Ocean Food Systems

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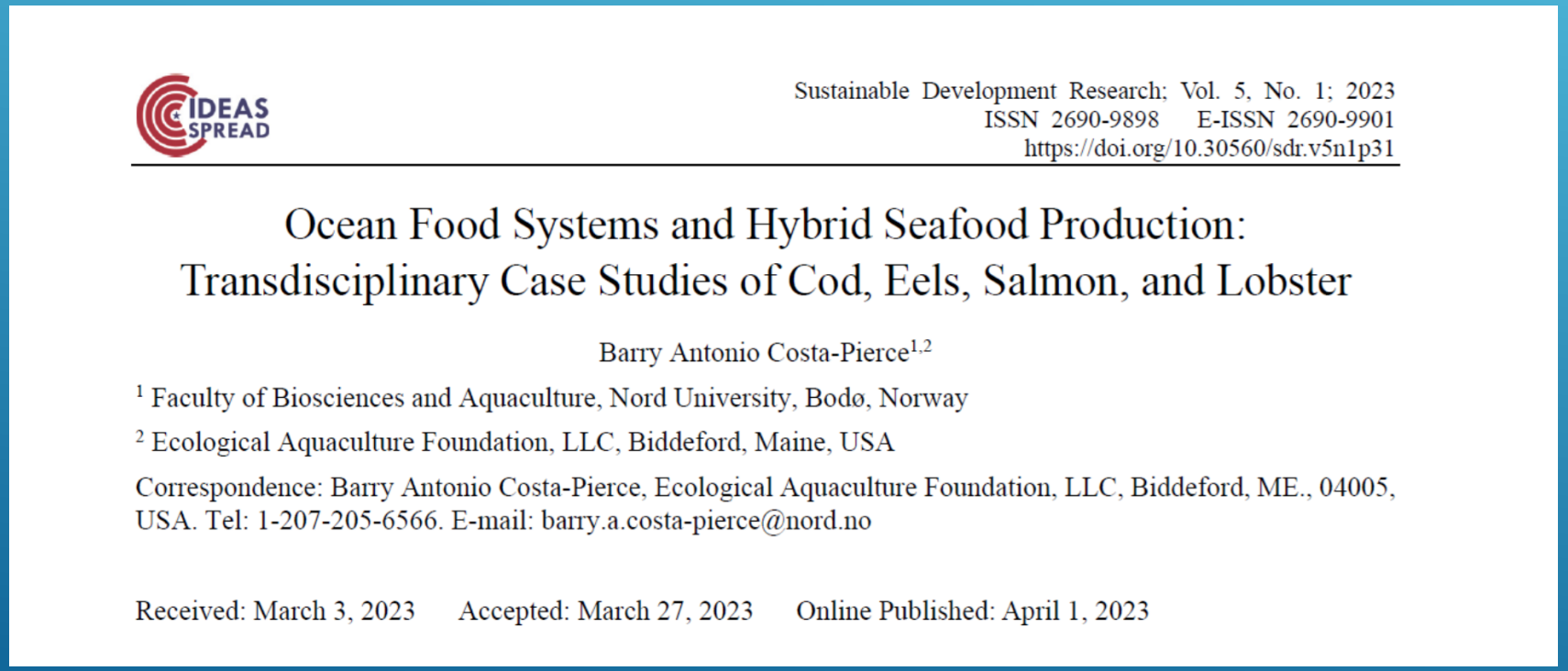

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Ocean Food Systems and Hybrid Seafood Production: Transdisciplinary Case Studies of Cod, Eels, Salmon, and Lobster

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GOALS

Accelerate the Supply & Delivery of Sustainable Seafoods to Humanity
Save/Enhance the Working Coasts – Sustainable Economic Development, JOBS

10 BILLION by 2050

50-75% increase needed

“FISHERIES”

“AQUACULTURE”

"FISHERIES" is a

Continuum of Capture and
Culture Fisheries (Aquaculture)
and Trade
for
Sustainable Seafood Supplies

Fisheries and aquaculture interact with increasing intensity as fishers shift from fishing to aquaculture and by competing in the same markets with similar products

The need to integrate planning and management of the two sectors seems vital to their future development and sustainability.

FAO. 2012. *The State of World Fisheries and Aquaculture. FAO, Rome.*

Fisheries, Aquaculture and Trade Systems Interact as Complex Social-Ecological Systems with

LOCAL TO GLOBAL CONNECTIONS THEY ARE

“Ocean/Aquatic Food Systems”

Climate & Social CHANGE

Markets/Trade
Local to Global

Seafood Waste/Utilization

Certification/Branding/Labelling

Nutraceuticals

Pharmacologicals

Rural Development

Policy/Legal/Regulatory

Senior Leadership/Mentoring of Youth

Food Justice

Youth Empowerment

Consumer Nutrition Education

Global to Local Learning

The Social License to Operate

Connections to People

Connections to the Economy

Ocean/Aquatic Food Systems

Connections to the Land

Connections to Technologies

Indigenous Food Systems

Innovations in Feeds, Ingredients

Connections to Inland & Other Seafood Deserts

Successful Cooperatives

The Seaweed Biorevolution

Submerged production systems

Restoration aquaculture

Aquaculture in exposed oceans

Capture based aquaculture

Aquaculture enhanced fisheries

Contributions to ecosystems goods & services

Climate & Social CHANGE

“FISHERIES”

“AQUACULTURE”

OCEAN/AQUATIC FOOD SYSTEMS

"FISHERIES"

is a

Continuum of Capture and Culture Fisheries (Aquaculture) *and Trade* for

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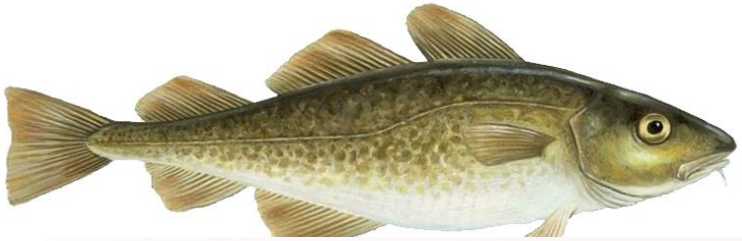
Seafood Expo GLOBAL | Seafood Processing GLOBAL | Seafood Expo NORTH AMERICA | Seafood Processing NORTH AMERICA

