Seminar 3

Management of Deep Sea Marine Resources and Oceans as a Means of Communication

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Maritime and Air Surveillance

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1. Introduction

Maritime traffic represents about 90% of the economic traffic around the world and it is a growing activity. From 1990 to 2012, there has been a huge growth in maritime traffic, especially in container traffic (from 6 million containers in 1990 to 34 million in 2012). Protecting maritime flows is necessary to insure regional and world economies. But what is true for legal activities is also true for illegal activities: drug trafficking, terrorism, piracy and illegal fishing activities are real threats to maritime flows and resources. For example, in the Southwest Pacific Ocean, illegal fishing activities consist of between 786,000 tons and 1,730,000 tons, (valued at between US$707 million and US$1,557 million), representing more than 10 % of legal fishing (11 million tons).

Hence, maritime surveillance is necessary to control not only France's national but also regional interests and resources.

France has in place maritime surveillance covering over 11 million square kilometers of exclusive economic zone (EEZ), significantly large because of its overseas territories. France has a particular military structure, with different assets located in various overseas territories. In the Pacific Ocean, France has armed forces in Tahiti with an Admiral as its commanding officer (CO) and in New Caledonia with a Brigadier General as the CO. The different COs have their own areas of responsibility.

2. Maritime surveillance from the French perspective

From the French point–of-view, maritime surveillance is about sovereignty, fighting illegal trafficking, search and rescue, and protection of the environment.

2.1. Sovereignty

Sovereignty and protection of national interests is the primary objective of the French maritime surveillance.

2.2. Illegal trafficking

Fighting maritime illegal trafficking and activities, is an everyday job. It is a problem of threat and deterrence. France has to demonstrate that it is able to arrest an illegal ship. The last time it dealt with a struggle with illegal fishing in New Caledonia was in 2007. Since 2007 France did not have to seize any fishing ship. However, it needs to regularly make its presence known, with airplanes and patrol boats. The fight against drug trafficking is less common in New Caledonia, but there was such a case with *Megalodon*, a sailing boat which was seized in March 2012 with about 200kg of cocaine onboard.

2.3. Search and rescue

According to the International Maritime Organization, New Caledonia and Tahiti have their own areas of responsibility. Nouméa Maritime Rescue Coordination Center (MRCC) covers about 1.6 million square kilometers executing about 200 rescue operations per year. Around 80% of these operations are in the lagoon.

2.4. Maritime safety

With one of the largest lagoons in the world, which includes vast areas still needing hydrographic surveys, maritime safety is a real issue and with the increase of cruise ship traffic it is becoming all the more important.

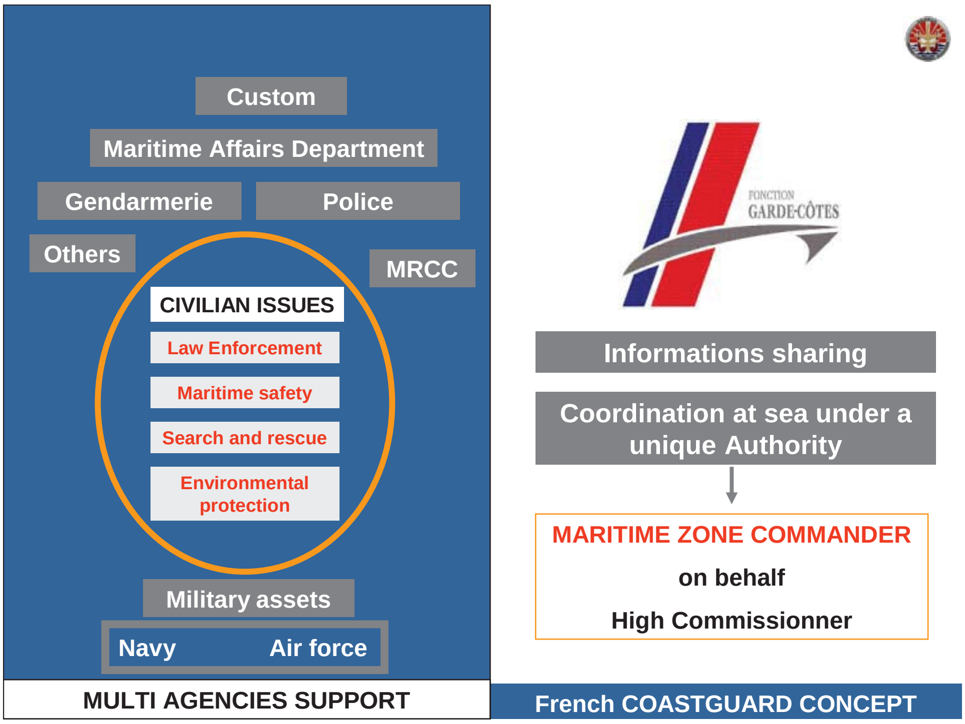
2.5. Protection of the environment

New Caledonia is an overseas territory of France possessing huge industries. It needs to import about 500,000 tons of fuel oil each year. Those industries need wharfs or big harbors made accessible at many points throughout the main island. Maritime traffic is significant (about 100 tankers each year) inside a lagoon which is very fragile. The role of the French State is to prevent any oil slick by enacting rules and training counter-pollution teams. Its role is also to ensure that the counter-pollution staff is ready to undertake annual training exercises organized for that purpose.

3. Organization

Sovereignty and protection of national interests are the mission of the armed forces and their commanding officer. For other missions, a French coastguard concept is in place. Different ministries participate in the enforcement of these missions. When combinations of resources from different ministries are at sea to carry out these missions, they are under the operational control of the maritime zone commander. The commander is under the authority of the High Commissioner, the local representative of the French Government.

Figure 1. *On civilian issues*



In NC, only the resources from the armed forces are able to survey the high seas, with frigate, patrol boats, air planes and helicopters. In Tahiti, it is quite the same, with one patrol boat coming from the customs administration as well.

4. Regional cooperation

When studying the map of the EEZ of the South Pacific, one can notice that EEZs are very close to each other –they are joined– which indicates that maritime surveillance of EEZ is not only a national topic but also a regional issue. Fighting illegal fishing in its own EEZ is necessary, but supporting the regional effort to protect the area is better. France and NC are part of the Western and Central Pacific Fisheries Commission (WCPFC) and the Inter-American Tropical Tuna Commission (IATTC) on the eastern side of the Pacific Ocean, engaging in high seas boarding and inspections. France dedicates a little over two hours daily or about 800 hours in a year for patrol in the EEZ of some Pacific island countries (PICs) and takes part in operations of the Pacific Islands Forum Fisheries Agency (FFA), such as *KuruKuru*, through the Quadrilateral Defense Coordination Group (QUAD). QUAD is a joint military forum with Australia, New Zealand, the United States of America and France. A political declaration dated September 1st, 2012 provides a political base for QUAD activities. They are the four principal providers of aerial and surface maritime surveillance that support the efforts of PICs to improve fisheries management.

Plastic Pollution in Marine System

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Abstract

The marine pollution is becoming an increasingly important issue today. Probably the most significant element in the marine pollution problem is plastics. Plastics tend to be resistant to natural decay and may leach various toxic chemicals. In addition, many types of plastics stay afloat and accumulate in the top layers of the world oceans. This paper focuses on the description of marine pollution movement, which is a connecting link between sources and sinks of marine debris. The model of surface ocean currents (Surface Currents from Diagnostic Model – SCUD) was developed with the aim of general marine pollution problems. The model was applied to study the general motion of floating marine debris. The earthquake of March 2011 in Japan is utilized to test the modeling results. On a large scale, the model is capable of capturing important features of marine pollution transport.

1. Introduction

With the mass production of plastic, the problem of marine pollution has become an increasing problem in the last few decades. It is estimated that over 80% of marine pollution is land-based[1], with the remaining originating from ocean-based activities (fishing, off-shore oil drilling). Marine pollution represents a threat to the marine environment in several ways. Large floating pieces of marine debris are hazardous for navigation, whereas derelict fishing gear and lines pose a threat of entanglement to larger marine animals. Ingestion of very small pieces of marine debris –plastics in particular– is potentially lethal for many marine birds and mammals. Even very small pieces of plastic in the ocean do harm by leaching toxic chemicals into the environment. Once those chemicals are released in the marine environment they can enter the food chain and potentially reach humans.

Plastic represents a major problem due to its persistence in the marine environment. Unlike many other materials, it is very resistant to degradation in the ocean. It does not decay like most natural materials (wood, natural fibers), nor does it rust like most metals. Also, several types of mass-produced plastics float and accumulate in the top layers of the oceans and on coastlines.

One of the major problems regarding the marine debris is a lack of complete understanding of its life cycle. The life cycle in general can be generally described by its source, transport and sink (deposition). Probably the best known component is the source, while the least understood is the sink term. For example, Law et al. (2010) noted no significant trend in plastic concentration sampled in the western North Atlantic over a period of 21 years. That is in spite of a sharp increase of plastic production over the same period. This paper focuses on the transportation segment of life cycle of marine debris, that is, the movements of marine debris. The approach is that of numerical modeling and experimentation using a model of surface currents.

[1] http://water.epa.gov/type/oceb/marinedebris/moreinfo.cfm

2. SCUD model

The Surface CUrrents from Diagnostic model (SCUD) was developed to obtain high-resolution maps of ocean surface currents applicable to general marine debris problems. The model is based on satellite data since they can provide high resolution in space and time. The surface currents are based on two satellite data sets, namely sea level altimetry from AVISO and surface wind from QuickSCAT and ASCAT satellites. The actual modeled surface currents are calculated as a linear combination of sea level altimetry and sea surface wind data. The model coefficients are calibrated such that modeled surface currents match observed trajectories of drifting buoys. The drifting buoy data were obtained from the Global Drifter Program[2] , which contains data from over 18,000 drifting buoys deployed since the mid 1970's. The SCUD model produces daily maps on ¼ longitude/latitude grid starting August 1999. For more detailed description of the SCUD model, the reader is referred to Maximenko and Hafner (2010).

3. Model applications

Since floating marine debris is transported by surface currents, it is possible to study the transport of marine debris with the use of SCUD model. The model has sufficient resolution in space and time to capture the nature of marine debris transport on a larger scale.

The first numerical experiment was conducted to better understand general motion of marine debris on ocean scales. In the model, the coastline was prescribed as a source of virtual tracers representing marine debris. The relative density of the coastline source is weighted by the total population in the coastal regions. Then the SCUD-modeled currents transport the virtual tracers. The solution for the virtual tracer location was integrated over 10 years and the resulting map is shown in Figure 1. The map shows relative concentration of the tracer after 10 years. It clearly shows five centers of accumulation, namely in the North and South Atlantic, the North and South Pacific and in the South Indian Ocean. The five accumulation zones are called “zones of convergences” or gyres. The gyres on the Northern Hemisphere (North Pacific and Atlantic) are known to collect marine debris and small plastic pieces in particular. However, until recently, this was not known about the Southern Hemisphere gyres in the South Pacific, Atlantic and Indian Ocean (Eriksen et al., 2013). Since the floating marine debris accumulates in those zones of convergences they are also popularly called garbage patches. The largest and most commonly known is the North Pacific Garbage Patch.

The tsunami of March 2011 provided a unique opportunity to study the behavior of marine debris on a large scale. Even though a very tragic event, it helped us to better understand the transport of marine debris over the North Pacific Ocean. Unlike the general marine debris, the case of tsunami debris is different as both the location and the time of marine debris released are known. Also the composition of the tsunami debris is different from general marine debris as the tsunami swept everything into the sea. Many such items can stay afloat for a long period of time and some can even be identified as tsunami debris from Japan.

The SCUD model was deployed to study the transport of tsunami debris. In a similar fashion as in the case of general marine debris, virtual tracers were released along the east coast of Japan affected by the tsunami. The virtual tracers were released in the numerical model on March 11th, 2011 and then SCUD model surface currents were applied to transport the tracers in the ocean. The tracer transport solution was updated daily since the SCUD currents are also calculated on a daily basis. The solution

[2] http://www.aoml.noaa.gov/phod/dac/gdp_drifter.php

on March 11th 2013 is shown in Figure 2. The modeled tsunami debris field is spread almost all over the North Pacific from the east coast of Japan to the west coast of North America. Also, the model captures the patchy character of the tsunami debris field.

Figure 1. *Relative concentration of virtual tracers after 10 years of transport by SCUD currents with continuous release from coastal sources (dated November 18th, 2009)*

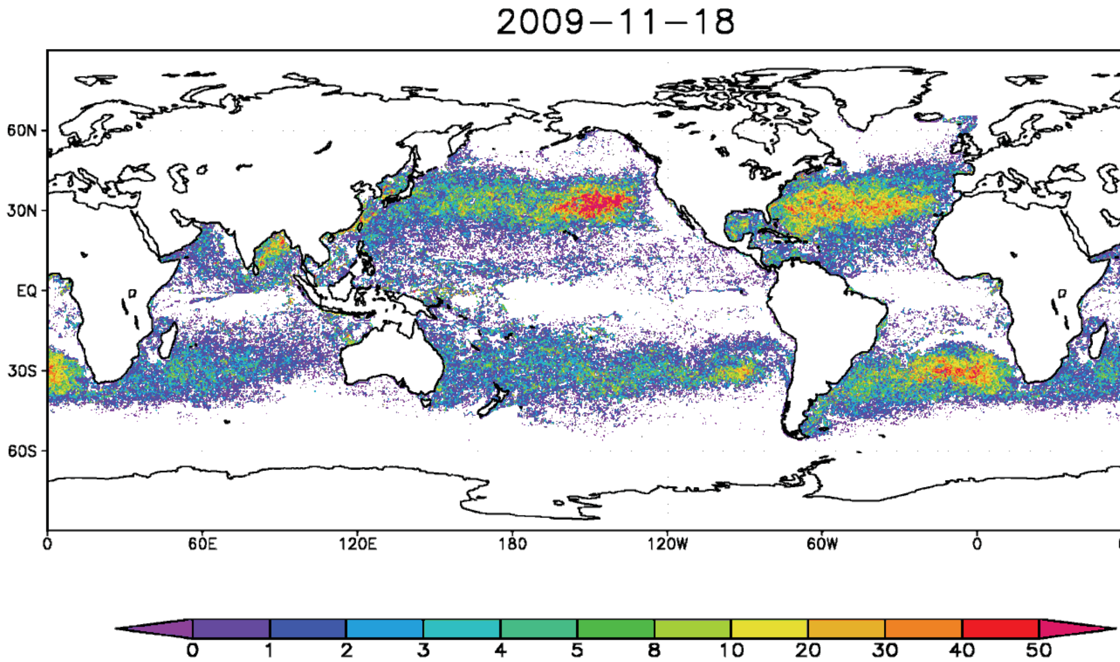
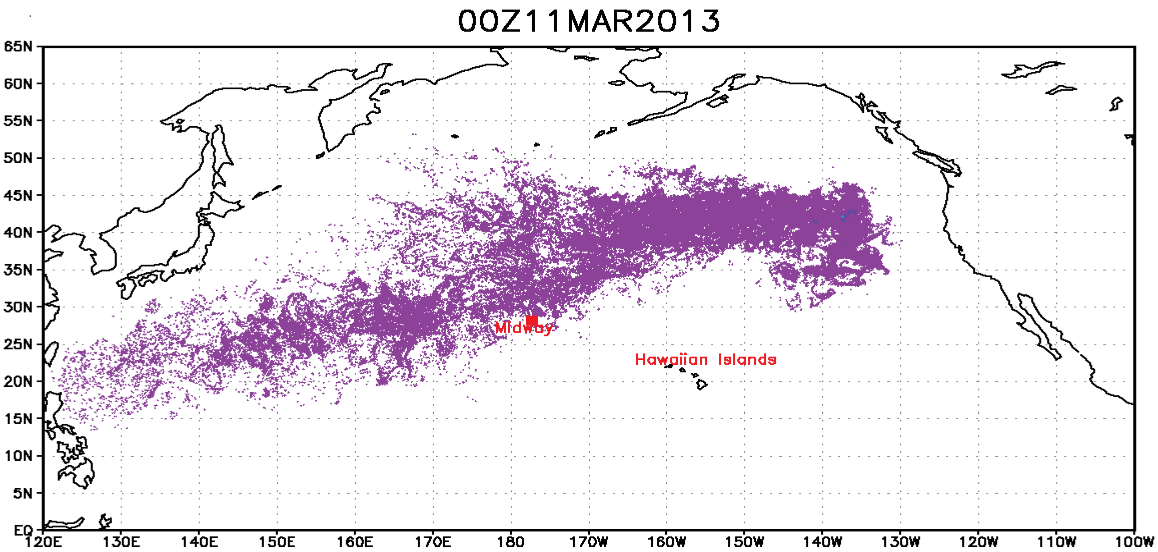


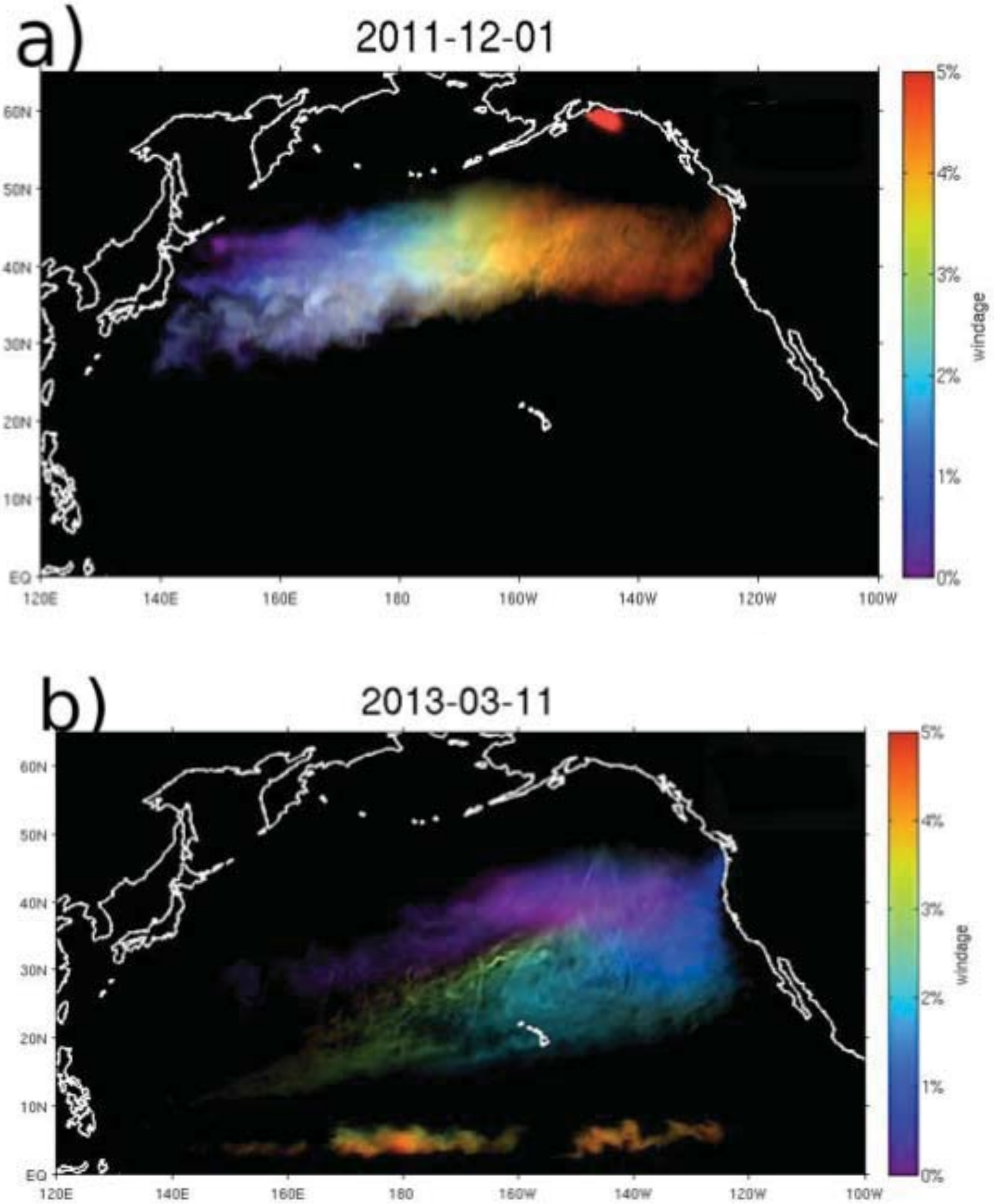
Figure 2. *Tsunami debris on March 11th, 2013 as modeled by SCUD currents*



However, the model as shown in Figure 2 does not take into account the effect of wind, or so-called "windage". As many types of floating debris are only partially submerged, they are exposed to the force of wind and move at a combined speed of surface currents and wind. The windage varies typically from 0% (completely submerged debris) to about 5% (light debris floating mostly on the water).

