Workshop

Building Capacities for Regional Ocean Governance: Marine Genetic Resources and Area-based Management Tools

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Marine Genetic Resources: from Sampling to Commercialisation

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Potential Benefits of Marine Bioprospecting

Offers advantage over comparable terrestrial resource:
- Superior performance
- Better economics

Unprecedented activity in particular application:
- Enzymes: new reactivity/new biotransformation
- Small molecules: novel chemical structures & new mechanism of action
- Materials: new properties
Marine Environments are Rich in Genetic Diversity

Of the major divisions of animal life ~20 have no representatives on land.

There is no clear estimate of marine microbial diversity or its economic value.
The Biodiscovery Pipeline

Sampling
**In situ**

Bioresource Repository
*(Ex situ)*

Genetic Sequence Data
*(In silico)*

Chemistry

Biological screening
Functional testing

Each step may take a significant period

In addition, there may be periods of inactivity/waiting for a variety of reasons

Species identification can take long time
Limited number of taxonomists globally

Product
Marine Scientific Research Planning

- **Application**
  - Cruise plan

- **Award**
  - Feasibility
  - Checks

- **After Cruise**
  - Cruise report

**MSR**
- Most cruises are for basic research
- Freedom of MSR
- File cruise report to funder

**How Might Bioprospecting be Accommodated?**
- Require updates on cruise report to alert to change of use
- Notify when commercialisation occurs

**Opportunity** – Global cruise data available in consistent format will benefit scientific community
Collecting Materials

RRS Discovery (UK)

ROV Isis (UK) (6500 m)
Sampling Devices
Biomass – Invertebrates and Microorganisms
Chemistry

Extraction

Compound Isolation

Compound Identification

Biological Testing
Alternative - Using Genetic Sequence Data

Diagram showing the process:
- **DNA** leads to **Protein**
- **Protein** leads to **Compound**
- **Compound** is visualized on the left side of the diagram.
The Biodiscovery Timeline

Universities

Sampling in ABNJ

Large companies

Universities and SME’s

Scientific knowledge & data

Commercial

‘Potential’ value

Actual value

Thomas Vanagt
The Marine Pharmaceutical Pipeline

Mainly derived from shallow reef dwelling organisms

Mainly anti-cancer with a few analgesics and antivirals

Mainly start-ups at early stage with large pharma at late stage

http://marinepharmacology.midwestern.edu/
Case study: Halaven

Current sales 
Ca US$ 350 M pa
(Usual Royalty Rates are 1-3%)

Laboratory tests and clinical trials 
2010: approval by US FDA

2001: Derivative synthesis
1996: Synthesis
Pre 1986: Screening Isolation & Structure
Bioprospecting

E7388 Eribulin

Halaven (eribulin mesylate) Injection
Pharmaceutical Products

Yondelis
Cancer treatment
Origin: Seasquirt
Location: Caribbean Mangroves
Production: Semisynthesis
Owner: PharmaMar

Prialt
Intractable pain
Origin: Cone snail
Location: Philippines
Production: Recombinant
Owner: Neurex/Elan

Non-Pharmaceutical Products

Vent Polymerase
DNA amplification
Origin: Vent bacterium
Location: Naples, Italy
Production: Recombinant
Owner: New England Biolabs

Fuelzyme
Enzyme used in biodiesel production
Origin: Deep sea bacterium
Location: Unknown
Production: Recombinant
Owner: Verenium (BASF)

Venceane
Cosmetic screening infra-red rays
Origin: Vent bacterium
Location: Unknown
Production: Fermentation
Owner: Sederma (Croda)

Brominated Furanones
Anti biofilm agents
Origin: Red seaweed
Location: Australia
Production: Synthesis
Owner: Unilever

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Mare Geneticum

**Balanced benefit sharing must consider:**
- Size and timing of benefits accrued by user(s)
- Cost and burden of benefit-sharing to the user
- Burden of benefit-sharing to the regulator – institutional cost
- Who are the beneficiaries?
- How many beneficiaries are there?
- Impact of benefit-sharing on the beneficiary
- Timing of the transaction

