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Challenges, Opportunities, and Future Perspectives of Marine Biotechnology

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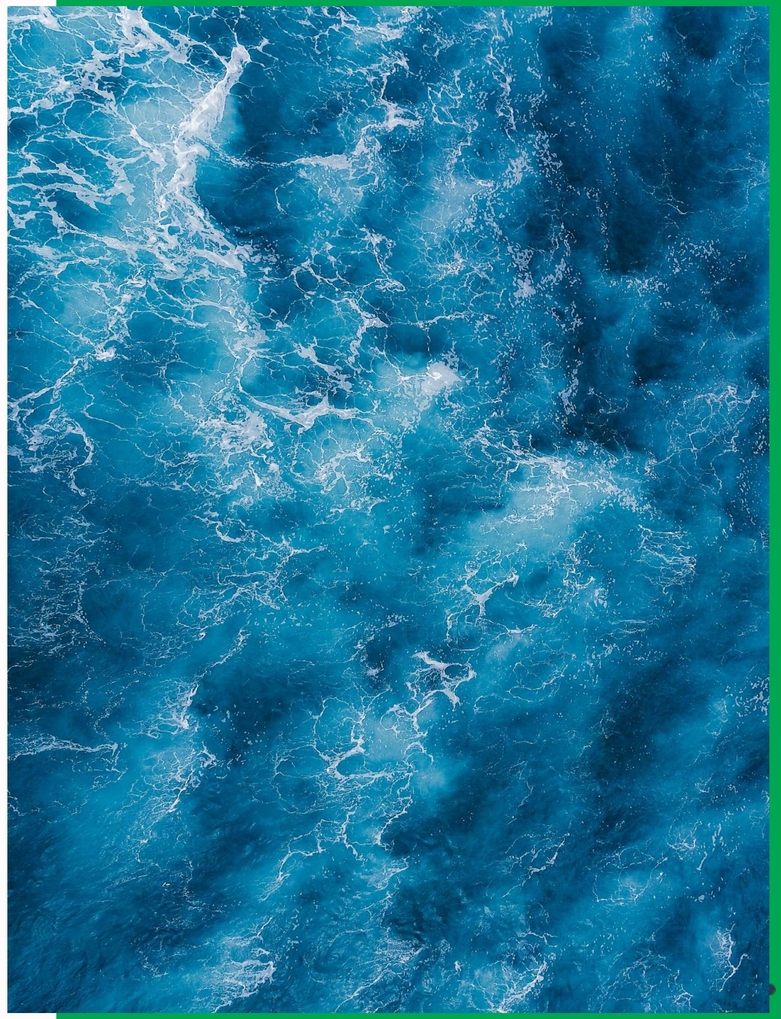

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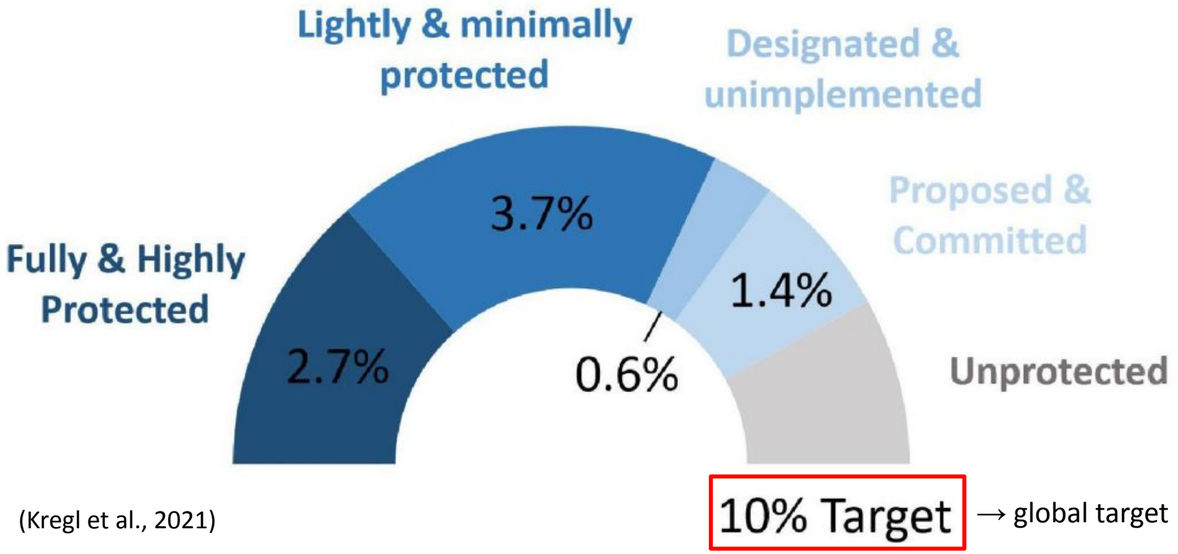
Introduction

Most marine areas in the world are sites for multiple human activities, such as fishing, aquaculture and mining which led to resources exploitation (Elliott et al., 2023).

