Marine Biotechnology: International Perspectives

Presentation to BioTech Annecto
May 2nd 2017

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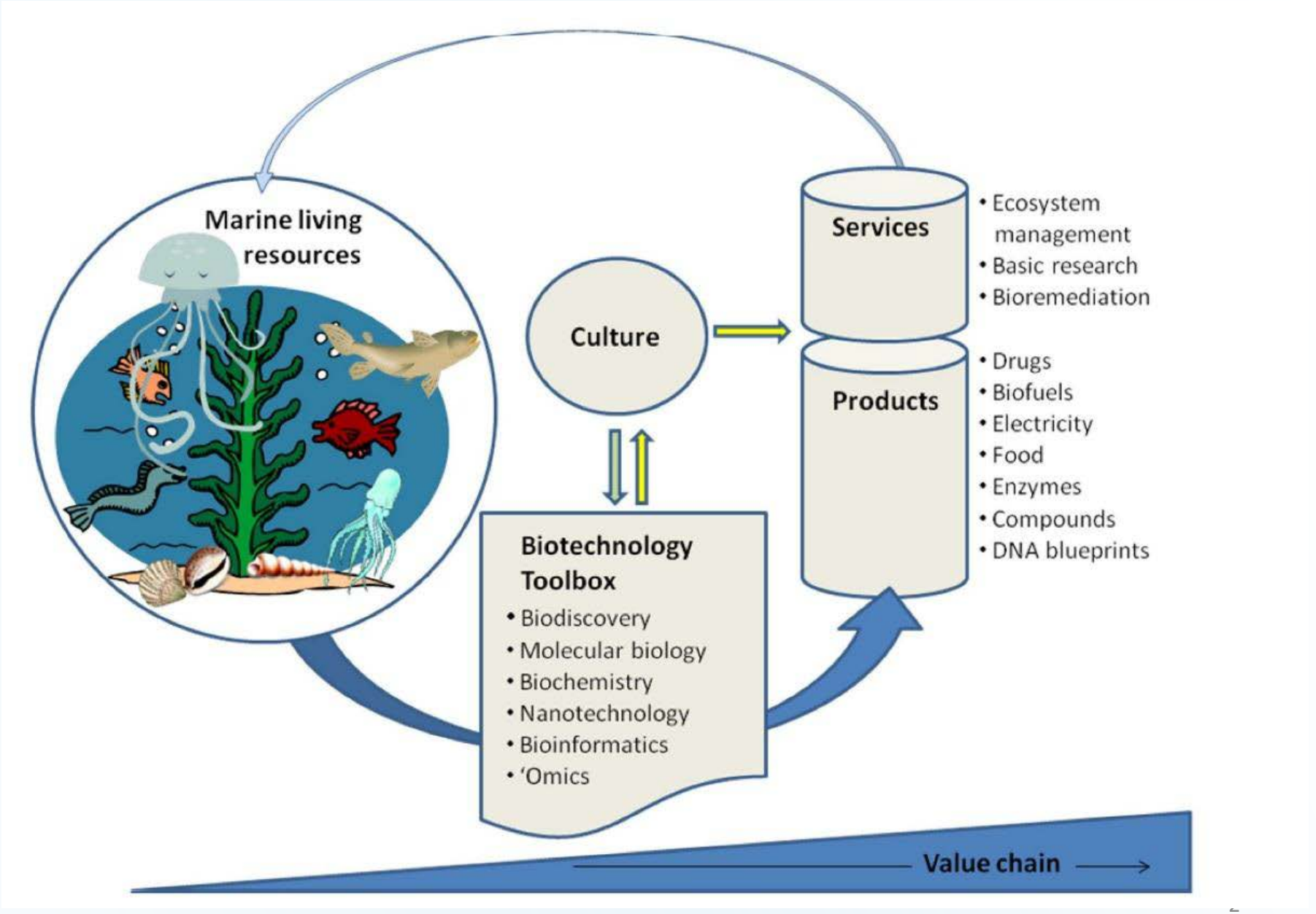
WHAT IS MARINE BIOTECHNOLOGY?



Source: Study in support of Impact Assessment work on Blue Biotechnology , Ecorys, 2014

MARINE BIOTECHNOLOGY APPLICATIONS

SUB SECTOR	POTENTIAL PRODUCTS	SPECIFIC PRODUCT AREAS
Health	Pharmaceuticals	Anti-cancer drugs, anti-viral drugs, novel antibiotics; wound healing; anti-inflammatory; immunomodulatory agents
	Biomaterials	Bio adhesives, wound dressings, dental biomaterials; alternative disinfectants; medical polymers; coating for artificial bones; medical devices
	Other	Tissues regeneration, 3D tissue culture
Cosmetics	Functional ingredients	UV-filter, after sun; viscosity control agents; surfactants; preservatives; liposomes, carrier systems for active ingredients; regulation of sebum
	Raw materials	Micro and Macro-algae extracts; colourants, pigments; fragrances; hair-styling raw materials
Food	Functional foods	Prebiotics; omega 3 supplements
	Nutraceuticals	Useful as antioxidants, anti-inflammatory; fat loss; reducing cholesterol ; anti-HIV properties, antibiotic and mitogenic properties anti-tumour; iodine deficiency, goitre and myxoedema; anti-influenza; treatment of gastric ulcers;
	Ingredients	stabiliser, suspending agents, bodying agents, prevents separation and cracking, suspending agent, foaming agent
	Food packaging	Films and coatings with antimicrobial effects

Source: Study in support of Impact Assessment work on Blue Biotechnology , Ecorys, 2014

MARINE BIOTECHNOLOGY APPLICATIONS cont'd

SUB SECTOR	POTENTIAL PRODUCTS	SPECIFIC PRODUCT AREAS
Energy	Renewable energy processes	Microalgae; produce polysaccharides (sugars) and triacylglycerides (fats) for producing bioethanol / biodiesel, large scale cultivation of macroalgae for production of biofuel
	Microbial Enhanced Oil Recovery (MEOR)	Enhanced oil recovery and productive life of oil reservoirs
	Industrial additives	Anti-blur additives for textile printing, binding agent in welding rods, drilling fluid
Aquaculture	Seed	Surrogate broodstock technologies; transgenic approaches; developing culture species; selective breeding of existing cultured species for novel and disease resistant hybrids
	Feed	Fish oils produced from algae; pigments in fish feed
	Disease Treatment	Diagnosis; treatment of disease; disease-resistant strains
	Aquaculture systems	Treatment of re-circulated water