6.1 MMT

1.3 MMT

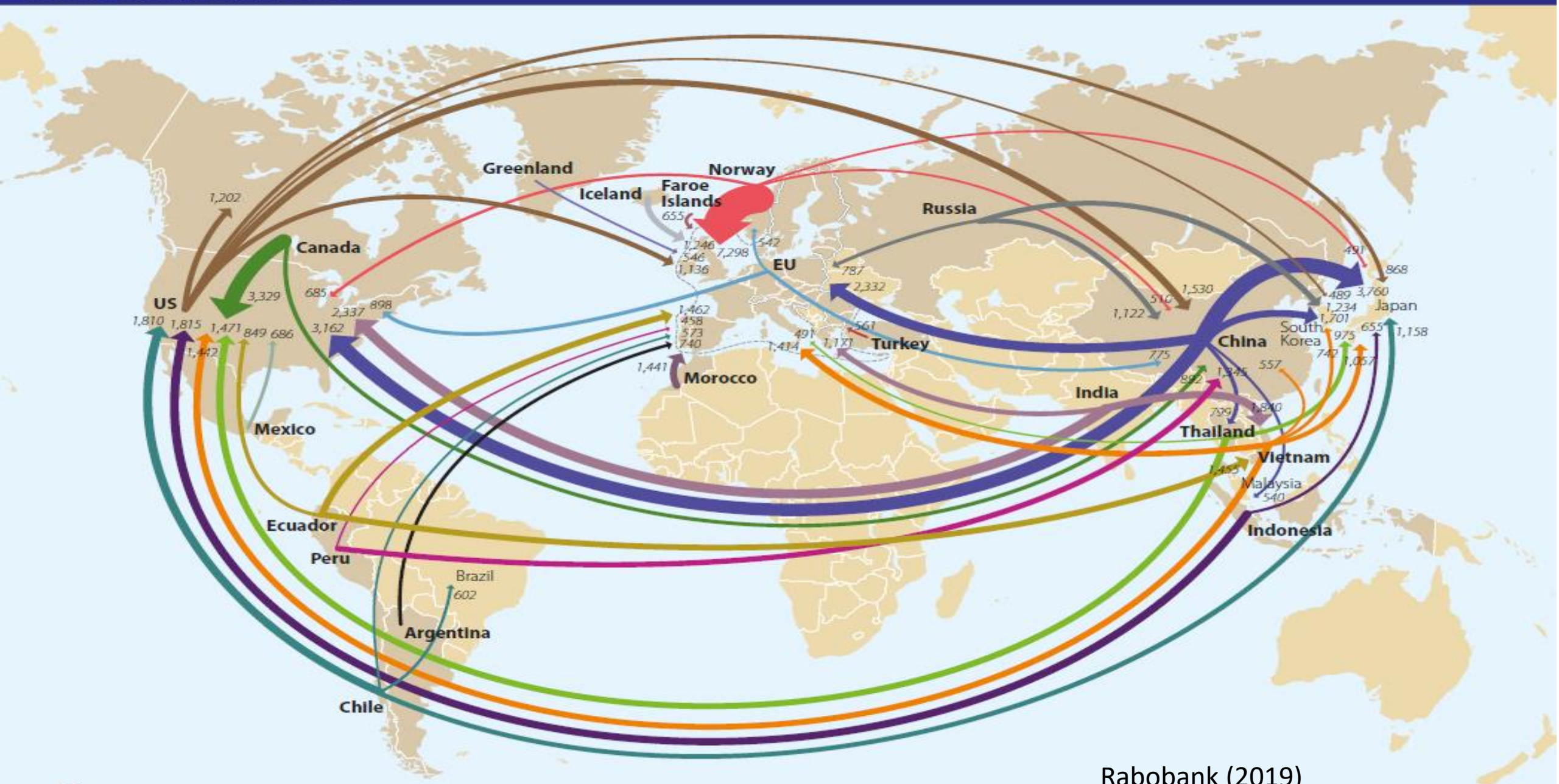


“White Fish” Market ~11 MMT

0.3 MMT

3.1 MMT

Trade Flows in Value, 2017

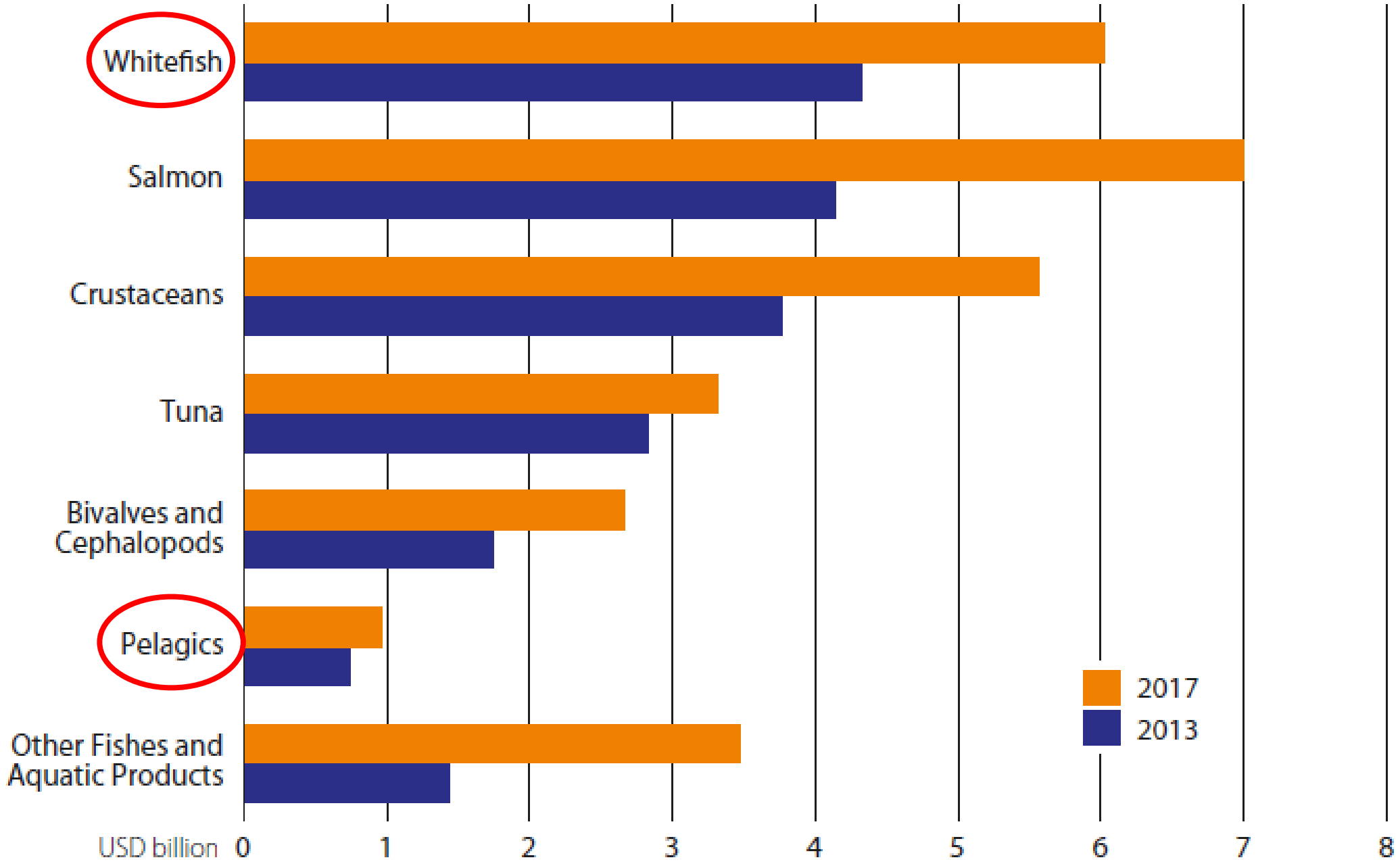


Rabobank (2019)

