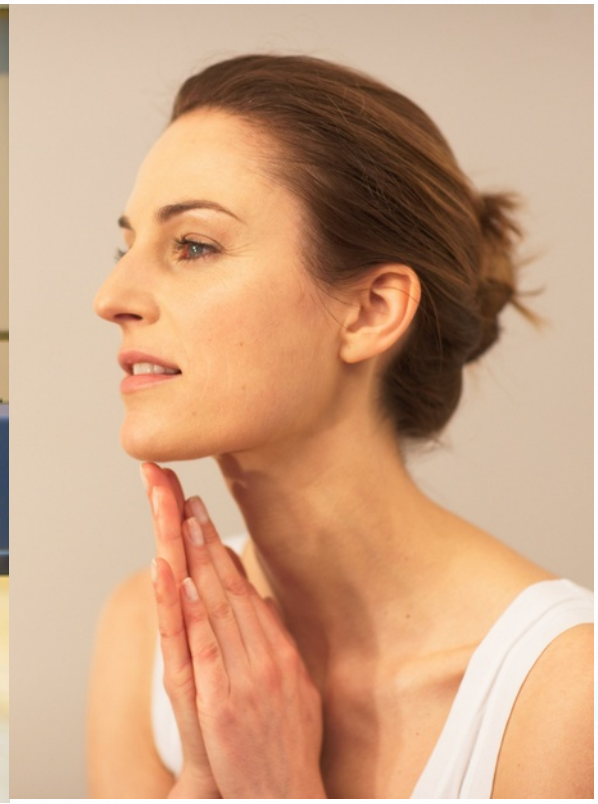
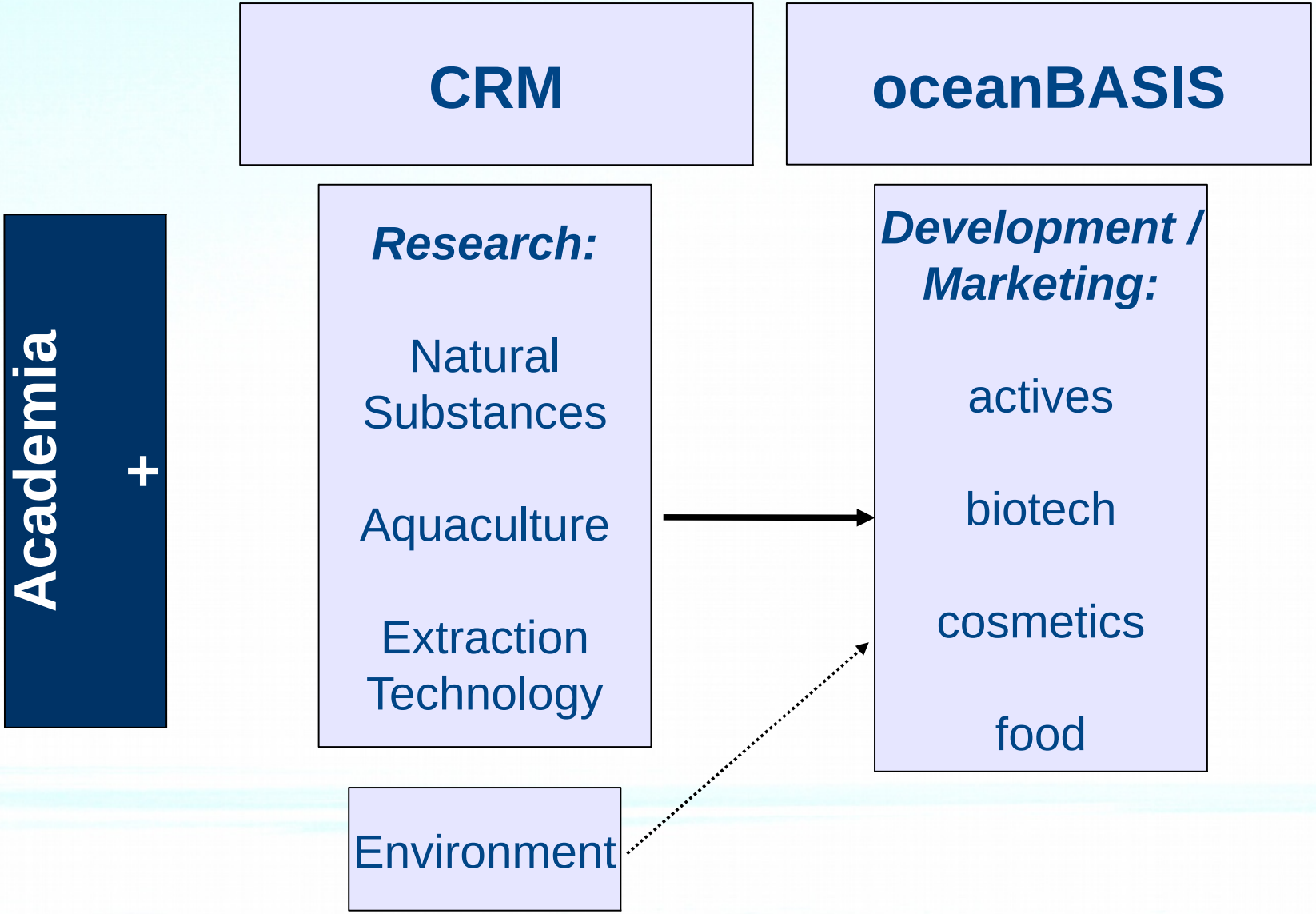
How we gamble away the innovation and value adding potential of marine living resources

Levent Piker
CRM – Coastal Research & Management
oceanBASIS GmbH, Kiel



We add Value to Marine Biodiversity



Key Topic Aquaculture

- Impact of fishery and aquaculture on the marine environment.
  Federal Environment Agency, 1995

- Aquaculture management and ecological interactions in the South of Latin America.
  EU-project AQUATOXSAL, in cooperation with partners in Chile, France, Argentina, 1998.

IMPACT

Restricted to fish farm area:

- Steep vertical gradients of oxygen, sulfide and redoxpotential
- Extraordinarily high carbon and nitrogen content in the sediment
- High rates of sulfide production forming gas bubbles
- Azoic sediment or low biodiversity with opportunistic and copiotrophic organisms

Regional scale (X. region of Chile in 2001):

- Input of **250,000 t y^{-1} C_{org}**
- Release of **17,000 t inorganic N and 110,000 t y^{-1} H_2S**

→ “Nordic Seaweed Project“

Seaweed Cultivation Potential in Greenland

→ “SPICE”

Sustainable Aquaculture in Indonesia

Science for the Protection of Indonesian Coastal Ecosystems

SPICE

2003-2007

A German-Indonesian Initiative in Earth System Research

→ NATO programme „Science for Peace“

Sustainable Aquaculture in the Gulf of Aqaba

Approaching the IMTA concept

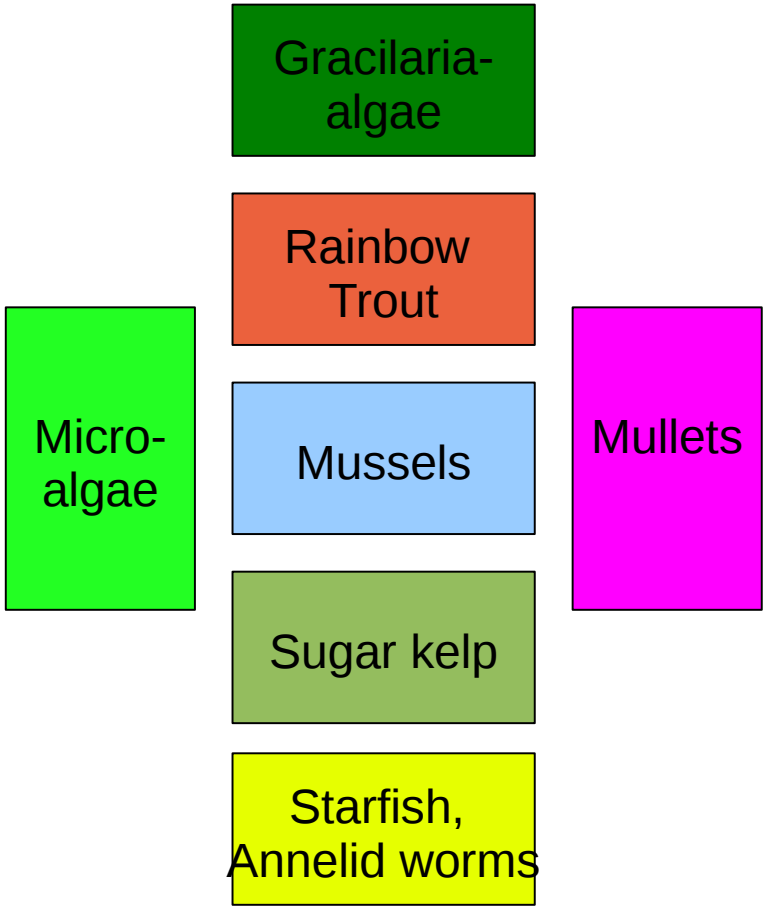
Goal:
Circular economy – like a small farm in the mountains