Source: Study in support of Impact Assessment work on Blue Biotechnology , Ecorys, 2014

MARINE BIOTECHNOLOGY APPLICATIONS cont'd

SUB SECTOR	POTENTIAL PRODUCTS	SPECIFIC PRODUCT AREAS
Marine environmental health	Bioremediation	Bio surfactants (BS), bio emulsifiers (BE) induce emulsification, foaming, detergency, wetting dispersion, solubilisation of hydrophobic compounds and enhancing microbial growth enhancement; marine exopolysaccharides (EPs) induce emulsification
	De-pollution	Removal of toxic elements including metals (lead, cadmium, zinc and metal ions); removal of dyes
	Bio-sensing	Biomarkers and biosensors for soil, sediment and water testing; to identify specific chemical compounds or particular physio-chemical conditions, presence of algal blooms, human health hazards
	Antifouling	Reduce drag and fuel use for boat-going vessels without any negative environmental impacts
	Bio-adhesives	Underwater industrial adhesives
Other	Bio-refineries	Biodiesel; feedstock for the chemistry industry; essential fatty acids, proteins and carbohydrates for food, feed for animals (replacement of feed with fishmeal) and production of proteins and chemical building blocks

Source: Study in support of Impact Assessment work on Blue Biotechnology , Ecorys, 2014

MARINE BIOTECHNOLOGY PRODUCTS - EXAMPLES

SUB SECTOR	FONCTION	SOURCE	COMPOUND	COMPANY
HEALTH	Anticancer	Colonial Tunicate	Yondelis	Pharmamar (Spain)
	Lower fat	Fish species	Lovaza	Pronova Biopharma (Norway)
	Nose spray	Red algae	Carragelose	Marinomed (Austria)
	Pain	Cone snail	Ziconotide	Jazz Pharmaceuticals (USA)
COSMETICS	Skin lotion	Sea fan	Sea whip extract	Estee Lauder (USA)
	Sun Cream	Red algae	*Porphyra* extract	Multiple
	Moisturizer	Brown seaweed	Algae extract	Thalgo (Fance)
FOOD	Antioxidant	Bladderwrack	Fucoidan	Multiple
	Colorant	Phaetophytes	Fucoxanthin	Multiple
	Bakery icings	*Laminaria*	Alginate	Multiple
	Antioxidant	*Microalgae*	Astaxanthin	BioAstin (USA)
ENERGY	Biofuel	Microalgae	Algae Oil	Solazyme (USA)
AQUACULTURE	Fishmeal	Algae	ReNew Feed	Cellana (USA)
	Pigment	Microalgae	Astaxanthin	Fuji Chemical (Japan)
MARINE ENVI. HEALTH	Biosensor	Marine bacterium	Alcanivorax	ATCC (USA)

GLOBAL MARKETS

"The global market for marine biotechnology has the potential to reach $**4.8 billion** by 2020, rising to $**6.4 billion** by 2025".

Pharmaceuticals:

- More than **1,000** novel marine chemicals in preclinical trials between 1998 and 2011.
- As of December 2015, **7** FDA approved marine origin drugs were in clinical use and a further **28** at various stages of clinical trials. Fish, sponges, tunicates, molluscs and bacteria are the main sources of compounds in these trials.

Nutraceuticals:

- By 2018 the global market is expected to be worth **$250 billion**

Cosmeceuticals:

- The global cosmeceuticals market was valued at USD **42.24 billion** in 2016 and is expected to reach a value of USD **68.72 billion** by 2022
- Marine compounds have a long history of use in the cosmetics sector
- **13%** of the global cosmetics market being products that incorporate marine ingredients

SOURCE: A 2015 market report from Smithers Rapra *"The future of marine biotechnology for industrial applications to 2025":*

http://marinepharmacology.midwestern.edu/preclinPipeline.htm

EUROPEAN RESEARCH AREA (ERA) - MARINE BIOTECH (ERA-MBT)

ERA-MarineBiotech is a consortium of **national funding bodies** seeking complementarities between national activities to pool resources to undertake joint funding of transnational projects in the area of Marine Biotechnology

Marine Biotechnology Strategic Research and Innovation Roadmap (2016-2030)

- Exploration of the environment
- Biomass production and processing
- Product innovation and differentiation
- Enabling technologies and infrastructure
- Policy support and stimulation