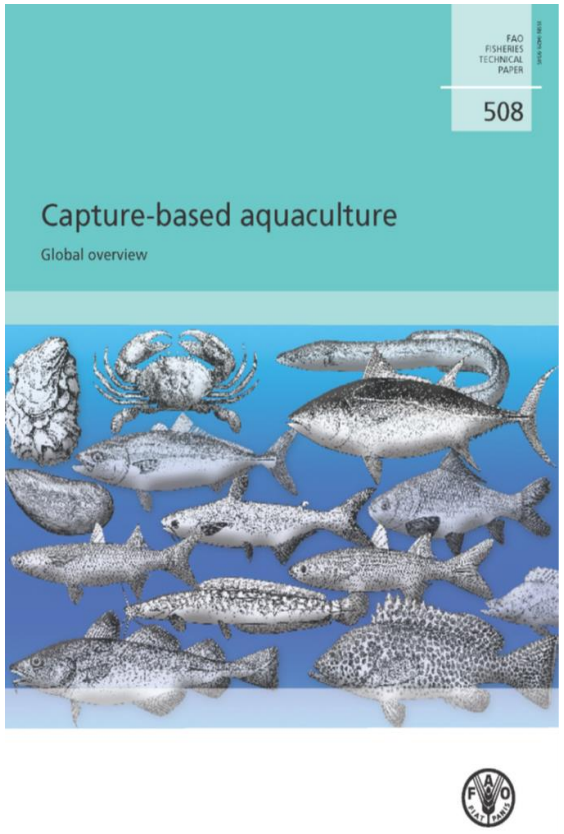
500 ⟹ Seafood trade value (USD million)

Arrow colors represent countries and bear no relation to those used in the main map.

EU Imports by Value, 2013 vs. 2017



20% total
food fish production
~US$ 1.7 billion



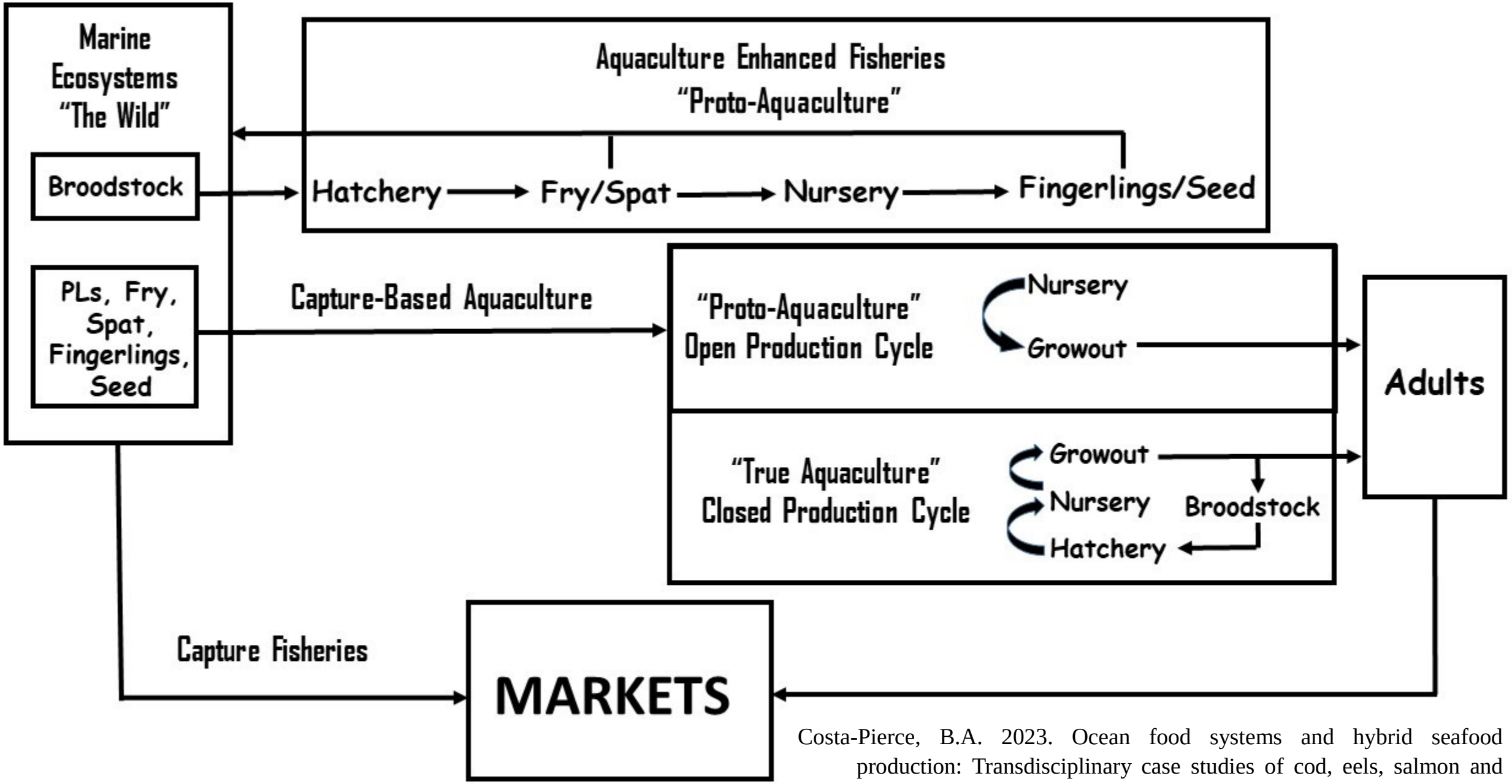
Lovatelli & Holthus (2008)

Review of just 4 case studies/limited number of countries
annual value >**US$4 billion**