The solution with the effect of wind taken into account is shown in Figure 3. Here the colors represent various windages, i.e. how much a particular type of debris is affected by wind. The color intensity is proportional to the relative concentration. The high windage debris (4 – 5 %) is moving faster and it is almost absent in the map by March 2013, as shown in Figure 3. Most of this fast-moving type of debris already washed on shore off the west coast of North America. The medium windage type of debris (2 – 3 %) is located in between Hawaii and the California coast, and it is making its way to Hawaii and further westward. Low windage (0 – 1 %), slow-moving types of tsunami debris are still present in the North Pacific and they are concentrated along 30-40°N in the eastern part of the North Pacific. Ultimately this low windage tsunami debris will be trapped in the North Pacific Garbage Patch.

Figure 3. *Tsunami debris on December 1st, 2011 (a) and on March 11th, 2013 (b) as modeled with SCUD, the effect of wind is included. The colors represent windage (0 – 5 %) and the color intensity is proportional to the relative concentration of tracers*



The direct comparison of SCUD-modeled tsunami debris with actual observation is a difficult task due to lack of reliable *in situ* data. Only few reports were available from volunteer sailors crossing the North Pacific. However, many reports of tsunami debris came from the west coast of North America.

The unusual type of debris and high numbers were indications that it is tsunami debris. The timing of arrival of tsunami debris in November/December 2011 corresponded well with the SCUD model results (see Figure 3a). Similarly, Hawaiian Islands received their first tsunami debris in the summer of 2012, which is in agreement with the SCUD model. This gives us a certain level of confidence that the SCUD model can capture the nature of long range transport of various types of marine debris.

4. Summary

The problem of marine debris -and plastics in particular- in the marine environment is becoming more pressing. Although the plastic pollution has been in the marine environment for several decades, little is known about its life cycle from its sources to its sinks. The SCUD model is applied to the problem of transport of marine debris on the ocean scale (Maximenko et al. 2012, Maximenko 2009). The March 2011 tsunami in Japan created a unique opportunity to apply and test the SCUD model. The SCUD model is able to simulate the features and the variability of floating marine debris transport on a large scale. The model has potential applications for various problems of marine debris transport; for example, identifying the zones of accumulation and pathways of debris flow from its sources to its sinks. This information can be utilized in optimizing clean-up operations, or in emergency response.

One of the problems hindering the progress in understanding the life cycle of plastic marine debris is lack of a comprehensive observation system. Current methods of collecting the data and samples are insufficient to describe the state of the marine pollution. A uniform protocol of collecting the marine pollution data on shore and at sea is needed. In addition, a completely new generation of environmental sensors capable of detecting even the minute plastic particles will be necessary to improve our knowledge of the state of marine pollution. An organization like the Asia-Pacific Economic Cooperation (APEC) forum could be a vehicle for establishing a cooperative research program and even eventually an international regime to better address the marine problem in the Pacific.

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EPA: http://water.epa.gov/type/oceb/marinedebris/moreinfo.cfm

An Update on Deep Seabed Mineral Activities in the Pacific Islands Region

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1. Introduction

Seabed mineral research and exploration were reported to have commenced in the Pacific Islands region in the late 1960s and continued to the mid 1970s, concentrating on Manganese Nodules assessment. From the mid 1970s to mid 1980s, other commodities such as 'precious coral, metalliferous sediments' and phosphate were explored together with manganese nodules. Additionally, a cobalt-rich crusts (CRC) survey was first conducted in the region during the Kiribati Phoenix Island Group expedition in the early 1980s. The first hydrothermal vent was discovered in the Lau Basin in 1982, and the first seafloor massive sulfide (SMS) (or 'black smoker') was found in the Manus Basin, Papua New Guinea (PNG) in early 1986.

Further assessments of manganese nodules, CRC and SMS were ongoing in the region from the mid-1980s to the mid-2000s. With the persistent research efforts of Australia's Commonwealth Scientific and Industrial Research Organisation (CSIRO), the presence of high-grade SMS deposits in the Manus Basin PNG was confirmed in the early 1990s.

These previous studies have confirmed the occurrences of SMS, CRC and manganese nodule deposits within the exclusive economic zones (EEZ) of most Pacific Island Countries (PICs) (see Table 1 below) and some of these deposits have very good potential to be further investigated for mining.

Table 1. *Deep seabed mineral occurrences within the EEZ of PICs.*

Country / Territory	MN*	CRC^	SMS
Kiribati	√	√	
Cook Islands	√		
Tuvalu	√	√	
Samoa		√	
Tonga			√
PNG			√
Solomon Islands			√
Vanuatu			√
Fiji			√
Republic of the Marshall Islands		√	
Federated States of Micronesia		√	
Niue	√	√	

* MN: manganese nodule
^ CRC: cobalt-rich crusts
SMS: Seafloor massive sulfide

2. Recent seabed exploration in the Pacific Islands region

Three exploration companies are currently active in the region, namely Nautilus Minerals Inc, Bluewater Metals and the Korea Institute of Ocean Science and Technology (KIOST), and they share a common interest in exploring and mining SMS deposits. Nautilus Minerals is exploring in PNG, Solomon Islands and Tonga, and has been granted exploration licenses in Vanuatu and Fiji. A subsidiary of Neptune Minerals (US), Bluewater Metals is based in Australia and has been conducting exploration activities in PNG, Solomon Islands, Vanuatu and Tonga, and the company has submitted an application to explore in Fiji. KIOST, a state-sponsored ocean science research institute is currently exploring in Tonga and Fiji.

2.1. Nautilus Mineral activities

The Government of PNG had granted a mining lease to Nautilus in January 2011, following the issuance of an environment permit in December 2009. Nautilus has been reported to have awarded contracts for the construction of mining equipments, and construction works are in progress, as well as the development of an Environmental Management Plan (EMP) for the *Solwara 1 Project* site. Mining is expected to commence at *Solwara 1* in the 4th quarter of 2013.

The pioneering of deep sea mining in PNG will lead to improved future deep seabed mining technology. Hence, development of new and robust technology will increase the economic viability of exploiting manganese nodule and cobalt-rich crust deposits. The design and manufacture of seabed mining technologies are adopted from existing mining, oil and gas and offshore technologies.

2.2. KIOST activities

KIOST has been actively exploring in Tonga in the last four years and the company intends to carry out resource definition activities in 2013 to better understand the geological potential of its licensed areas. According to the company's work plan, an Environment Impact Assessment (EIA) will be carried out at the end of 2013 and an application for a mining license is expected to be submitted in 2014. This will be followed by preparation for commercial mining, including the construction of mining equipment and facilities between 2014 and 2016 with commercial mining to commence in 2017.

According to a KIOST representative based in Suva, Fiji, the company believes the work plan is achievable but it will largely depend on the resource definition that is scheduled to be conducted in 2013 to determine the geological potential of KIOST's tenements. KIOST is supported by its joint-investment partners; namely, Samsung Heavy Industries, Daewoo Shipbuilding & Marine Engineering, LS-Nikko Copper and SK Networks. These joint investment partners are well established and well resourced to support KIOST in realizing its vision.

3. Recent deep sea minerals interest in "the Area"

In recent years, some PICs have expressed their interests to participate in the exploration and possible exploitation of deep sea minerals in the International Seabed Area ("the Area"). Nauru and Tonga were the first two countries to provide sponsorship, as required under the United Nations Convention on the Law of the Sea (UNCLOS), to two exploration companies. Nauru Ocean Resources Incorporation (NORI) is sponsored by Nauru and Tonga Offshore Mining Limited (TOML) is supported by Tonga, and the International Seabed Authority (ISA) has granted both companies exploration licenses in the reserved areas of the "Clarion-Clipperton Fracture Zone" (CCFZ). Marawa Research and Exploration Limited, a state-owned company in Kiribati has recently been granted exploration licenses in the CCFZ under the Kiribati Government sponsorship. Other PICs such as Tuvalu and Fiji have also shown interest to participate in deep sea mineral activities in "the Area".

4. Secretariat of the Pacific Community (SPC)-European Union (EU) Deep Sea Minerals (DSM) Project

With the recent growing interest to further explore these seabed minerals in the region for commercial exploitation, PICs have regarded this as an excellent economic development opportunity. While this new development is exciting, some stakeholders are concerned about the lack of necessary legal instruments and the likely adverse impacts of deep sea minerals activities on marine living resources. Further, there is a need for harmonized legal, environmental and fiscal regimes for the management of offshore mineral resources in the region.

In the face of limited resources and capacity in the region to deal with this new industry, the need for a regional cooperative approach for the governance and management of deep sea mineral resources was evident. Hence, the SPC-EU Deep Sea Minerals (DSM) Project was conceived. The overall objective of the DSM Project is to expand the economic resource base of Pacific ACP (African, Caribbean and Pacific) states by facilitating the development of a viable and sustainable marine minerals industry. This regional project is funded by the European Union and is implemented by the South Pacific Applied Geoscience and Technology (SOPAC) division of the SPC in 15 Pacific ACP States.

The Project has the following four Key Result Areas:

- **Key Result Area 1:** Regional Legislative and Regulatory Framework (RLRF) for deep seabed minerals exploration and exploitation;
- **Key Result Area 2:** National DSM policy, legislation and regulations;
- **Key Result Area 3:** Building national capacities – supporting active participation of Pacific ACP States nationals in deep sea mineral activities; and
- **Key Result Area 4:** Supporting effective management and monitoring of offshore exploration and mining operations.

4.1. Implementation of project activities

Notwithstanding the competing demands on project personnel, the implementation of project activities has been progressing steadily over the last two years. Significant efforts have been dedicated during the last year in developing, reviewing through an extensive stakeholder consultative approach, and finalizing the RLRF. The official launching of the RLRF at the margins of the Forum Leaders' meeting in Rarotonga, Cook Islands in August 2012 signifies the completion of Key Result Area (KRA) 1 of the Project.

4.2. Country visits and consultations

A significant amount of time and effort were dedicated to country visits and in-country stakeholder consultations in 2012 due to the pressing need of visiting the remaining participating countries of the DSM Project. The following twelve countries received visits between January and October 2012: Tonga, Samoa, Fiji, Niue, Cook Islands, Tuvalu, Vanuatu, Solomon Islands and the Republic of the Marshall Islands, Federated States of Micronesia, Palau and Timor Leste.

The main objectives of holding a national consultation workshop in each country are to: (1) present the DSM Project to in-country stakeholders, (2) discuss various issues and concerns relating to deep sea minerals and mining, (3) collectively identify and agree on national deep sea mineral priorities and plan for a way forward, and (4) provide the necessary guidance for the implementation of the DSM Project in-country. This visit also poses an opportune time to meet with in-country stakeholders and discuss deep sea minerals-related issues with them.

In addition to the consultation workshop, separate meetings with key stakeholders were organized prior to and after the workshop in an effort to make them aware of issues related to DSM. Further, a questionnaire has been distributed to stakeholders in order to ascertain each P-ACP State's current legal framework and relevant national policy (if any), to identify the gaps and to establish the particular support that each country would require from the DSM Project.

4.3. In-country stakeholder concerns

A number of concerns have been raised during various regional and national stakeholder consultations meetings that need to be addressed during the life of the DSM Project and future DSM initiatives. Firstly, competing interests for ocean resources, including fishery activities, marine conservation, scientific research initiatives, deep sea mineral activities and others will contribute to increase in marine pollution. In addition, very little is known about environmental, social and cultural impacts of DSM exploitation, which warrant more scientific studies. At the same time, stakeholders have been hearing conflicting messages from NGOs, researchers, developers and governments about the benefits and adverse impacts of DSM activities.

Secondly, stakeholders are concerned with the distribution and equitable sharing of DSM benefit streams, hence the need to learn from the sharing of funds derived from terrestrial mining and the fishing industry in the region. Stakeholder awareness and information sharing are called for. Lastly, the lack of capacity (i.e. lack of knowledge on technical issues related to mineral exploration and mining) at all levels is recognized together with the need to build national capacity to enforce national DSM legislation and regulations. Independent monitoring of offshore mining activities and data-sharing are also necessary and there should be a process in place to facilitate this. Due to the potential economic benefits that will derive from DSM mining, there is a tendency for people to claim ownership of DSM resources and nearby fishing grounds.

4.4. DSM documentary

The production of a DSM documentary is in progress in collaboration with the ISA, Woods Hole Oceanographic Institute (WHOI), National Science Foundation (NSF) 2000, Pennsylvania State University and Neptune Minerals (US). The SPC Regional Media Centre is contracted to produce two high-quality documentary films (a short and a full version) on DSM issues in the Pacific Islands region.

The main purpose of the documentary is to enhance the understanding of issues related to DSM for various stakeholders, including policy-makers and local communities, ultimately to achieve better-informed decision-making among the Pacific ACP states. The documentary is expected to be finalized in early 2013.

4.5. Information brochures

In addition to the six information brochures that were prepared in 2011, five country-specific information brochures were prepared in the last year. Each information brochure summarizes the DSM potential of one of the following countries: Kiribati, Tonga, Samoa, Fiji and RMI. Copies of these information brochures have been distributed to each target country and other interest groups. Each country is encouraged to use the information brochure to promote its mineral potential to investors and to use them for educational and awareness purposes. Additional country-specific information brochures will be prepared in the next six months.

In an effort to provide stakeholders in the region with relevant information on various issues relating to DSM, a mini-website for the DSM Project has been established within the SOPAC Division website: http://www.sopac.org/dsm.

Managing New Zealand's Offshore Mineral Resources: Striking a Balance between Economic Development and Environmental Protection

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Abstract

The legal framework governing activities conducted in New Zealand's exclusive economic zone and continental shelf has developed over time in a piecemeal fashion. Historically, there has not been a comprehensive regulatory regime for the minerals industry. Instead, reliance has been placed on a small number of specific regulations and a heavy onus on self-regulation and industrial best practice. However, a variety of recent factors, both local and global, have culminated in an increased focus on the need to develop a comprehensive offshore environmental permitting regime in New Zealand. The impetus towards regulation has resulted in the Exclusive Economic Zone and Continental Shelf (Environmental Effects) Act.

This paper briefly canvasses the historic legal framework for governing offshore activities and details the various "drivers" for increased environmental regulation. It goes on to outline the key features of the Exclusive Economic Zone and Continental Shelf (Environmental Effects) Act, including some of the more contentious aspects of the legislation.

1. Introduction: New Zealand's exclusive economic zone

New Zealand's exclusive economic zone (EEZ) extends from the outer boundary of the territorial sea (the area that extends 12 nautical miles out from shore)[3] to a point 200 nautical miles out from shore.[4] New Zealand's EEZ is 15 times larger than its land area and covers approximately 4 million square kilometers.[5] It is the fifth largest EEZ in the world and covers an area larger than the whole of India, or equivalent to half the land mass of Australia. In addition, New Zealand has an extended continental shelf that covers a further 1.7 million square kilometers beyond the EEZ.[6]

While collective knowledge about the EEZ is still in its infancy, it is already known that in addition to petroleum resources, New Zealand's waters are rich in other mineral resources.[7] So too is New Zealand's EEZ an area of high biological diversity and home to many environmental treasures.[8]

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[3] Enfocus Ltd, URS New Zealand and Hill Young Cooper Ltd, *Ocean Policy Stocktake: Part 1 – legislation and Policy Review* (prepared for the Oceans Policy Secretariat 2002). The precise definition of territorial sea can be found in section 3 of the Territorial Sea, Contiguous Zone, and Exclusive Economic Zone Act 1977.
[4] Territorial Sea, Contiguous Zone, and Exclusive Economic Zone Act 1977, s 9. UNCLOS, Art 2.
[5] Ministerial Advisory Committee on Oceans Policy *Healthy Sea: Healthy Society – Towards an Ocean Policy for New Zealand* (2001) and Ministry for the Environment *Offshore Options: Managing Environmental Effects in New Zealand's Exclusive Economic Zone* (Ministry for the Environment, Wellington, 2005). See also http://www.mfat.govt.nz/Media-and-publications/Features/990-NZ-extended-seabed-claim.php.
[6] http://www.mfat.govt.nz/Media-and-publications/Features/990-NZ-extended-seabed-claim.php
[7] The seamounts along the Kermadec Ridge are rich in copper, zinc and lead and also have a good gold and silver content. Chatham Rise also has phosphorite nodules that are a potential source for phosphate fertilizers: Raewyn Peart, Kelsey Serjeant and Kate Mulcahy *Governing our oceans: Environmental reform for the Exclusive Economic Zone* (Environmental Defence Society Incorporated, Auckland, 2011).
[8] Ibid.

2. The legal framework

The historic legislative framework governing offshore activities reflects the differing forms of jurisdiction that New Zealand has under the United Nations Convention on the Law of the Sea (UNCLOS) in relation to the distinct zones making up our offshore waters – the territorial sea, the EEZ and the outlying continental shelf.[9]

New Zealand has sovereignty over the territorial sea. In a general sense, the territorial sea is treated in the same manner as the land mass itself, and all relevant New Zealand laws apply. In an environmental context, the Resource Management Act 1991 (RMA) provides a comprehensive environmental permitting regime for onshore activities and activities within the territorial sea.

While New Zealand does not have sovereignty over the EEZ, it does have specific rights over the exploration, exploitation, management and conservation of the natural resources of the seabed and water column. New Zealand also has jurisdiction in relation to the protection and preservation of the marine environment.[10] In exercising its jurisdiction, New Zealand has a general obligation to "protect and preserve the marine environment".[11]

The legal framework governing activities conducted in the EEZ and continental shelf has developed over time in a piecemeal fashion. A range of different statutes apply, but these are generally sector-specific (for example, regulation of fishing activities) and only protect elements of the marine environment. With regards to the minerals industry, there has not been a comprehensive regulatory regime and New Zealand has relied instead on a small number of specific regulations and the onus of self-regulation and industry best practice. Generally, there has been no problem with this approach due in large part to the low level of activity in the offshore minerals space. Those offshore projects that have occurred have typically been conducted in shallow water and have occurred without any environmental incidents.