- Closed (preferably natural) nutrient cycles
- Organisms from different trophic levels
- Metabolic remains of one species is food source for other species
- Resembles natural cycles, focused on species attractive to humans
- Stability problem
- Development time: decades

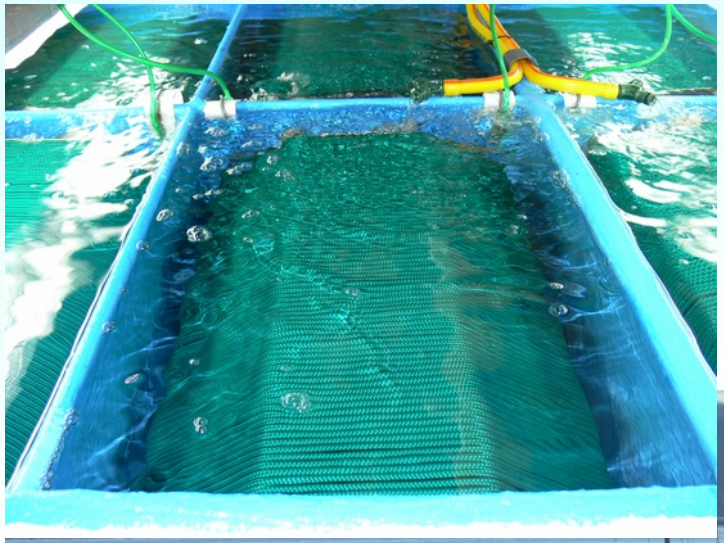
IMTA in the Bay of Fundy, New Brunswick, Canada

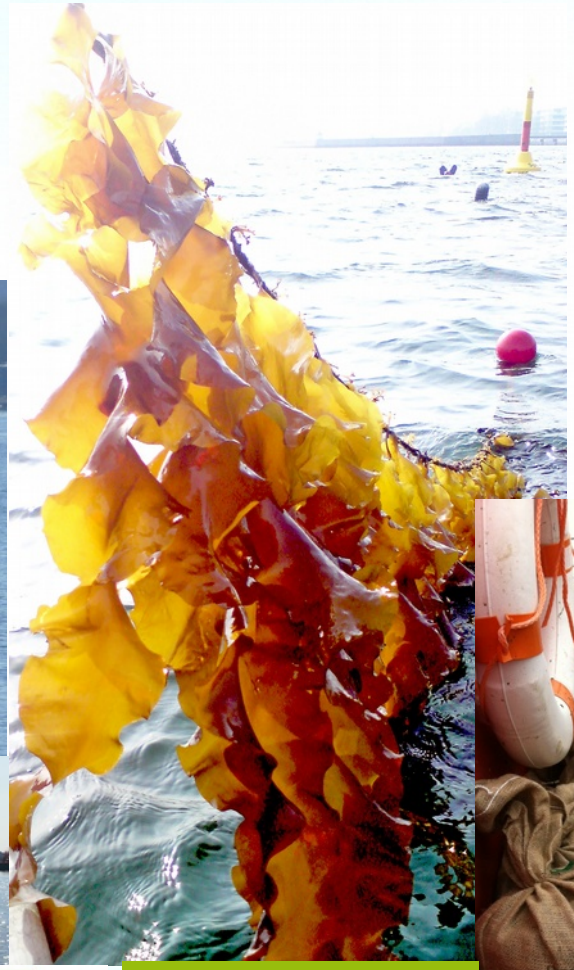
Photo courtesy of Thierry Chopin

Integrated Multitrophic Aquaculture (IMTA) in the Baltic Sea



Development of a Sustainable Mariculture





BIO
nach
EG-Öko-Verordnung

Algae-based active ingredients

ocean actives

- **minerals, salts:** sodium, calcium, magnesium, potassium, chloride, sulphate,...
- **trace elements:** zinc, iodine, selenium, strontium
- **special polysaccharides:** alginate, fucoidane, laminaran, carrageenan, agar-agar,...
- **polyphenols**, phytosterols, terpenes,
- special **amino acids** (taurin, MAA,...)
- **vitamins** (B, C, E,...)
- **carotinoids**: α-, β- und γ-carotin, lutein, zeaxanthin, violaxanthin, fucoxanthin
- **other** secondary phytochemicals and antioxidants

ocean actives

Lamocrude 'S

- Aquous extract from ***Saccharina latissima***
- Provides **mineralising, revitalising** and protecting properties of active polyphenols and carbohydrates
- Gentle processing preserves chemical **integrity and bioactivity**
- First cosmetic ingredient with **carbon footprint**
- **NATRUE certification** for natural cosmetics

ocean cosmetics

oceanwell

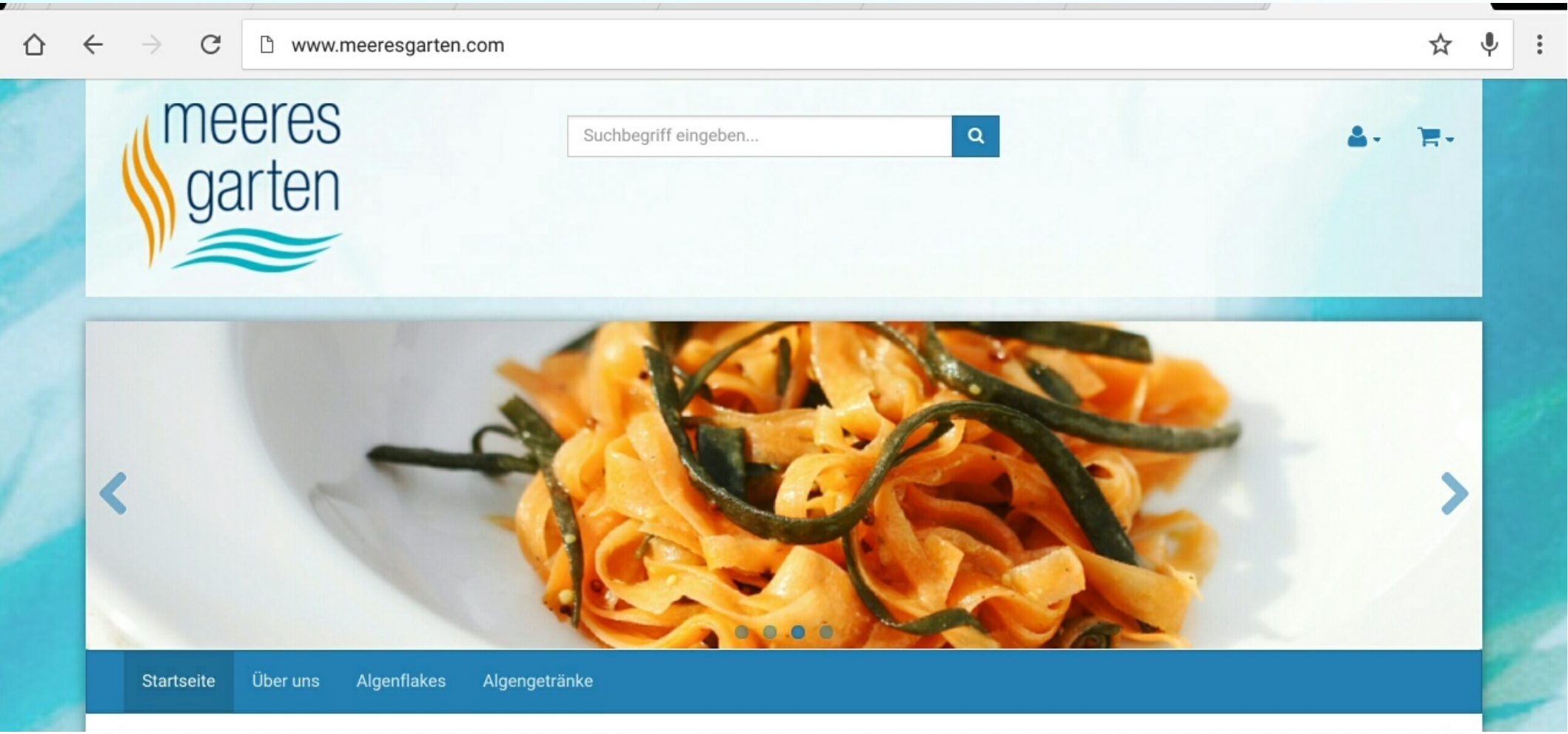
Maritime Naturkosmetik

feuchtigkeitsspendend

regenerierend

schützend

vegan


www.meeresgarten.com
meeres garten
Suchbegriff eingeben...
Startseite
Über uns
Algenflakes
Algengetränke