*the value of eels as a CBA ~US$2.3 billion/2 countries

*for salmon as an AEF ~$1.7 billion only one USA state

*lobsters as fed fisheries/CBA ~$825 million for the USA & Vietnam



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FED AQUACULTURE with HATCHERIES

UNFED FISHERIES with no HATCHERIES

FED AQUACULTURE with HATCHERIES



Cod
Eels

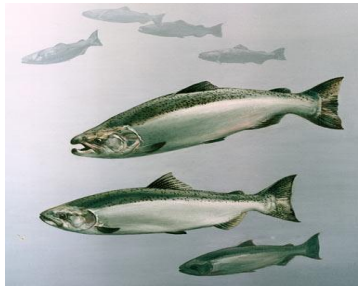
Salmon

FED AQUACULTURE with no HATCHERIES

"Capture-Based Aquaculture" (CBA)


UNFED FISHERIES with HATCHERIES

"Aquaculture-Enhanced Fisheries" (AEF)



UNFED FISHERIES with no HATCHERIES

FED AQUACULTURE with HATCHERIES



FED AQUACULTURE with no HATCHERIES

"Capture-Based Aquaculture" (CBA)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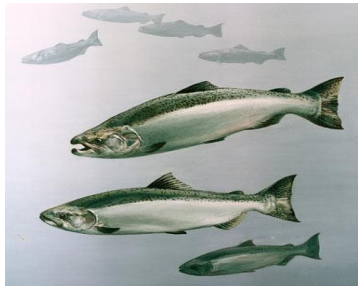
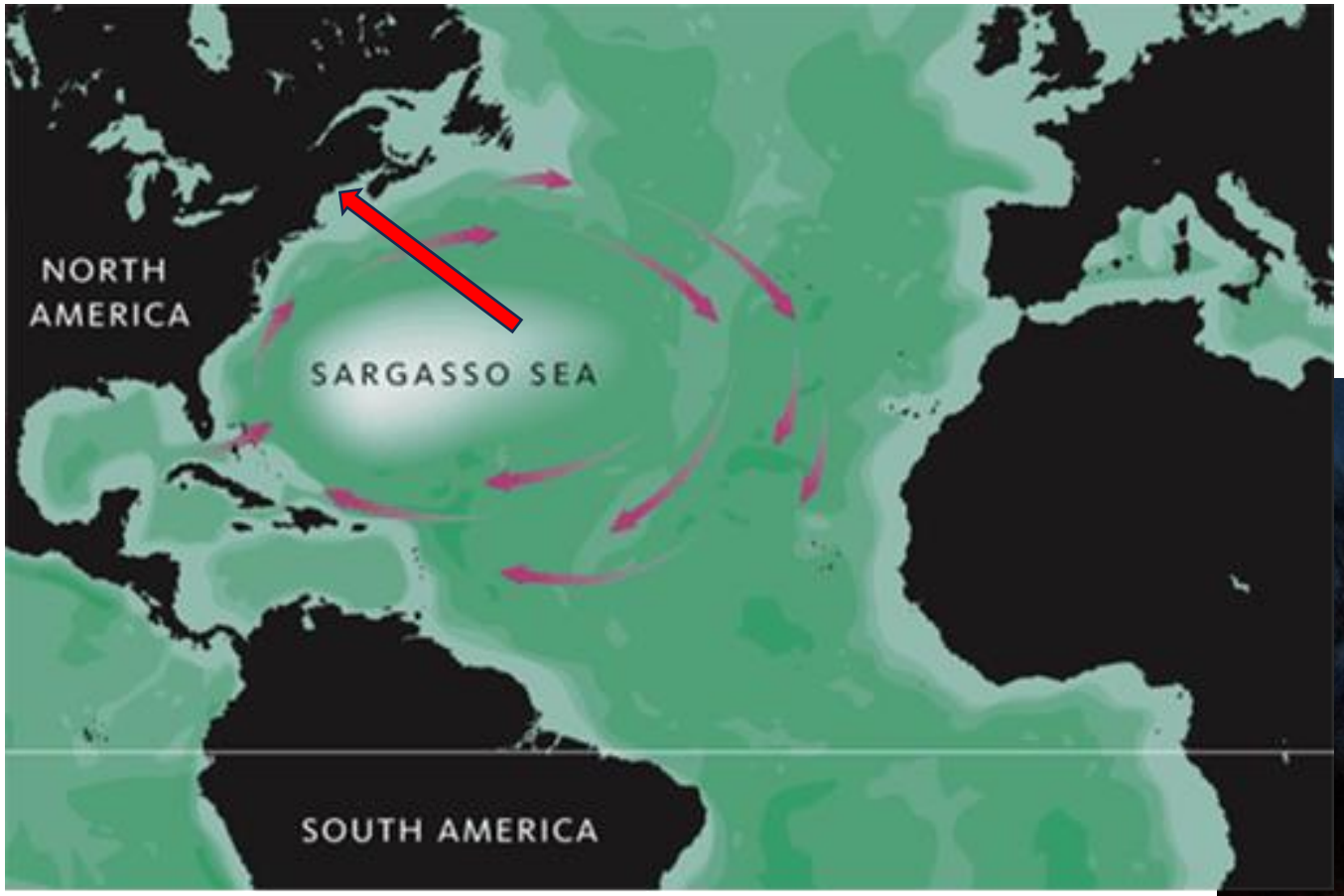