3. Oceans Policy

While there have not been any significant issues, New Zealand has been cognizant for some time of the need for, and benefits of, a comprehensive legal framework. Discussions surrounding the adequacy (or otherwise) of the legislative framework for New Zealand's waters (including specifically, an environmental protection regime) is not a new issue and has been the subject of significant policy work over more than 10 years.[12] In 2000, the Government decided to develop an Oceans Policy with the aim of ensuring integrated and consistent management of the ocean within New Zealand's jurisdiction.

However, developing a comprehensive approach for environmental protection (that assesses the effects of an activity both on its own and cumulatively with other activities in the marine area) was a job requiring significant time and resources. Policy work began and continued for a number of years, but without any overwhelming urgency, especially in relation to devising a legislative solution.

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[9] The United National Convention on the Law of the Sea was ratified by New Zealand in 1996.
[10] UNCLOS, Art 56.
[11] UNCLOS, Art 192.
[12] See for example Atkins Holm Joseph Majurey Ltd and ERM New Zealand Ltd *Comparative Review of Health, Safety and Environmental Legislation for Offshore Petroleum Operations* (prepared for the Ministry of Economic Development, 2010) and Raewyn Peart et al, above note 4.

4. "Drivers" for increased regulation

However, in the last few years, a number of events and factors (discussed below) have created an impetus for change. The development of a comprehensive environmental management system for the EEZ moved swiftly up the Government's priority list.

4.1. Increased awareness of the potential resources and the environmental treasures located in the EEZ

The considerable work carried out in preparing New Zealand's submission to the United Nations Commission on the Limits of the Continental Shelf enhanced domestic knowledge of the resources within the EEZ. The submission revealed additional offshore potential including iron sands, seafloor gold and base metals, phosphate and other minerals, the value of which may eventually exceed that of onshore resources. The success of the submission (and the subsequent expansion of New Zealand's EEZ) also helped to raise general public awareness of the area and its economic potential.

4.2. Increased global demand for natural resources

Increased demand for natural resources (primarily from developing Asian economies) resulted in increased prices for minerals. Coupled with technological advancements, this has helped to make offshore projects a more attractive and realistic investment for a number of industry players.

4.3. Increased interest in New Zealand projects

Increased global interest in offshore mining generally, has flowed through to increased interest in New Zealand's offshore resources. Interests in oil and gas opportunities were generated in the mid-2000s by the success of the Maari and Tui oil fields. More recently, minerals projects involving iron sands and phosphate have increased the profile and perceived likelihood of serious offshore mining in New Zealand. Coupled with considerable interest by the Government in the economic potential of the resources sector, interest in New Zealand projects has risen.

4.4. Public awareness of environmental risks

Public interest in offshore activities has been heightened by publicity surrounding protests over offshore petroleum exploration activities. While there have been no incidents in New Zealand waters, the possibility of a catastrophic event, such as the Deepwater Horizon explosion in the Gulf of Mexico highlighted the potential environmental (and economic) impact of an offshore incident. The grounding of the container ship *Rena* and consequent fuel spill (although not related to the minerals industry) also served to bring environmental risks into sharp focus.

A comparative review (commissioned by the Ministry of Economic Development) of the adequacy of New Zealand's health, safety and environmental legislation for offshore petroleum operations took place in 2010, and highlighted the absence of a comprehensive environmental permitting regime.

Overall, these factors led to a general (if not universal) acceptance that environmental legislation for offshore activities was needed. Legislation was welcomed by those concerned with environmental risks seeking comfort that adequate environmental protection was in place. Industry welcomed the clarity and certainty that legislation could provide in relation to responsibilities and process. The key task for drafters was to deliver a legislative framework that could balance these two, often competing, interests.

5. The Exclusive Economic Zone and Continental Shelf (Environmental Effects) Act

The result was the Exclusive Economic Zone and Continental Shelf (Environmental Effects) Act (Act). The Act is enabling legislation that establishes the general framework of the regulatory regime to manage the environmental effects of certain activities (including minerals exploration and mining) carried out in New Zealand's EEZ and continental shelf. The Act supplements, but does not replace existing legislations.

It is important to note that the Act is not concerned with resource allocation and the granting of permits over onshore or offshore resources. The allocation of mineral rights to prospect, explore or mine resources is governed by the Crown Minerals Act 1991 (for the territorial sea) and the Continental Shelf Act 1964 (for the EEZ and continental shelf). Allocation of a resource does not, of itself, allow a permit holder to mine. A permit holder must obtain access rights and meet the requirements of the relevant environmental legislation. This is where the EEZ Act comes into play.

The Act will apply to any "activity" carried out in the EEZ or on the continental shelf. "Activity" is defined broadly in the Act and includes things such as "the construction, placement, alteration, extension, removal or demolition of a structure on or under the seabed" and" the removal of non-living natural material from the seabed or subsoil". The definition of "activity" will catch most prospecting, exploration and mining activities.

Activities will be classified as permitted, discretionary or prohibited according to criteria set down in regulations, which will focus largely on the adverse environmental effects of different activities. Permitted activities will not require marine consent and may be carried out as of right, subject to compliance with any specific conditions set down in regulation. Activities classified as discretionary will require the interested party to seek and obtain a marine consent prior to commencement. Applications for marine consent must be accompanied by an environmental impact assessment and are decided by the Environmental Protection Authority (EPA).

The Act has not yet come into force. Minister for the Environment, Amy Adams, has announced that the Act will come into force in June 2012 by making regulations that permit lower impact activities. A "discussion draft" of the permitted activity regulations has been released and is currently being consulted on. A suite of other regulations containing the operational and technical details and standards underpinning the Act will follow.

We canvas some of the key (and most contentious) aspects of the Act, below.

5.1. Purpose

As initially drafted, the Bill had the overarching purpose of seeking to balance environmental protection and economic development. The operative decision-making provisions included a balancing test requiring the economic benefits of an activity to be measured against its environmental effects. The balancing test proved to be incredibly polarizing. In particular, many opponents argued that it was inconsistent with New Zealand's obligations under the UNCLOS to "protect and preserve the marine environment".[13]

In response to strong opposition, the Bill was amended to remove the reference to balance. The Act now incorporates the concept of sustainable management, taken from the RMA. Some opposition parties still believe this does not go far enough, suggesting that in order to meet its international obligations the New Zealand legislation needed to be drafted such that the right to exploit resources is conditional upon ensuring protection of the environment.

[13] UNCLOS Art 192.

5.2. Classification of activities

One of the major outstanding aspects of the new environmental regime is how different activities will be classified in practice. As stated above, regulations classifying activities are still in the process of being developed. The Ministry for the Environment issued a discussion paper in May 2012 proposing a methodology for determining classification and outlining its initial views on how various activities (such as seismic surveying, exploratory sampling and drilling of oil wells) might be classified. As with the Act itself, the discussion document proved very contentious and extensive submissions have resulted in modifications to the original proposals. All parties are waiting anxiously to see the approach taken in the proposed regulations.

5.3. Decision-making criteria

In determining consent applications, the EPA must take into account specific criteria set out in the Act including the effects on the environment and existing interests, economic benefits and the efficient use of natural resources.

When considering an application for marine consent, the EPA must base decisions on the "best available information" and take into account any uncertainty or inadequacy in the information available. "Best available information" means the best information that, in the particular circumstances, is available without unreasonable cost, effort or time. If the information available is uncertain or inadequate, the EPA must favor caution and environmental protection. If favoring caution and environmental protection means that an activity is likely to be refused, the decision-maker must first consider whether taking an adaptive management approach would allow the activity to be undertaken.

5.4. Adaptive management approach

The EPA may incorporate an adaptive management approach into a marine consent. This includes allowing an activity to commence on a small scale or for a short period so that its effects on the environment and existing interests can be monitored; or any other approach that allows an activity to be undertaken so that its effects can be assessed and the activity discontinued, or continued with or without amendment, on the basis of those effects.

Not surprisingly, there is some concern from both environmental and development camps as to how adaptive management will work in practice. Environmentalists are worried that it will allow activities to commence, notwithstanding that they pose a risk of serious or irreversible damage. On the other hand, developers are concerned that it will become an "easy-out" for the EPA, leading to commercially unrealistic consent conditions whereby a risk with a serious consequence, but a small probability of occurring is taken out of context.

5.5 Public involvement

The Act provides for significant public involvement. All applications for marine consents are to be publicly notified, a process which differs from the RMA and reflects the idea that the marine environment is one of national importance. Any one (irrespective of whether or not they are personally impacted in any way) is entitled to make a submission on an application for a marine consent. Furthermore, any submitter can then require that the matter is dealt with by way of a public hearing.

5.6. Appeals

The EPA's decision on a marine consent application can be appealed to the High Court (and subsequently higher appellate courts), but only on points of law. This is the same as for projects of national significance on land, but has been a bone of contention as most decisions under the RMA provide the ability for a fresh hearing by the Environment Court. This approach reflected a concern that the consent process should not be unduly long. However, a point to note is that, in the event of an appeal to the High Court, the consent does not become active until the Court has made its decision.

5.7. Penalties

The Act imposes significant penalties that the EPA is responsible for enforcing. Offences are strict liability. A person who commits an offence against the Act, such as carrying out an unauthorized activity, is liable, in the case of a natural person, to a fine not exceeding NZ$300,000 and in the case of a person other than a natural person, to a fine not exceeding NZ$10 million. The penalties were increased significantly from earlier drafts of the Bill. Continuing offences attract an additional maximum penalty of NZ$10,000 per day or part day. In addition to monetary penalties, the Court may make an enforcement order or an order requiring the EPA to review the relevant marine consent.

6. Conclusion

The Act seeks to provide a robust framework for regulating the environmental effects of activities in New Zealand's EEZ and continental shelf. Overall, the Act's purpose, the decision-making criteria and the information principles seek to establish a regime that achieves a balance between the protection of the environment and economic development. The meaning of, and methods for striking the right balance have raised a number of key issues that, on occasion, have seen interested parties divided. We envisage that the question of whether the Act weighs these matters "correctly" or not will be the subject of a judicial consideration before too long.

As the Act moves towards commencement, all parties are waiting with interest to see the regulations and how the Act will work in practice.

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Enabling the Management of Offshore Mining through Improved Understanding of Environmental Impacts – a New Zealand Perspective

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Abstract

There is growing interest for marine mining in the south west Pacific, from coastal ironsand to deep sea minerals. Deep sea mineral resources include seafloor massive sulfides, phosphate and manganese nodules, and cobalt-rich ferromanganese crust. These deposits occur in different regions of the south west Pacific. The challenge currently facing national and inter-governmental agencies is to facilitate development of mining operations while ensuring that environmental sustainability is not compromised. Legislation is still developing and there are only limited regulatory guidelines in place.

In the New Zealand context, scientific research can support exploitation of minerals by providing data for resource assessment and evaluation, for baseline pre-mining information, robust monitoring programs and precautionary conservation measures. Research can also identify and quantify the nature and extent of impacts, and form an integral component of environmental impact assessment and ecological risk assessment. A strong collaborative approach in the early stages of exploration is occurring between New Zealand minerals companies and researchers, which is providing a solid foundation for subsequent environmental management.

1. Introduction

As defined by the United Nations Convention on the Law of the Sea (UNCLOS), a coastal state has sovereignty rights over its exclusive economic zone (EEZ) and extended continental shelf (ECS) for the purposes of exploring and exploiting, conserving and managing natural resources of the waters, seabed and subsoil. To date, 76 states have either made a submission or submitted preliminary information to the Commission on the Limits of the Continental Shelf with the aim of maximizing or protecting their sovereign rights.

Interest in offshore petroleum and minerals exploration has grown rapidly worldwide as investors have identified large potential economic returns from marine resources. As the technological ability to access deep seafloor resources continues to improve, so too does the pressure for access, and for adequate management of the negative impacts that exploitation could have on the environment. The challenge for management agencies and scientists is to facilitate exploration and exploitation of the seafloor –to benefit from the potential economic derivatives- while ensuring environmental sustainability is not compromised.

New Zealand's EEZ and outer continental shelf together cover 7.7 million km^2 from sub-tropical to sub-Antarctic waters. This represents more than twenty times the country's emerged land area, although half of this ocean is deeper than two thousand meters. Because of its vastness and the scarcity of emerged land, the EEZ-to-emerged-land ratio in the South Pacific region is staggering, with a value greater than 1,000 (see Table 1).

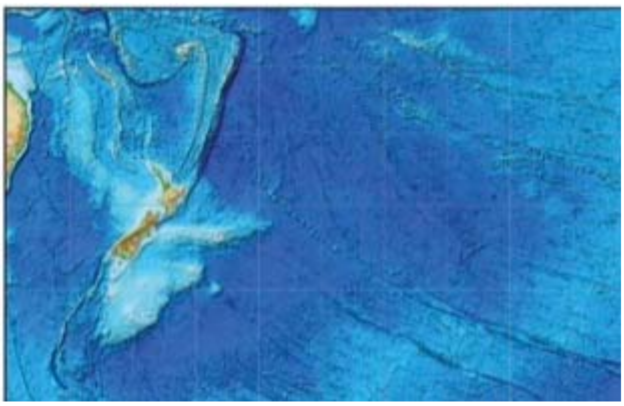
In this short paper, we review the type of marine mineral resources that have been identified or inferred in the Southwest Pacific region; the main impacts that exploration and exploitation may have on the environment and the approaches taken, and being taken, by New Zealand to enable access to the resources without compromising the sustainability of the environment.

***Table 1*.**

Country/ Territory	EEZ (km^2)	Land Area (km^2)	EEZ/Land
United States	8,078,169	9,158,960	1
Australia	6,664,107	7,682,300	1
French Polynesia	4,553,115	3,827	1190
New Zealand	3,887,441	262,443	15
Kiribati	3,387,648	811	4177
Fed States Micronesia	2,906,416	702	4140
Marshall Islands	1,877,282	181	10372
Cook Island	1,830,000	236	7754
Papua New Guinea	1,613,759	452,860	4
Solomon Islands	1,377,128	27,986	49
New Caledonia	1,347,964	18,275	74
Fiji	1,055,048	18,274	58
Tonga	844,978	717	1178
Vanuatu	530,162	12,189	43
Tokelau	319,031	12	26586
Samoa	109,932	2,821	39

2. New Zealand in the Southwest Pacific region

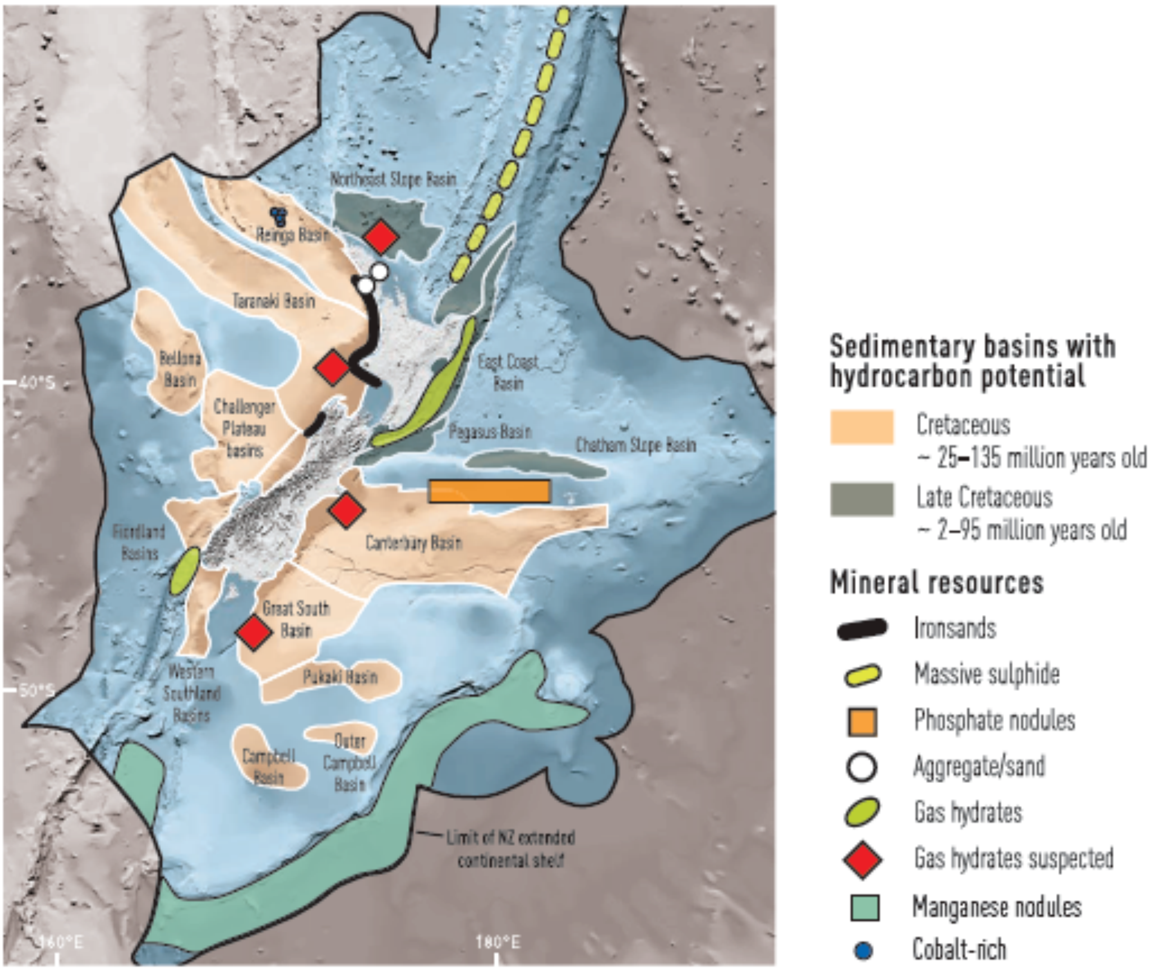
Figure 1. *The Southwest Pacific (NOAA, http://maps.ngdc.noaa.gov)*



Here we loosely define the Southwest Pacific as the region delimited by the equator to the north, the 60°S parallel to the south as the boundary to the Antarctic regions, and from Pitcairn to the east and the east coast of Australia to the west (Figure 1). This represents an area of approximately 52 million km^2, which include 27 Pacific Island Countries and Territories (PICTs) as well as New Zealand.

The Southwest Pacific ocean and its seafloor are influenced by major oceanic currents, weather patterns and climate influences. The seafloor supports an often unique but very diverse biota. New Zealand's EEZ and ECS cover 5.7 million km^2, over 20 times the land area (Figure 2). As most other PICTs, New Zealand has a complex seabed associated with a tectonically active environment and a diverse range of habitats. This situation is far more complex than that encountered for onshore mining exploration and exploitation endeavors. Yet much less is known about potential environmental impacts of offshore mining.