Algae-Relish („Algenwürze“)

Replacing or supplementing conventional chemically produced relish products by **natural products**

→ **Algae relish („umami“)**

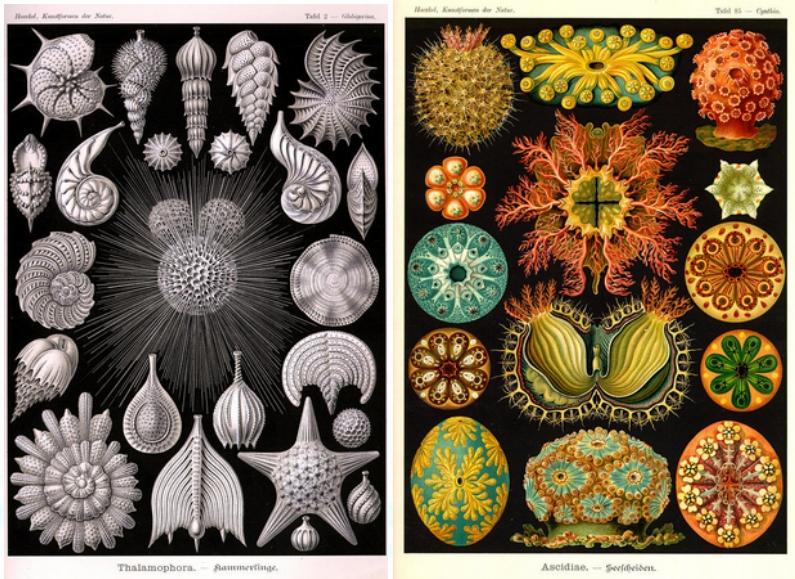
Turning knowledge into products: oceans serve as a treasure trove for innovations

Structures / functions in nature

Academia

SME/Industry

Consumer's / society's **demands**



Erich Haeckel: Kunstformen der Natur, 1899-1904

For example:

Biological pest control

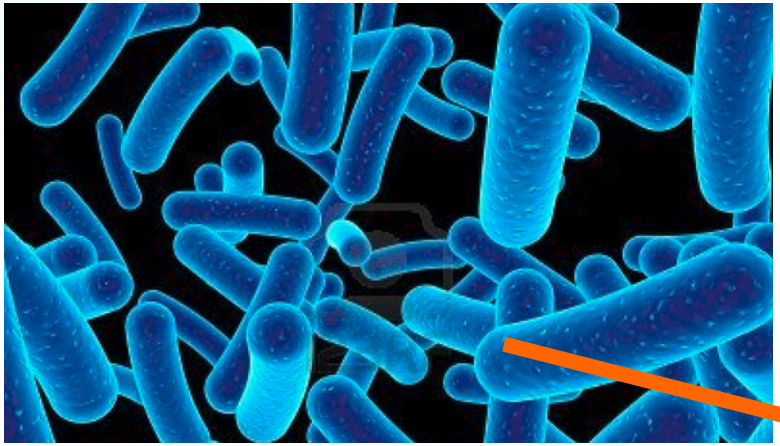
Food

Personal care

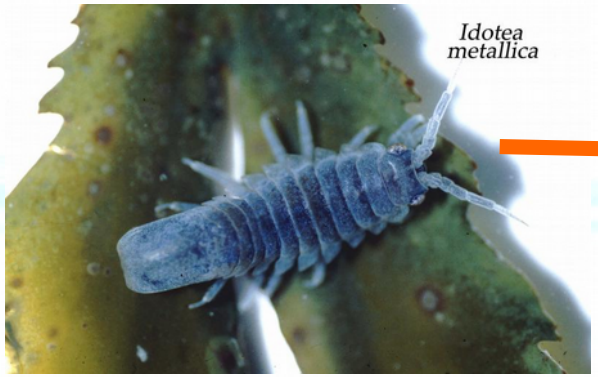
Anticipating demands and trends

High hostile pressure on algae surface

Grazing, colonising, degrading etc.
→ mechanisms of protection



Number of bacteria in sea water:
10^6 – 10^9 / ml



Prevention and protection 1 → antibacterial activity

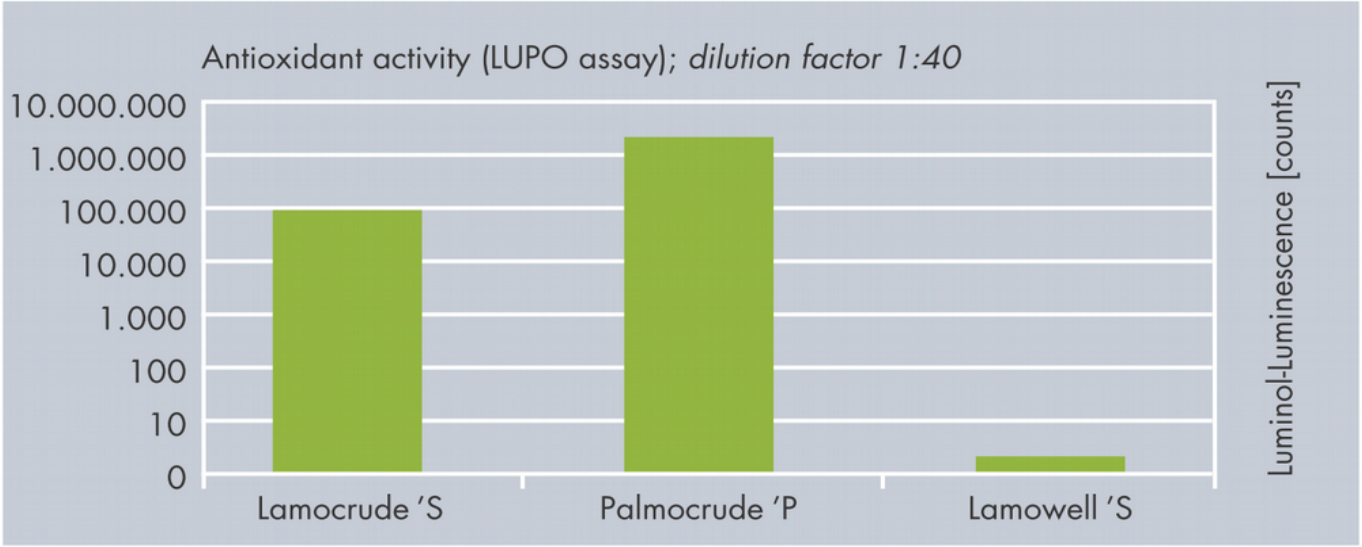
Inhibition [%]

		St. aureus		*MRSA*		*St. epidermidis*		*Ps. aeruginosa*		*B. epidermidis*	
Commercial Extracts		**5%**	**10%**	**5%**	**10%**	**5%**	**10%**	**5%**	**10%**	**5%**	**10%**
Lamocrude'S	**Ex242**	47***	52***	neg.	neg.	neg.	neg.	neg.	neg.	neg.	neg.
Lamowell'S	**Ex243**	33	72***	neg.	neg.	neg.	neg.	neg.	34	neg.	neg.
Palmocrude	**Ex244**	neg.	neg.	neg.	neg.	neg.	neg.	neg.	neg.	neg.	neg.
Fucoidan	**Ex245**	49	41	neg.	26	72	82	30	31	neg.	26
Kollagen	**Ex246**	34	neg.	neg.	neg.	neg.	neg.	33	29	20	29
Extracts under Development		**1%**		**1%**		**1%**		**1%**		**1%**	
CCL16	**Ex247**	n.b.		96		87		n.b.		n.b.	
AAC148	**Ex248**	100		100		100		26		neg.	
Control	**DMSO**	neg.		neg.		neg.		28		20	
AAC 150F	**Ex249**	n.b.		n.b.		n.b.		n.b.		n.b.	
CLA1	**Ex250**	n.b.		n.b.		n.b.		n.b.		n.b.	