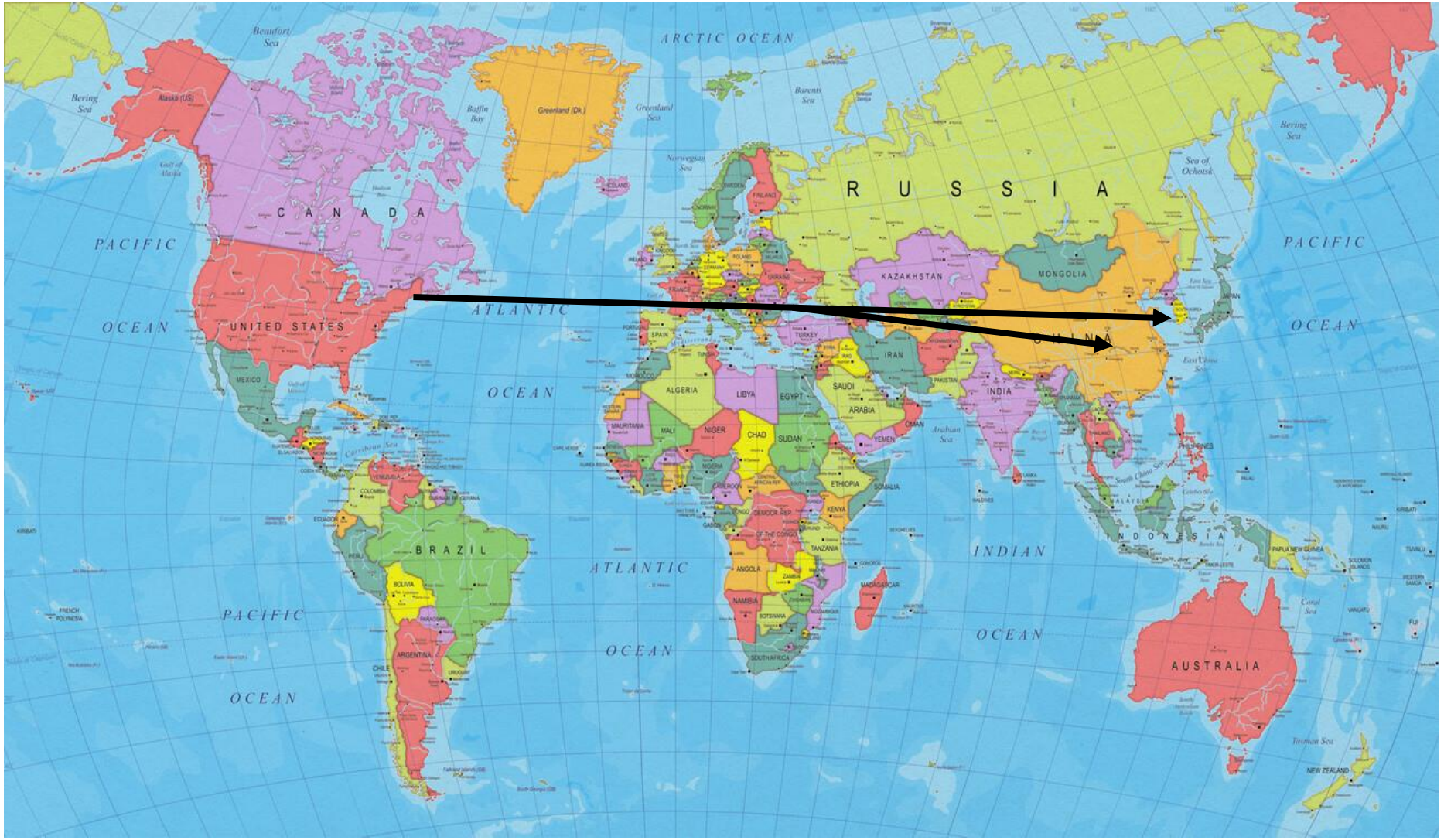
Lobsters

FED FISHERIES with few/no HATCHERIES

UNFED FISHERIES with no HATCHERIES

Anguilla rostrata


NORTH
AMERICA
SARGASSO SEA
SOUTH AMERICA



FAO

90-95% of global eel aquaculture production is from wild-caught elvers

***90% of freshwater eel unagi eaten in USA is farm-raised in Asia**

***US increasing its consumption of eels**

Aquaculture?

BILLIONS $$ OVER 50 YEARS

- Sexual maturation complex set of environmental cues
- Do not mature spontaneously
- **Most farmed eels turn out to be male**
- Scientists developed a set of hormone treatments and produced reliable supply of fertilized eggs **but few healthy larvae**
- Leptocephali to glass eels takes **250-300 days in culture vs. 110 to 160 days in nature**
- Survival rates **very low** <10%
- Leptocephali feed on marine snow in nature
- In hatchery we make an expensive, thick, pinkish paste made primarily of shark eggs, soy protein, and vitamins
- Light-wary leptocephali need to be kept in **darkened rooms**
- Paste causes **large water quality problems**
- etc., etc., etc.

Is a Hatchery Really Needed?

High Capital, Operating Costs

Genetic Issues – Panmixia

Can Insure Genetic Integrity

Can Aquaculture Lead to Fisheries Sustainability?

The Aquaculture Toolbox

Fisheries –Unregulated “Wild West”

“bags of cash”

….a gold rush of sorts is on along the rivers and streams of coastal Maine…since the season began last week, stories have abounded of people making a small fortune in this often hard-luck state. “The first two days of the season were extremely amazing,” said Bill Quinby, an exporter…who shipped about 40 kg (90 lbs.) of elvers to Asia on Tuesday after buying them from Maine fishermen. “People were making $30,000, $40,000 a night.”

Sustainable well managed fishery with well enforced quotas

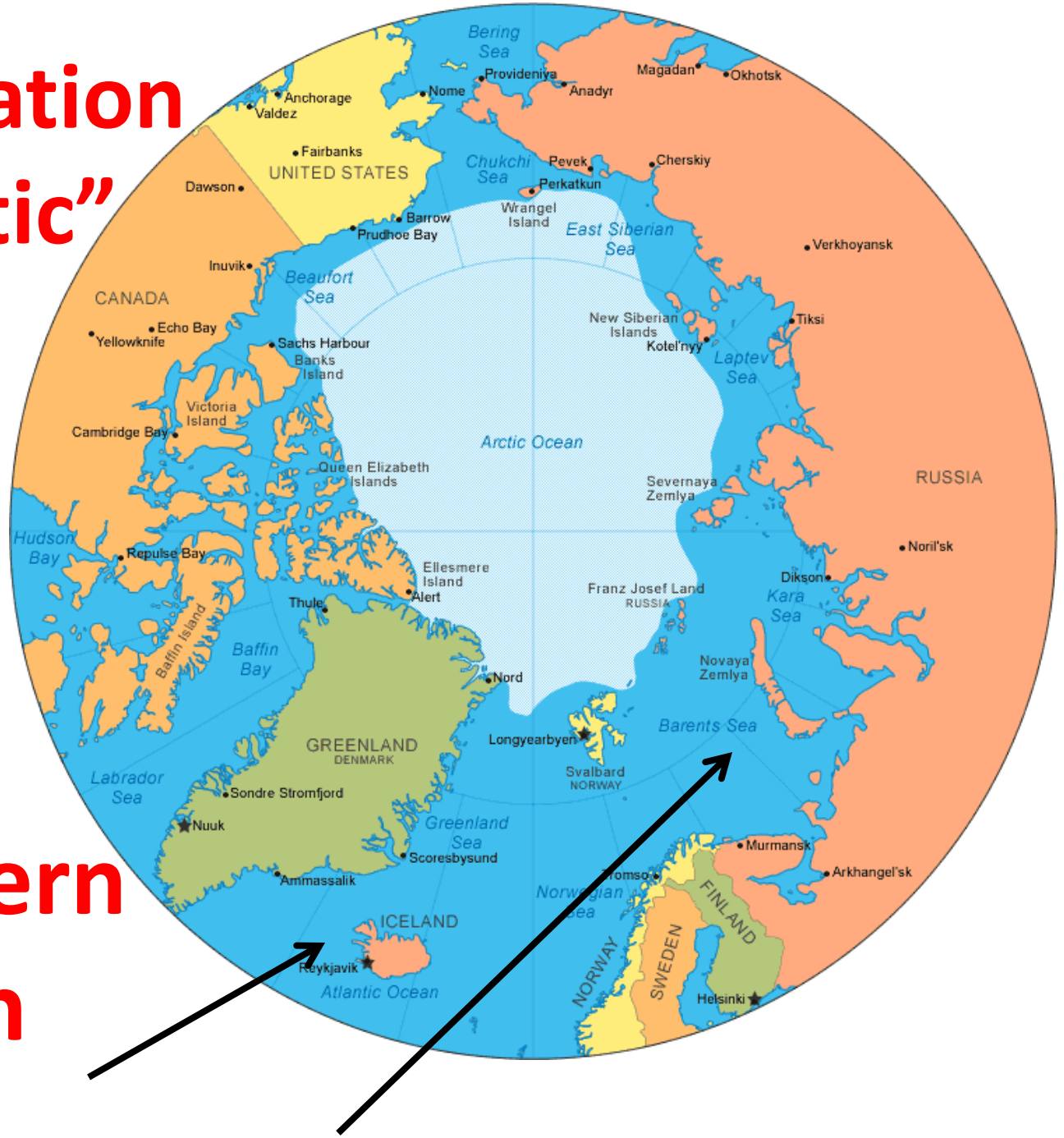
~400 licenses, TAC, limited seasons, entrants