Figure 2. *The NZ EEZ and mineral resources*



3. Marine mineral resources

Marine geological resources are generally separated into petroleum (oil and gas) and mineral resources. Here we look at marine minerals which include: (1) coastal resources, which are essentially sand and aggregates, and placer deposits (heavy minerals and gems), and (2) deep sea minerals which include massive sulfides and precipitates (phosphorites and manganese nodules). We also present the promising non-conventional gas hydrate resource.

Unlike oil and gas, marine mineral resources have been poorly investigated and resource estimates vary greatly. Another important difference is that very little mining is currently taking place in the shallow and coastal regions apart from sand and aggregates, and no mining is occurring in the deep sea.

Different deep sea minerals occur throughout the Southwest Pacific depending on a number of physical parameters such as water depth, seafloor geology and active tectonic processes such as volcanism. Hence most PICTs have an interest in the issues associated with discovery, exploration and mining of this potential source of revenue and in the potential impact of such activities on the environment. The SPC-SOPAC deep sea mineral project (see htt://www.sopac.org/dsm for more information, including country-specific data), recognized three types of deep sea minerals bearing potential economic resources; namely manganese nodules, cobalt-rich crusts (CRC) and seafloor massive sulfide (SMS).

An illustration of the potential economic returns is given by New Zealand. Its marine economy is currently worth about US$3.3 billion a year in a GDP of US$127 billion (NZ$750 million of which comes from the production of offshore minerals, primarily oil and gas, *Statistics New Zealand 2006*). Oil and gas production in 2007 contributed about 0.5% to the New Zealand economy.

3.1. Placer deposits

Placer deposits include minerals that have been concentrated by physical processes such as waves, wind and currents. Globally, diamonds dominate this sector, but in the Pacific region, sand, gravel, coral and shell are valuable to the local economies as they provide material for beach refurbishment, landfill and cement (Faure and Wood, 2012), for example.

Ironsands constitute a very large potential resource. Ironsands essentially occur in the coastal zone. New Zealand has aggregate gold and ironsand placer deposits, generally in shallow waters close to the coast (Figure 2). Ironsands exploration presently concentrates off the west coast of the North Island.

3.2. Deep sea minerals

Deep sea minerals have been recognized as a potential source of revenue and economic development for the Pacific Island Countries and Territories and New Zealand. The SPC-EU EDF 10 Deep Sea Mineral Project run by the SPC-SOPAC has indicated that the Pacific seafloor is rich in minerals.

Seafloor massive sulfides (SMS) contain iron, manganese, gold, silver, copper and zinc. Such deposits are associated with active and inactive submarine hydrothermal vents (Figure 3). SMS are known to be found in Papua New Guinea (PNG), Vanuatu, Solomon Islands, Fiji, Tonga, Samoa and New Zealand. The Kermadec-Havre Trough volcanic region between New Zealand and Tonga-Fiji is well known for a large number of SMS fields (Figure 2).

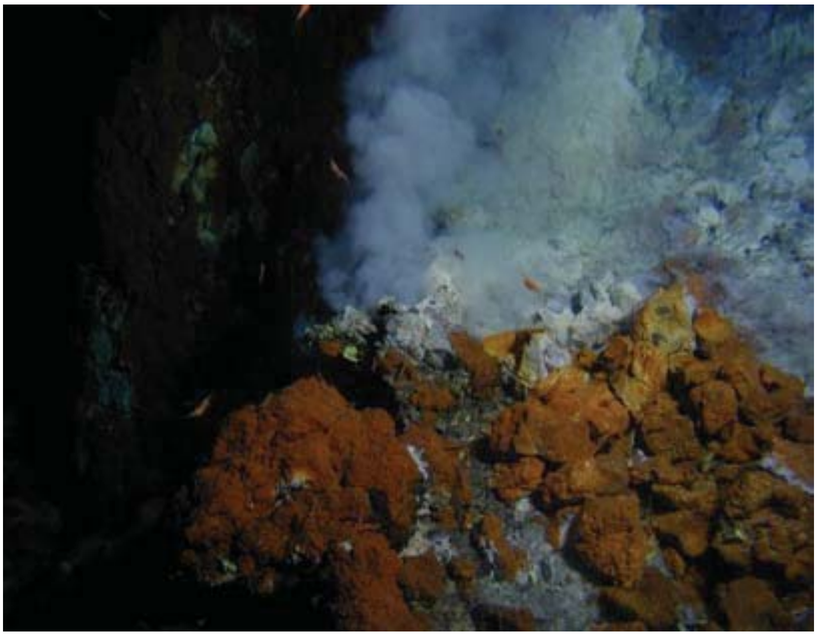
Manganese nodules have been identified in the EEZs of Kiribati, Cook Island, Tuvalu and Niue and in New Zealand, on the Campbell Plateau.

New Zealand's marine estate contains ironsand along the west coast of North Island, ferromanganese nodules on the Campbell Plateau, phosphorite nodules on the Chatham Rise, cobalt-rich crust on seamounts north off the North Island and hydrothermal polymetallic sulfides in the region of the Kermadec Arc (Figure 2).

Occurrence of phosphorites on seamounts in the Southwest Pacific has been known since the early 1950s, but has been deemed uneconomical. Very recently, strong interest arose again in New

Zealand, with a particular focus on phosphorite nodules on the Chatham Rise, with exploitation aimed at the fertilizer industry.

Figure 3. *A hydrothermal vent (SMS habitat) at a depth of 1,400 m on Brothers seamount (Kermadec Ridge), which supports high densities of vent shrimps (Alvinocaris spp.) (photo NOAA-GNS-NIWA).*



Cobalt-rich ferromanganese crusts are formed by precipitation from seawater onto nearly all rock surfaces in the deep ocean. They are of variable thicknesses -from less than one mm to about 260 mm thick. They only occur where the rock surfaces are free of sediment, forming pavements of intergrown manganese and iron oxides. They form at water depths of between 600 and 7,000 meters on the flanks of seamounts (undersea mountains with a height of more than 1,000 m), knolls (heights of 200-1,000m), ridges and plateaus. Crusts of economic interest commonly occur at depths of about 800-2,500 meters (Hein et al., 2009). They are found in the Southwest Pacific in Kiribati, Tuvalu, Samoa and FSM. Off the coast of New Zealand, they have been recorded on the flanks of the Norfolk Ridge.

3.3. Gas hydrates

Gas hydrate is an ice-like form of water containing gas in its cavities. Methane hydrate is found in vast quantity buried in continental margin sediments at water depths greater than about 600 m. Gas hydrates represent a potentially vast source of natural gas.

In the South Pacific, gas hydrates are found almost exclusively in New Zealand, where they were first discovered only ten years ago. They have been inferred over an area of approximately 50,000 km^2 along the east coast of the North Island. GNS Science conservatively estimates that up to 8 trillion cubic feet (tcf) of recoverable gas may be stored in this region (Henrys et al., 2008), more than 100 times the amount of gas that is currently produced in the Maui field. At present, the technological cost makes the production of gas hydrates uneconomic.

4. Environmental impacts and management

Human activities invariably have some impact on any ecosystem, and activities in the deep sea are no exception. Seafloor ecosystems are increasingly affected by human activities such as bottom fishing, oil drilling and waste disposal (Polunin et al., 2008; Ramirez-Llodra et al., 2011). With the emerging industry of deep sea mineral extraction, there is a need for appropriate and responsible management strategies to ensure the sustainability of marine ecosystems.

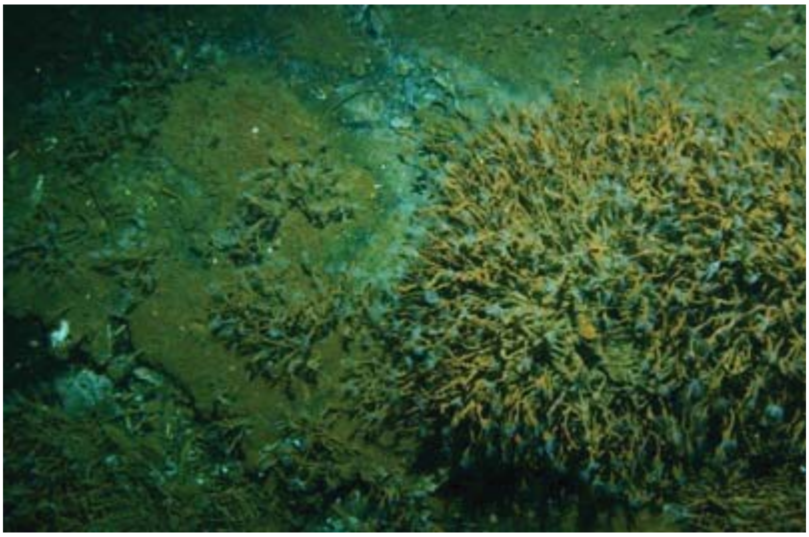
4.1. Deep sea mining impacts

There are numerous impacts that deep sea mining operations can have on marine ecosystems. Most attention tends to focus on benthic effects, which include:

- The direct physical impact of gear-scraping, ploughing and digging which damages or kills the animals that come into contact with the mining equipment. The weight of equipment can also crush animals under the seabed surface;
- The digging operation will create a sediment cloud above the seafloor. This can bury or smother small animals, or may clog the feeding apparatus of others (such as filter feeding corals and sponges);
- Toxic effects may occur with metal release as the mineral-containing rock is broken up and crushed on the seafloor. In addition, disturbance of the seafloor will increase the mixing of sediments and overlying water, with potential changes in the chemical makeup of the seawater adjacent to the seafloor. There have been few studies on eco-toxicity related to deep sea mining activity, and potential chemical changes are difficult to predict, and may act in different ways (Zhou, 2007); and
- Habitat characteristics will change with the modification of the seafloor by mining. Essential features of the habitat for particular animals may be lost.

Mobile animals may be able to move aside, but most sessile benthic fauna in the path of the mining operation will be affected (Figure 4). Seamount environments and hard-seafloor (rocky) habitats can host a high proportion of 'emergent' epifauna extending above the seafloor, such as corals, sponges, anemones and crinoids (Clark et al., 2010).

Figure 4. *Dense clumps of stalked barnacles (Vulcanolepas osheaii) at a depth of 1,000m on Tangaroa Seamount near a hydrothermal vent (SMS habitat) (photo NIWA).*



These long-lived animals may perform a structural role within benthic communities, providing a microhabitat for other species. In the south west Pacific, colonies of cold water coral species such as

Solenosmilia variabilis and Goniocorella dumosa provide niches for many animals including fishes, other corals, stylasterids, bryozoans, stoloniferans, sponges, polychaetes, ophiuroids, asteroids, bivalves, gastropods, crabs and anemones. Removal of such benthic animals from areas where they form the dominant communities will potentially cause a reduction in habitat complexity and associated benthic invertebrate biodiversity. Physical disturbance of these communities can cause dominant species to alter from large sessile types to small, fast-growing, opportunistic colonizing species, scavenger, and juveniles (Clark and Rowden, 2009).

The operation of seafloor equipment will increase levels of introduced noise, vibration and light. Noise and vibration together can affect the auditory senses and systems of animals. There can be direct damage to animals, discomfort which may cause avoidance reactions, or an increase in background noise that can interfere with communication between animals or limit their ability to detect prey (Popper et al., 2003). Light can repel or attract some animals, and bright lights can blind some species, and this has been a concern with research operations around hydrothermal vents (InterRidge code of conduct). These types of indirect effects are not well understood and will need monitoring from the outset. Animals that can be affected include benthic invertebrates, fishes, and deep-diving marine mammals.

Effects will also extend into the water column, through the active transport to the surface of the seabed material and the discharge of processing wastes from the surface vessel. The nature and extent of these will depend on the specific equipment used and mode of operation, but could include:

- Indirect sediment plume effects, with migration of the plume both vertically and horizontally extending beyond the actual mining area. This can smother and clog (as for benthic animals) and also reduce light levels and potentially localized productivity
- Toxins and contaminants may accumulate through the food chain, having an effect on higher level predators
- Oxygen depletion can occur, linked to changes in light levels through sediment loading or to the release of nutrients from the seafloor increasing production

Dewatering involves the separation of the seawater from the mineralized material (ore) and discharge back into the sea. This activity will likely occur immediately above or near to the extraction site, generally on the production platform. This discharge could occur at the surface, somewhere within the water column, or back near the seafloor. The processed water will likely contain some fine material, have elevated metal concentrations compared to ambient seawater, and may also have different physical properties (e.g. temperature, salinity) to the body of water to which it is returned to. There will also be surface impacts, depending upon the type and size of vessels and/or platforms deployed at the mine site. There will be normal impacts associated with surface vessel operations, which are not exclusive to mining, but will need to be considered. These include noise and lighting from the main vessel operation, as well as from support vessels and bulk carriers moving in and out of the area. There is also air pollution and routine discharge associated with these vessels (governed by international legislation such as MARPOL[14]).

The risk of these types of impacts needs to be evaluated early in the exploration stage of a potential mining operation.

4.2. Risk analysis

Risk assessment has been developed as a technique to support Ecosystem Based Management in order to identify, evaluate and reduce the risk of undesirable consequences due to human activities. There are many definitions of risk and many methods of risk assessment (Suter, 2006). Some include

[14] short for 'marine pollution,' in reference to *International Convention for the Prevention of Pollution From Ships*

social and economic factors, but the majority focuses on ecological risk assessment (ERA). In the New Zealand context, the Australia/New Zealand Standard, defines risk as “the effect of uncertainty on objectives” (AS/NZS 2009, 2009).

The literature has many examples of methods developed for assessing the risk on land from threats such as contaminants and there is a rapidly increasing body of research and advice on ecological risk assessment for fisheries. The general principles involved are just as relevant to an ERA for mining and a risk evaluation for various types of marine mining undertaken for the Ministry for the Environment (MacDiarmid et al., 2011) was based on fisheries methodology. Risk assessment should consider components at several biological levels (species, population, community, habitat, ecosystem) at appropriate, spatial scales (Dale et al., 2008), and be integrated with monitoring to reduce uncertainty and to evaluate management decisions. It is important to stress that risk assessment and risk management are separate processes. This is clear in the Risk Standards, but they can be easily confused when considering existing activities where some management is already taking place. Risk, therefore, needs to be evaluated against objective criteria and thresholds which are independent of management measures. Following this argument, it is also important to keep in mind that risk assessment itself should not be precautionary. However, risk management, or treatment, should be.

Most current ERA methods are broadly similar and conform to a multi-stage process whereby assessments are carried out at certain levels of detail:

- Level 1 (largely qualitative)
- Level 2 (semi-quantitative)
- Level3 (quantitative)

The key output from an initial risk assessment (at Level 1 such as MacDiarmid et al., 2011) is to enable the subsequent EIA/EIS processes to focus on the areas and aspects of highest risk, and to reduce the amount of time and effort dealing with aspects of the mining operation that are unlikely to have significant consequences.

4.3. Developing an environmental assessment

A critical stage in progressing any mining operation is a formal evaluation of potential environmental impacts. There are a number of different terms used to describe these assessments, but the two common ones for offshore mining are:

- Environmental Impact Assessment (“EIA”): the International Association for Impact Assessment (IAIA) defines an Environmental Impact Assessment as "the process of identifying, predicting, evaluating and mitigating the biophysical, social, and other relevant effects of development proposals prior to major decisions being taken and commitments made." The EIA process will involve conducting various studies (see below).
- Environmental Impact Statement (“EIS”): the EIS is the report that compiles all the information gathered during the EIA process and is often the statutory basis for the environmental assessment of the Project. The EIS sets out a development proposal intended to enable engineering, cost, environmental and commercial implications to be assessed. The EIS characterizes the Project’s benefits, adverse impacts and risks, and describes measures to mitigate and monitor those impacts and risks. A workshop in 2009 developed a template for an EIS (ISA, 2011).

Part of the EIA process involves carrying out environmental studies to define the existing environment before development occurs. A description of the existing environment will be needed, including habitat, faunal communities (benthic, pelagic and marine mammals, etc.), meteorology, air quality, oceanography, water and sediment quality, mid water and surface water biology, and other uses of the area. There are a number of key aspects that need to be considered in this associated research and below we list some of the principal generic disciplines and tasks (see ISA, 2007, pp. 398-417).

Physical topography/bathymetry

- Description of the specific habitats the minerals are associated with
- The spatial scale at which habitat types vary
- The likely distribution of mining sites (the spatial scale of impact versus habitat)
- Substrate type (to address sediment disturbance potential)
- Natural sedimentation rates and spatial variability over the area

Oceanography

- Current flows need to be described, stratified through the water column, to determine the likely dispersal of sediment or waste and aid placement of tailings/waste management systems. Currents are drivers of the spatial scale of animal distribution and dispersal, as well as mining impacts, and also link with chemical composition/toxic release, and turbidity
- Temporal variability needs to be measured because offshore tidal flows can occur

Benthic biodiversity

- Describe a range of faunal types, from mega-epifauna down to meiofauna and infauna
- Standardization of survey design, sampling techniques and sampling protocols
- Determine species distribution & abundance
- Mining site biodiversity can be small-scale, but regional biodiversity context is large-scale
- Evaluate vulnerability to impact: sessile animals, low dispersal capability, slow growth rates, restricted distribution etc.

Pelagic biodiversity

- This has received less attention than the benthic habitat and is of less immediate concern depending upon surface and mid water impacts. Same elements as benthic biodiversity.

Effective evaluation and monitoring of any impact will depend upon detailed baseline studies that establish a benchmark prior to exploitation.

4.4. Environmental baselines

Effective monitoring will include an evaluation of natural variability in the structure and function of communities to ensure that changes caused by mining can be separated from natural fluctuations in species distribution and densities. The nature and extent of baseline studies required to support adequate management of a particular mining operation will vary with management objectives, site characteristics, the size of the proposed mining area, the techniques to be used in mining and available equipment and resources for carrying out environmental studies.

Natural variations in environmental factors occur in both space and time. Spatial variations can be measured through a survey design that is stratified by area. Temporal changes are more difficult to determine, without costly surveys that are repeated over several months or years. Surface conditions (data collected by remote-sensing satellites) can help, but there may be no avoiding of several surveys at different times of the year to determine how conditions change naturally in order to then interpret the human-induced impact. Many deep sea benthic species are long-lived and slow-growing, and recovery from disturbance can be very slow (of the order of at least decades, e.g., Bluhm, 2001; Williams et al., 2010).

Consistent sampling strategies are critical to ensure robust and comparable measurements are made of the key factors that are to be monitored. Robust scientific protocols are also necessary with sample processing,and statistical analysis of data. Particular attention is required with the survey design, as measuring changes in the distribution, composition and abundance of variable marine communities can be challenging. This can also be a complex and expensive undertaking. Yet, it is critical for a monitoring program to support adequate environmental management.

4.5. Environmental management

Responsible environmental management objectives involve balancing resource use with the maintenance of deep-ocean ecosystem biodiversity, and hence management should include linkages of the ecosystem with the subsurface biosphere, the water column, the atmosphere and the coasts, as well as considering the full range of goods and services that the ecosystem provides (Armstrong et al., 2010).

Environmental management plans should be based on the principles of Ecosystem Based Management and the Precautionary Approach. They will be situation-specific, but likely to include a combination of best-practice mining operation to reduce environmental impacts, spatial management that protects similar areas and communities from impact and temporal actions that improve the chances of recolonization and recovery of the fauna in mined areas. Management strategies may also need to consider other national and regional initiatives directed at conservation and sustainable use of the marine environment.

