9. Emerging industries and research

Australia's marine resources provide a number of opportunities for emerging industries due to the vastness of the ocean and its high biodiversity. This section addresses emerging industries in the East Marine Planning Region including biodiscovery, renewable energy, water resources and aquaculture.

9.1 Marine biodiscovery

9.1.1 Background

Biodiscovery is the investigation of biological resources such as plants and animals, for properties or characteristics that have a commercial value or some other wider application. Products such as drugs, agrichemicals and industrial enzymes may be created from biological resources and used in a number of applications (PMSEIC, 2005). Marine organisms in particular have few physical defence mechanisms and therefore protect themselves by chemical means. As such, many organisms produce venoms, antifouling agents and other biochemical agents that may be utilised for commercial and biomedical applications (Volkman, 1999). Their discovery may result in better vaccines, faster diagnosis of diseases, better quality foods and more environmentally friendly products. Sea sponges and other invertebrates, as well as marine algae, have been some of the most common sources of extracts used in pharmaceuticals. Heat loving microbes from hydrothermal vents may be suitable for use in novel biotechnological processes including oil, coal and waste-gas desulphurization as well as in the treatment of industrial effluents. Other industries utilizing marine genetic resources include the food, aquaculture, agriculture and nutritional supplement industries (UNU-IAS 2007).

Australia is one of twelve megadiverse countries in the world, therefore prospects for biodiscovery are high (Quinn *et al*, 2002). Both the land and the sea surrounding the country provide possibilities for biodiscovery; however the sea provides much greater potential resources than land due to the larger diversity of life forms (Quinn *et al*, 2002). This is particularly important as Australia has a large Exclusive Economic Zone of 11 million square kilometres and one of the world's largest coral reef systems which support many endemic species (Volkman, 1999). The Australian Exclusive Economic Zone comprises 60 marine bioregions, each with their own unique biota, physical and chemical features (Quinn *et aI*, 2002). Approximately, 30,000 species from 28 marine phyla inhabit the bioregions of the Australian Exclusive Economic Zone (ABRS, 2001). Therefore scope for marine biodiscovery in Australia is large due to the richness of genetic marine diversity. The genetic diversity and vastness of Australia's Exclusive Economic Zone has generated great interest and promise for new scientific knowledge and wealth through biodiscovery.

Recently discovered compound from Australian marine organisms are listed in **Table 9-1**.

Table 9-1 Potential therapeutic compounds from Australian marine species

Compound	Source of compound (organism)	Medical condition
Lamellarin a 20 sulfate	Tunicate	HIV
Dithiocyanates	Sponge	Nematode infection
Conotoxins	Snail	Pain

Source: Adapted from Kijos and Swaangwong (2004).

Compounds from some Australian marine species have become commercial such as the ziconitide from the cone shell.

Conus Magnus

More recently, the chronic pain treatment called Prialt (ziconitide) has been released on to the market. It is derived from peptides isolated from the cone shell Conus Magnus (Olivera, 2000). More than 100 patents and patent applications with "conotoxin" in the title have recently been listed on the database esp@cenet (UNU 2007)

Source: Nature, 2005.

9.1.2 Regional activity

A recent report by UNU-IAS and UNESCO (2007) explains that patents reflect the intellectual and/or industrial property of discoveries, which confer to their holders exclusive rights on the exploitation of the patented invention. Approximately 135 patents relevant to marine genetic resources have been identified, which were filed in the period comprised between 1973 and present. These have been categorised and constitute of Pharmacology; 32%, Agriculture; 1.7%, food; 5.7%, cosmetics; 1.2%, chemistry; 53.5% and other; 5.7% (UNU-IAS and UNESCO, 2007). The numbers of patents have increased at a rapid rate each year from 1973, particularly from the mid 1990's to present. At the time that this report was compiled, information on compounds sourced from organisms specifically from the East Marine Planning Region was not available.

Access to Commonwealth waters of the East Marine Planning Region for the purposes of biodiscovery is regulated by EPBC Regulation Part 8A and a permit to undertake the activity is required. In coastal waters off Queensland, marine biodiscovery falls under access and benefit sharing legislation – the *Biodiscovery Act 2004* - which extends its scope as far as 3 nautical miles.