Global-local development of closed cycle, capture based eel aquaculture

AMERICAN UNGAI

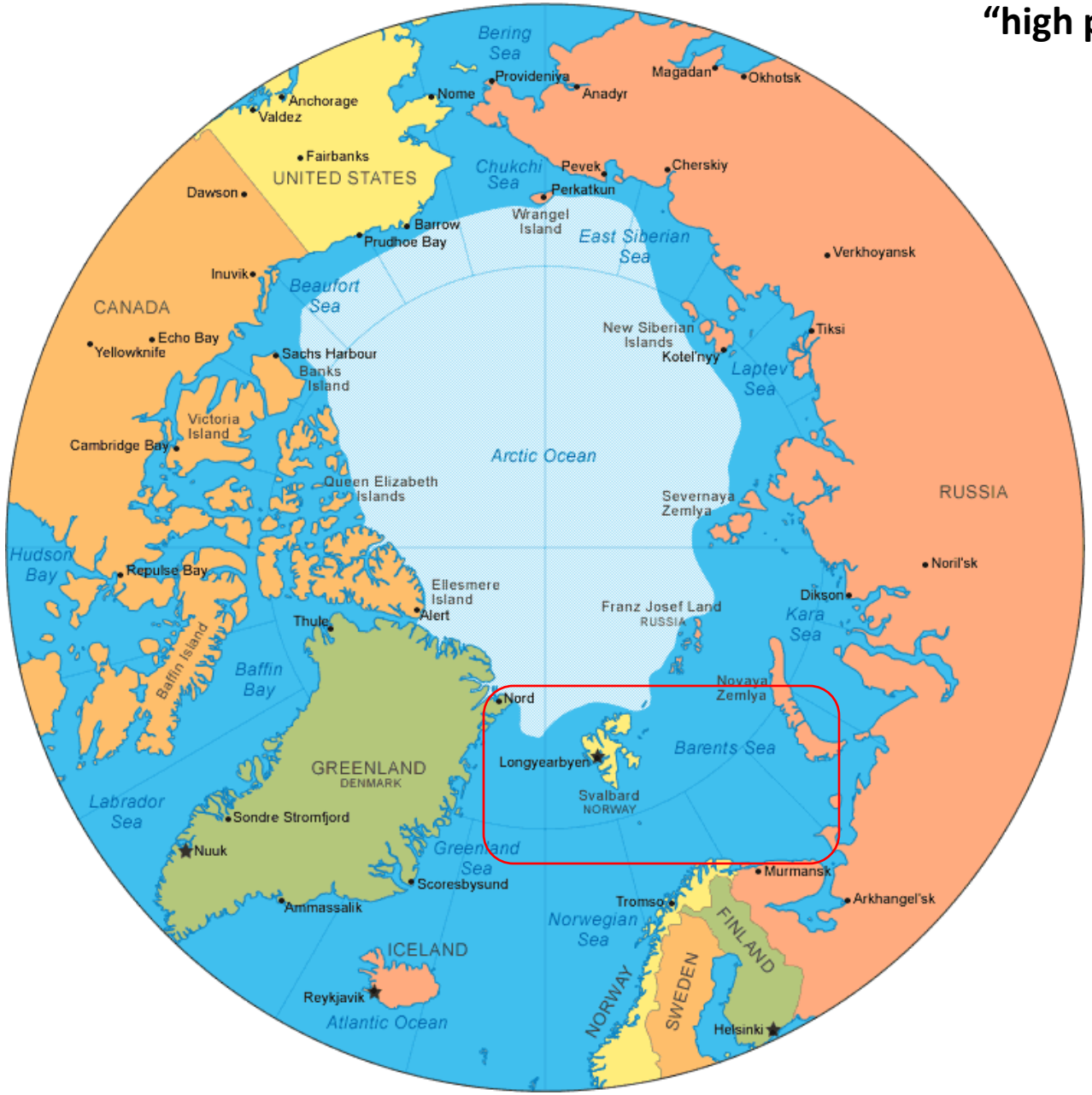
- **Next generation innovator**
- **Modest 240 MT capacity in 2500 m^2, US$ 7 million**
- **International collaboration with EU/Japan**
- **RURAL Waldoboro, a town ~5,000…a town with one of the highest densities of elver fishermen**

“Atlanticification of the Arctic”



The Southern Invasion

Hallowed et al. 2013. Potential movement of fish and shellfish stocks from the sub-Arctic to the Arctic Ocean. *Fish. Oceanogr*. 22(5): 355-370.