ERA-MBT ROADMAP – BIOMASS PRODUCTION AND PROCESSING

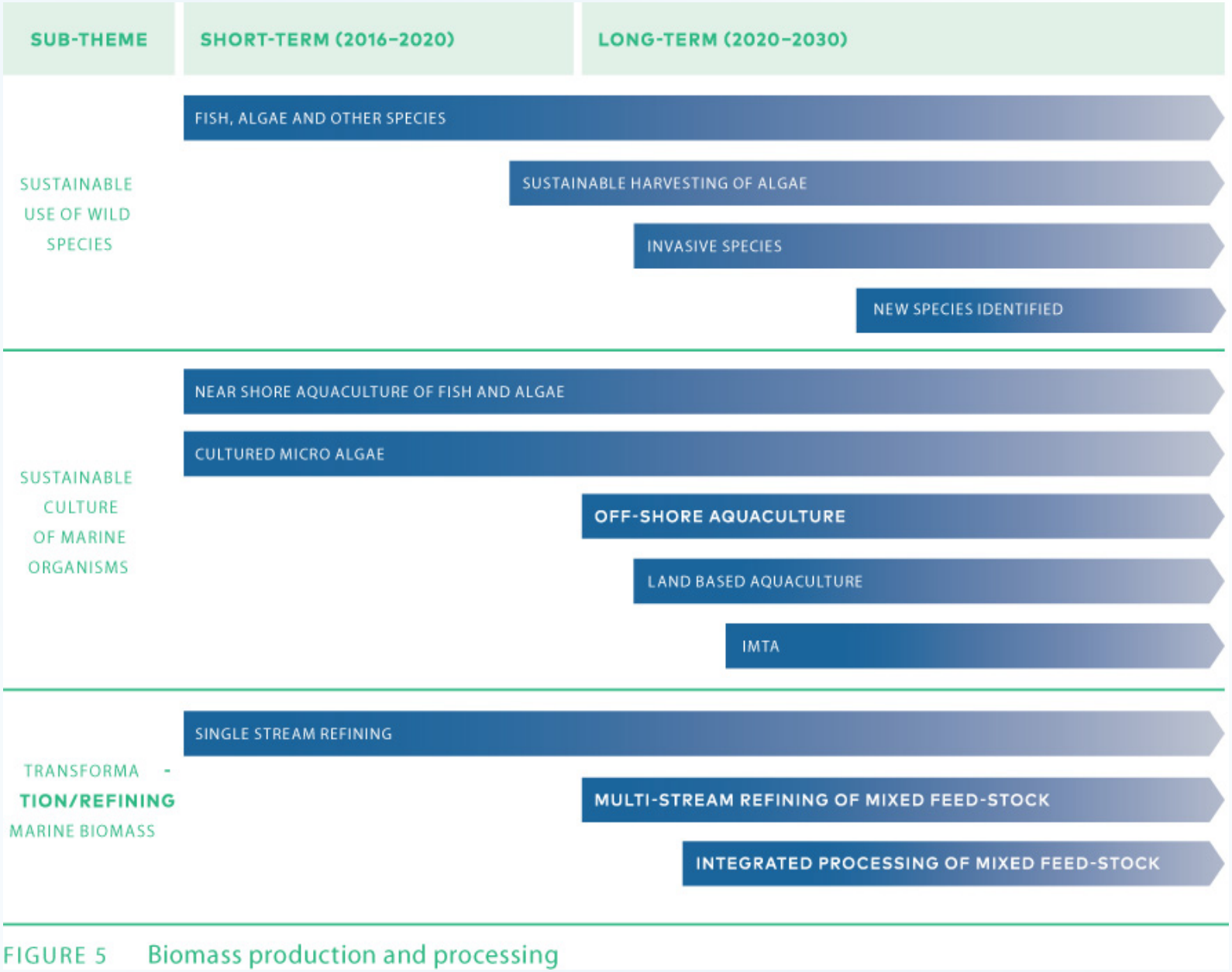


FIGURE 5 Biomass production and processing

Source: Marine Biotechnology Strategic Research and Innovation Roadmap, ERA-MBT, September 2016

ERA-MBT ROADMAP – PRODUCT INNOVATION AND DIFFERENTIATION

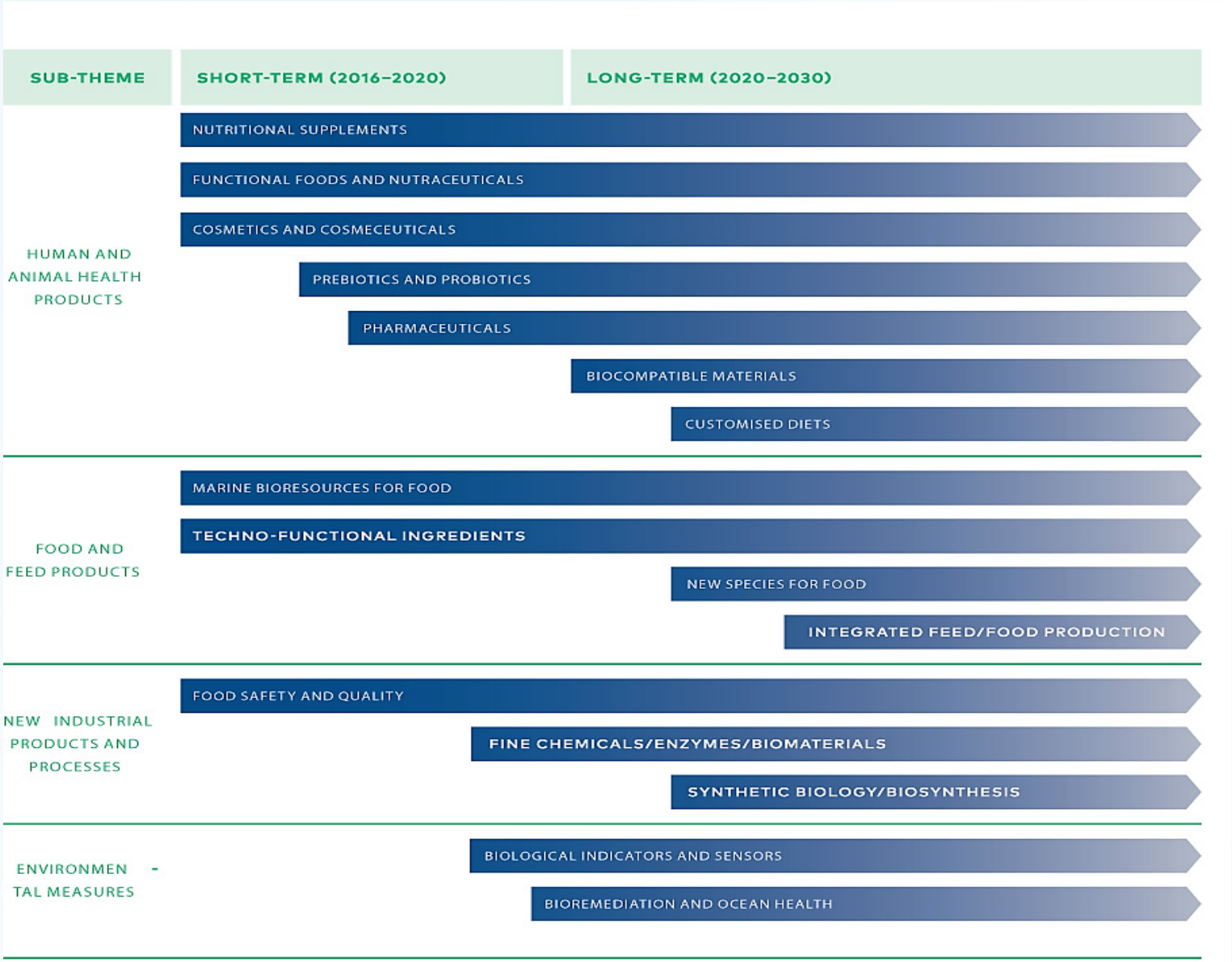


FIGURE 6 Product innovation and differentiation

source: Marine Biotechnology Strategic Research and Innovation Roadmap, ERA-MBT, septembre 2016

