.</td>
</tr>
</tbody>
</table>

Source: Adapted from Leary et al. (2009)
The larger the quantity of source biota needed to produce the new drug or other product, the larger the environmental impact will be. To some extent, this environmental impact can be minimized by chemical synthesis during the research and development process, or through culture in the laboratory where the original source is microbial in origin. Even where only small samples are originally required for research and development, “the fact that you may only require the celebrated ‘teaspoonful’ of the exciting [organism] is no guarantee that you will not trash a larger area in getting it” (Hemmings 2009, 60). For many new products, and especially some promising drug leads series, the environmental impact of bioprospecting urgently needs to be considered.

Within areas of national jurisdiction, this can be managed under national environmental legislation. In Australia, for example, assessing the environmental impact of biological sampling for research and development purposes is a pre-condition of permits for bioprospecting, as mentioned earlier in this chapter.

In areas beyond national jurisdiction, no international regulation of the environmental impact of bioprospecting currently exists. Surprisingly, this issue has received little if any attention in the international fora where bioprospecting has been discussed. In any future international legal or governance regime, managing the environmental impact of bioprospecting will prove a key issue. So far, no detailed study has been undertaken on the nature and scale of these environmental concerns, and clearly this must be a first step in designing a future response (Leary et al. 2009). Well-established concepts – such as environmental impact assessment and management, the precautionary principle, and ecosystem-based management – should play a central role in any such future regime (Leary et al. 2009).

However, designing such a regime will not be easy, especially given the very close relationship between marine scientific research and bioprospecting. To date there is no clear agreement on the difference between the two, a necessary distinction if existing high seas freedoms, such as marine scientific research, are to be maintained. Future bioprospecting may require a separate access and benefit sharing regime that clearly separates it from the special status accorded marine scientific research under international law.

CONCLUSION

Marine biodiversity holds great promise for future developments in biotechnology. From treatments for illnesses such as cancer, to development of new enzymes for use in a range of chemical and industrial processes and applications, the oceans now offer us many new and exciting prospects. But as discussion in this chapter has shown, these developments unfold rapidly in an environment without adequate regulation, whether of access and equitable sharing of potential benefits, or in managing a still vaguely-understood environmental impact. The challenge now is for policymakers to show leadership on these unresolved concerns.
WORKS CITED


the human community insistently pushes the oceans’ limits, seeking to exploit all of its varied resources – fisheries, fuels, minerals and genetic material – now at the centre of the world economy. All of these developments draw oceans closer to the heart of contemporary human societies.

International governance is challenged by the blurring frontier between the mainland and the ocean, constantly redefined by new technologies, scientific discoveries, industrial demands and most recently, by ecological imperatives. No sea escapes these onslaughts.

This volume takes the reader straight to the heart of how human-ocean interactions, work, and identifies contemporary trends, mechanisms and tools that can influence current strategies and choices.

FEATURING
▶ Papers by leading international experts and scholars
▶ New perspectives through in-depth analyses
▶ Multiple maps, charts, tables
▶ A wealth of ideas for specialists and non-specialists alike (policy-makers, administrators, concerned citizens, development professionals, entrepreneurs, journalists, students, and others).