A number of biotechnology companies, universities and government agencies from New South Wales and Queensland are interested in the collection of marine species from State and Commonwealth waters including the East Marine Planning Region. These include but are not limited to:

- The Australian Institute of Marine Science;
- CSIRO Molecular Science;
- Queensland Institute of Medical Research;
- University of Wollongong;
- University of Queensland;
- Griffith University;
- University of New South Wales; and
- James Cook University.

The Australian Institute of Marine Science (AIMS) based in Far North Queensland, is actively working in the field of marine biodiscovery, concentrating largely on the development of pharmaceuticals, healthcare products, agrichemicals and bioremediation agents (Arico & Salpin, 2005). Currently, AIMS are working on two bio-initiatives including the development of sensitive bioassays to evaluate the risk to marine organisms and communities posed by climatic change and environmental contaminants. It will also determine sub-lethal impacts of adverse water quality on marine organisms, as well as the synergistic effects of environmental stress on ecosystem health (Australian Institute of Marine Science, 2003).

The Queensland State government has been actively investing in biotechnology research, having helped establish two research centres at the University of Queensland and Griffith University in addition to biotechnological collaborations with foreign universities and the establishment of Queensland Biotechnology Strategic Plan 2005-2015: Biotechnology – Setting New Horizons. This plan arose from the Smart State Strategy and outlines measures to assist the industry in Queensland to reach its revenue projections.

Some of the research in progress includes (Environment Australia, 2001):

- AIMS research creating synthetic analogues of specialised amino acids found in organisms such as reef building corals, sponges and anemones that allow them to be protected against sunlight. The compounds are being tested for commercial viability.
- The University of New South Wales in cooperation with multinational companies is investigating the commercial application of natural compounds from marine algae that prevent bacteria biofilms from forming, potentially preventing or reducing infections in humans and solving industrial problems. Application may include the development of antifouling paint and contact lens cleaning solutions.
- A collaboration between AIMS and James Cook University to produce natural herbicides from marine compounds. These herbicides present potential applications for farmers worldwide.

- A significant breakthrough in the management of marine compounds is the development of the Queensland Compound Library, an online tool that collates molecules and natural product extracts.

In addition, a number of Australian marine research laboratories are developing relationships with major companies from Japan, the EU and the US. Canada has also shown significant interest in accessing Australian marine biodiversity.

9.1.3 Economic context

The economic contribution of marine biodiscovery and biotechnology of the East Marine Planning Region is difficult to quantify as the industry is in its growth stage and biodiscovery revenue is expressed as a whole of biotechnology activities. Australia's current biotechnology related revenue is derived from pharmaceuticals, agrochemicals and nutraceuticals industry which is worth approximately $6 billion, which is small by international standards but it is growing rapidly. In 2004, the Queensland biotechnology industry employed over 5,200 people and generated revenues of approximately $690 million (Thorburn *et al*.2006).

Given Australia's large and unexplored genetic diversity, there is scope for future economic revenue from marine compounds in the Region. Therefore investment in the industry is growing. The AIMS Marine Biotechnology Group estimates their approximate level of investment, based on 2003-04 figures, to be $1.72 million in Bioactive Molecule Discovery, $2.01 million in Bio-innovation, and $3.18 million in Tropical Aquaculture (AIMS, 2003).

Globally, the investments in marine bioresearch and biodiscovery from industry sectors known to be patenting marine compounds is unknown. The UNU-IAS (2007) paper has reported the profits made by particular industries known to be linked with marine biodiscovery as an indication of the industry value, however, exact figures of such investments are unknown. Estimates put worldwide sales of marine biotechnology-related products at US$ 100 billion for the year 2000. Profits from a compound derived from a sea sponge to treat herpes were estimated to be worth US$ 50 million to US$ 100 million annually, and estimates of the value of anti-cancer agents from marine organisms are up to US$ 1 billion a year (UNU-IAS 2005).