Some marine areas are designed to be Marine Protected Areas (MPA) to reduce the effect of human activities on biodiversity. In 2020, only 6,4% areas are known protected, which is far short of the global target (Kregl et al., 2021).



(Kregl et al., 2021)

So, we need policies!

"30 by 30" Commitment—The World Biodiversity Convention agreed to conserve and restore an area at least 30% of the ecosystems, including marine, by 2030 (Convention on Biological Diversity).

That means every country are needed to **strength up their policies** in order to achieve this target, especially in protecting the ocean.

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Key challenges in utilizing marine resources sustainably: policy

SDGs no. 14 as the main policiy

SDGs no. 14 is to Conserve and Sustainably Use the Oceans, Seas and Marine Resources for Sustainable Development. This policy holds important role in marine resources utilization in order to prevent environmental impacts, such exploitation and marine pollution.

Key Targets

- Reduce Marine Pollution
- Protect and Restore Ecosystems
- End Subsidies Contributing to Overfishing
- Support Small Scale Fisher
- Reduce Ocean Acidification
- Sustainable Fishing
- Increase the Economic Benefits from Sustainable Use of Marine Resources
- Implement and Enforce International Sea Law
- Conserve Coastal and Marine Areas
- Increase Scientific Knowledge, Research and Technology for Ocean Health

(Global Goals)

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Key challenges in utilizing marine resources sustainably: ethics

The biggest threats in utilizing marine resources is reduction resources, especially for the living species resources, which may caused by natural disasters and pollution (Zhong, 2019). Therefore, ethical principles in using marine resources are needed as guiding lights for individuals, organizations, or even governments to promotes sustainable use of marine resources (Sustainability Directory, 2025).

What are these ethics?

Sustainability	Using marine resources at a rate that allows them to regenerate naturally, ensuring their availability in the future.	Responsibility	Acknowledging a duty of care towards marine ecosystems and the life they support.
Equity	Ensuring fair distribution of benefits and burdens associated with marine resource use.	Transparency	Conducting marine bioeconomy activities openly and making information accessible to stakeholders.

(Sustainability Directory, 2025)

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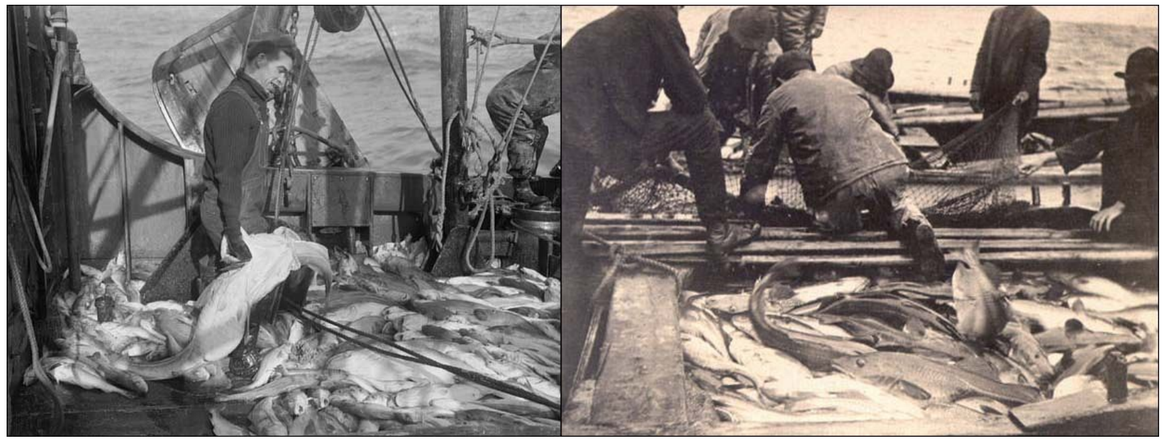
Key challenges in utilizing marine resources sustainably: environmental impacts by case study



(Higgins, 2008; Higgins, 2009)

The Newfoundland Cod Stock Collapse

Starting in 1990s, one of the world's largest fisheries — **the Newfoundland cod** — experienced a dramatic decline, **dropping to less than 5%** of its original population. As a result, in 1992, **the Canadian government declared a moratorium** on cod fishing to prevent further collapse and allow the stock to recover.