EUROPEAN RESEARCH AREA (ERA) - MARINE BIOTECH (ERA-MBT)

1ST CALL: "The development of biorefinery processes for marine bioresources"(*closed April 2015*)

MARBioFEED - Enhanced bio refining methods for the production of marine biotoxins and microalgae fish feed

Mar3Bio - Bio refinery and biotechnological exploitation of marine biomasses

MicroMBT - Discovery and training of microbial biocatalysts for biomass conversion using moving bed technology (MBT)

NEPTUNA - Novel Extraction Processes for mulTiple high-value compoUNds from selected Algal source materials

SeaRefinery - The Seaweed Bio refinery – for high value added products

ThermoFactories - Thermophilic cell factories for efficient conversion of brown algae biomass to high-value chemicals

2ND CALL: "Biodiscovery - Bioactive molecules from the marine environment (*closed March 2016)*

BlueShell - Exploring Shellfish By-products as sources of Blue Bioactivities

BLUETEETH - Marine Origin Biopolymers as Innovative Building Blocks from the Sea for the Development of Bioresorbable Multilayered Membranes for Guided Bone Regeneration

CYANOBESITY - Cyanobacteria as a source of bioactive compounds with effects on obesity and obesity-related co-morbidities

MARPLAST - Marine microorganisms for bioplastics production

Novofeed - Novel feed ingredients from sustainable sources

3RD CALL: "*Metagenomic approaches for valorization from the marine environment*"
(announcement July 2017)

REGIONAL COOPERATIONS

NORTH ATLANTIC OCEAN CLUSTERS

- Created in 2011
- 50 members
- Canada, Iceland, Scotland, Ireland, Norway, Denmark, Sweden and Finland
  - North Atlantic Marine Biotechnology Cluster
  - Marine Food Cluster in the North Atlantic
  - North Atlantic Marine Energy Cluster
  - North Atlantic Marine Transport Cluster

INTERREG BALTIC SEA REGION

- Sweden, Finland, Estonia, Latvia, Lithuania, Poland, Germany, Denmark
- Programme 2014-2020: EUR 278.6 million

INTERREG ATLANTIC AREA

- France, Ireland, Portugal, Spain and the United Kingdom
- Programme of a total budget of EUR 185 million

EUROPEAN NETWORK OF MARITIME CLUSTERS

Confederation of Clusters **(**not THE European Maritime Cluster)

NORWAY

Country: 5 million people

Fishing industry: production: exports: US$ 6MM (Herring: 0,5 MT: cod: 0,5 MT)

Important salmon aquaculture: 1.16 MT in 2013

Main catches: herring, cod, mackerel, Snow crab is growing

Biotech Strategy:

In 2011, the Norwegian Government launched the "National Strategy for Biotechnology 2011 – 2020: For the future of value creation, health and the environment":

- Aquaculture, seafood, and management of the marine environment
- Land-based food and biomass production
- Environment-friendly industrial processes and products
- Health, health services and health-related industries

In 2015: bioeconomy strategy for Norway

Research Centers:

Norwegian Institute of Food, Fisheries and Aquaculture Research (NOFIMA) (142PhD)

NAMAB – Nofima National Facility for Marine Bioprocessing; mini-factory for processing of marine and plant-based biomass

NORWAY

Research Centers:

CREATE - Centre for Research-based Innovation in Aquaculture Technology

UiT – The Arctic University of Norway

Stavanger University

UIN - Nordland University

NMBU – Norwegian University of Life Sciences

Cluster: BiotechNorth

38 companies and R&D centers

- Borregaard AS is one of the largest industrial biotechnology/biobased industry companies in Norway. Borregaard claims to have one of the world's most advanced biorefineries
- Biotec Pharmacon ASA
  - Biotec BetaGlucans AS, a wholly owned subsidiary of Biotec Pharmacon, develops and manufactures immune modulating compounds for the human health sectors
  - ArcticZymes AS, is focused on developing cold adapted enzymes for use in various RNA and DNA processes

Financing:

Research Council of Norway, innovation Norway, SIVA

ICELAND

Country: 331 000

Fishing industry: Landings: 1.1 MT; Main catches: herring, cod, mackerel, capelin,

Biotech Strategy: No specific strategy for marine biotech in Icelandic 2020

Research Centers:

Matis is an independent research institute active in the food industry, biotechnology and food security.

Provides consultancy and services to companies in fisheries and agriculture as well as governmental agencies

The Marine Research Institute is a government institute.

Conducts research regarding marine organisms and provides scientific advice based on its research on marine resources and the environment

University of Iceland – Life and environmental science, Food science and nutrition, Center for System biology researchers

University of Akureyri – Natural Resource Sciences

Hólar University Collage - Department of Aquaculture and Fish Biology

Cluster: Iceland Ocean Cluster

Financing:

The Icelandic Centre for Research (Rannis) - supports research, innovation, education and culture

The Ministry of Industries and Innovation

ICELAND - COMPANIES

Zymetech: Enzymes from cod: Penzyme® for skin problems

Lipid Pharmaceuticals: New drugs from marine oils

3Z.is: preclinical drug focusing on the discovery of Central Nervous System (CNS) drugs.

Risk Medical Solutions: focuses its efforts in developing innovative IT-solutions

Codland: network of companies with a common goal of increasing the value of fish products

Primex: pure chitin and chitosan derivatives, manufactures chitosan from shrimp shell.

Herberia: over the counter herb-based medicine

Marinox: UNA skincare™ cosmetic brand, bioactive substances derived from marine algae

Lysi: world's largest producer of marine oils for human consumption and an original pioneer of fish oil (cod liver oil and other marine lipids) production.

Genis: aminosugars derived from shrimp shells.