Spatial management is a key management tool for marine systems and important design elements for protected areas include maintaining biodiversity, ensuring ecological connectivity between areas, replicating conservation areas, ensuring that size and spacing maintains population viability, and that sites are representative of both localized and widespread species and communities (e.g., Van Dover et al., 2011).

5. NIWA research to support environmental management

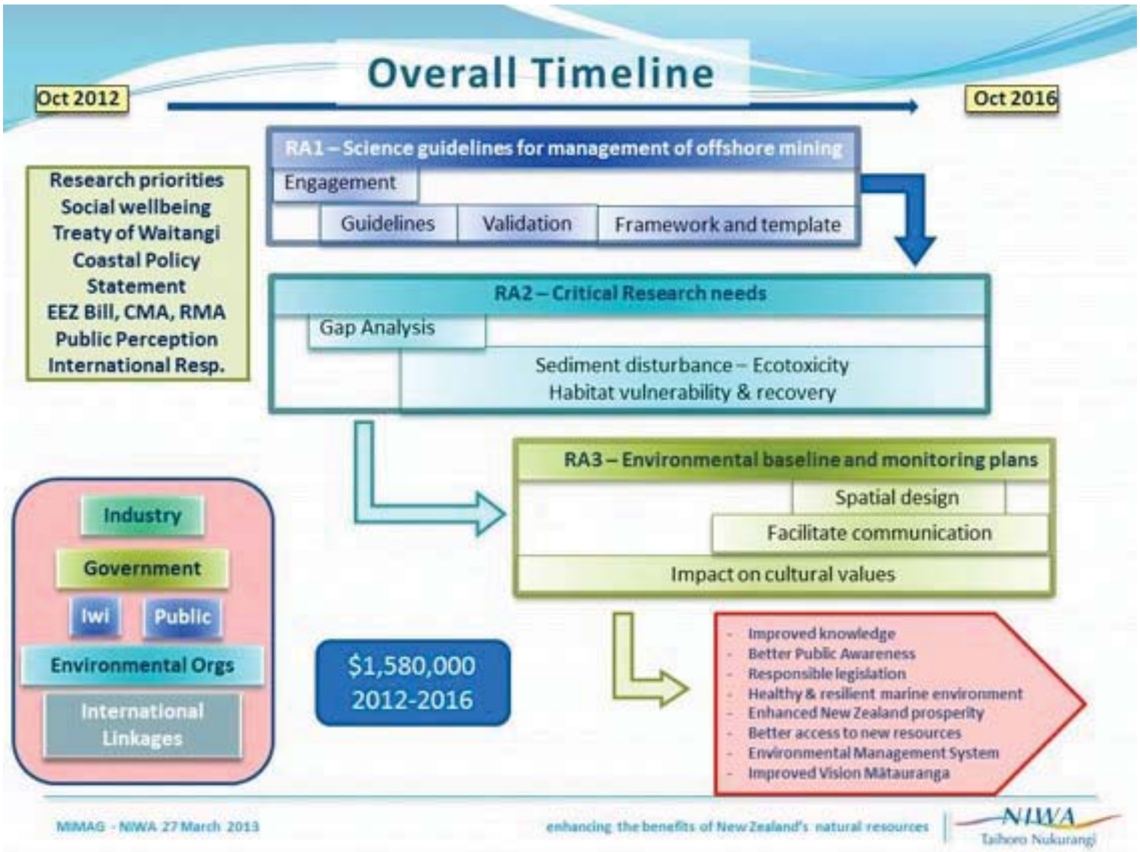
In October 2012, NIWA was funded by a four-year research project from the Ministry of Business, Innovation and Employment (MBIE) to help enable management of offshore hydrocarbon and mineral operations through improved understanding of environmental impacts. The program aims to provide guidelines for consistent, appropriate and robust assessment of environmental impacts across the range of marine activities. The impact management guidelines will be based on both Environmental Risk Assessment (ERA) and Environmental Impact Assessment (EIA) processes (Figures 5 and 6). The project outputs will include:

- Guidance to establish baseline data on the characteristics and distribution of offshore seafloor habitat, and the vulnerability of offshore marine communities to industry operations
- Guidelines to support carrying out environmental impact assessments for offshore mining operations
- Development of numerical models of the distribution and dispersal rates of sediment plumes
- Conduct of experiments on deep-water chemistry and ecotoxicity
- Improvements in our understanding of the biological connectivity between offshore ecosystems, to determine the likely scale of impacts and potential impediments for recolonization of impacted areas

This research will support the development of guidelines for monitoring the impacts of marine industry operations, techniques to determine key parameters of spatial management, and improve our understanding of the impact in the broader ecosystem context. The program is adopting a strong collaborative approach between industry, research and government organizations, as well as iwi and environmental groups. The involvement of a wide range of stakeholders will ensure that the research delivers outcomes that have relevance across all sectors and will help New Zealand benefit from utilizing offshore resources while maintaining the sustainability of our marine ecosystems.

Figure 5. *Possible organization and key actions of an Environmental Mining Management System (EMMS)*

Figure 6. *Flow chart for NIWA's Environment Management research program.*



6. Conclusions

Seafloor minerals are back in fashion and could provide much needed resources for the Pacific Island Countries and Territories. However, the balance between economic benefits and environmental impact must be considered carefully and robustly before any exploration and mining may proceed. Such assessments need scientific expertise and independence. Although the ISA has published information on how to develop responsible environmental management, Environmental Management Plans (EMP) should be site-specific and developed in collaboration with all stakeholders.

A new NIWA research program, linked to other scientific projects and stakeholder research will provide a solid foundation for improving our understanding of deep sea ecosystems and the impacts of potential mining. Ultimately this will help improve management of offshore mineral, and oil & gas resources.

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Deep Sea Mud in the Pacific Ocean as a New Mineral Resource for Rare-Earth Elements (REE)

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1. Introduction

At present, 97% of the world's production of rare-earth elements and yttrium (REY) comes from China, although it has only one-third of the world's reserves. The Commonwealth of Independent States, the United States and Australia together account for another third of reserves. China's dominance pertains to heavy rare-earths, which are especially important materials for high-technology products, including electric automobiles and flat-screen televisions. Heavy rare-earth reserves are almost all in ion-absorption-type ore deposits in southern China, whereas light rare-earths can be obtained from carbonatite/alkaline igneous complexes in other economies. The great potential of the Pacific deep sea mud as a new mineral resource for rare-earths, especially heavy rare-earths, has already been documented (Kato et al., 2011). The deep sea mud covers an area of approximately $14 \cdot 10^6 km^2$ on the Pacific Ocean floor, with an average thickness of approximately 20m and has average total REY content of roughly 700ppm, constituting a possible resource three orders of magnitude greater than the world's current land reserves of $8{,}800 \cdot 10^4$ tons of rare-earth oxides (tREO).

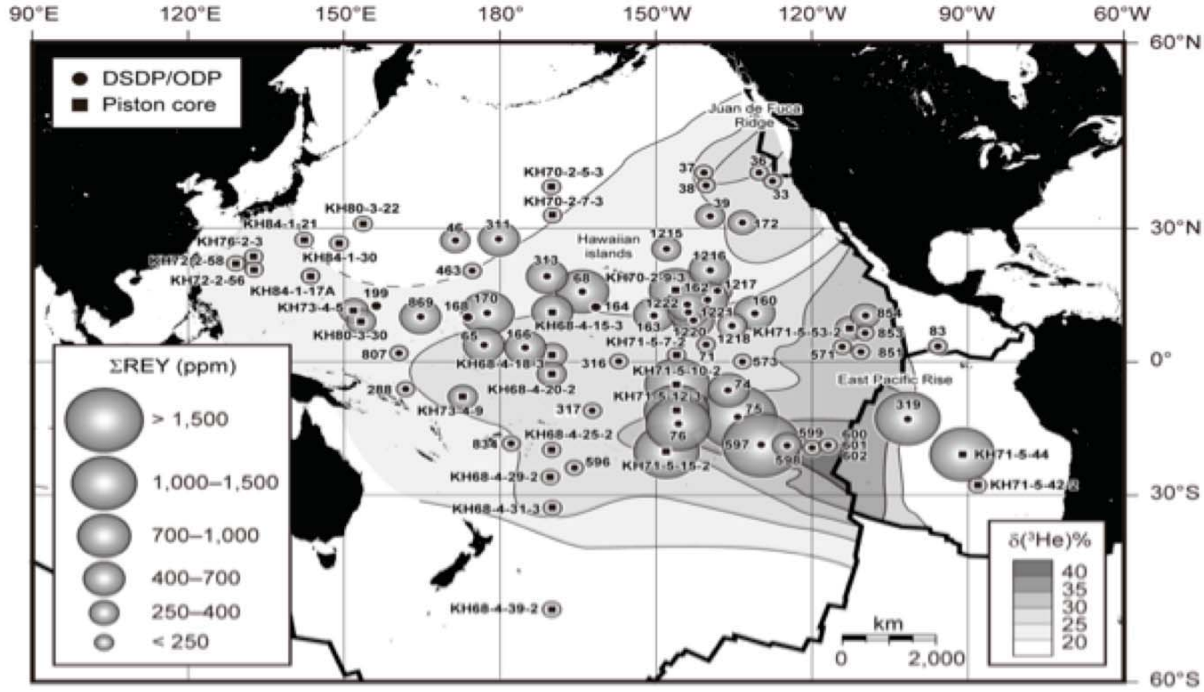
2. REY-rich mud deposit

Core samples obtained from 51 sites by the Deep Sea Drilling Project/Ocean Drilling Program (DSDP/ODP) and core samples from 27 sites obtained by the Ocean Research Institute, University of Tokyo, were studied. Many of the DSDP/ODP holes penetrated a depth greater than 50m below seafloor (mbsf), whereas most of the University of Tokyo's piston cores are ~10m long (some are less than 3m long). Chemical compositions of 2,037 bulk-sediment samples were measured to evaluate the potential of seafloor sediment as a rare-earth resource.

The Pacific REY-rich mud can be broadly divided into two types. The first type is mud with high rare-earth contents, 1,000–2,230ppm total REY contents and 200–430ppm total heavy rare-earth element (HREE) contents, found in the eastern part of the South Pacific (5–20°S, 90–150°W; Figure 1). The rare-earth content of this mud type is comparable to or greater than those of the southern Chinese ion-absorption-type deposits (REY = 500–2,000ppm; HREE = 50–200ppm). Notably, the heavy rare-earths are nearly twice as abundant as in the Chinese deposits. The core profiles reveal that this type of REY-rich mud has accumulated to thicknesses of about 10m at Sites 76 and 319. The REY-rich mud lies at the surface and is less than 3 m thick at Sites 75 and 597, although the average rare-earth contents are very high (REY = 1,530 at Site 75 and 1,630ppm at Site 597). At Site 596, approximately 2,000km west of these areas, high-REY mud (2,110ppm maximum, 1,110ppm average) occurs in a range of about 40m thick, deeper than 13.5mbsf whereas the surface sediment has REY content of less than 250ppm.

The second type of Pacific REY-rich mud has moderate rare-earth contents (REY = 400–1,000ppm, HREE = 70–180ppm) and is distributed in the North Pacific, east and west of the Hawaiian Islands (3–20°N, 130°W–170°E; Figure 1). Deposits of this type are much thicker than those of the first type, mostly >30m and occasionally >70m (e.g. Site 1222). Cores from the east of the Hawaiian Islands commonly show that broad peaks of REY content extend deeper than 10mbsf. West of the Hawaiian Islands, some cores have relatively high REY contents ranging from 680 to 1,130ppm (Sites 68 and 170). Although the cores are relatively short (less than 20m) in this region, the thickness of the REY-rich mud is probably comparable to that in the eastern region, considering its presence deeper than 40mbsf at Sites 164 and 168.

Figure 1. *Distribution of average REY contents for surface sediments (<2m in depth) in the Pacific Ocean*



Source: Kato et al., 2011. Circles represent DSDP/ODP sites and squares represent University of Tokyo piston core sites. Contours represent helium-3 anomalies (^{3}He) of mid-depth seawater. REY-rich mud with average REY >400ppm is designated as a potential resource.

REY-rich mud with moderate REY content is also found in the northeast Pacific, west of the Juan de Fuca Ridge, generally between 5 and 40mbsf. The cores from Sites 33 and 36 contain significant amounts of terrigenous material and have low REY contents, which suggests that the materials from the North American continent greatly reduces the REY contents of mud near the coast.

Metalliferous carbonate is found in areas near the East Pacific Rise shallower than the carbonate compensation depth, where carbonate oozes near-zero REY content and accumulates together with a smaller amount of REY-rich metalliferous material (e.g. Sites 598 and 854; Figure 1). The REY contents of the metalliferous carbonate reach no more than about 200ppm, thus it has poor potential as a rare-earth resource. In regions closer to either mid-ocean ridges or the equator, more intense dilution from rapidly deposited carbonate or siliceous (radiolarian) oozes occur, leading to extremely low REY contents (e.g. Sites 601 and 573).

Besides being enriched in rare-earths, the REY-rich mud is enriched in transition metals, including V, Co, Ni, Cu, Zn, Mo, and Mn, by up to two orders of magnitude greater than the average continental crustal values. Hence, the resource value of the mud may be greater if these metals are recovered together with rare-earths. Moreover, the Th and U contents are a small fraction of the average crustal abundances. Because these radioactive elements can pose environmental problems during development of carbonatite/alkaline igneous complex deposits, strong depletion of Th and U makes the mud more suitable as a rare-earth resource.

3. Great potential as a rare-earth mineral resource

The distribution map of the average REY contents for the seafloor sediment -except for areas of dilution by biogenous carbonate/silica and contamination by terrigenous material- is generally consistent with the helium-3 anomaly (^3He) map of mid-depth seawater in the Pacific, which reflects far-field spreading of hydrothermal plumes from the East Pacific Rise and Juan de Fuca Ridge (Figure 1). This coincidence suggests that the source of the rare-earths is related to mid-ocean ridge hydrothermal activity. Our bulk-sediment data also indicate that one of the main sources for rare-earths is a Fe-oxyhydroxide precipitate from hydrothermal plumes that has taken up rare earths from ambient seawater, which is well known as a scavenging mechanism for rare earths in the submarine setting. The distribution of the REY-rich mud evident in Figure 1 reflects the interplay among mid-ocean ridge hydrothermal activity producing Fe-oxyhydroxide particulates, deep or intermediate water currents dispersing these particulates, and biogenous activity entraining carbonate/silica-diluting materials as well as contamination of lithogenous (mainly terrigenous) material. Bulk-sediment compositional data, as well as multivariate statistical analysis (Independent Component Analysis; Iwamori and Albarède, 2008), clearly show that another REY-rich component exists with relatively low Fe and high Al contents, similar to phillipsite in major element composition. This is consistent with the long-held notion that phillipsite may be one of the main carriers of rare-earths in pelagic sediments, although the origin of phillipsite associated with high REY contents is not well understood. Consequently, our measurements demonstrate that the REY-rich mud occurs in pelagic deep sea regions more than 2,000km from mid-ocean ridges (Figure 1), where high-REY materials were deposited slowly (< 0.5cm/kyr), without significant dilution by biogenous carbonate or silica. The REY-rich mud extensively and thickly distributed in the Pacific Ocean represents accumulation dating from the Paleogene (partly Cretaceous) period to the present, and it constitutes an enormous rare-earth resource under the sea.

Our experiments using dilute acid (0.2mol/L H_2SO_4 or 0.5mol/L HCl) reveal that almost all rare-earths, except for Ce, are readily leached from the mud in 1 to 3 hours. The REY-rich mud also has the advantage of simple and cost-effective exploration, because it exists as continuous beds, probably extending over 100 km. In addition, pulverization and beneficiation are not needed before metal leaching. These features enhance the potential of the REY-rich mud as a rare-earth resource.

Assuming an average REY of 1,150ppm and density of 0.66g/cm^3, the 10m thick bed of REY-rich mud in an area of just 1km^2 at Site 76, in the eastern part of the South Pacific, has the potential to yield 8,800tREO, or one-twelfth of the global annual rare-earth consumption [108,000tREO]. Such a REY-rich mud resource may cover more than 10,000km^2 (100km x 100km) of the deep sea pelagic environment near Site 76. Similarly, assuming an average REY of 650ppm and density of 0.477g/cm^3, the 50-meter thick REY mud layer at Site 1222 in the central North Pacific holds 18,100tREO. Just 6.0km^2 (about 2.5km x 2.5km) of this material at Site 1222 could supply the entire annual rare-earth consumption of the world. In conclusion, there are enormous rare-earth resources in parts of the Pacific seafloor, three orders of magnitude greater than the world's reserves on land. These resources are mostly in international waters and thus represent the common property of all mankind.

4. Conclusions

Wide distribution of REY-rich mud on the Pacific Ocean seafloor and its great potential as a rare-earth resource are mentioned here. REY-rich mud containing up to 0.2% rare-earths occurs across the central North and eastern South Pacific in average thicknesses of approximately 20m. Uptake by mineral phases such as hydrothermal Fe-oxyhydroxides and phillipsite appears to be responsible for the high rare-earth contents. Rare-earths stored in the REY-rich mud amount to a possible resource 10^3 times greater than all current reserves on land. Moreover, the mud has distinctive advantages as a resource: easy leaching of rare-earths by dilute acid and low contents of radioactive Th and U, constituting a highly-promising resource of rare-earths.

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A New Social Contract for the Blue Planet

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1. Introduction

To manage the sea is, in fact a recent concern. Misunderstood by the land peoples who constitute the immense majority of the world population, the blue planet appears to be the place of many paradoxes. On the scale of humanity's limited means prior to industry, the sea seemed infinite, its resources inexhaustible and its regeneration capacity unlimited.

When in 1497, John Cabot landed on the coast of Newfoundland, he was able to tell the King of England Henri VII that the schools of codfish were so dense there that they slowed down the ship. Yet today, in spite of some decades of conservation measures implemented by Canada, the stock of codfish on the Grand Banks of Newfoundland is still not replenished. Resources which seemed inexhaustible mysteriously disappeared without our knowing why.

It seemed normal to throw garbage in the sea, to pour out ballast wastewaters, to empty purification collectors into it. And the numerous wrecks of both world wars hardly seem to have left any trace of pollution. It is no longer possible to let these pass unknowingly today.

However immense it is, the sea is a limited universe. Continents of garbage cover its floor, pollution soils coasts and telluric pollution affects the quality of oceanic waters. Halieutic resources are running out, species are disappearing, and coral reefs are affected by incurable diseases. More recently, permanent installations have been appearing on the sea surface - offshore resource extraction platforms, wind turbines and even human housing - creating competition or conflicts in the use of maritime space.

After the brutal twist of the second half of the 20th century when we switched from the perception of a marine world of infinite size to the consciousness of its fast exhaustion through human activities, the beginning of the 21st century offers us another paradox. This blue planet, which we now know mankind is capable of exhausting or even destroying, is in reality very little known or understood.