Impacts

Environmental:

- Stock collapse of cod; possible long-term ecosystem shift
- Damage to ocean floor due to trawling; excessive bycatch

Social & Economic:

- ~30.000 jobs lost directly and indirectly
- Communities devastated; rural Newfoundland's economy broken
- Long-term reliance on government aid; cultural and identity crisis

(Mason, 2002)

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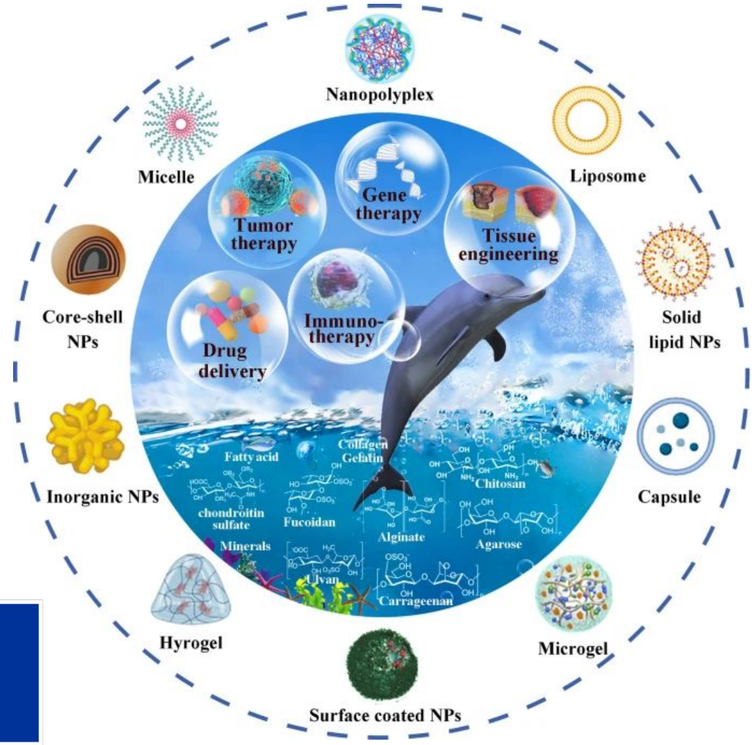
Opportunities for innovation and entrepreneurship in marine biotechnology

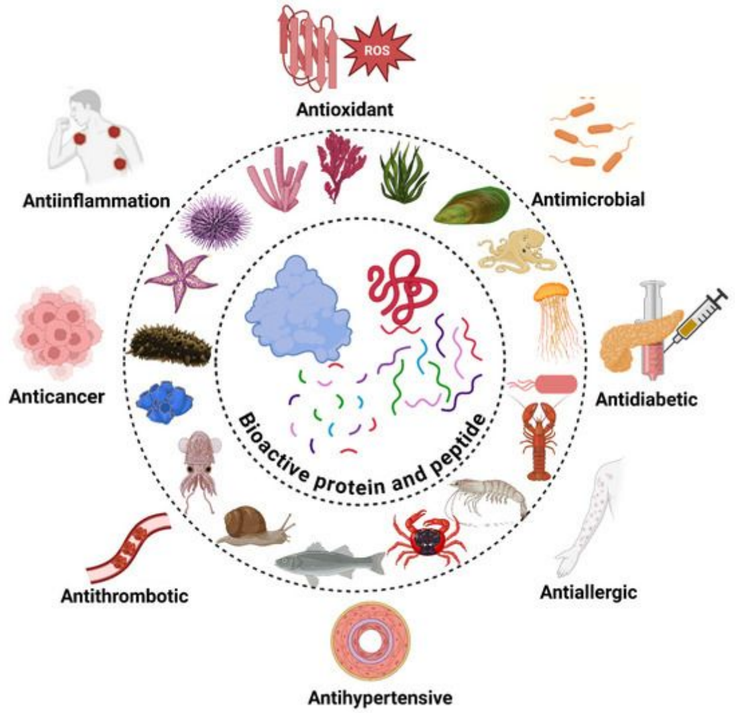
Bioprospecting Marine Resource

- Is the process of identifying unique characteristics of marine organisms for the purpose of developing them into commercially valuable products and scientific knowledge (Krabbe & Langlet, 2024).
- Relates to several goals in Agenda 2030, especially SDG 9, 14, and 15 (Krabbe & Langlet, 2024).