**Requirements:**
- Inclusivity of developing states
- Facilitated access for the scientific community
- Legal certainty, predictability and stability for industry
- Enforceability for the regulator
Mare Geneticum

**Access:**
Online notification system: OPEN
Free but conditional access
Exclusivity period

**Benefit-Sharing:**
Mandatory deposit of material in biorepositories
Mandatory sharing of meta data and raw data (including GSD)
Possibility of extending exclusivity period in return for a fee
If monetary benefits are requested: at the point of commercialization, and not negotiated
Biodiscovery Pipeline and Benefit-sharing

Sampling in ABNJ

Scientific knowledge & data

Deposit in biorepository
Sharing of metadata

Commercial

Sharing of MGR data

Embargo period (fee)

Monetary BS?

Thomas Vanagt
Sample and data management from origin to exploitation is possible
Already part of good scientific practice but needs standards & improved data infrastructure

Source: OpenNAPIS, White Point Systems
Real World Example

Example of sediment
100 new microbes (10 used)
Each microbe grown in 4 different media
Each one gives 8 fractions
Each fraction tested in 10 assays

1 10 40 320 3200
Total 3596 datapoints – for 1 sample & Genetic Sequence Data
Network Analysis of PharmaSea Dataset (150,000 datapoints) shows complexity of data.
Obligatory Prior Electronic Notification (OPEN)

Sampling *In situ*

Submit OPEN

Obtain Unique Identifier

Bioresource Repository *(Ex situ)*

Update OPEN
*(Location, metadata, species etc)*

Share Materials

Researchers accessing material provided with Unique Identifier

Genetic Sequence Data *(In silico)*

Chemistry

Biological screening

Functional testing

Share Data

Product

Unique Identifier Needed for Publication/IP
Online Prior Electronic Notification

- Use of cruise plans and cruise reports builds on existing practice.
- Agree on minimal dataset to accompany each sample collected.
- Share materials, but have processes to ensure maximum value is obtained from rare samples.
- Develop unique identifier to work with existing ex situ collection data infrastructure and digital sequence information databases.
- Fee-free access to materials and raw data – scope to be clarified but initially intended to mean nucleotide sequence data (DNA/RNA sequences).
- Possibility for exclusivity period on samples/data to enable scientific research to be completed, or for commercial research to be protected. Exclusivity period can be granted without fee for defined period, after which payment to central fund must be made.
Exclusivity Periods in Scientific Practice

• Protein Data Bank entries are placed on hold for one year from the date of deposition. They may be released earlier on a date specified by the Contact Author. When the corresponding electronic or paper publication occurs, the entry must be released if the journal policy requires release upon publication.

http://www.rcsb.org/pdb/home/home.do
Current Thinking on Exclusivity Periods for DSI

INSIGHTS

POLICY FORUM

DATA ACCESS

Toward unrestricted use of public genomic data
Publication interests should not limit access to public data


Science 2019, 363, 350
Data Must Be:
Findable
Accessible
Interoperable
Reusable
IT Solutions (e.g. Blockchain)

Build on existing data infrastructure
(Data Curation Essential)

But: Human Compliance main issue

Feasibility Study?
Marine Science
Collections/Curation
Marine Bioprospecting
Computing Science
Behavioural Science
Law/Policy

Decentralised/Minimal traceability requirement

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Search ‘Mare Geneticum’

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Strengthening Marine Science and building Capacities: for Regional Governance.

Dr. Judith Gobin
Faculty of Science and Technology, Dept. of Life Sciences, University of the West Indies, Trinidad and Tobago
The largest habitat on earth

Above Sea Level (29.1%)

• The deep ocean (>200 m) comprises 2/3 of the planet
• > 90% of habitable volume
• We have only seen < 5% of the deep sea floor
• Most marine species are undescribed
What makes the deep ocean special?

- Depth
- Light
- Pressure

Science & Technology

“We know there are some things we do not know; but there are also unknown unknowns -- the ones we don't know we don't know.”

--U.S. Secretary of Defense, Donald Rumsfeld (2002)
• Cold (2-4° C)
• Dark (no sunlight)
• High Pressure (1 atm/10 m)

• Homogeneous
• Stable
• Food Limited
New exploration tools reveal a wealth of environmental heterogeneity.