The overall area of the marine ocean deep-waters investigated so far is more or less equal to the area of a big metropolis like Paris. We only know a small spot. The rest remains totally undiscovered. The biodiversity of the oceanic depths remains to be revealed. New live species and new molecules are inventoried every year. The mining resources of the marine basement not yet registered are immense and we still have mere embryonic knowledge of the unlimited energy of these tremendous solar cells that the oceans are capable of restoring.

These resources, which people are only beginning to discover, can give the latter future solutions to problems which terrestrial continents cannot offer any more. The sea was not its natural habitat and did not show any of its sufferings. It suffers until it hits the limits. But today, we know. We can no longer pretend to not take notice of the effects of our actions. In the face of tremendous hopes that hold the oceans for humanity, we have to learn to manage the sea.

2. The oceans: Stakes in the 21st century

Since mankind ventured into the sea, the ocean was always a stake of power. Most of the world's major powers built themselves around the sea and made use of the sea. The empires were built by maritime nations, whether they be military empires, commercial empires or colonial empires. The globalization is only the modern continuation of this story and the geopolitical and economic stakes are growing even more significantly.

Throughout history of mankind, it is at sea that nations fight for power, mainly over the four traditional reasons of conflict: communication, control of resources, feeding the development of their economies, and widening their living space.

The largest part of international exchanges in the world is made by sea route: on the surface of the sea for the goods, raw materials and consumer goods; and at the bottom of the oceans, via optical fibers, for information and financial flows. Without effective and cheap transport, without these optical fibers which, at the bottom of the water, carry 95% of our telecommunications -faster and more safely than satellites- no economic development would be thinkable. Energy is transported by ships and also by networks of pipeline which represent an increasingly important stake.

The freshwater, indispensable to life - and rare in numerous regions - is also often transported by submarine pipes. Extensions at sea of road and railroad networks, of ports and international tunnels are growing. The ocean does not only serve the purpose of enabling exchanges and transport. It holds specific resources itself, such as biological resources, whether they be halieutic reserves or well-known marine cultures. There is an increasing demand for products of the sea for use in human food or less-known genetic resources, which offer great hopes for mankind. New medications will be developed much more quickly thanks to the useful molecules already in existence in bacteria or microorganisms of the seabed. New technologies grant access to rare mineral resources, gases and hydrocarbons, of which 30% already comes from offshore operations; metals and minerals contained in nodules and sulfuric minerals. Reserves of rare-earths, in quantity largely superior to the continental resources, should become increasingly accessible thanks to continued innovation and perseverance. Freshwater, essential in the life but becoming a rare commodity in numerous regions, can be extracted from the sea by desalination, as long as the necessary energy is available.

Oceans are a major stake in this century. The ocean permanently accumulates the heat energy of the sun and restores it in numerous forms: wind, swell, sea currents, heat energy from seawater, and osmotic energy. Extracting even a minor portion of what the oceans receive from the sun, other celestial bodies or the internal processes of our globe would guarantee a long-lasting supply for mankind. Building at sea is becoming feasible: beyond ports, we see artificial islands appearing, industrial installations which permanently mark human activity in maritime space.

Finally, the sea and the coast represent major environmental stakes for the balance of our planet. Covering 70% of the Earth's surface, the sea holds species whose evolution began 2.7 billion years earlier than those on the ground. The major part of the marine biodiversity is probably still unknown. The marine ecosystems play an important role in the biological production. Furthermore, the regulating effects of the ocean on the climate no longer need to be demonstrated.

We understand that the stakes in the sea are fundamental for the planet, for the very survival of mankind and for the development of our economies. Maritime industries and economic activities linked to sea already represent an immense economic value, eclipsing all other activities, second to probably agriculture. Here are some striking figures:

- Extraction of ores and transformation of seawater already represent US$50 billion;
- Fishing, transformation and aquaculture generate US$160 billion;
- Exploration and extraction of oil and gas represent a wealth of more than US$900 billion;
- Sea transportation and services industries total US$500 billion;
- Maritime activities already represent a total US$1.8 trillion.

New dimensions appear: dimensions of depths, of the ecosystem to be seen and understood on the scale of the planet, of an unstable world where a polluted molecule travels for thousands of kilometers, dimensions of resources yet to be discovered and exploited in spaces without owners, ethical dimensions and responsibility towards future generations. New dimensions, new complexity facing the old sets of rules often based on outdated compromises of a certain past. Applying the traditional, continental modes of management of human activities to the maritime space seem inadequate to be able to adapt to these new dimensions.

3. The management of the sea

Why is it necessary to manage the sea? A first element of answer is the recognition of the predominant role of technology. When Man appeared on the ground, he learned to survive, then to improve its living conditions, step-by-step, developed more complex technologies.

This attitude of Man towards his environment is different at sea. One does not go out to sea without first having built a ship. The conquest of the sea always depended on planning and to more sophisticated human organization.

Oceans are suffering from mankind's intervention; everyone takes advantage of them but no one feels responsible for them. For a long time *res nullius*, indeed belonging to nobody, the sea became little by little *res communis*, common thing, thus common property. This property is not an ordinary property that an owner can use and dispose of to his convenience, holding the discretional power to even destroy it if wanted. This common property is situated in fact at the global level. Those who use it have responsibilities, are subject to obligations, not only towards their fellow citizens, but also towards humanity at large and generations to come.

Yet, the threats which weigh on the sea are as important as the hopes that it carries. We have to act as co-owners of the sea (shareholders) and not like simple beneficiaries (stakeholders). Our responsibility is much broader, ampler and deeper:

- We can only use this property, but on the condition that we are able of protecting it, sharing the profits fairly
- We cannot content ourselves with the passive attitude of simply preserving it. We have the obligation to implement positive measures that value it while protecting it
- We cannot leave states claiming unlimited ownership and privileges to the sea without risking a generation of new, difficult and endless conflicts. We have to frame and to proactively master this new phase of expansion of mankind in the sea space.

Using while protecting, valuing while preserving, these apparent conflicts need to be managed. This is the profound reason why we have to manage the sea.

Managing the sea is a recent concern. For a long time, the supervision of every maritime activity by a specific sector regulation prevailed, and was sufficient (fishing, transport, marine cultures, mining extractions, sailing) because the activities used to be locality-specific or temporary. Simple rules of navigation and priority were enough.

All this worked well for centuries. But little by little, the mechanics began to jam:

- The destructive consequences of the ground activities at sea appeared, in particular, the pollution;
- Natural resources, which we considered inexhaustible mysteriously disappeared;
- Conflicts for space or resources developed while the permanent presence of activities at sea increased.

We now have to recognize that the sea is not infinite, the known resources are limited and that different actors (public, socioeconomic, non-governmental organizations) are numerous. If we are not cautious, the competition will aggravate and can even become violent. The sea is intrinsically and generically different from the land. In fact, the sea behaves as a complex, unpredictable system, where solutions for some become problems for others, because of the number and the nature of the interactions among human beings, the resources exploited and the limitations of the environment. And indeed, the sea is a place of probabilism while the land is one of determinism.

The absence of natural boundaries at sea forbids the use of common solutions applied on land such as the allocation of a specific space for a determined activity. And these solutions would not be justifiable under the concept of public good. The solution is consequently to share among users and not to divide among owners. If it is proven true that an active management of the sea has become indispensable, it is clear as well that the modes of management used traditionally to organize the coexistence of human activities on land cannot be suitable to handle all the dimensions of the blue planet.

Even so, assuming that the sea is a public good, it seems unjustifiable, from an ethical standpoint, to reason in terms of ownership and ownership rights. The only justifiable angle must be the regulation of shared use. The sea cannot be owned in legal terms. It can only be used as a common good.

4. A new social contract

To manage the sea, it is consequently necessary to switch from a sectoral to an integrated management, from a territorial to a global management.

The convention of Montego Bay was a compromise between the upholders of the freedom of the sea, led by the old naval nations, and those who wished to appropriate the oceanic space either with the intention to protect it or to exploit it. It is fashionable today to criticize this approach. However, this compromise took us away from the risks of the mere absence of management on the one hand and land-based solutions of cornering space on the other, now rendered ineffective.

Nevertheless, Montego Bay based its measures only on topographic criteria. What we would like to see emerging, is the introduction of a new dimension, the emphasis on a new responsibility, in the moral sense. It is about proposing a new Montego Bay convention based on the principle of common management of the oceans.

In the history of societies, the 18th century was a century of rupture. The philosopher J.J. Rousseau, in his time, said that new rules were necessary to deal with a new world. He proposed a new "contrat social," a new social contract. It is about proposing a new social contract for the management of the sea.

One cannot define here the terms of a new international treaty, but simply define some premises:

- The prerequisite has to be the continuation of a shared knowledge of the oceans. We should remember the predominant role of technology in the access to the sea and to the seabed. Without knowledge there is no access;
- A governance taking into account the management of the space in its undivided entirety must be organized. It must be based on the common striving for a reasoned, well-balanced management among stakeholders;
- The place of mankind in the reasoned exploitation of the blue planet must be defined. In particular, the modalities of permanent living at sea, safety in the face of natural or technological risks, protection against hostile and illegal acts and attacks of all kinds, must be envisaged from the beginning and be an integral part of the future common modalities of management. The rights of the coastal peoples, whose existence may be threatened by unreasonable exploitation, must be protected. The cultures connected to the sea, stemming from a secular human adventure must all have their place in the new social contract;
- Finally, the principle of responsibility, which nobody can escape, will prevent from excessive cornering the wealth of the sea and unilateral appropriation of the common goods.

Not only the states, but all stakeholders, including the industry are bound by the contract. The industry will have an ethical responsibility in this new order as it will contribute to spreading the technical skills and consequently contribute to avoiding the direct confrontation of interests around the new places of wealth. Industry has to play a driving and stabilizing role, favoring shared prosperity among stakeholders of the common goods.

Servicing Geographically Distributed Customers in the Pacific - New Zealand Steel

Blandina Diamond, Logistics Manager, NZ Steel, Auckland, New Zealand

> *"The Islands of the Pacific, which are fragmented and "sea-locked" with limited access to world markets, suffer from the challenges of small-ness and geographical isolation."*
>
> *The World Bank Report 2009 – Pacific Islands Development in 3D*

New Zealand Steel is owned by Bluescope Steel, formerly a business group of BHP Billiton, with four main divisions operating in Australia, New Zealand, Asia and North America, covering a total of 17 economies with 91 manufacturing sites and employing 18,000 people.[15] New Zealand Steel has been exporting steel products to the Pacific Islands for three decades and has come to understand the importance of allowing for the essential passage of goods and services throughout the Pacific Ocean. In doing so, New Zealand, along with other economies, contribute to a collective effect that helps the Pacific Island economies enhance competitiveness and prevent economic isolation despite the geographical challenges. The World Bank aptly describes the challenge for the Pacific Islands and economic growth in one of its' key factors – distance:

> *"Distance is not just a physical concept, but also an economic one. It is the ease or difficulty of which goods, services, labour, capital, information and ideas move between places. Locations close to markets have a natural advantage over those that are distant from them, Besides their own small market size, distance from markets and main centres of economic activity has hampered progress in the Pacific Islands. The correlation between access to markets and economic growth is strong (...). The average Pacific Island is 11,5000km from any other randomly selected country (...) comparison with the Caribbean Islands (...) 8,100km."*[16]

1. NZ Steel exports

Currently 43% of New Zealand Steel's sales volume is domestic, while 57% heads to export markets, which represent an annual export of 324,536 tonnes. The annual export to the Pacific Islands is 36,054 tonnes – our 4th largest export market.[17] New Zealand supplies all leading merchants, distributors and manufacturers in the region on behalf of Bluescope Steel. Papua New Guinea is the largest single market followed by Fiji and New Caledonia.

So how does an exporter move tonnes of heavy goods across oceans to the geographically dispersed customers of the Pacific Islands? The answer lies in achieving an optimal frequency of delivery that shares the risk of inventory costs and transportation costs. The difficulty in the solution is finding a shipping provider or providers that can achieve the frequency of delivery at an acceptable cost – the classic logistic dilemma.

[15] *Bluescope Steel Information Bulletin*.
[16] The World Bank, The International Bank for Reconstruction and Development, *Pacific Islands: Development in 3D*, 2009, page 7.
[17] Garland, Gary, NZ Steel Pacific Island Markets Presentation, Oct 2012.

2. Pacific Islands shipping characteristics

The logistic character of the Pacific Islands present a number of considerations for shipping from low-end port infrastructure to tranship requirements, from oceans and weather conditions to port congestion and competition with cruise liners and finally labor and small-nation political constraints. The considerations for shipping trade lanes to the Pacific Islands are similar to some of the considerations of Deep See Liners. In particular these include: cargo for all legs of the trade lanes (journey), suitably sized vessel to ensure profit and suitably geared vessels to facilitate loading and discharge.

3. Shipping service planning

In very basic terms a shipping provider plans trade routes and services from a basic model that risks and estimates are applied too. For example: calculate the time for a round trip voyage via ports A, B and C, then add the known load and unload times as well as traditional port delays. This gives us the base time, say 21 days. Then, an estimate of the optimal delivery schedule is decided, for example 'a service every 7 days' which means, in our example, the shipping provider would need 3 ships for the 21-day trade route to achieve a 7-day service. Now the shipping provider needs to fill the 3 ships as much as possible to make every leg of the route profitable. Of course the more trade routes any one shipping provider has, the better the peaks and troughs of any one trade route can be shared across the one business and consequently the better the choices for the shipping provider to tailor their service and rate offers to any one client.

4. The Pacific Islands as a domestic market

At New Zealand Steel, we like to approach the Pacific Islands as a domestic market. What does this mean? The most important aspects of a domestic offer are:

- A high-frequency of delivery schedule and therefore a short lead-time for customers, which ultimately results in low inventory requirements for customers
- Investment by New Zealand Steel in the Pacific Island markets
- Intimate and speedy after-sales support

Every customer avoids having capital and cash tied up in inventory and the Pacific Island customers are no exception. The business factor is even more crucial given the small economic size and wealth of any Pacific Island nation. For New Zealand Steel, it is very important that we are able to provide these 3 offers to our Pacific Islands customers and most importantly, the high frequency of the delivery schedule through a reliable shipping service provider or network of providers.

Recently, New Zealand Steel went to the market for the first time to find a shipping provider who could provide all services into the central and eastern parts of the Pacific Islands. This decision was designed to drive a need for stable shipping services into the Pacific, to drive better rates, to simplify the logistic model and to develop a long-term innovative partnership with our shipping provider. The initial results have achieved an equal or better schedule, good rates and stability for both organizations. The opportunities for innovation and improvement exist through the desire to grow a long relationship which offers 'win–win-win' solutions in the future, that is, win for New Zealand Steel, win for the shipping provider and win for our Pacific Island customers.

The Pacific Market for Submarine Cable Systems: Opportunities and challenges

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Laurie Doyle, Alcatel-Lucent Submarine Networks, Singapore

Abstract

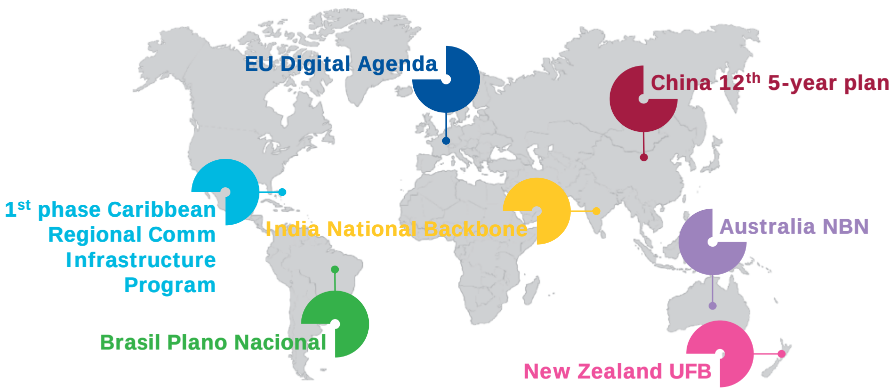
As much as 90% of world's communication flows are carried via submarine cables and the annual internet traffic growth is as high as 50% per annum in certain markets, observed between 2010 and 2016. Without doubt, laying more submarine cables and increasing the access to high-speed cost-effective broadband connectivity lead to accelerated social and economic development. However, the majority of Pacific Island economies remain under-connected and they are still dependent on satellite networks which are now inadequate to meet their growing needs. This paper presents some of the key challenges in providing cost-effective solutions to meet these needs, and the financing of such infrastructure.

1. Universal broadband trends

A quick review of any of the available sources of data documenting the trends in broadband penetration and usage continue to show strong growth on a global scale for both penetration and consumption of bandwidth per user.

Governments have now launched national broadband plans in several economies, and others are in the planning phase, as indicated in Figure 1.

Figure 1. *National broadband plans*



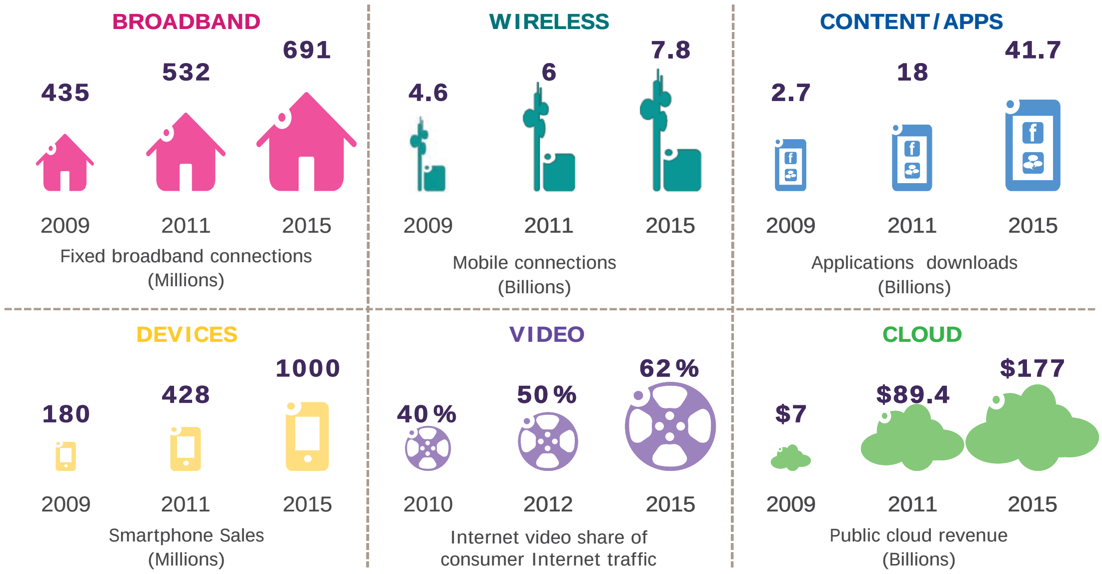
In the more mature broadband markets, reports show that there has been a dramatic shift towards "experience now" applications and away from "experience later" bulk downloads. Real-time entertainment traffic now represents a significant portion of total internet traffic as shown in Figure 2. On-demand entertainment applications have been embraced in these markets, while peer-to-peer (P2P) remains a popular source of content in developing markets[18].

Broadband penetration and subscriber count are also losing relevance in the mature markets, since many connected devices are becoming multi-functional, e.g. smart phones, tablets and gaming

[18] Doyle, Laurie, What's Cooking for Submarine Networks?, *SubOptic*, 2010.