(Wang et al., 2023)

(Siahaan et al., 2022)



(Shahidi & Saeid, 2025)

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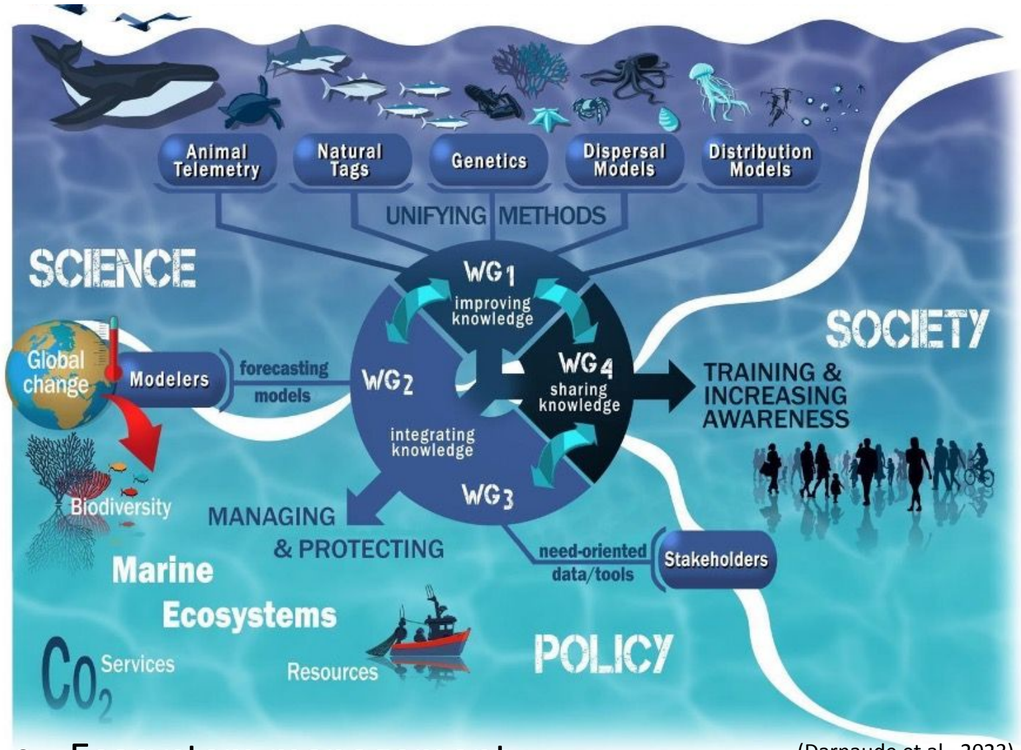
Opportunities for innovation and entrepreneurship in marine biotechnology

Bioentrepreneur

Product innovation

Services



(Darnaude et al., 2023)