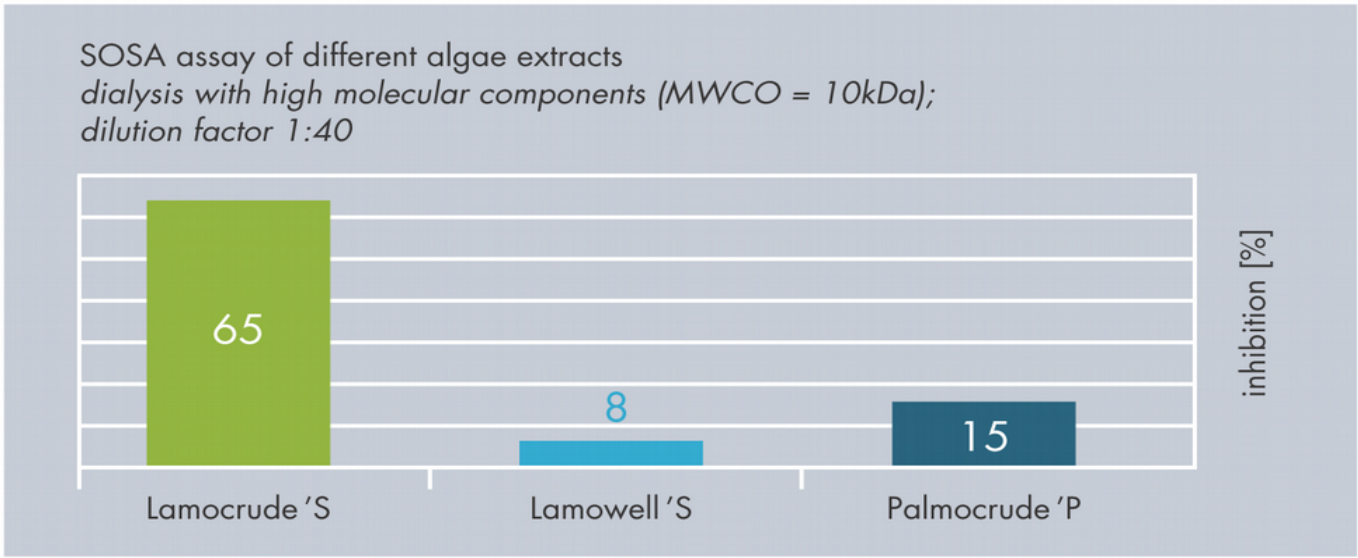
Algae compounds can strongly inhibit growth of *S. aureus*, *S. epidermis* and *MRSA*

Prevention and protection 2
→ antioxidant activities

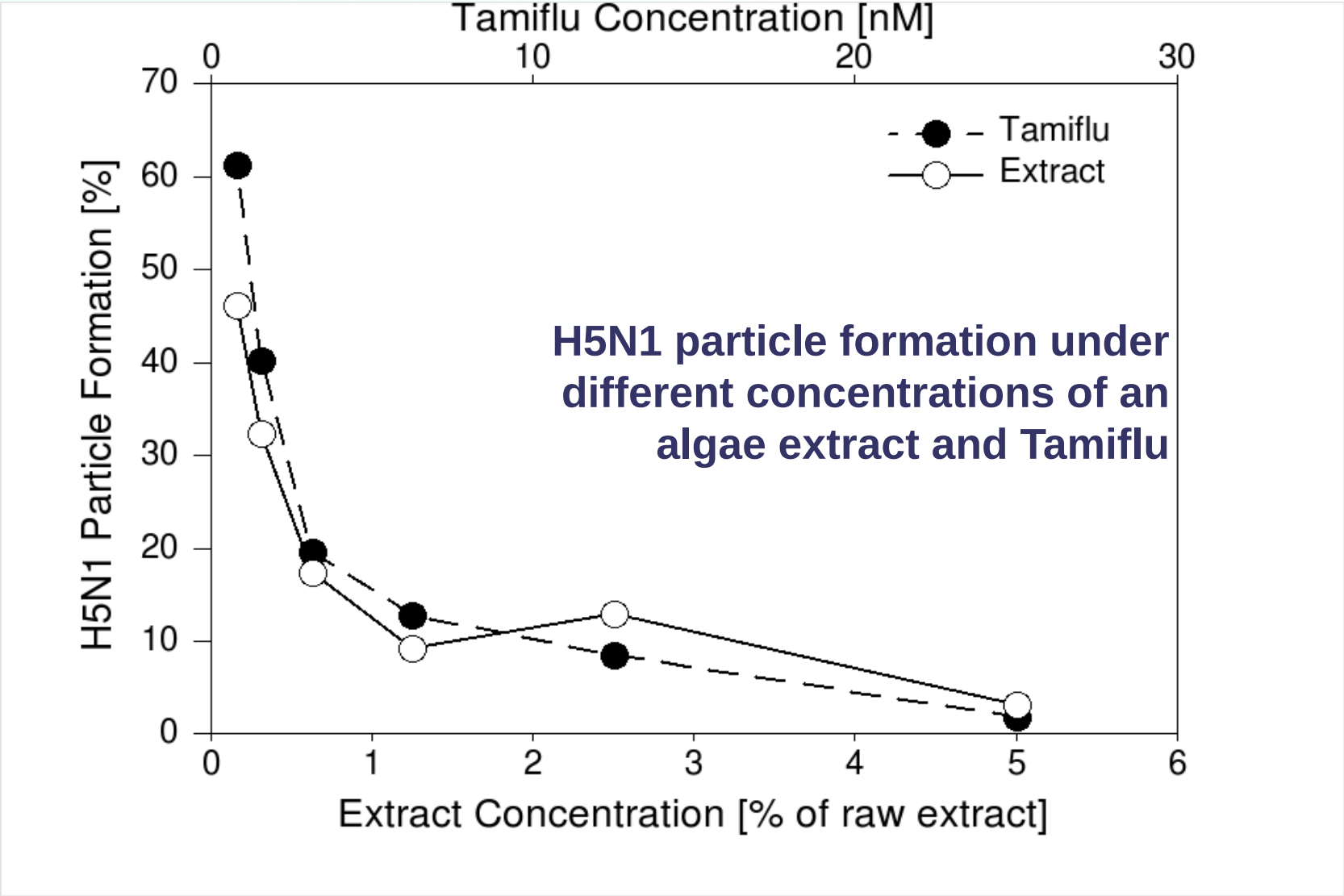
Antioxidant capacity (LUPO)



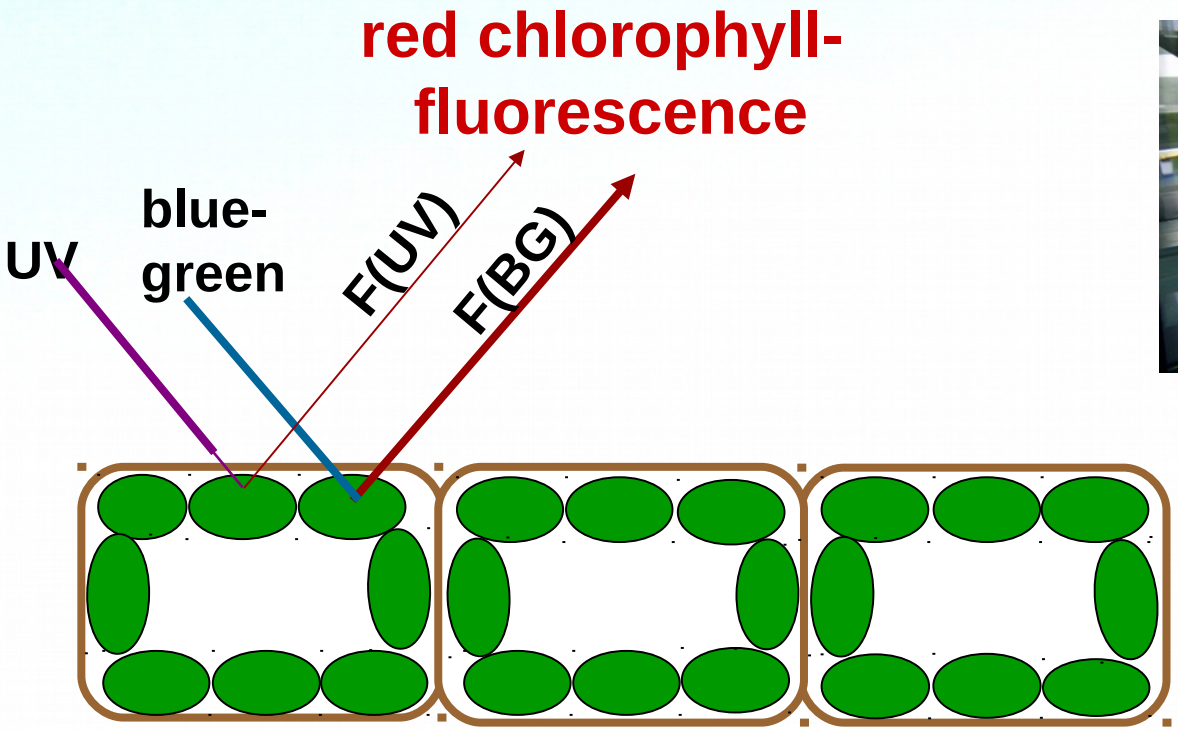
Radical scavenger activity (SOSA)