**MULTI BEAM SONAR**

As the ship passes over a survey area, bin-shaped sonar beams four times as wide as the depth of the water into the seabed. It takes many passes to produce a continuous set of images.

**Jason (ROV)**

**DTIS (photo by D. Stevens)**

**HOV**

**SENTRY (AUV)**

**ABE (AUV)**

**ES0: 38kHz**

**RRS JAMES CLARK ROSS**

**British Antarctic Survey**

Photo: D. Stevens
Seamounts, Underwater Volcanoes

Dense fish aggregations

Crusts rich in cobalt, titanium, nickel, platinum, cerium, molybdenum, tellurium

Lush invertebrate populations
Cold Water Corals

SPONGE REEFS
Cu, Gold, Zn, Silver

Hydrothermal Vents, Methane Seeps and MGRs

Gas Hydrates

Patagonia

Toothfish

Worlds without sunlight

clccharter.org

en.wikipedia.org
Why is deep-ocean biodiversity important?
Provisioning Services:

Support Functions:

Regulating Services:

Biodiversity:

Scientific Research
Communications
Artistic Inspiration
Industrialization of the Deep Ocean

Demanding more:
- FOOD
- MATERIALS
- ENERGY
- RARE EARTHS

World Population: 1950-2050

Source: U.S. Census Bureau, International Data Base, July 2007 version.

Diagram of world population growth from 1950 to 2050, showing an exponential increase towards 9 billion by 2050.

Images of various technologies and industries, including:
- A hybrid car
- A smartphone
- Wind turbines
- A solar panel
- Smokestacks and industrial buildings
Satellite guided GPS

New mining tools

Mapping Tools

Deepsea News

Nature.com
Overfishing

Endangered Species via Bycatch

Ghost Fishing

Fishing ever deeper

Log10 Catch (tons)

Watson and Morato 2013

Our trawling legacy
Waste Disposal in the Deep Sea

Radioactive Waste in the NE Atlantic

Sewage Disposal in NW Atlantic

TRASH Okeanos Explorer 2011

Terrestrial Mine Tailings

Tsunami Debris in the W. Pacific

Plastics!
Rising CO$_2$ will alter resilience in the deep ocean.

- Warming
- Ocean Acidification
- Oxygen Loss
At the same time there is already a hunt for resources in international waters.
We are Leasing even before Learning

Marine Geochemistry, Schulz
“9 new seep sites discovered off New Zealand in 2006, all trawled & disturbed”

North Island
Seep Sites & Trawl records

Baco et al. 2009
Voluntary code of conduct.

**BIODIVERSITY AND HABITATS:** Convention on Biological Diversity (CBD) & UN General Assembly

**MINERALS:** United Nations Convention on the Law of the Sea (UNCLOS) International Seabed Authority

**SHIPPING & POLLUTION:** International Maritime Organization

**FISHING:** Regional Fisheries Management Organizations/ FAO

**CABLE & PIPELINES, BIOPROSPECTING:** Unregulated
“Despite over 200 research expeditions and 40 years of work in the Clarion-Clipperton Zone (CCZ1) there are almost no published taxonomic records of animals living in the (CCZ1). This is remarkable given the intensity of work there, and the widespread knowledge that the abyssal Pacific is one of the most biodiverse regions of our deep-seafloor, based on macrofaunal community studies”.

Deep-Ocean Stewardship Initiative (DOSI’s Briefing Note: Taxonomic Knowledge of the Clarion-Clipperton Zone)
Principles for Deep Ocean Management

Precautionary Approach - minimization of human impact

-shift burden of proof to those who wish to carry out the activity
-comprehensive baseline research requirements
-regional planning including systems of marine protected areas

Lack of knowledge requires mechanisms to improve deep ocean research:

connectivity, ecosystem function, benthic-pelagic coupling, resilience, non-market ecosystem services.

Require preservation as key form of restoration unless and until appropriate restoration mechanisms established.