Kerecis: patent-pending MariGen™ Omega3 fish-skin acellular dermal matrix transplantation technology

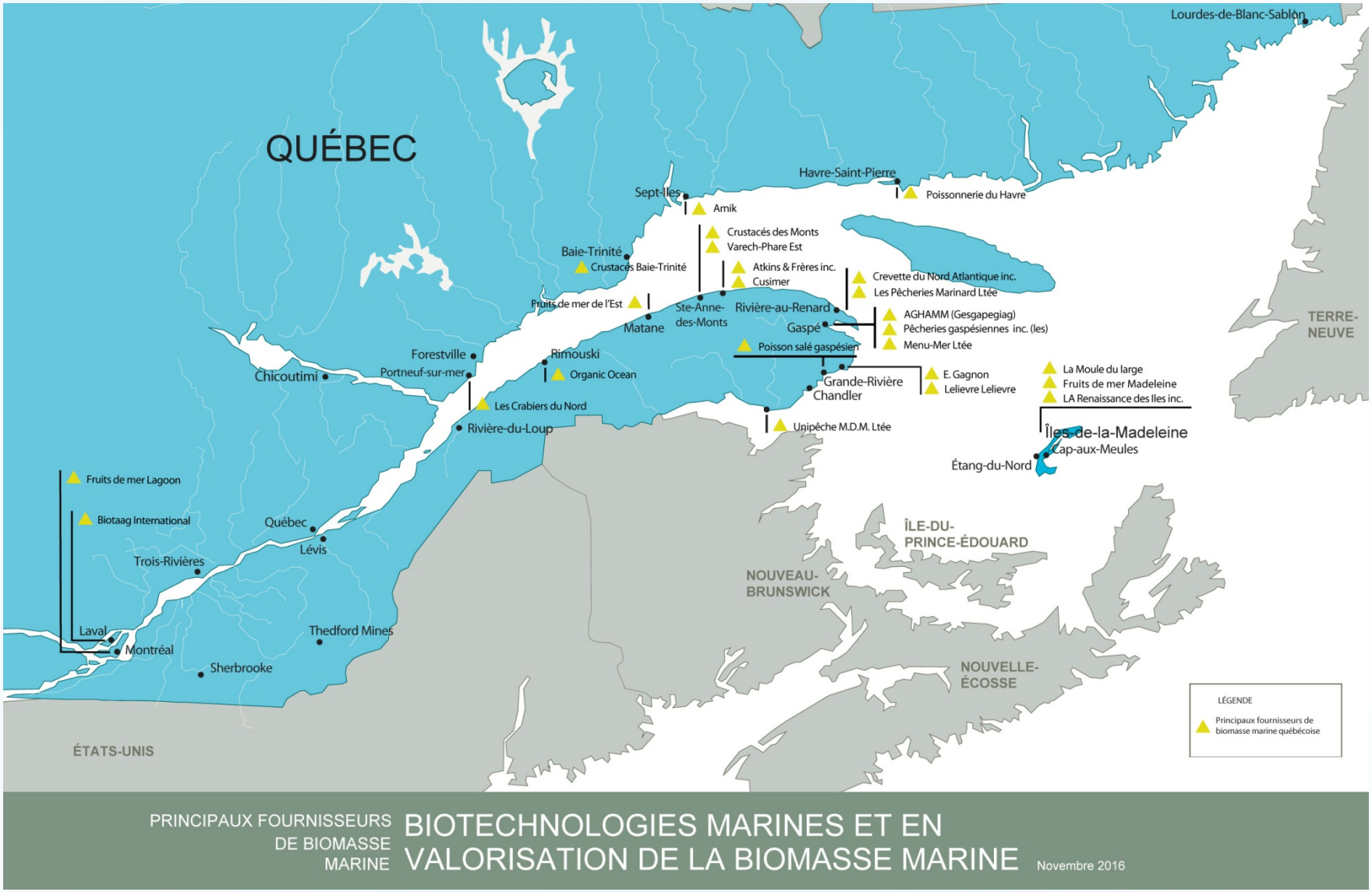
Hafkalk: high quality marine supplements from calcified red algae.

IceProtein: Atlantic cod protein hydrolysates, Arctic char protein hydrolysates and Arctic shrimp shell protein hydrolysates.

USA - MAIN RESEARCH CENTERS ACTIVE IN BIOTECHNOLOGY

STATE	RESEARCH CENTER
California	Scripps Institution of Oceanography CMBB,UC San Diego
	California Institute of Technology
North Carolina	Marine Biotechnology Center of Innovation
South Carolina	Center for Coastal Environmental Health and Biomolecular Research
Colorado	Colorado State University
Delaware	The University of Delaware
Florida	The Harbor Branch Institute, Florida Atlantic University
	The Smithsonian Institute's Marine Station
Illinois	Argonne National Laboratory
	The University of Illinois
	The University of Illinois Institute for Genomic Biology
	The University of Illinois Energy Biosciences Institute
Maine	Center for Blue Biotechnology
Maryland	The Department of Marine Biotechnology, University of Maryland
	The Institute for Marine and Environmental Technology, U. of Maryland
Massachusetts	the Woods Hole Oceanographic Institution
Minnesota	University of Minnesota
Mississippi	The National Institute for Undersea Science and Technology
New Jersey	Rutgers University Center for Marine Biotechnology
New York	Cornell University
Oregon	The Oregon Health and Science University School of Medicine
Pennsylvania	Drexel University