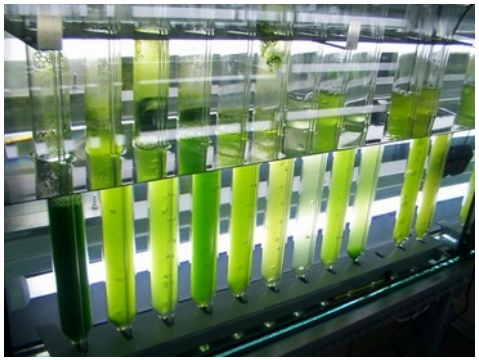


Prevention and protection 3 → antiviral activities



PP 4: Protection against UV-B-radiation





Algae filament with cell wall and chlorophyll

F(UV)/F(BG) ➡ UV- transmittance

Projekt „Suntec“

Wir fördern Wirtschaft

EU.SH

Landesprogramm Wirtschaft: Gefördert durch die Europäische Union - Europäischer Fonds für regionale Entwicklung (EFRE), den Bund und das Land Schleswig-Holstein

FucoSan

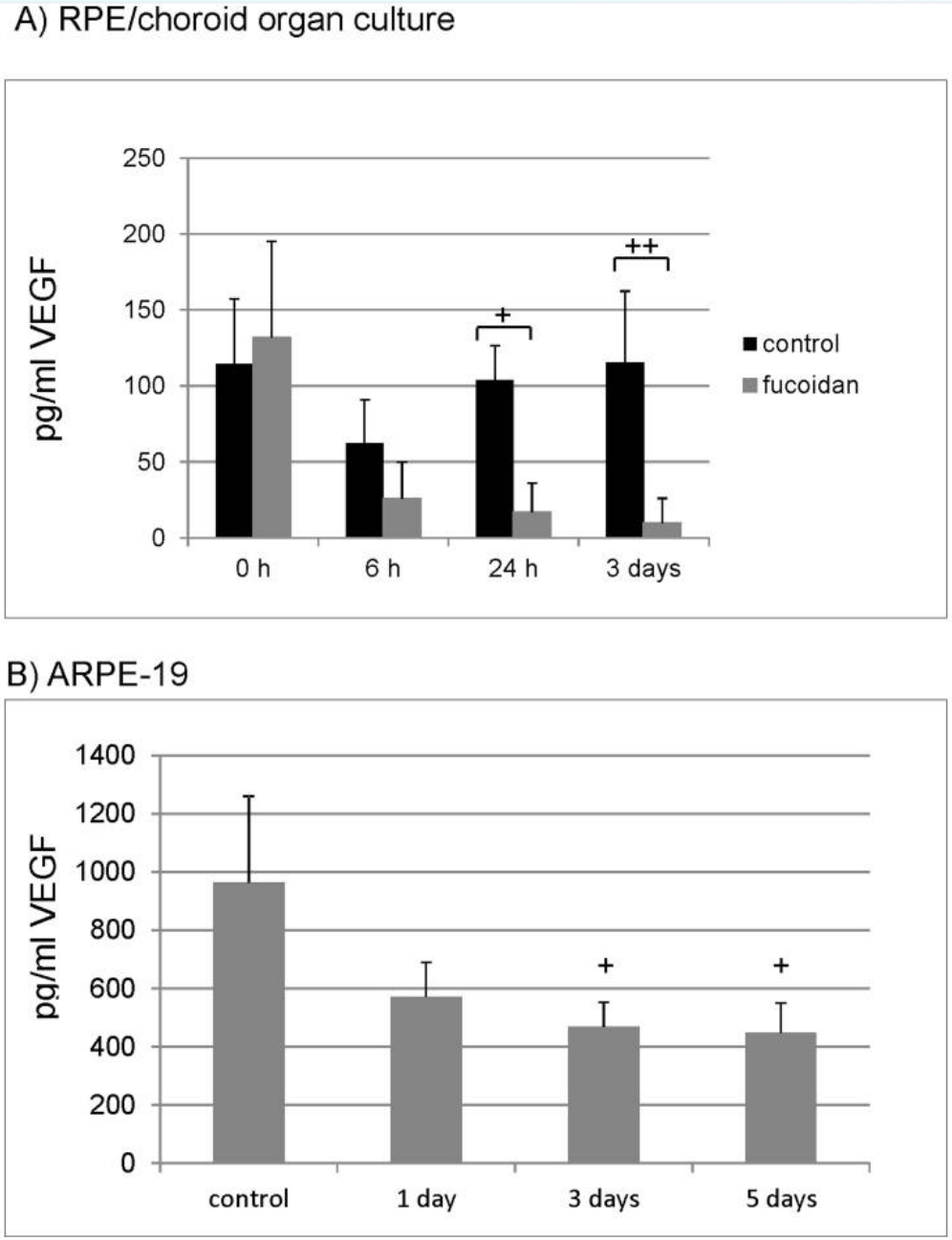
Establishment of a **fucoidan**-based value chain using endemic seaweed

- ➔ Sustainable harvest (sampling/cultivation)
- ➔ Controlled quality of endemic algae
- ➔ Innovative processing
- ➔ New compound quality
- ➔ New products (cosmetics, pharma)

Interreg Deutschland - Danmark

EUROPEAN UNION

PP 5: Algae preventing severe ageing symptoms (e.g. AMD)

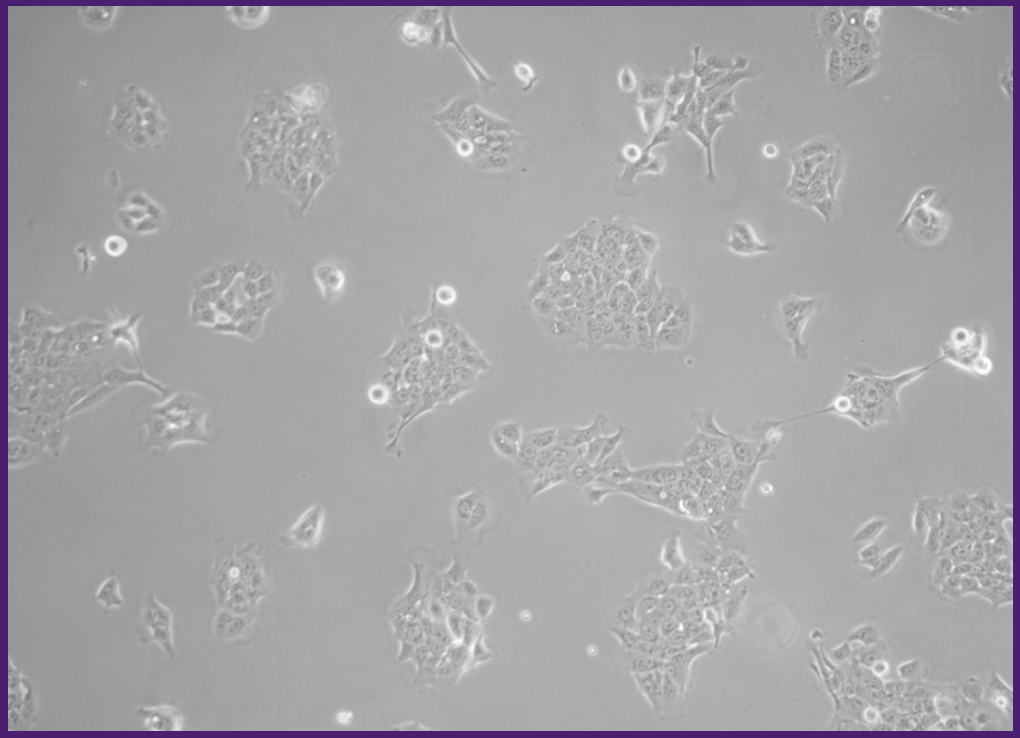


Fucoidan reduces secretion and expression of Vascular Endothelial Growth Factor (VEGF) in the retinal pigment epithelium and reduces angiogenesis *in vitro.*