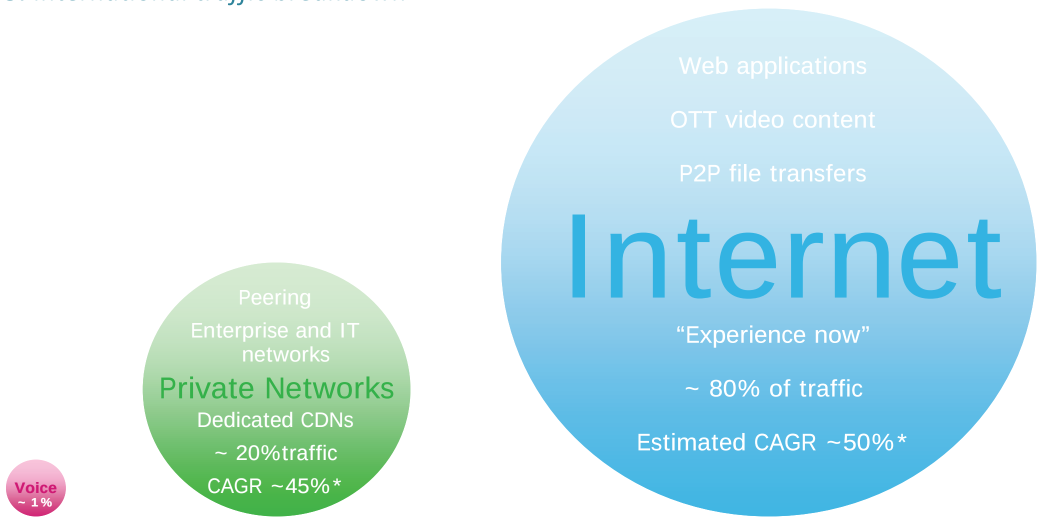
consoles. Connected device penetration may rise to 300-400% going forward, as mobile internet services become more embedded into the daily activities of people and enterprises.

Figure 2. *Major traffic drivers*



Data published by TeleGeography over recent years indicates that globally, the internet accounts for about 80% of international traffic, with private networks accounting for about 20%, and traditional switched voice traffic has diminished to about 1%, as depicted below in Figure 3.

Figure 3. *International traffic breakdown*

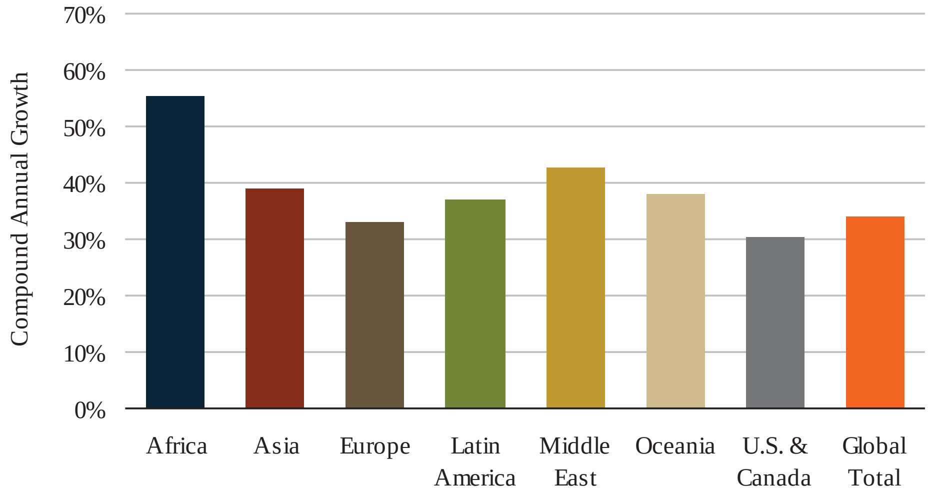


**Source TeleGeography 2011*

The most recent data shown in Figure 4 below indicates that the growth rate has decreased a little compared to the previous 3 years, but still remains between 30 and 40% in most markets, and even stronger in Africa and the Middle East where growth is still reflecting the recent dramatic improvements in connectivity after the commissioning of several new submarine cables[19].

[19] Global Bandwidth Forecast Service, *TeleGeography* Q4, 2012.

Figure 4. *International traffic growth forecast*



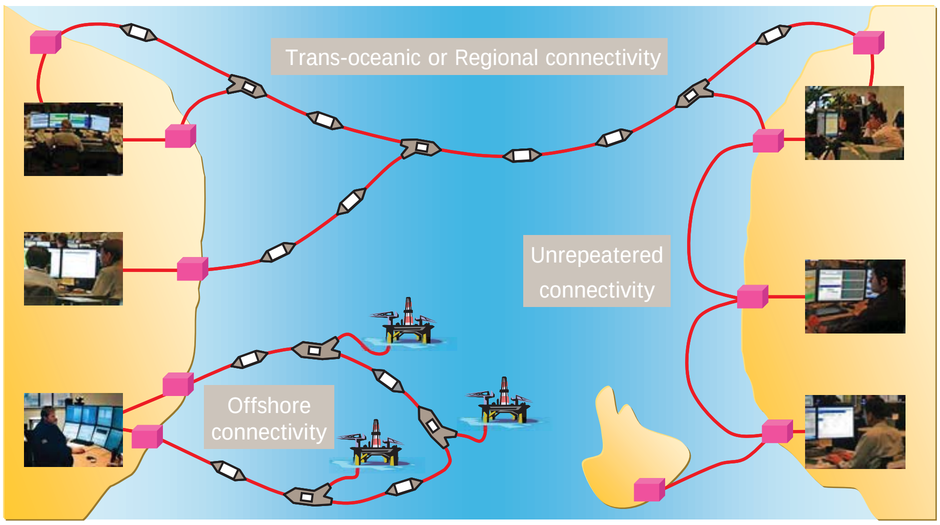
Source: TeleGeography

2. Submarine connectivity solutions

Submarine cable solutions have been developed progressively since the birth of the industry in the 1850s. Initially based on telegraph technology and Morse code, the cable and transmission technology took about 100 years to evolve to co-axial cables and analogue voice transmission in the 1950s, including the development of powered subsea repeaters. A shift to digital networking technology in the 1970s and the development of fiber optic communication methods in the early 1980s saw the introduction of the first trans-oceanic optical cables in the late 1980s.

Since that time, introduction of optical amplification in repeaters and increasingly sophisticated optical transmission techniques have led to current system designs supporting up to 10Tb/s of capacity per fiber pair over trans-oceanic distances, and enhanced connectivity using various types of subsea branching units to connect intermediate stations to large capacity trunks. Using the available technology, network configurations can be optimized for different applications, as shown below in Figure 5.

Figure 5. *Submarine cable connectivity solutions*



The improvements in transmission technology have been accompanied by progressive improvements in the methods and tools used for installation and maintenance of cables. These include recovery, repair and relaying techniques when cable damage occurs due to human activities such as seabed fishing and anchors, or seismic events.

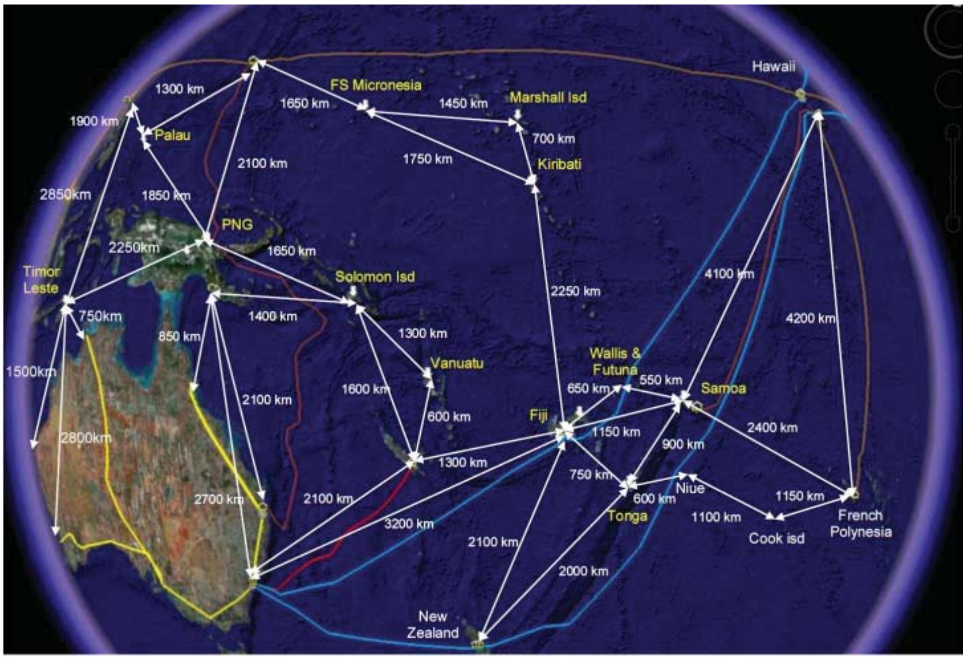
3. Challenges for the Pacific

As seen above, there is no shortage of technology to serve any requirement for connection of Pacific nations with optical fiber to the world's internet backbones.

The international capacity needs of most small nations is usually in the tens of Mb/s, even though there is a degree of pent-up demand due to relatively high pricing of the currently available services, usually satellite based.

However, the distances to the main internet transit or peering points in locations such as Fiji, Sydney, Hawaii or Guam is substantial, due to the huge expanses of ocean which can be easily seen on the map shown in Figure 6. Even with the most economic of submarine cable solutions, connections to one of these hubs require several tens, if not hundreds of millions of US dollars to construct[20].

***Figure 6**. Pacific Ocean cables and distances*



There is thus no classical "business case" which makes sense to connect small nations, so the value of the social and economic development of the country which can be unlocked over the service life of a cable (25 years) must be considered by governments and development financial institutions. Thus financing the infrastructure remains the key concern preventing some of the projects from going ahead. To alleviate this problem, governments have crucial roles to play along with regional or global financial institutions and other private financing platforms.

[20] Polyconseil for the World Bank, Regional telecoms backbone network assessment and implementation options study, January 2009.

4. Project models

A number of different ownership and governance models have been applied to international submarine cable systems over the years. The main ones are listed below:

- Consortium model: a number of telecom operators jointly own and operate the network;
- Private model: a privately owned and operated system;
- Special Purpose Vehicle (SPV): a company specifically created to own and operate the network; and
- Hybrid model: a consortium project where one or more of the owners is a SPV.

A brief analysis of these models is presented in the works of Bitange Ndemo and Victor Kyalo, 2010[21]. An alternative model, which has been successfully applied in the absence of a compelling business case, is the public-private partnership (PPP) model. This model was successfully applied to the TEAMS system constructed in 2008-9 to connect Kenya to the hub of Fujairah in the UAE[4]. The PPP model allows for mixed ownership, in the forms of joint-funding and joint-operations or maintenance.

Typically, such projects are funded by both established telecommunications service providers and Development Financial Institutions (DFIs). The DFIs apply development objectives as pre-conditions to the funding of such projects, which usually include:

- Regulatory environment and governance to ensure open access and fair competition;
- Non-discriminatory bandwidth pricing in line with market rates; and
- Ongoing monitoring of the governance and achievement of development objectives by the DFIs.

On such projects, the involvement of established service providers usually guarantees financial success as their customer base and traffic demands are somewhat guaranteed, but the system does not stifle the development of small ISPs or the entry of other licensed service providers in the served economies by providing the opportunity to purchase even small amounts of capacity at competitive rates.

Governments can play an important role in such projects to mitigate the initial project risks and to bring the existing service providers together. Examples which can be cited include not only TEAMS but also SEAS, WACS and EASSy.

5. Funding

The sources of funding available for new subsea cable projects include all the "usual suspects", plus some special arrangements adapted to the submarine cable industry:

- Private equity
- Operating income from the system
- Bank debt:
  - Can be backed by Export Credit Agencies
  - Typically limited to a maximum of 85% of the construction cost

[21] Ndemo, Bitange and Victor Kyalo, "Government's Role in Developing Critical Developmental Infrastructure: Case of the East African Marine System (TEAMS), Ministry of Information and Communications, Kenya, Information and Communications Technology Board, Kenya, *SubOptic,* 2010

  - Typically 15% minimum down-payment
  - Business case / Information Memorandum required
  - Environmental studies required
  - Surveillance of progress payments and variations during construction
- Combination of capital from different sources
- Operators directly financing the projects
  - ACE: France Telecom and its affiliates (part funded) + World Bank
  - ASH: American Samoa-Hawaii + SAS: Samoa-American Samoa
  - Gondwana/Picot: OPT New Caledonia
- Government
  - State-owned or partly state-owned “special” companies
  - WACS (Infraco – Ministry of Public Enterprises Republic of South Africa)
  - Government funds, such as TEAMS (initially funded by the Government of Kenya then transferred to Kenyan Operators) and SEAS (Government of Seychelles)
- Development banks
  - World Bank, ADB, IFC, EIB, KfW, Proparco, DBSA, IDFC, AFC Private Equity
  - Example: Tonga-Fiji

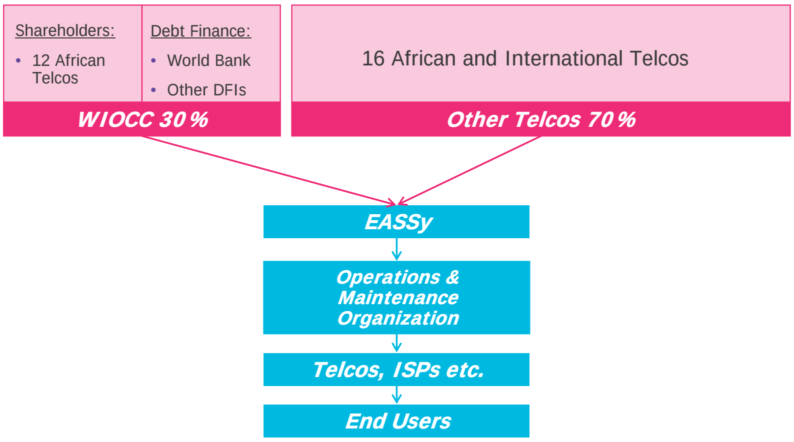
6. Examples

Public-private partnership models have been applied successfully in rolling out some submarine cable projects in recent years. One example is the East African Submarine System (EASSy) depicted in Figure 7.

Figure 7. *EASSy – East African Submarine System*

The model applied to the funding, ownership and operation for this system is shown in Figure 8 below.

Figure 8. *EASSy - Example of Public-Private Partnership*



The capacity managed by the special purpose WIOCC entity (West Indian Oceanic Cable Company) is used to ensure fair and competitive access to the "small players" who do not have the same scale as the established telcos.

Another example is one currently under construction by Alcatel-Lucent between Tonga and Suva as part of a bigger regional connectivity project in the Pacific to eventually connect several Pacific Islands with fiber optic cable (Figure 9). The 837km link was financed by the World Bank, the Asian Development Bank and the Tongan Government, and for the licensed operators and ISPs in Tonga it will give access to the Southern Cross Cable in Suva, Fiji which serves as the main trans-Pacific link between Australia, New Zealand and the United States.

Figure 9. *Tonga Cable System*

Gondwana-1 is another regional submarine cable project in the Pacific, stretching 2,100km between Sydney and Nouméa, New Caledonia (Figure 10). This one was directly funded by the incumbent operator in New Caledonia.

Figure 10. Gondwana Cable System

7. Solutions for the Pacific

The success of submarine cable projects depends on an optimal mix of technical expertise, long-term financial commitments and mutual confidence shared among neighboring economies for a collective regional approach to achieve an economy of scale. If political, regulatory and funding obstacles can be overcome, there are clear economies to be achieved if several Pacific countries or territories with international connectivity needs can collaborate in a shared regional initiative instead of each trying to develop and fund their own independent system[22].

However, building such submarine infrastructures involves careful planning and route engineering. For example, shortest route was not always the least expensive and certain seabed conditions and/or environmental concerns can dictate longer, but safer routes. The protection of cables has to be reinforced in shallow waters where substantial maritime or other human activities may create risks of damage.

There is also a need to diversify cable routes to create a more robust connectivity. Multiple routes reduce the risk of an incident on a single submarine cable to create large disruptions to the lives of people, government institutions and enterprises in the impacted countries or territories. Governments therefore need to analyze and assess the potential risk factors by studying various scenarios which will ultimately help decision-making on how to best invest in costly infrastructure projects such as submarine cables.

8. Conclusion

The needs of the Pacific Island nations to connect to the world's internet backbone continue to increase. The benefits of cheaper international connectivity and higher available bandwidth will serve to gradually decrease the so-called "digital divide" as improved domestic services are rolled

[22] Polyconseil for the World Bank, Regional telecoms backbone network assessment and implementation options study, January 2009.

out. It will also underpin potential social and economic benefits – in areas such as health, government, education, commerce and tourism.

From the supply side of the submarine cable industry, durable technical solutions are available based on proven technologies to ensure a 25-year product life. Technology advances throughout the system life typically result in decreasing cost per unit for successive upgrades of capacity over time. Currently, the South Pacific is also well served with a dedicated submarine cable installation and maintenance vessel based permanently in the region to service the regional needs.

The direction for longer term development of connectivity for Pacific countries and territories should be oriented to optimize the necessary CAPEX and OPEX for such systems. This should lead to the most economic connection of small countries and territories to one or more of the hubs on existing trans-Pacific routes (e.g. Fiji). The development of multi-party regional infrastructures to achieve these connections will most likely be the best use of funding from Development Financial Institutions and/or PPP structures.

Finally, to produce the desired results, regulatory and governance arrangements need to guarantee an "open access" to at least a portion of the available capacity for smaller non-incumbent service providers. This pre-condition for funding should result in the creation of a more competitive market for services offered to end users.

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Economic Impacts of Submarine Cable Disruption: Starting to build the evidence base

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1. Introduction

Seemingly, barely a week passes by without a news article appearing that reports damage to a submarine communications cable from natural disasters or shipping/fishing activities that inadvertently leads to cable breakage. These articles often highlight the potential inconvenience to internet users or to firms that rely on international communication flows. Given the potential problems associated with submarine cable disruption, it makes sense for governments to work together with the private sector –which usually owns the cables– to ensure that disruptions are minimized and any repairs are facilitated speedily. The question, however, is *how much* should governments invest in preventing disruption?

This is essentially a cost-benefit analysis issue. In trying to protect against submarine cable disruption, a government will incur fiscal costs, such as from building new infrastructure to protect cables close to shore or from having repair ships on standby. The benefits from investing in these activities are the avoided economic costs from disruption. Identifying the fiscal costs associated with submarine cable protection should be a fairly simple matter. But quantifying the benefits (avoided costs) is more difficult. This leaves officials and politicians in an awkward position when it comes to forming a view on the appropriate level of investment in cable protection.

In this paper we use a Computable General Equilibrium (CGE) model of the world economy as an economic framework to look at the costs of cable interruptions in the APEC region. It is indicative only and does not purport to be an assessment of the likely costs of disruption. Rather, it highlights the importance of developing more detailed analysis to help inform policy discussions on this important infrastructure and connectivity issue.