QUEBEC - SUPPLIERS OF BIOMASS



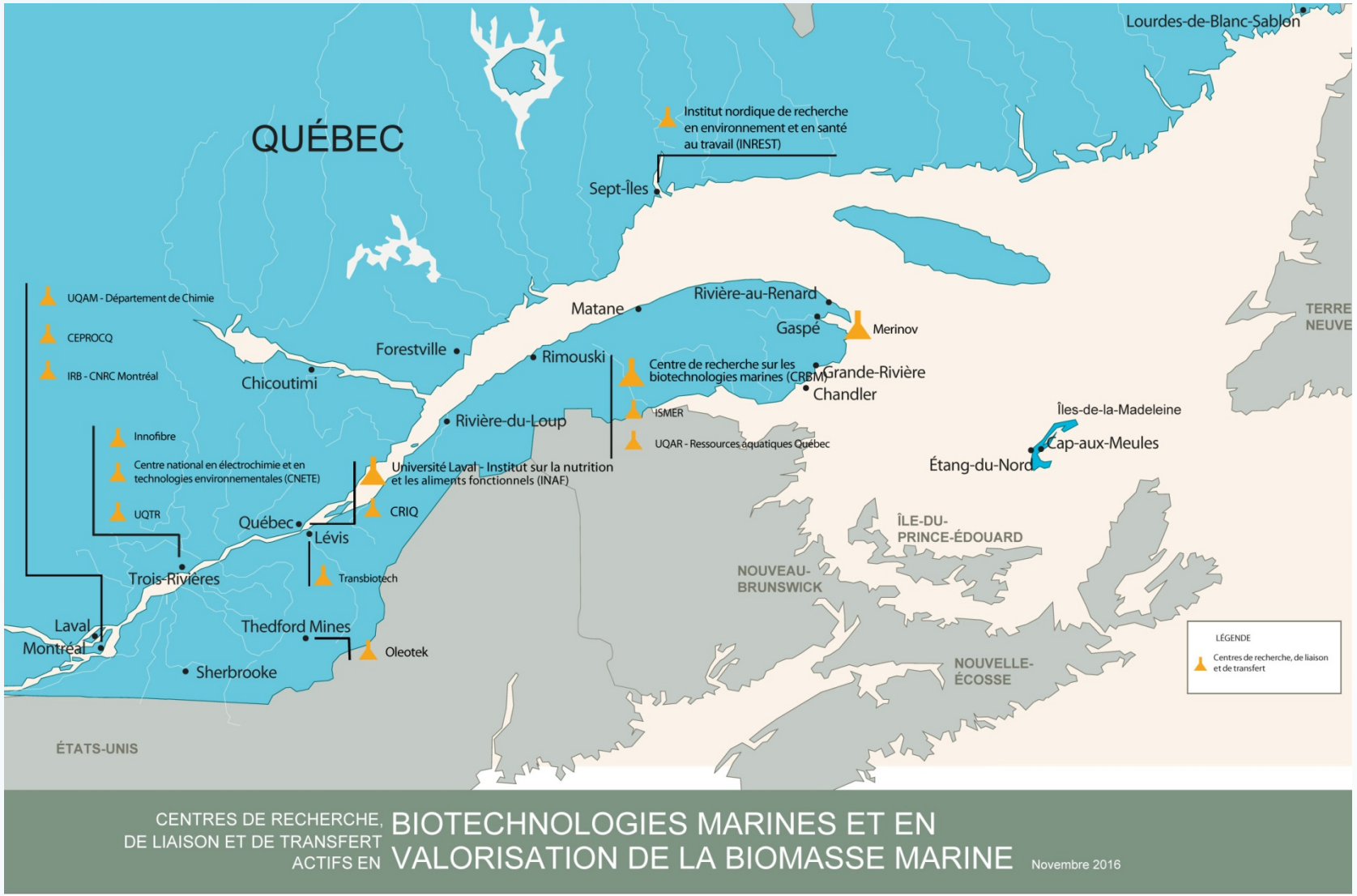
QUEBEC - SUPPLIERS OF BIOMASS

	PRODUCTS								EMPLOYMENT				
	FROZEN	CANNED	FLOUR	DRIED/SALTED	FRESH	COOKED	UNPELLED	SMOKED	PRODUCTION	PRODUCTION (PEAK)	R & D	OTHER	TOTAL
AGHAMM												5	5
AMIK					X					13	1	1	15
Atkins et Frères Inc.						X	X		7	10		10	20
Biotaag International				X								1	1
Crevette du Nord-Atlantique Inc.	X		X		X	X	X		130	130		15	145
Crustacés Baie-Trinité	X	X			X				120	120		10	130
Crustacés des Monts Inc. (Les)	X				X	X	X		45	45		2	47
Cusimer (1991) Inc.	X				X				35	35		4	39
E. Gagnon et Fils Ltée	X	X			X				150	150		25	175
Fruits de mer de l'Est du Québec	X	X			X	X	X		136	136		14	150
Fruits de mer Lagoon	X				X				50	50		24	74
Fruits de mer Madeleine	X	X		X	X				135	135		4	139
Les crabiers du Nord Inc.	X	X			X		X		60	75		8	83
Lelièvre Lelièvre et Lemoignan Ltée	X			X	X			X	141	141		9	150
Menu-mer Ltée	X			X	X		X		9	11		3	14
Moule du large (La)					X				24	24			24
Organic Ocean				X					9	12	3		12
Pêcheries Gaspésiennes Inc. (Les)	X			X			X	X		60		5	65
Pêcherie Marinard Ltée (Les)	X		X		X	X	X		184	184		27	211
Poisson salé Gaspésien Ltée					X	X	X		240	240		6	246
Poissonnerie du Havre	X	X			X				146	146		4	150
Renaissance des Îles	X	X							350	350			350
Unipêche M.D.M. Ltée	X				X	X	X		10	260		5	265
Varech Phare est				X						1			1
	16	7	2	6	17	7	10	2	1981	2328	4	182	2511

QUEBEC - MAIN SOURCES OF BIOMASS

Sources	Description	Volume
RESIDUES FROM PROCESSING PLANTS (+/- 20 COMPANIES)		**22 305 t**
Shrimps	Shells (68-70 %)	11 500 t
	Eggs (July to September)	300 t
Lobsters	Shells	3 100 t
Capelin	400 t of male rejects on a catch of 1 000 t	400 t
Snow Crabs	35 % of weight	3 900 t
Rock Crabs	Contains chitin	680 t
Greenland Halibut	Head accounts for15 % à 20 % of the weight	400 t
Goundfish	Various species	2 000 t
AQUACULTURE		
	26 companies	**500 t**
MACRO-ALGAE		
	6 companies (potential 10 000 t)	**800 t**
UNEXPLOITED MARINE BIOMASS		**unknown**
	More than 90 species identified	