12 of 17 key stocks had "high potential" or "potential" to move into the Arctic

HIGH POTENTIAL

Beaked redfish
Greenland shark
Arctic skate
Polar cod
Snow crab

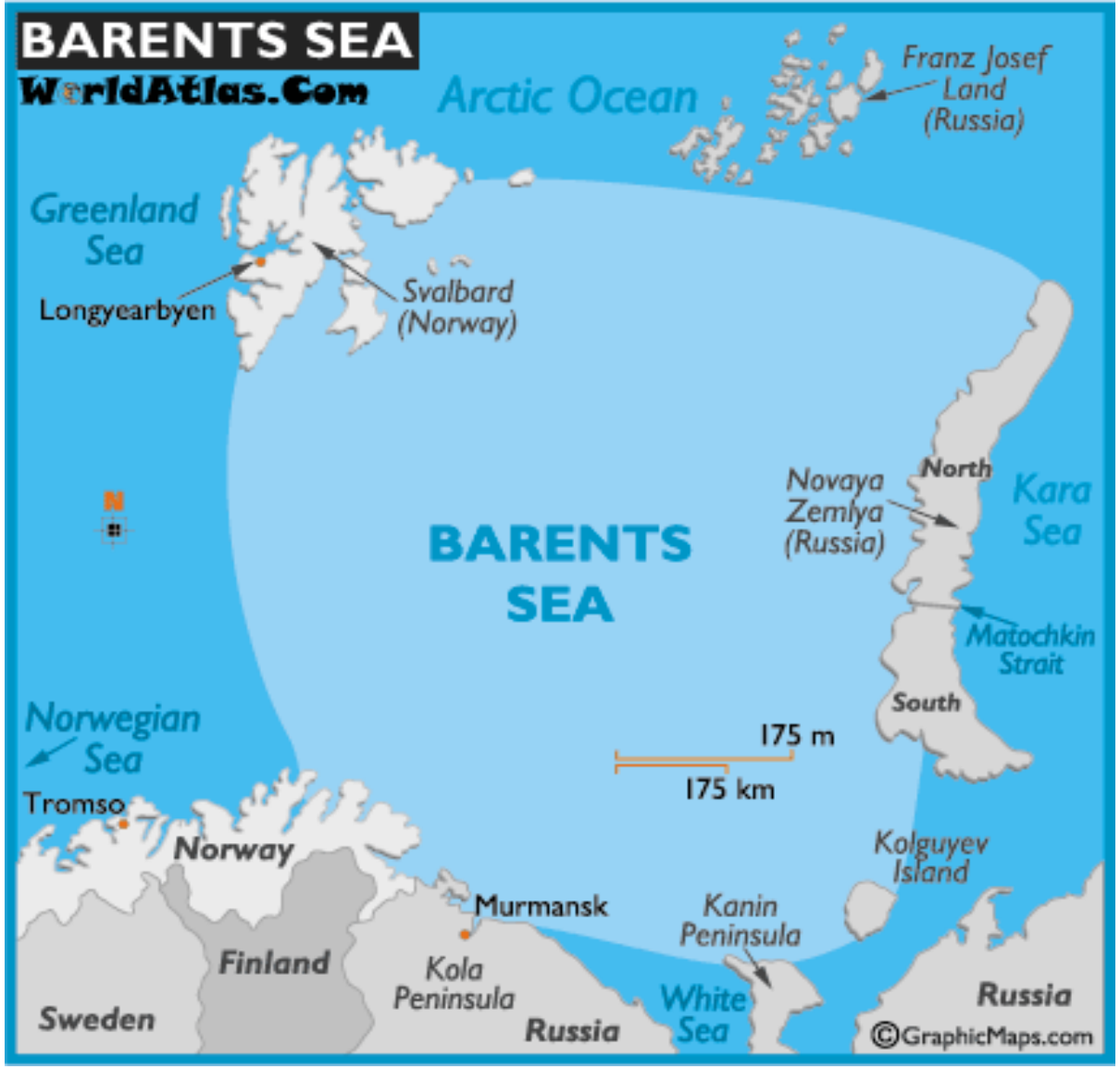
POTENTIAL

Atlantic herring
Capelin
Yellowfin flounder
Greenland halibut
Other elasmobranchs
(thorny, round, spinytail, common skates)
Alaska plaice
Bering flounder


Barents Sea
Svalbard
GREENLAND
Greenland Sea
Jan Mayen
RUSSIA
Denmark Strait
Norwegian Sea
ICELAND
FINLAND
Faroe Islands
NORWAY
Shetland Islands
SWEDEN
Atlantic Ocean
Baltic Sea
North Sea
DENMARK
UNITED KINGDOM
POLAND
IRELAND
GERMANY
NORTH
0 200 400 600 800
Kilometres

Norway's Record Cod Catches Fetching Good Prices in Overseas Markets
News in English by Nina Berglund - April 18, 2016

While Norway's important oil and offshore industries battle what's widely believed to be a "crisis," the seafood industry is booming. That's best illustrated by the fishing boats berthing along Norway's coast that have been so full of cod this season that ***they're pulling into harbours very low in the water. "It's like a fairy tale,"*** Per Norum…as he navigated off the island of Sommarøya west of Tromsø in Northern Norway. "There are masses of fish in the water, it's just gorgeous. It's good to be in fishing now."



Cod, haddock
2016
1,138,000 MT

Africa	**1,485,367**	**MT**
Europe	**2,880,641**	**MT**
Americas	**3,187,319**	**MT**
Oceania	**184,191**	**MT**

Sources: FAO (2014), Norwegian-Russian Fisheries Joint Commission (2015)

National Centre for Capture-Based Aquaculture

Tromsø

NOT recruitment overfishing

Live captures – smart fishing
Limits the race to fish and associated market swings

Uses “aquaculture’s knowledge-based toolbox”

- **Fish acclimatization to containment procedures**
- **High quality care re: fish stress, health & welfare**
- **Disease prevention, diagnosis & treatment**
- **Advanced slaughtering & rapid delivery to year-round markets**

The CBA "**quota bonus system**"

*temporary…tied to the annual capture fisheries quota for cod

*evaluated regularly

*CBA offers the **potential for a win-win** for both cod fishing industries and consumers

CBA allows fishing companies to spread the supply of cod throughout the year. Cod catches are highest in the January to April period when the highest quality fish the famous "Skrei" migrate from the high Arctic to spawn in the region around Lofoten, Norway.

Hermansen (2017)…"**It's still in the early stage with actors involved being the pioneers**", and that: "It remains to be seen whether CBA for cod can survive without the quota bonus". Pettersen et al. (2023) concluded that, with an average price premium of 26% for CBA cod compared to wild cod, combined with reductions in the CBA quota bonus, that this price premium was "**not sufficiently large to incentivize further development of the CBA branch of the Norwegian cod industry**."