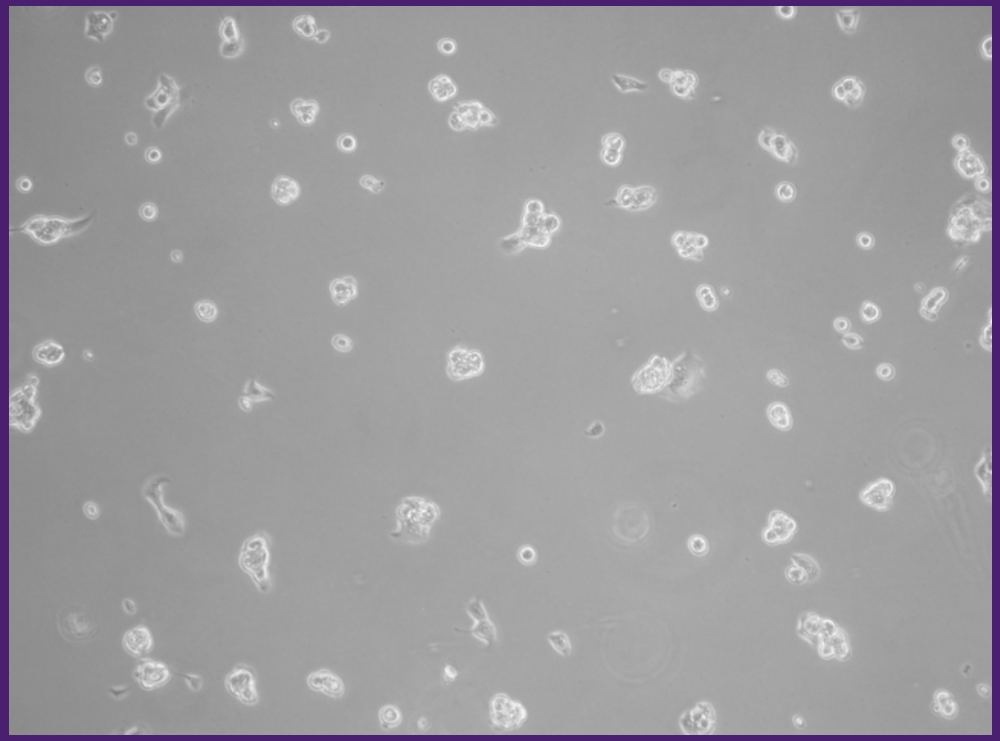
(Dithmer *et al.* 2014)

Extract from *Fucus vesiculosus* inhibits growth of pancreatic cancer cells

Control



KF1 extract

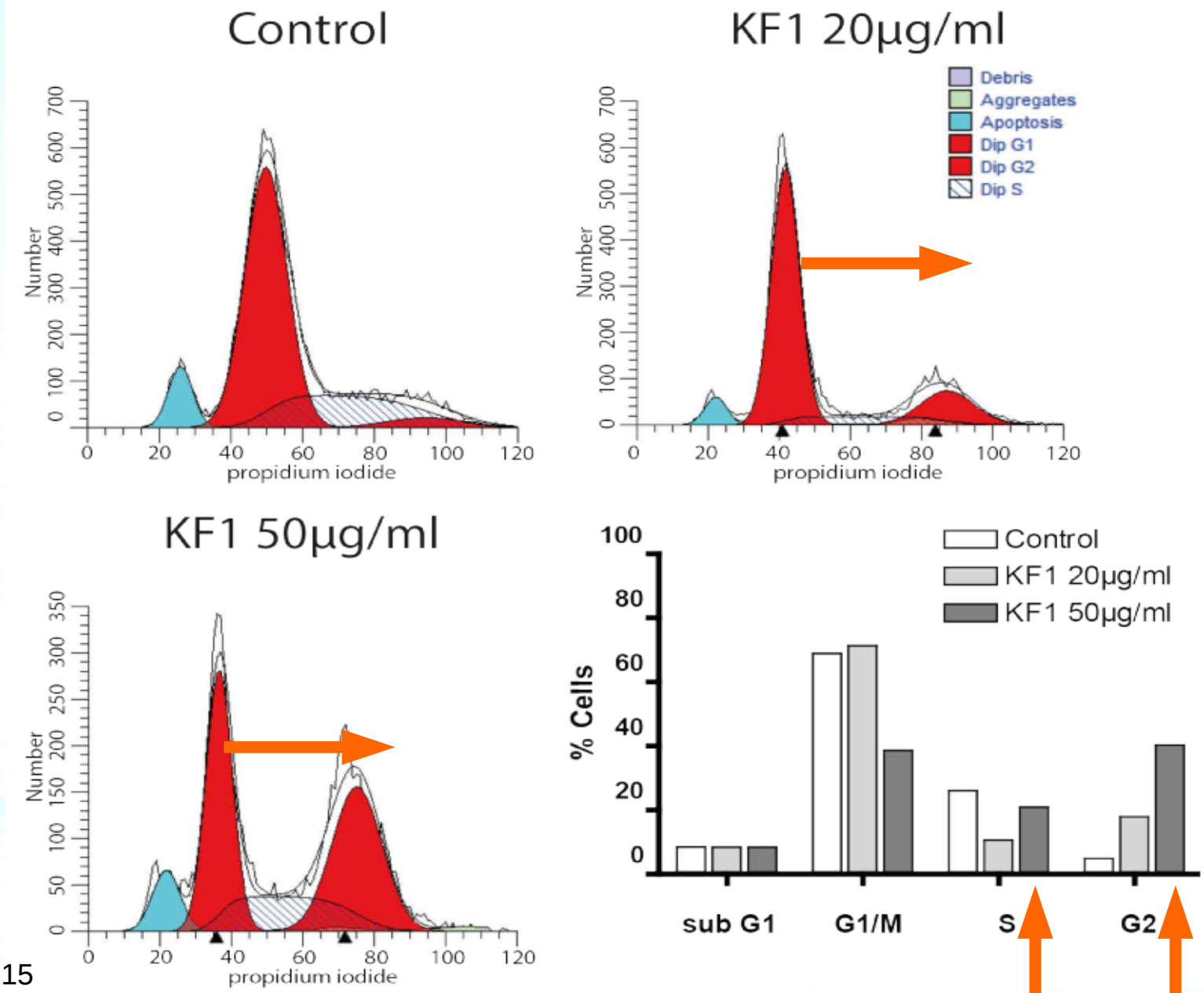


(after 24 h incubation)

Bundesministerium für Bildung und Forschung

Geisen *et al.* 2015
Zenthoefer *et al.* 2017

→ Cell cycle arrest



Geisen *et al.* 2015

Bioinformatics / „Algaeomics“

oceanBASIS's first level Algae-Enzyme catalog:

Proteins	1639
EC-numbers	610

Based on green plant homologous proteins only

EC-number	Algae species/Contig	orient.	homolog. protein	score	perc.ident.	description
EC=1.10.2.2	Eremosphaera_3607	rev	F6H425_VITVI	414	77.78	RecName: Full=Ubiquinol-cytochrome c reductase iron-sulfur subunit; EC=1.10.2.
EC=1.10.2.2	FucusVesiculosus_1382	rev	I0Z7G8_9CHLO	750	53.82	RecName: Full=Ubiquinol-cytochrome c reductase iron-sulfur subunit; EC=1.10.2.
EC=1.10.2.2	Polysiphonia_12913	for	A8J126_CHLRE	662	59.61	RecName: Full=Ubiquinol-cytochrome c reductase iron-sulfur subunit; EC=1.10.2.
EC=1.10.2.2	Saccharina_5966	rev	A8J126_CHLRE	617	56.00	RecName: Full=Ubiquinol-cytochrome c reductase iron-sulfur subunit; EC=1.10.2.
EC=1.10.2.2	SaccharinaNorm_14100	for	A8J126_CHLRE	635	50.19	RecName: Full=Ubiquinol-cytochrome c reductase iron-sulfur subunit; EC=1.10.2.
EC=1.10.2.2	Ulva_4904	rev	I0Z7G8_9CHLO	753	59.24	RecName: Full=Ubiquinol-cytochrome c reductase iron-sulfur subunit; EC=1.10.2.
EC=1.10.3.3	Polysiphonia_2404	rev	Q9ZR61_CUCME	498	34.84	SubName: Full=L-ascorbate oxidase; EC=1.10.3.3; Flags: Fragment;
EC=1.10.3.9	FucusVesiculosus_490	for	PSBA_PSEAK	1449	89.04	RecName: Full=Photosystem Q(B) protein; EC=1.10.3.9; AltName: Full=32 kDa thyla
EC=1.10.3.9	Polysiphonia_2855	rev	PSBA_CHAGL	1578	81.67	RecName: Full=Photosystem Q(B) protein; EC=1.10.3.9; AltName: Full=32 kDa thyla
EC=1.10.3.9	Porphyridium_958	for	Q09WH4_9MARC	1679	88.06	RecName: Full=Photosystem Q(B) protein; EC=1.10.3.9; AltName: Full=32 kDa thyla
EC=1.10.3.9	Saccharina_5799	for	Q09WH1_9MARC	1595	83.93	RecName: Full=Photosystem Q(B) protein; EC=1.10.3.9; AltName: Full=32 kDa thyla
EC=1.10.3.9	Spirulina_1318	rev	PSBA_CHLEL	781	89.44	RecName: Full=Photosystem Q(B) protein; EC=1.10.3.9; AltName: Full=32 kDa thyla
EC=1.10.3.9	Ulva_897	for	PSBA_PSEAK	1340	93.96	RecName: Full=Photosystem Q(B) protein; EC=1.10.3.9; AltName: Full=32 kDa thyla
EC=1.10.9.1	Ulva_11514	for	UCRIA_SOLTU	505	52.10	RecName: Full=Cytochrome b6-f complex iron-sulfur subunit, chloroplastic; EC=1.
EC=1.10.99.1	Eremosphaera_3797	for	I0Z524_9CHLO	292	52.42	RecName: Full=Cytochrome b6-f complex iron-sulfur subunit; EC=1.10.99.1;
EC=1.10.99.1	FucusVesiculosus_7310	for	A8J9Y1_CHLRE	703	70.31	RecName: Full=Cytochrome b6-f complex iron-sulfur subunit; EC=1.10.99.1;
EC=1.10.99.1	Polysiphonia_14316	rev	D8TME4_VOLCA	589	62.78	RecName: Full=Cytochrome b6-f complex iron-sulfur subunit; EC=1.10.99.1;
EC=1.10.99.1	Ulva_6218	for	I1LUB3_SOYBN	513	58.60	RecName: Full=Cytochrome b6-f complex iron-sulfur subunit; EC=1.10.99.1;
EC=1.1.1.100	Eremosphaera_5666	for	B9T9J6_RICCO	269	32.84	SubName: Full=Short-chain dehydrogenase, putative; EC=1.1.1.100;
EC=1.1.1.100	FucusVesiculosus_7476	for	B9TAF7_RICCO	377	41.33	SubName: Full=3-oxoacyl-[acyl-carrier-protein] reductase, putative; EC=1.1.1.100;
EC=1.1.1.100	Polysiphonia_23806	rev	B9TN94_RICCO	225	41.60	SubName: Full=3-oxoacyl-[acyl-carrier-protein] reductase, putative; EC=1.1.1.100;
EC=1.1.1.100	Saccharina_23600	rev	B9TAF7_RICCO	448	40.40	SubName: Full=3-oxoacyl-[acyl-carrier-protein] reductase, putative; EC=1.1.1.100;

Bioinformatics / „Algaeomics“

A straightforward way to go **from candidate sequences to protein**:

Candidate transcript sequence: ORF

↓

Gene synthesis

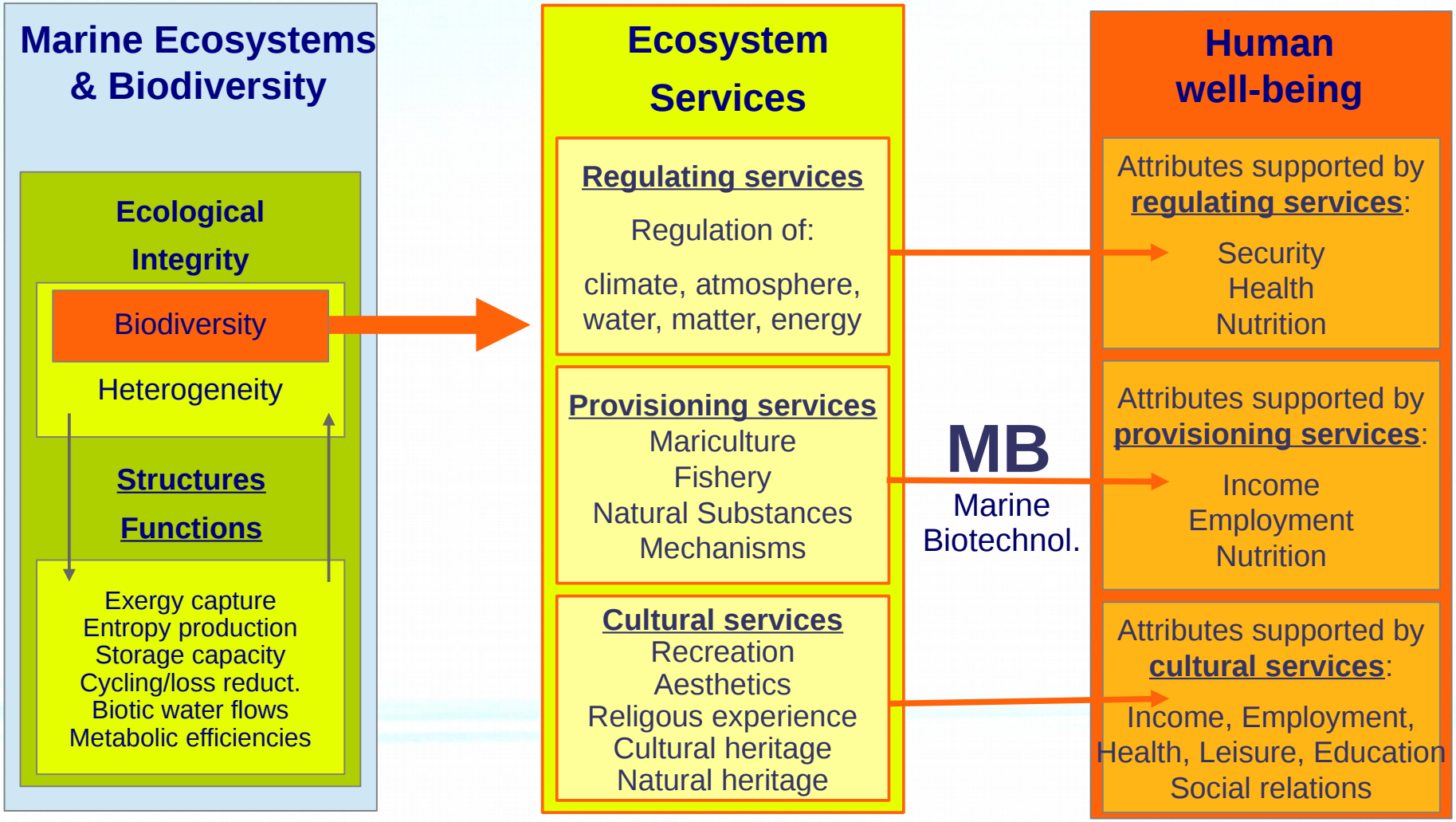
↓

CFS: Cell-Free protein expression

Pharma **Food** **Cosmetics**

< 1 mg protein

Marine ecosystem services (MES)



Modified after Kandziora *et al*., 2013

What is the Monetary Value of Ocean's Biodiversity ?

At-risk ecosystem service value:

US $ 563 billion – 5.69 trillion for anti-cancer drugs of marine origin

(Erwin *et al.* 2010)

Opportunities...
Chances...
Potential...

Marine Ecosystems & Biodiversity → **Ecosystem Services** → **Human well-being**

Marine Biotechnology

Modified after Kandziora *et al*., 2013

Humans are **gatherer and hunters in the seas**, NOT „*blue engineers*“.