Companies using products of marine origin include the cosmetics giant Estée Lauder, which uses Pseudopterosin, an anti-inflammatory extracted from a seafan, in skin lotions. Total profits by Estee Lauder for 2001-2002 were reported to exceed US$258 million. Other examples of companies using marine sources for cosmetics include the French Phytomer, a specialist in marine cosmetics, and the US-based AGI Dermatics, which uses a blue-green algae extract in some of its products. Specific sales figures for marine-based products were not available, but successful new products might command similar sales figures to the perfume "Lovely" ($60 million annually in

2006) and the Hawaiian Tropic skin care line ($340 million annually in 2006) (UNU-IAS and UNESCO, 2007).

9.1.4 Impacts on the environment

There is limited information available regarding the environmental impacts of marine biodiscovery. Hunt & Vincent (2006) identified the following environmental concerns:

- The use of destructive or non-selective collection methods (such as trawls or grabs) may not control samples sizes or avoid non target species. However, this practice should only be deployed where careful methods such as scuba collecting are unfeasible. Additionally, collection methods can be regulated by collection protocols such as those provided under the Australian Commonwealth's *Environmental Protection and Biodiversity Conservation Act 1999.*
- The possible introduction of pathogens or exotic species by collectors. A Commonwealth inquiry conducted into Biodiscovery in Australia however, found the risk of introduction was negligible (Voumard, 2000).
- The possible over collection of target organisms for clinical workup could significantly reduce local populations and genetic diversity especially for rare or range restricted organisms. The low natural concentrations of some compounds used for biotechnology compounds, could result in an unfeasible large-scale exploitation of wild harvests. For example, Hunt & Vincent (2006) reported rare organisms such as the New Zealand deep-water sponge *Lissodendoryx* sp. required 1 tonne of the organism to produce 300g of the pharmaceutical compound. However, it is often difficult to ascertain the degree of impact resulting from large scale collections of specific organisms because often the local abundance and population life history parameters are unknown (Hunt & Vincent, 2006).

Collection is regulated in Commonwealth waters through the EPBC Act 1999 and legal collection is assessed for sustainability.

9.1.5 Future uses

Measures undertaken by the Queensland Biotechnology Strategic Plan 2005-2015 outlines aims to significantly develop the biotechnology industry, to employ over 16,000 staff and create revenue projections of $4 billion by 2025 (Department of State Development and Innovation, 2005). Currently, over 22% of national public sector research funding is invested in research and development in biotechnology in Qld (Department of State Development and Innovation, 2005). However, these funding measures will not necessarily lead to further development of marine Biodiscovery in the East Marine Planning Region. Due to the nature of this industry, interest in the marine resources of the East Marine Planning Region are likely to come from anywhere in the world.

9.1.6 Information Gaps

There is limited information regarding the extent of marine biodiscovery in the East Marine Planning Region, this is in part to be due to the importance of intellectual property rights in the pharmaceutical and biotechnological industries. Hunt & Vincent (2006) found that most bioproduct collection data is protected by confidentiality agreements between bioprospectors and the source country.

In addition, a large expanse of the Australian Exclusive Economic Zone has not yet been investigated. A lack of reliable data on the distribution and abundance of many marine organisms makes assessing the sustainability of the biodiscovery industry difficult to determine. Further research needs to be conducted into the locations, methodologies and impacts of marine Biodiscovery.

Furthermore, collection is regulated in Commonwealth waters through the EPBC Regulations. Legal collection is assessed for sustainability and the industry has no interest in dependency on small populations, for economic as well as ecological reasons – rare and threatened biological resources are simply not worth investigating if they cannot be suistainably harvested in the long term. However, important breakthroughs have been made in bio-synthesis in recent years, as well as significant work being done by the likes of AIMS in aquaculture of sponges to produce valuable biochemicals. These subsidiary industries increase the economic benefits of marine bioprospecting.

The UNU-IAS and UNESCO (2007) suggests that there needs to clearly identify and define the scope of biodiscovery, as well as develop criteria and guidelines to assist governments in ascertaining the nature and implications of marine scientific research.

9.2 Renewable energy

9.2.1 Background

Australia primarily relies upon non-renewable energy such as fossil fuels to provide power to the population. Unsustainable consumption of fossil fuels including oil, gas and coal has reduced the availability of hydrocarbons required for power generation. Consequently government and industry are investing in renewable energies that are a sustainable source of power and will be available for future generations. Renewable energies such as wind, solar, wave, tidal, biomass and hydroenergy have also become increasingly popular due to concerns about greenhouse gas emissions.