-set aside areas for preservation in response to spill or as mitigation measures.
Science and Technology - key Governance enablers
Science & Technology needs are global

Deep Sea (DSea) challenges = ABNJ challenges

Unknown Deep Sea & ABNJ biodiversity

Funding - DSea/ABNJ scientists, sophisticated & high-tech equipment

Scientific opportunities (DSea research vessels)

Access to data
SIDs challenge- competing in the global environment: Science and Technology

DSea & ABNJ access- limited opportunities on ocean-going ships

Data availability- lacking

Data storage- lacks IT infrastructure for big data needs

Data analysis – computationally demanding with significant advances in data analyses
- **Initiate strategic environmental assessment**

- **Generate baseline data to characterize natural variability**

- **Early engagement of stakeholders with outcomes that bind**

- **Develop research funding sources**

- **Strengthen legal framework & regional agreements** -

- **Take advantage of global expertise:**
Global effort includes network of scientists, lawyers, economists (9 working groups)

e.g. DOSI Deep-Sea Genetic Resources Working Group (2013)

• GOAL: Explore and identify options to:
  Conserve and sustainably use deep-sea marine genetic resources (MGR)
  Include access and benefit sharing of marine genetic resources in areas beyond national jurisdiction (ABNJ)
  Can assist at a regional level
Financial support for research, development & innovation

Bridge gaps between science, industry & education

Improved understanding of the value of ecosystem services

Improved understanding of seabed resource mapping for sustainable exploitation of marine resources

Scientists, engineers & skilled workers who are able to apply new technologies
Regional Strategies

• Active networking to involve regional scientists in large deep-sea research projects; Global assessments

• Innovative regional funding mechanisms to address knowledge gaps

• Advance progress towards regionally coordinated sampling eg. mapping of the deep sea floor and Research Projects

• Promote regional programs for communication and education on the importance of the Deep Sea. Educated communities will connect and better understand the need for investment in Deep Sea research towards conservation & management

• Corporate responsibility

• National & Regional Policy including Legislation
Regional Strategies- building Capacity

• Research clusters (international) to achieve internal & external integration (industry, government, research institutes, universities etc.)

• Promote/expand training & career opportunities for scientific research, policy & industry

• Financing & Funding mechanisms; scholarships, training workshops, exchange research visits

• Develop Science & Technical/IT expertise

Range: Education & Institutional capacity-building to more specific training (eg. MGRs)
Successful Regional Partnerships: Caribbean Fisheries Management

- United Nations University, University of the West Indies
- IOI/Dalhousie: Marine Law and Policy
- ANCORS, Univ. of Wollongong, Australia, VIMS – Univ. of Virginia, Univ. of Florida, Univ. of Belize
- IOC/UNESCO
- Public & private sector including fishers (CNFO)

WECAFC 16, July 2016:

The Commission agreed to launch a process to establish RFMO in the WECAFC area of competence, and to collaborate in fisheries management and conservation in the Areas Beyond National Jurisdiction (ABNJ) of straddling stocks, deep sea fish stocks and highly migratory species that are not under the mandate of ICCAT (International Commission for the Conservation of Atlantic Tuna)
Continued attempt to fill gaps in knowledge

Enabling a science-based approach to conservation & sustainable use of biodiversity in the deep sea & ABNJ
TT’s ocean to be explored

LET'S GO: Alan Turchik (right) mechanical engineer for National Geographic shows off a deep-sea camera, which can be used up to 6000 metres deep, to ecologist Dr Diva Amon (middle) and The UWI's lecturer Dr Judith Gobin (left) at the launch of SPEEAS's My deep sea, My back yard project at UWI. PHOTO BY SUREASH CHOLAI
• Grenada - 1st in the world to initiate a pro-active & comprehensive national coastal master-planning approach to Blue Growth.

• Grenada follows the Maldives as the 2nd global SIDs & 1st Caribbean SIDs to “join in partnership with Parley for the Oceans to adopt and implement Parley’s AIR (Avoid, Intercept and Redesign) strategy – to end ocean plastic pollution”!

• Grenada & The Blue Innovation Institute-working with Parley for the Oceans, Adidas (using recycled plastics to produce athletic shoes), UN-OHRLLS and UN Environment (AIR)

The Tide is turning – the GRENADA success story: 1st OECS (Organisation for Eastern Caribbean States) to have Developed a Blue Growth Master Plan
Thank you

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Photo credit: EV Nautilus