QUEBEC – RESEARCH CENTERS AND TRANSFER CENTERS



QUEBEC – RESEARCH CENTERS AND TRANSFER CENTERS

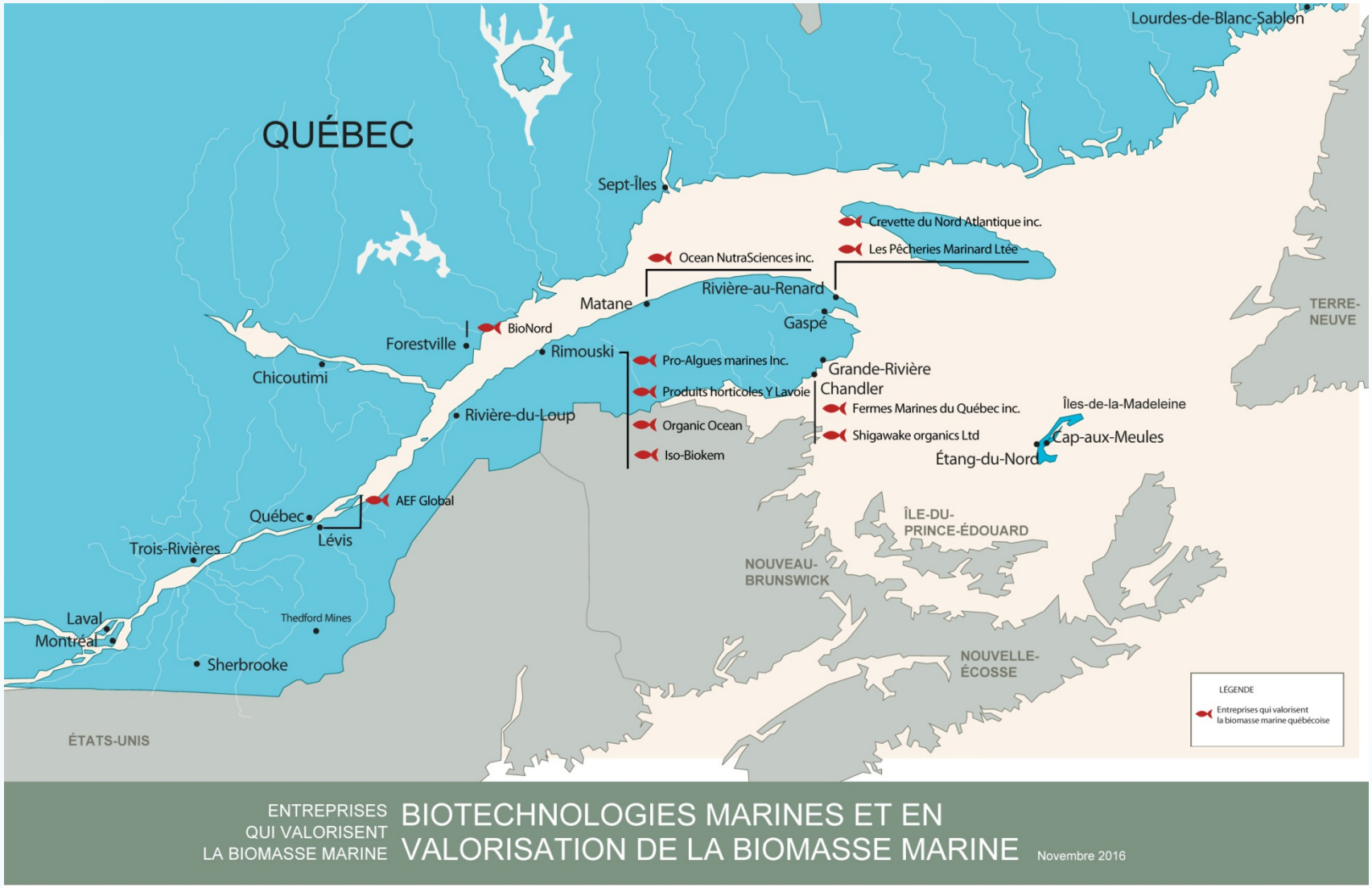
	CREATION	SECTOR OF ACTIVITY									EMPLOYMENT				
		Natural Health Products and nutraceuticals	Cosmetics cosmeceuticals	Biomedical et bio-pharma	Processing	Horticulture	Feed	Industrial bioproducts	food	Aquaculture	PhD	M. Sc	BA	Other employees	Total
CEPROCQ	1997	X	X		X		X				5	1	3	5	14
CNETE	1993	X		X	X										
CRBM	2004	X	X	X	X	X	X	X	X	X	4	6	9	14	33
CRIQ	1970	X			X						10	42	52	91	195
Innofibre	1989				1						6	7	2	12	27
INREST	2013	X	X		X		X				1	1	1	1	4
INAF / Université Laval	2001	X	X		X						15				15
IRB / CNRC	1916	X	X	X	X	X	X								
ISMER	1999	X	X	X	X		X				22	5	100	6	
Merinov	2010	X	X		X	X	X	X	X	X	6	20		60	86
Oléotek	2002	X	X		X	X					2	5	5	3	15
Transbiotech	1999	X	X	X							3	2	6	4	15
UQAM - chimie	1988	X	X	X	X						2	4	4		10
UQAR – Ress.Aqua. Qc	2004	X		X	X	X	X				7	5	167		179
UQTR - Chaire en enviro.	2008	X	X			X	X				7	6	3	1	17
TOTAL		**14**	**10**	**7**	**12**	**5**	**7**	**2**	**2**	**2**	**90**	**104**	**352**	**197**	**743**

+/- 25 PRODUCTS AND PROCESSES READY FOR TRANSFER

QUEBEC – UNIVERSITY PROGRAMMES

University	Programme
U. Q. à Rimouski	BA environmental chemistry and bio resources; BA with a major in marine sciences
	Master in marine resources management); Master in oceanography
U. Q. à Chicoutimi	BA in chemistry of natural products
U. Laval	Certificate in biotechnology
	BA in biochemistry; BA in food science and food technology
	Master in cell biology; Master in biochemistry
	Master and PhD in food science
U. de Sherbrooke	BA in molecular biology; BA in bio engineering; BA in chemistry major in environment; BA in biochemistry
	BA and Master in chemical engineering
	Master in organic and pharmaceutical chemistry
U. de Montréal	BA in biochemistry
	Master in molecular biology
U. Q. à Trois-Rivières	BA in biochemistry and biotechnology
	Master and PhD in cell biology and molecular biology
U. Concordia	BA in cell biology and molecular biology
	Master in cell biology and molecular biology
U. McGill	Master in applied biotechnology