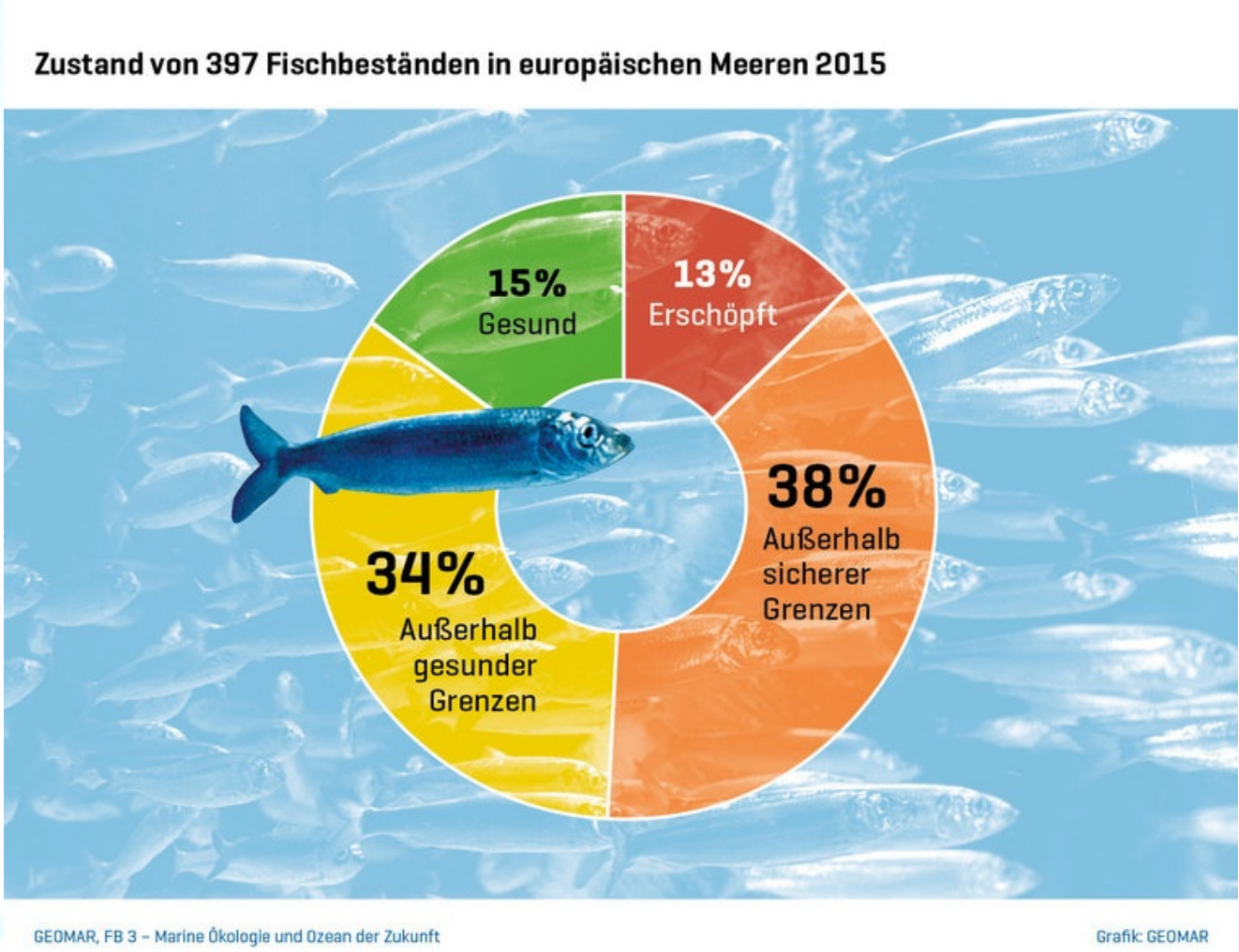
Exploitation and management of the ocean is **shallow-brained and short-sighted**

„Bei nachhaltigem Management könnten

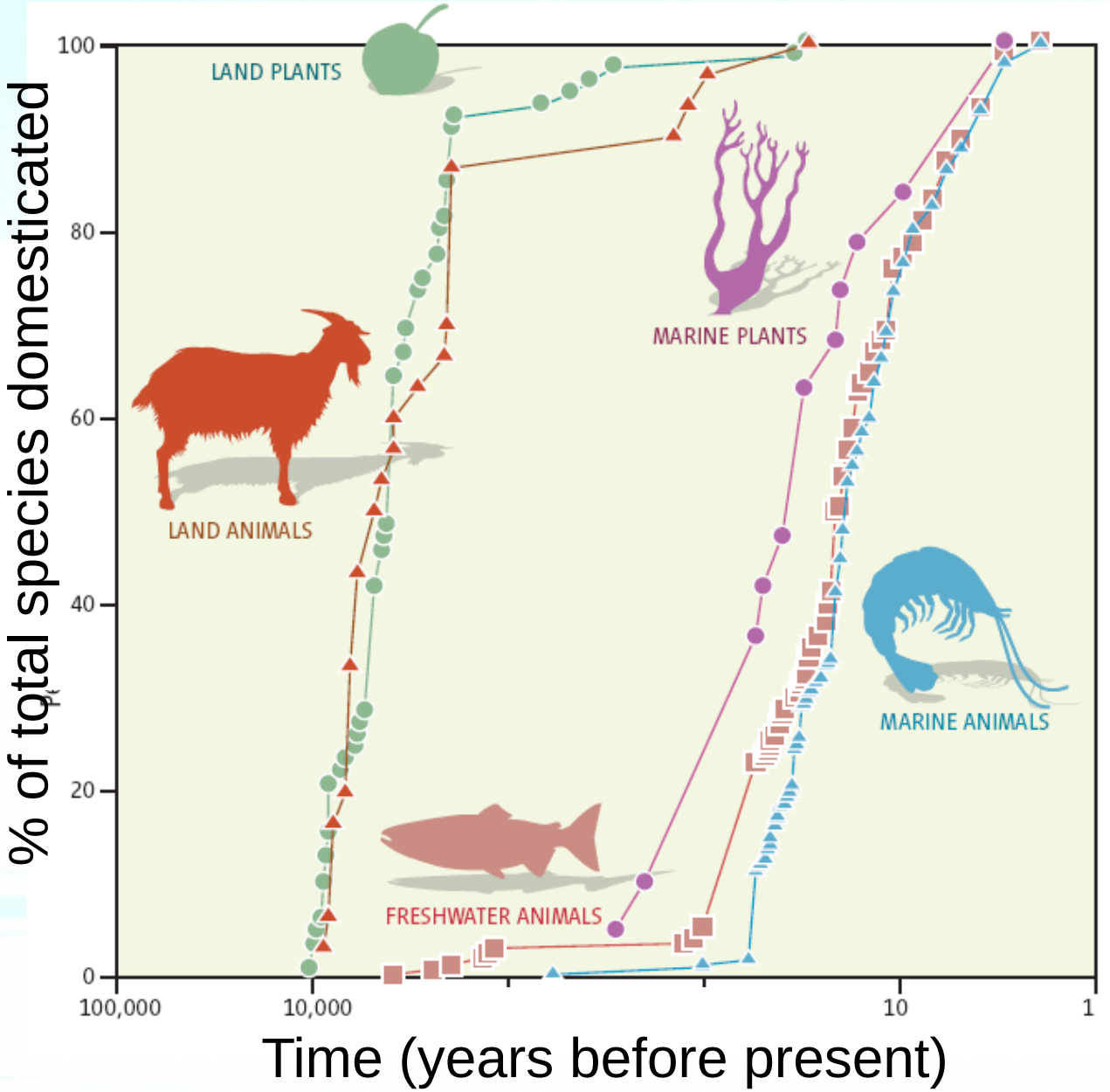
57% mehr Fisch

gefangen werden.“

(Dr. Rainer Froese GEOMAR, 15.11.2016)



Obstacle: Low stage of development in aquaculture



Duarte *et al*., 2007

→ Achievements

- **Precautionary principles** → UN, EU, ...
- **„Common Heritage of Mankind“** →e.g. UNCLOS,…
- **Sustainable Development Goals** (SDGs)

SUSTAINABLE DEVELOPMENT GOALS

Conserve and sustainably use the oceans, seas and marine resources

How to master the change...

(...from gambling away the potential of marine living resources to an intelligent utilisation)

- Consequently implement scientific and political achievements (**good governance; SDG 14**)

- **Stop self-delusion** in science, politics and economy: a change needs more than a human‘s generation

- Strategically, long-termed **management of knowledge**, infrastructure and (capital/human) resources in order to liberate innovation potential

- **More risk capital** and investments

Vielen Dank für Ihre Aufmerksamkeit!

Coastal Research & Management

oceanBASIS
sea.science.solutions.