Wave and tidal energy are particularly valuable sources of renewable energy along the vast Australian coastline due to natural coastal processes. Wave energy can be readily harvested to produce power which can be connected to the grid system for household consumption.

9.2.2 Regional activity

Use of renewable energy in the East Marine Planning Region is restricted to the coastal environment within state waters. Investigations into the viability of renewable energy are underway with Australia's first trial wave energy system being installed on the breakwall of Port Kembla near Wollongong, New South Wales in December 2006. Installation of the wave energy generator developed by Energetech Australia Pty Ltd (now Oceanlinx Limited) was undertaken to determine if the harvesting of wave energy was a feasible option for energy production. The Port Kembla Wave Energy Plant has been highly successful with connection to the main power system forecast for the near future. Several intensive trails have produced promising results with continual deployment of the turbine system expected to produce 1GWh of electricity each year (Port Kembla Port Corporation, 2006).

9.2.3 Economic context

The economic contribution of renewable energy in the East Marine Planning Region is nil at this stage, however advances in wave energy systems and the potential development and installation of offshore wind farms may contribute to the economics of the East Marine Planning Region.

9.2.4 Impacts on the environment

Environmental impacts associated with renewable energy projects such as the wave energy harvesting off Port Kembla are not widely documented as the project is in its preliminary stages.

9.2.5 Future uses

The wave energy harvesting program off Port Kembla has not yet been linked to the grid to provide power to the local area of Wollongong (Port Kembla Port Corporation, 2006). However, the project trials has been highly successful and it is likely that the system will be used to provide energy to the local community (Port Kembla Port Corporation, 2006).

9.3 Aquaculture

9.3.1 Background

There is constant and increasing pressure on the wild fisheries of the East Marine Planning Region, with a majority of commercial species being classified as fully or over exploited. With this pressure comes the realization that commercial fishing alone cannot provide for the increased demand for seafood worldwide.

Australia currently ranks around 55th in seafood production, despite having the third largest fishing zone in the world. Australia's fisheries resources are not as productive or as abundant when compared with many other parts of the world. With the ever-increasing population, demand for seafood is outstripping supply. Aquaculture has been heralded as a sustainable method of commercial production of fish, molluscs crustaceans and marine plants.

Aquaculture is a rapidly developing industry in Australia and worldwide, representing approximately 30% of total Australian fisheries production. Aquaculture worldwide has a growth rate of 11% per year and is worth an estimated $US56.5 billion dollars (NSW DPI 2005). At present however, aquaculture is largely restricted to the coastal state waters although there is vast potential for expansion of aquaculture activities in the East Marine Planning Region.

Aquaculture in NSW

NSW aquaculture has always been dominated by Sydney Rock Oyster farming, worth approximately $38 million annually. Black mussels, marine fish, prawns and scallops are all seen as important species to NSW, with research currently being conducted into the optimal methods for production by NSW Fisheries.

Marine fish aquaculture in NSW has been hampered by a lack of suitable sites for marine fish farming along the coast, a lack of a consistent supply of juvenile fish and the expenses related to production. There is currently one marine fish commercial production farm in Botany Bay, Sydney which utilizes floating mesh cages with others planned within the region.

Land based aquaculture makes up only one quarter of the value of NSW aquaculture, with approximately $4 million in prawns produced annually.

Aquaculture in NSW is predicted to increase to $100 million by 2010 (NSW DPI 2004)

Aquaculture in QLD

Aquaculture in Queensland saw a 4% increase for the 2005-2006 period, with total value estimated at $70.5 million, comprising 28% of Queensland's fisheries resource (QLD DPI&F 2007). This has been combined with a 12% reduction in the wild-catch fishery over the same period.

Aquaculture research in Queensland is currently focusing on (QLD DPI&F 2007):

- crab aquaculture (mud and blue swimmer);
- scallop ranching;
- prawn broodstock domestication;
- rock lobster aquaculture; and
- inland prawn farming.