QUEBEC – PROCESSORS OF MARINE BIOMASS

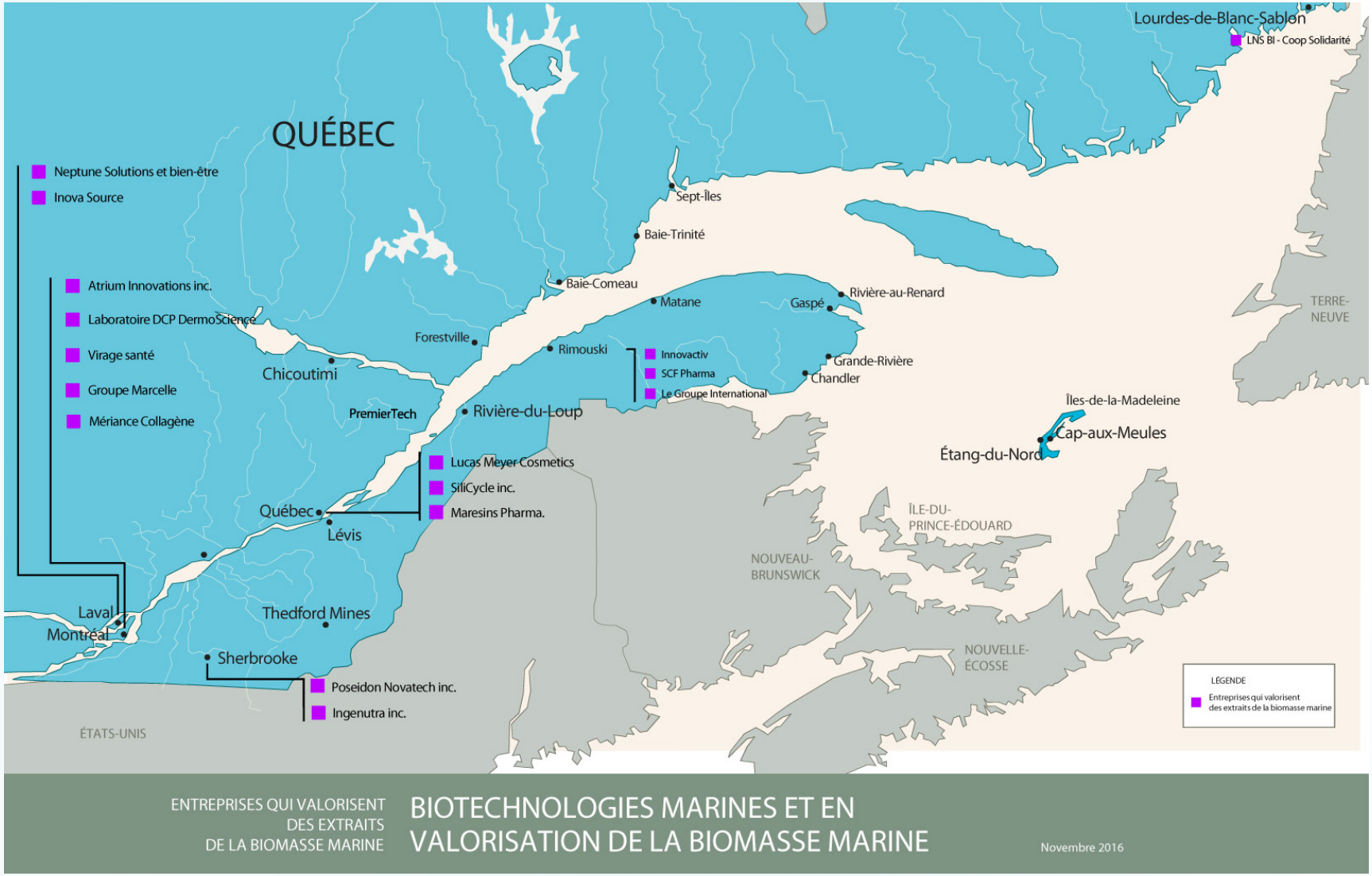


QUEBEC – PROCESSED PRODUCTS FROM MARINE BIOMASS

COMPANIES	PRODUCTS									
	ANIMAL FEED	FOOD	AQUACULTURE	BIOMATERIALS	BIOPRODUCTS	COSMETICS	ENERGY	ENVIRONNEMENT/ AGRICULTURE	PHARMACEUTICALS	NATURAI HEALTH PRODUCTS
AF Global								X		
Bio Nord								X		
Crevette du Nord-Atlantique (La)		X								
Fermes Marines du Québec Inc.		X								
Iso-Biokem									X	
Ocean NutraSciences Inc.*		X								
Organic Ocean	X	X	X			X		X		X
Pêcherie Marinard Ltée		X								
Pro-Algue Marine								X		
Produits horticoles Y. Lavoie								X		
Shigawake Organics Ltd								X		
Totaux	**1**	**5**	**1**	**0**	**0**	**1**	**0**	**6**	**1**	**1**

* Also contract manufacturer

QUEBEC – PROCESSORS OF MARINE EXTRACTS



QUEBEC – PROCESSORS OF MARINE EXTRACTS

COMPANIES	TARGET MARKETS						
	ANIMAL FEED	FOOD	BIOMATÉRIALS	COSMETICS	ENVIRONNEMENT/ AGRICULTURE	PHARMACEUTICALS	NATURAL HEALTH PRODUCTS
Atrium Innovations Inc.							X
Groupe International							X
Groupe Marcelle				X			
Ingenutra Inc.	X	X				X	X
Inova Source							X
Innovactiv				X			X
Lab. DCP DermoScience				X			
LNS Bio Coop Solidarité		X	X	X	X		X
Lucas Meyer Cosmetics				X			
Maresins Pharma		X					
Mériance collagène				X			
Neptune Solution bien-être							X
Poseidon Novatech Inc.		X					
SCF Pharma		X				X	X
SiliCycle Inc. (projet Total Océan)	X	X				X	X
Virage Santé							X
TOTAUX :	**2**	**6**	**1**	**6**	**1**	**3**	**10**

Thank you for your attention