- Ecosystem management
- Basic research
- Bioremed

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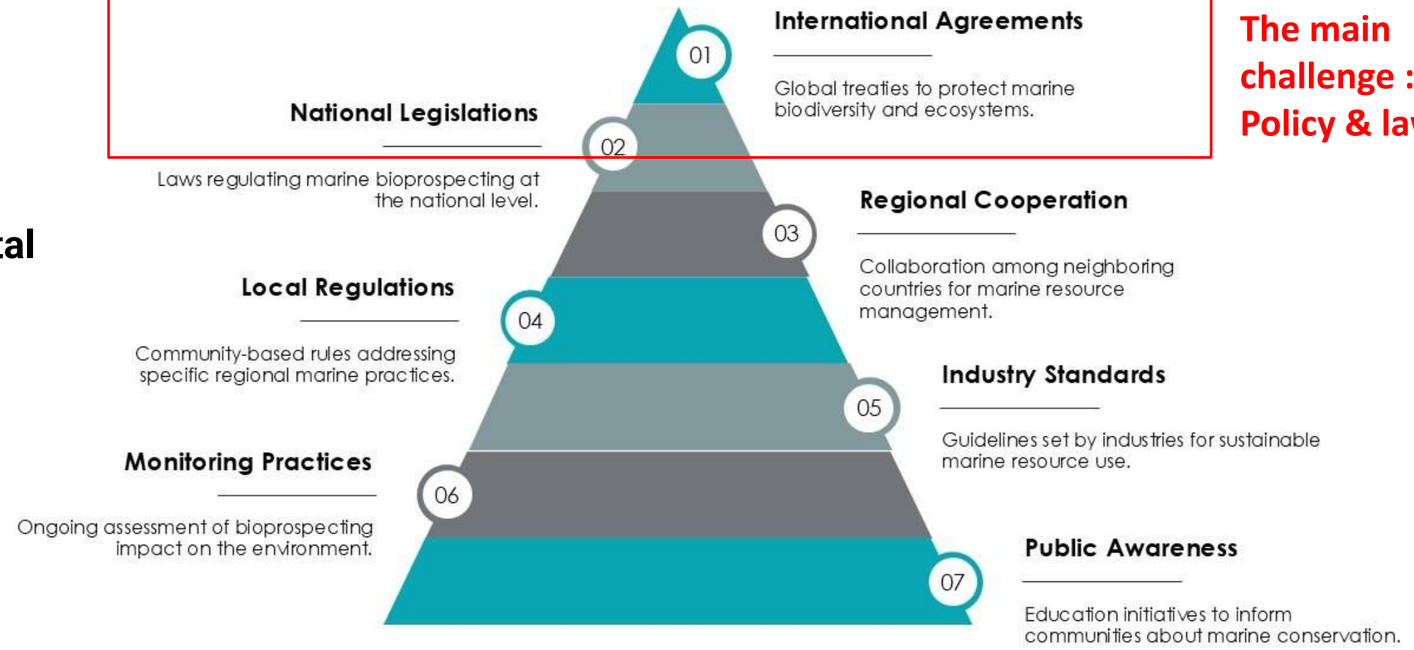
Opportunities for innovation and entrepreneurship in marine biotechnology

Challenges of Bioprospecting Marine Resource

(Garcia & Cortês, 2022)

- **Scientific Research**
- **Environmental Protection**
- **Ethics**
- **The Law**



The main challenge : Policy & law

- In-situ bioprospecting activities can significantly harm marine organisms and their environments (Garcia & Cortês, 2022).
- Long-term effects : alteration/destruction of marine ecosystems, decreases in population, and species extinction

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Successful Startups in Marine Biotechnology: JALA Tech

JALA Tech is an **Indonesian technology company** that focused on transforming the shrimp farming industry through data-driven solutions. They provide an end-to-end platform that integrates technology, aquaculture analysis, and real-time information to help shrimp farmers increase production, efficiency, and sustainability.

Smart Farming with JALA Tech

JALA Tech offers various services including:

- Water quality monitoring tools: provides cost-effective tools to monitor pond conditions in real-time
- Farm management applications: to help farmers track key metrics, manage their operations, and make informed decisions.
- Community platform: fosters a community among shrimp farmers, experts, and other stakeholders to facilitate knowledge sharing and collaboration.
- Integrated solutions: combines technology, analysis, and information to provide a holistic solution for shrimp farmers.

(Jala Tech)

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Successful Research in Marine Biotechnology: OceanX

(OceanX)

OceanX is a **non-profit organization** with the mission is to explore the ocean and "bring it back to the world", combining breakthrough scientific research with high-end storytelling to spark global interest and meaningful action.

What are they doing?

Exploration & Science

→ explore the ocean using cutting-edge technology including deep-sea expeditions, seafloor mapping, water sampling, eDNA collection, bio-tagging, discover new species, etc.

Media & Storytelling

→ bring the ocean back to the world by creating captivating content, such as hollywood-quality documentaries, live streaming, immersive educational experiences, and impactful stories.

Education & Community Engagement

→ train future ocean leaders and empower communities through OceanX education programs, workshops, etc.