9.3.2 Regional activity

Aquaculture in the East Marine Planning Region is primarily restricted to coastal waters within state jurisdictions. The major aquaculture industries in the East Marine Planning Region include the farming of scallops, prawns, edible oysters and silver perch. In terms of value, the majority of aquaculture production in the East Marine Planning Region lies with inland aquaculture, however

there is a large amount of research being conducted into expanding the marine component of this resource.

9.3.3 Economic contribution

The economic contribution of aquaculture in the East Marine Planning Region is difficult to distinguish as both land-based and marine-based aquaculture occur in New South Wales and Queensland and as such are amalgamated in industry reports. **Table 9-2** presents the value of the aquaculture industry in New South Wales and Queensland for the periods 2003-04 to 2005-06. Queensland aquaculture production generally has a higher value than New South Wales production. This may be attributed to the size of the marine prawn production industry which presents the highest value aquaculture production overall. The value of prawn production was highest for the period 2003-04 with a value in excess of $53 million.

Table 9-2 Value of aquaculture in New South Wales and Queensland (value:$000s)

Industry	2003-04	2004-05	2005-06	2003-04	2004-05	2005-06
Fish						
Salmon	5	-	-	-	-	-
Trout	1,552	1,784	1,742	-	-	-
Tuna	-	-	-	-	-	-
Silver perch	2,322	2,431	2,770	450	516	510
Barramundi	1,128	1,360	1,238	10,050	11,920	13,900
Others	516	1,184	720	300	259	320
Total	5,523	6,758	6,470	10,800	12,695	14,730
Crustaceans						
Prawn	4,432	4,464	3,387	53,330	45,900	46,500
Yabbie	354	362	214	-	-	-
Marron	-	-	-	-	-	-
Redclaw	-	2	-	1,240	1,280	1,270
Total	4,788	4,827	3,602	54,570	47,180	47,770
Mollusca						
Edible oysters	37,921	35,880	34,093	730	736	570
Pearl oysters	-	-	-	340	-	-
Mussells	261	215	207	-	-	-
Other	-	-	-	-	-	-
Total	38,182	36,101	34,300	1,070	736	570
Other NEI	1,154	686	655	2,200	3,889	3,050
Total	**49,647**	**48,372**	**45,027**	**68,640**	**64,500**	**66,120**

Data sourced from ABARE (2006).

9.3.4 Future uses

Aquaculture remains primarily a land-based activity in Queensland and New South Wales. Consequently values in **Table 9-2** are not truly representative of the value of aquaculture occurring in the East Marine Planning Region. Comprehensive research programs are currently being conducted with the view to expanding importance of marine species in aquaculture. Specific research programs include (NSW DPI 2005):

- Hatchery and breeding technologies for oysters and molluscs;
- Technologies and systems for finfish breeding and farming; and
- Fish feeds and feeding.

Research specific to developing commercial production of currently less productive marine species is being undertaken throughout the East Marine Planning Region in an effort to meet some of the increased demand for fresh seafood in Australia and world-wide.

9.4 Desalination plants

9.4.1 Background

Drought conditions affecting the mainland of Australia have placed enormous pressure on the nations' water resources. In order to manage this issue and meet the requirements of the Australian population the Australian government is investing in various water management strategies including water restrictions, water recycling and desalination plants.

9.4.2 Regional activity

Water resources on the mainland of Australia are declining as our current water storages reserves can no longer meet demands as a result of unpredictable drought conditions, with increasing populations in major centres placing more pressure on scarce water resources. Consequently, government organisations have researched alternative water sources with seawater being identified as one such option. Seawater may be treated through desalination which involves reverse osmosis to reduce the salinity of the water to a level that in acceptable for consumption. At this stage, desalinisation plants are planned for the major capital cities in the East Marine Planning Region including Sydney and the Gold Coast.

The Sydney desalination plant will use reverse osmosis technology to remove salts and other impurities from seawater to produce drinking water (Sydney Water 2007a). Sydney Water has listed 5 key environmental priorities including (Sydney Water 2007b):

- protect the marine and estuarine environment;
- protect terrestrial ecology in the conservation area;
- ensure no net greenhouse gas emissions;
- prevent clearing of native vegetation; and

- prevent invasion of weed species into native plant communities.