2. Drivers of disruption costs

Estimating the economic cost of cable disruption is complex. It depends on the answers to many questions such as:

- What's the probability of a disruptive event?
- How severe is it?
- How long will it last?
- How much data can be re-routed via other cables?
- Which sectors are most at risk and what mitigation strategies do they have in place?
- Will it lead to a permanent loss of output or will there just be a delivery delay?
- Is it just a transaction cost increase whereby users experience slower telecommunications speeds temporarily?

At present, there does not appear to be much information gathered across APEC economies on these issues. What does exist seems to be ad hoc and anecdotal in nature. To help inform policy-making on this topic, it would be very helpful for researchers and officials in the region to agree on some common data collation approaches.

3. Identifying "at-risk" sectors

While we do not yet have answers to many of the questions above, we can at least investigate which sectors are most likely to be at risk of submarine cable disruption. Using input-output tables, which all APEC economies produce as part of their official economic statistics, it is possible to identify how much sectors rely on certain inputs to produce their outputs.

The table below shows for New Zealand the proportion of various sectors' input costs that are accounted for by communication services, finance services and computer services (Table 1). It gives a sense of how reliant these sectors are on the services that are heavy "users" of submarine cables. The table also shows the share of each sector's production that is exported.[23]

Table 1. *Input cost vs. output exported in New Zealand*

Sector	Comms/finance as % of input costs	% of output exported
Superannuation fund operation	63.3%	0.0%
Life and health insurance	44.6%	1.8%
General insurance	38.9%	1.9%
Communication services	23.1%	3.8%
Services to finance and insurance	20.9%	6.0%
Finance	12.5%	1.3%
Computer services	11.3%	7.0%
Motor vehicle retailing and services	9.2%	3.3%
Central government administration and defense	8.1%	0.1%
Other personal and household good retailing	7.6%	1.4%
Average across economy	**5.8%**	**12.2%**

Source: New Zealand Input Output Tables

The table shows two broad themes:

1. Traditional goods-exporting sectors do not feature highly in terms of being exposed to submarine cable disruption
2. The most exposed sectors are those with low export shares, suggesting that it is the non-tradable sector that will suffer most from submarine cable disruption, rather than the traditional manufacturing or agricultural tradable sector

So when we are thinking about which sectors might be most affected by cable disruption, it appears that we should be focusing on the commercial services sector. Given that these sectors are becoming more important across most economies as a share of total GDP, this suggests that the risks from submarine cable disruption are increasing over time. While this sector is not highly export-focused, this is not to say that these services are not traded. Indeed, based on 2009 OECD data, there were around US$875 billion worth of traded services that relied heavily on submarine cables[24], which equates to US$2.4 billion per day or US$100 million per hour across all OECD

[23] The table is sorted in order of reliance on submarine cable services. Only the top ten sectors are shown. A full list of the 85 sectors is available upon request.

[24] This is the sum of trade in communication services, insurance services, financial services, computer and IT services and "other" business services.

economies. Clearly this indicates that the costs of disruption are potentially high, although the precise costs will depend on the length of outage, ability to re-route data, etc.

4. Economic modeling of cable disruption: illustrative example

One way of thinking about the economic impacts of cable disruption is that an outage leads to a decrease in the supply of communications services. This supply shock pushes up the price of these services temporarily. This price increase then affects all other sectors of the economy that use communication services, potentially reducing their output as their costs rise. This in turn could lead to reduced exports (and imports) between trading partners.

Assessing the economy-wide impacts of shocks such as this – and especially of shocks that can affect multiple economies at any one time – can be done using CGE models. One of the key benefits of such models is that the trade and economic linkages between all APEC economies can be taken into account when considering the economic impact of cable disruptions. This is crucial given the interlinked nature of APEC supply chains and the multi-country channels through which submarine cables operate.

One such CGE model is the well-known Global Trade Analysis Project (GTAP) model of the global economy.[25] The version used in this analysis is based on a representation of the global economy for 113 economies and 57 sectors, benchmarked to 2004.[26] It contains data on the economic and trade structures of all APEC economies apart from Papua New Guinea. To illustrate the potential impact of submarine cable disruption, we impose a 5% price increase on the cost of communication services simultaneously across all APEC economies. This modeling scenario is clearly unrealistic, as it is highly unlikely that all APEC economies would be hit at the same time by a disruption event. It is important to note that this is a purely arbitrary simulation design. Much more work is required to determine what a more realistic supply shock might look like (which economies? how long? how severe? etc.) and how it should be calibrated for use in a CGE modeling exercise.

Since we are using a static version of the GTAP model that only compares pre- and post-shock scenarios, we do not have to make a judgment on how long the disruption lasts, although this is important if using more complicated, dynamic models.

The results of the modeling exercise show that if such a supply shock were to occur, all APEC economies suffer welfare losses. The extent of the losses is shown below and range from 0.05% of GDP for Myanmar to 0.30% of GDP for New Zealand. The relative magnitudes will reflect the different economic structures of the various APEC economies, and in particular, each economy's reliance on communications-based services.

The higher cost of communications services has detrimental impacts on goods traded in the APEC region. Exports of goods and services of APEC economies fall by amounts ranging from 0.04% for Myanmar to 0.26% for Peru (see Table 2)[27].

[25] See https://www.gtap.agecon.purdue.edu/ for more detail on the GTAP model and databases.
[26] An updated and expanded database has since been released.
[27] Japan's exports rise by 0.09%. This result appears difficult to reconcile, but more detailed investigation of the country-specific outcome was outside the scope of this note.

Figure 1. *Supply shock modeling for Asia-Pacific economies*

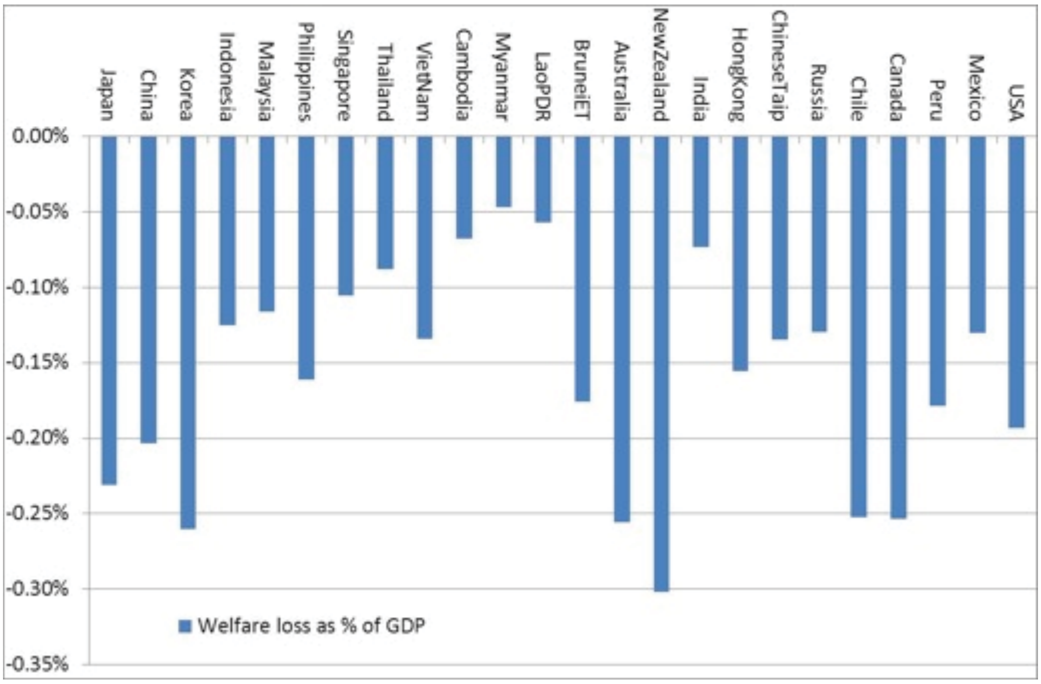

Table 2. *GDP and export results - impacts of a 5% increase in communications service prices across the Asia-Pacific*

Economy	Change in welfare, % of GDP	Change in exports, %
Japan	-0.23%	0.09%
China	-0.21%	-0.21%
Korea	-0.27%	-0.15%
Indonesia	-0.13%	-0.16%
Malaysia	-0.10%	-0.05%
Philippines	-0.20%	-0.14%
Singapore	-0.12%	-0.06%
Thailand	-0.11%	-0.17%
Vietnam	-0.10%	-0.09%
Cambodia	-0.08%	-0.13%
Myanmar	-0.01%	-0.04%
Laos PDR	-0.06%	-0.14%
Brunei ET	-0.09%	-0.06%
Australia	-0.25%	-0.06%

Economy	Change in welfare, % of GDP	Change in exports, %
New Zealand	-0.30%	-0.08%
India	-0.08%	-0.18%
Hong Kong	-0.14%	-0.05%
Chinese Taipei	-0.15%	-0.10%
Russia	-0.10%	-0.04%
Chile	-0.25%	-0.12%
Canada	-0.25%	-0.05%
Peru	-0.18%	-0.26%
Mexico	-0.13%	-0.14%
USA	-0.20%	-0.21%
EU25	-0.21%	-0.03%
Latin America	-0.13%	-0.13%
Rest of World	-0.19%	-0.08%

Source: GTAP modeling simulation

5. Next steps: Filling the data void

This note has aimed to highlight that APEC policy-makers are faced with some significant data problems when it comes to assessing the costs of submarine cable disruption (and thus the economic benefits of investments that might act to prevent such disruptions). This creates difficulties when it comes to making informed policy recommendations as to the size of potential government investments in protecting submarine cables from natural disasters or fishing/trawling accidents. It is possible to get a sense of which sectors might most be affected by submarine cable disruptions by examining countries' input-output tables. This process will also give some insights into which APEC economies are most exposed overall to cable damage. New Zealand's input-output tables suggest that the largest impacts of disruptions are likely to be felt domestically, rather than through the tradable sector.

If consistent data can be collected across economies and over time into the length and severity of outages, it should be possible to use CGE models of the APEC and global economies to gauge the potential trade, investment and overall GDP impacts of cable disruptions. The key to using these models is developing realistic modeling scenarios. In this case, the scenarios need to be based around the effects of disruptions on the cost/price of communications services.

Transfer and Financing of Technology and Innovation in the Framework of Public-Private Partnerships, to Better Protect the Oceans and Coastline

Nicolas Renard, Advisor to the Chairman & CEO of Veolia Environnement, Paris, France

1. Introduction

Veolia is a world leader in environmental services. It is working for many major coastal cities in the world to help them protect their environment by collecting and treating wastewater and solid waste. Such cities include Shanghai, Shenzhen, Hong Kong, Sydney, Hiroshima, and Manila.

Two numbers highlight what is at stake with technological transfer and innovation: according to the United Nations Environment Program, in East Asia, 90% of wastewater returned to rivers or the sea does not undergo any treatment. In the Southeast Pacific, the rate is 85%.

Innovation is central to Veolia's strategy, since it is a springboard for maintaining its leadership and since half of the technologies that will be used in 15 years time to protect the environment have not yet been invented. Today, Veolia has a portfolio of more than 2,000 active patents, 850 researchers and 200 research partnerships with universities and centers.

However, R&D is not enough. There is a great need for a professional management of new technologies. No matter how much R&D one invests in, it will amount to nothing if the technologies invented are not used in a professional manner. Even the most efficient technologies will disappoint if they are not properly applied. Therefore it is vital to organize appropriate technology transfers as well as intensive training, in order to fight against marine pollution.

2. Technological and economical innovation in the framework of public-private partnerships (PPP)

2.1. Not innovating alone, but in tandem with our clients

The strong relationships we have forged in public-private partnerships with our clients and the resulting trust are conducive to innovation. They allow us to “dare” to do things together. We can test innovations with these clients, industrialize them and distribute them together.

PPPs are laboratories for shaping the knowhow of the 21st century, achieved by working in close cooperation with public clients. Our contracts are not just “*deals*”, but also important tools for creating and showcasing the future expertise of the century. That is what our public partners want. For instance, Chinese public authorities require foreign companies to invent the technologies of the future in their economy.

We have also the good fortune to work for demanding clients, who constantly push us to improve the services we provide. It is not always easy to satisfy them. However, by regularly raising the standards to meet, they encourage Veolia to surpass itself and show creativity.

2.2. City and R&D in the framework of PPPs

In the knowledge economy of this century, the success of cities will increasingly depend on their capacity to attract researchers and innovators. Innovation plays a crucial role in the economic competition between cities, but it is also critical in the deployment of the best urban public policies, by broadening the array of technologies at the disposal of policymakers.

Therefore, many public authorities require private operators, not only to transfer technology, but to undertake R&D:

- In Berlin, we have founded, in partnership with our public client, the city-state of Berlin, one of the most advanced water research centers in the world. It is studying groundwater recharge processes, a solution for combating water scarcity, preserving freshwater resources and satisfying growing demand. This research center is contributing to Berlin's technological reputation in water and wastewater management.
- Another example is the one of the Caserne dam project, operated by Veolia in the form of PPP. It helps to keep France's historic Mont-Saint-Michel free of 5 million m^3 of sediment that encircles it. Situated on the Couesnon River, the dam's eight 20-ton gates keep the water moving and contribute to increasing the depth of the bay by 70cm in a 2km radius. The project is described as "repairing what man has damaged" on the World Heritage Site.

2.3. One of the most promising and recent innovations in terms of PPPs is the total traceability of water in large distribution networks

In 2002, the Shanghai municipality awarded Veolia the contract to manage its water services for 50 years. Pudong is one of the fastest growing areas in China: from 1.9 million people at the start of concession to 4 million today. Tenders' evaluation was based on all aspects, not just on price. Each aspect had an evaluation weight: 20% for the price proposal, 20% for the detailed financial plan, 20% for the detailed technological plan, 20% for the detailed customer service plan and 20% for the detailed management organization and human resources plan. The three last components of this evaluation weight are directly or indirectly linked with innovation and technological transfer.

Fifty years ago, networks grew according to a tree structure: a main trunk split into multiple branches without any of these crossing each other. Today, the network's branches crisscross to enable constant supply. However, quality control has become extremely complex as a result and traceability a real headache. Tracking in real time the quality of water in pipes spread out over several thousand kilometers is a Herculean task, since water flows every which way, under the ground and continuously. This innovation is making water even safer.

Our engineers trialed an innovative solution on a small section of the Shanghai network, namely the area devoted to the Universal Exhibition held in the city in 2010. The system is comprised of: 1) a new ultra-compact, multi-parameter probe; 2) a detailed network modeling program; and 3) a software application to cross-reference network data. A new probe measures the various key parameters as soon as water exits the production plant and flows throughout the network. This combined data is used to establish an identity card for the water. This in turn is used to produce a water label based on the composition and origin, just like a bar code. Water quality can now be checked in real time at all points throughout the network.

Veolia is now implementing a larger-scale version of this solution for the Ile-de-France Water Authority (the largest European water services authority), which is serving 4.1 million inhabitants.

3. Technology transfer in the framework of PPPs

3.1. Technology transfer is an expectation in most PPPs

Training and technology transfer are a priority for most public authorities. Since improving public services will not be achieved without boosting local means and skills.

There are many technical reasons for a public authority to enter into a PPP:

- to benefit from technical skills and managerial know-how;
- to integrate an international network and benefit from the best expertise, innovation and research available;
- to intensify training and transfer high-level know-how; and
- to obtain technical and legal security in the very sensitive fields of public health and environmental protection.

PPPs accelerate the transfer of knowhow. Through outsourcing, clients can access the advanced expertise of high-level operators. The size of a global company like Veolia enables each municipality, wherever it is located, to benefit from best practices and latest innovations.

3.2. Developing long-term contracts facilitates technology transfer

It is necessary to allow the operator sufficient time to efficiently transfer technology and ensure that the local staff is capable to control the technology transferred. The longer the contract, the deeper the technological transfer. By adopting a long time frame, PPPs provide the possibility of achieving significant progress in technology transfer and training in many fields.

Figure 1. *Long-term contracts facilitate technology transfer*

	Types of contracts	Typical length
Heavy Capex	Build Operate Transfer	10-25 yrs
	Concession	10-30 yrs
Light Capex	Operations & Maintenance	3-15 yrs
	Design Build Operate (DBO)	2-15 yrs
No Capex	Works	< 1 year
	Design and Build	< 3 years
	Service contracts	~ 5 years

Latitude (°N)

3.3. How do we organize technology transfer in PPP?

Our approach is based on two major components.

1) Intensive training programs for all levels of the organization (technical, H&S, management, IT, English language, financial, etc.):

- Target 100% of the employees to be trained;
- Increase training budgets;
- Create training centers close to the needs (Veolia currently manages 20 campuses and learning centers in 11 economies around the world); and
- Access training courses outside.

2) A pragmatic and rigorous approach to transfer technologies:

- Expertise transfer programs, for managing the intellectual capital within the Group;
- Twinning Veolia operations in different economies to facilitate the dissemination of technologies and methods;
- Constant benchmarking of best practices between the services that we manage, to showcase local innovation and put it to use;

- Networking so that the outsourced service benefits from the progress made in other services managed by Veolia; and
- Complementary seminars for the exchange of experience.

4. Financing technology transfer

4.1. Context

Financing technology transfer is an integral part of most PPP contracts, in particular, in concession contracts. Wanting the best service, major cities are more inclined to finance added-value solutions and technology transfers in PPPs.

In China, we are capturing organic growth to fund technology transfers. Veolia manages installations in key economic growth locations: Shenzhen, Shanghai, Tianjin, Hong-Kong, etc. These clients are first-class cities, looking for first-class services. They agree to pay for technology upgrades. Our company has also been leveraging volume and price increases to fund the technology transfers required. Long contract durations allow distributing the costs of technology and investment over several years.

4.2. An example of technology transfer financing in the solid waste sector

Most of the pollution of the coastline and the sea is coming from the land: untreated wastewater is transported by rivers to the sea. Many uncollected solid wastes end up in the ocean.

Since several years ago, the Chinese Central Government has decided to seriously address the issue of treatment of hazardous industrial waste, which is definitely one of the main environmental problems facing the economy.

In July 2012, the Hunan Environmental Protection Bureau awarded Veolia Environmental Services, in partnership with a Chinese company, the concession for a hazardous waste-treatment center in Changsha, the capital of Hunan Province. The contract covers the design, construction and operation of facilities with the capacity to treat up to 54,500 metric tons of hazardous waste a year. The plant will come into operation in 2014.

The treatment center will use a variety of techniques: energy recovery from waste, physical-chemical treatment, solidification and landfilling. Veolia is introducing innovative solutions to reduce energy consumption and greenhouse gas emissions: reduction of the use of fossil fuels, reuse of the steam produced by the waste incineration process and implementation of a low-energy treatment process that produce very little CO_2 (during physical-chemical treatment, the hazardous waste will be treated by high-environmental-performance “cold” processes).

The market and financial conditions, which allow technological transfers, are the followings: the concession contract lasts 25 years; Veolia Environmental Services will take a controlling interest in the JV; the contract includes an exclusivity clause for over 10 cities, which account for 85% of the Province’s GDP; cumulative revenue over the contract period is over €320 million.

5. Conclusion

Innovations depend as much on our research as on our dreams: the dream of storing electricity, the dream of membranes that do not become clogged, the dream of protected oceans and coastline.