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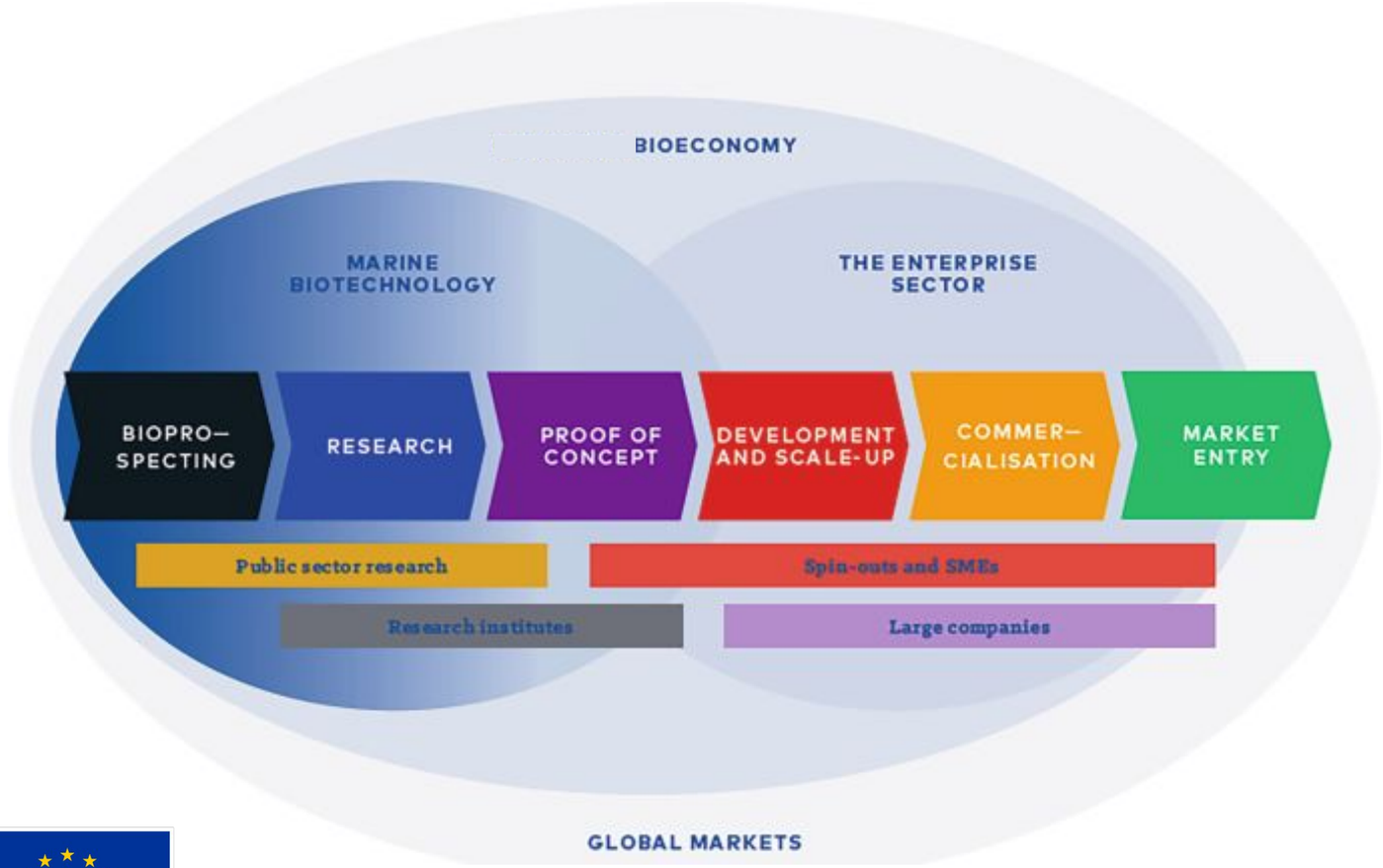
Reflection: Future directions of marine biotechnology in supporting sustainability and the blue economy



(Premanik et al., 2023)

From Discovery to Impact

- Marine biotechnology must go beyond research — reaching product development and global market entry.
- Collaboration between research institutes, SMEs, and large industries is essential to scale innovation.
- Many marine discoveries stay in labs — we need stronger pipelines from bioprospecting to commercialization.
- A sustainable blue economy depends on how well we connect science with enterprise.
- Government facilitation

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Conclusion

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Marine biotechnology offers enormous potential to support a sustainable blue economy by harnessing marine resources for innovation, products, and solutions. However, its success depends on balancing opportunities with responsibilities:

- **Strong policies and ethical frameworks** are crucial to avoid overexploitation and environmental damage.
- **Interdisciplinary collaboration** among governments, industries, researchers, and communities is essential to advance research, ensure sustainable practices, and bring discoveries to market.
- **Education and public engagement** are key to fostering ocean stewardship and achieving global targets like “30 by 30”.

By integrating ethical principles, robust governance, and technological innovation, marine biotechnology can become a powerful driver for economic growth and ocean conservation—securing benefits for current and future generations.

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