9.4.3 Economic context

The economic contribution of desalination in the East Marine Planning Region is difficult to distinguish as these initiatives are predominantly in a pre-developmental stage. With an initial outlay of $1.126 billion for the Gold Coast desalination plant, $1.76 billion for the Sydney desalination plant and water bills expected to increase by $100 a year, the economic contribution of desalination in the East Marine Planning Region is likely to be vast.

Desalination Case Study – Gold Coast, Queensland

Like many parts of Australia, south-east Queensland has been suffering from extended drought periods. Two options were assessed to secure an emergency bulk water supply by the end of 2008: desalination and reclaimed potable drinking water (purified recycled water).

As with other areas in Australia, there has been community criticism regarding the reclamation of potable drinking water, with 81% of respondents in the Gold Coast community supporting the desalination option compared with 50% supporting reclaimed potable drinking water (Gold Coast City Council 2007).

Other countries such as Singapore have successfully adopted reclaimed potable drinking water into the main supply system after dealing with initial public criticism. Reclaimed potable drinking water costs Singapore approximately half what desalination would have (Reuters 2002).

The Gold Coast desalination plant is estimated to cost $1.126 billion for installation of infrastructure including the plant, intake and outlet works and the construction of a distribution pipeline to integrate the project into the south-east Queensland water grid (Gold Coast City Council 2006). The Gold Coast desalination plant will supply 125 million litres of desalinated water per day into the water grid.

Research into marine impacts was undertaken by scientists from Griffith University, the University of New South Wales and other industry experts.

Potential impacts to water quality include (GCD 2006):

- Increased salinity;
- Decrease dissolved oxygen; and
- Increased heavy metals.

The potential water quality impacts relate to impacts on marine ecology through potential (GCD 2006):

- Toxicity to benthic fauna from salinity;
- Suffocation of in-fauna, due to a decrease in dissolved oxygen;
- Changes to fauna abundance, diversity and community composition where tolerant species dominate sensitive species;
- Release of sediment-bound metals to the water column; and
- The stimulate plant growth through the release of nutrient laden water.

Conclusions of the study found that it is unlikely that there will be any significant impacts on fish or fisheries in the region from the intake of seawater and discharge of brine.

Source: Gold Coast Water (2007)

9.4.4 Impacts on the environment

Desalination plants draw in seawater through intakes at sea, and output seawater concentrate that is twice as salty and one to two degrees warmer than the water drawn into the plant (Sydney Water 2007a). The plants are designed with diffusers, which disperse salt content and temperature through the profile at the outlet to return the seawater to normal levels around 50-75 metres from the discharge point (Sydney Water 2007a). Elevated salinity is believed to effect some smaller marine organisms such as corals, sponges and sea anemones. The effects of desalination plants on iconic marine creatures such as the weedy seadragon and migratory whales will be monitored throughout the process.

Potential implications for works within transitional areas between commonwealth and state waters (the 3 nautical mile limit of coastal waters) were mitigated by limiting development of desalination infrastructure to near shore works. Other potential commonwealth approvals were avoided as there were no ecological issues (endangered species / communities etc) of commonwealth significance.

The intake and outlet tunnels associated with the desalination plant will be located in the Tasman Sea, approximately 300 - 400m offshore. Impacts associated with increased salinity, temperature and the operation of infrastructure were assessed (Sydney Water 2006a).

The impact the desalination plant may have on migratory whales was assessed with four potential impacts being identified (Sydney Water 2006b):

- The potential for whales to collide with intake and outlet structures;
- Entanglement in desalination infrastructure;
- Increased salinity within the outlet mixing area (the near field); and
- Increased bubbles and noise from the outlet.

These impacts were all determined to be not significant, although there were no studies to reference against for increased salinity. There will be some temporary effects on the whales as they pass the intake and outlet, but these impacts are expected to dissipate with increased distance from the infrastructure.

An impact on the East Marine Planning Region associated with the desalination plant and migratory whale populations is potential loss of ecotourism dollars. It is anticipated that fewer whales will be observed during the construction of the intake and outlet channels, as the whales are likely to avoid the disturbance and move further out to sea (Sydney Water 2006a). Scaling down or stopping construction works when whales approach have been suggested as mitigation measures to reduce the effect on the whale-watching industry.

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