More CBA Evolution

FED AQUACULTURE with HATCHERIES



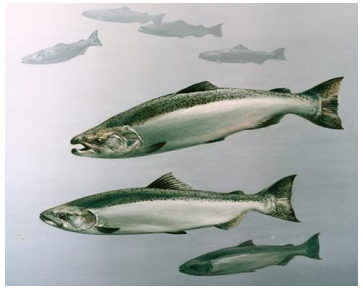
Bivalves
Seaweeds

FED AQUACULTURE with no HATCHERIES

"Capture-Based Aquaculture" (CBA)


UNFED FISHERIES with HATCHERIES

"Aquaculture-Enhanced Fisheries" (AEF)



UNFED AQUACULTURE with HATCHERIES




FED FISHERIES with few/no HATCHERIES

UNFED FISHERIES with no HATCHERIES

More Evolution

Restorative Aquaculture

UNFED Bivalve AQUACULTURE with HATCHERIES

UNFED Bivalve FISHERIES

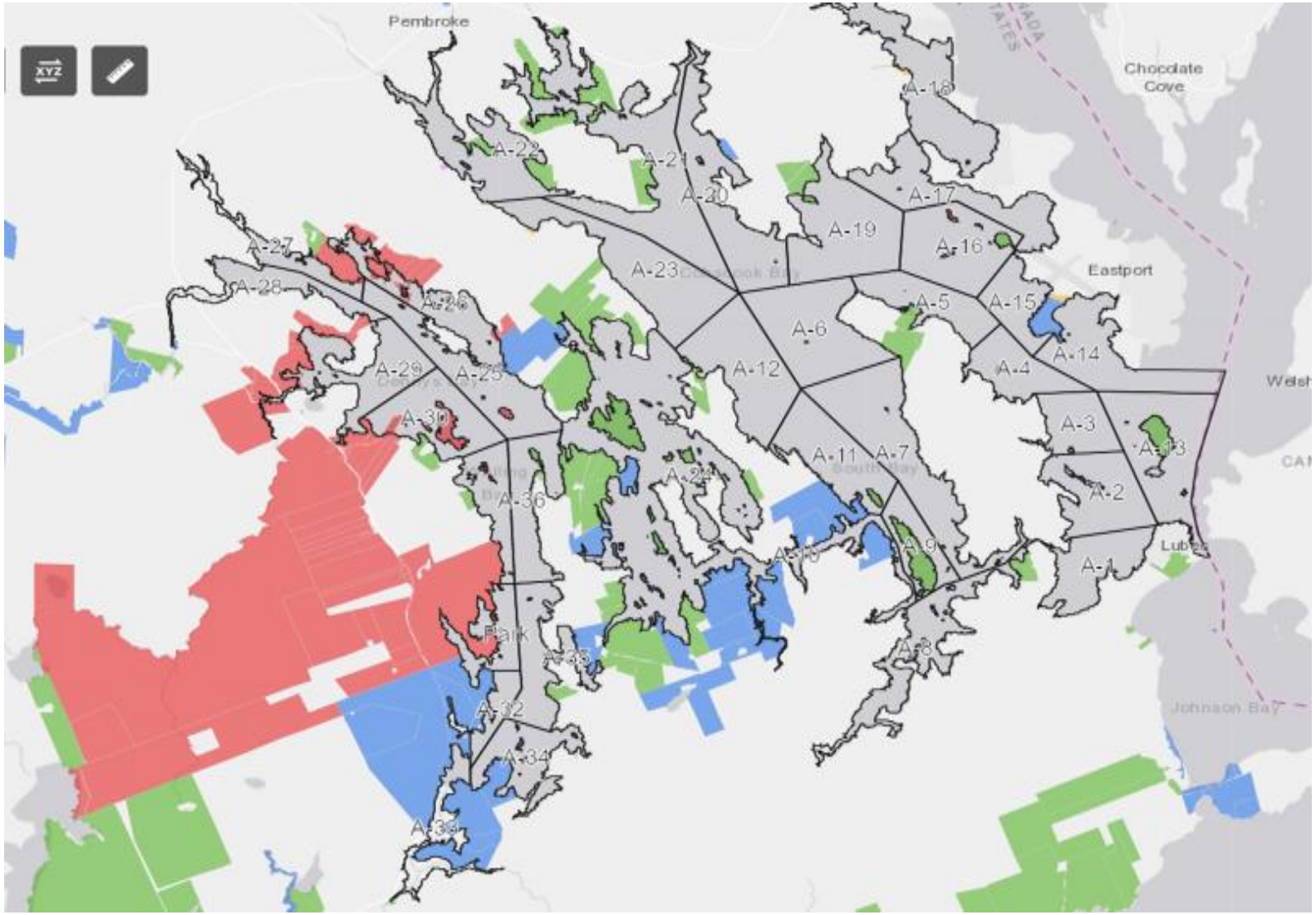
The Nature Conservancy®
Saving the Last Great Places

Alleway (2023). Global principles for restorative aquaculture to foster aquaculture practices that benefit the environment. *Conservation Science and Practice* e12982. https://doi.org/10.1111/csp2.12982


FLYING POINT
NEWCASTLE, ME
MOOKIE BLUES
WALPOLE, ME
WILD OYSTERS!
DAMARISCOTTA RIVER
WOLFE'S NECK
CASCO BAY, ME
NONESUCH
SCARBOROUGH, ME
TABASCO

Seaweeds?

Mostly Fished in EU (Norway) & NoAmerica…



Seaweeds?

Mostly Fished in EU (Norway) & NoAmerica…

Farming?

Aquaculture ⟷ **Fishery**

OAFS ARE DISRUPTIVE!

They require radically changed science, education, management, and development institutions and policies… that are in contrast to current binary fisheries and aquaculture management approaches which do not fit the current OAFS realities, or opportunities, or accelerate innovations, plus poorly integrate knowledge across professions…

Governance
- governments
- civil society
- NGOs
- law, policy, management
- spatial planning

Conservation
- endangered species
- invasive species
- biological pollution

Total Allowable Catch
- biological production
- stock assessments
- allocations
- ownership
- operations
- consultation
- utilization
- enforcement

Human Ecosystems

Aquaculture Ecosystems

Fisheries Ecosystems

Aquatic Ecosystems

2020-2030's are

"The Decades of Doing"

Our Workplans

- Examine replacement alternatives for imports
- Examine alternatives for OAFS: Capture Based Aquaculture & Aquaculture Enhanced Fisheries

NEW PROFESSIONS

Schools, Institutes/Centers of Aquatic/SeaFood

NEW GOVERNANCE

Ministry of Food

- Agriculture
- Fisheries
- Aquaculture
- Food Trade

2021 **Ministry of Fisheries and Agriculture**

"primary industry"

Courtesy of Dr. Ögmundur Knútsson
Director
Iceland Directorate of Fisheries

Ministry of Food
All Food Production
- Fisheries
- Aquaculture
- Agriculture

Administration and surveillance for agriculture, aquaculture, and fisheries remain separate

Directorate of Fisheries https://island.is/en/o/directorate-of-fisheries	Icelandic Food and Veterinary Authority (Agriculture, Aquaculture, Animal Welfare & Health) http://www.mast.is/en

Merge administration and surveillance to encompass the entire value chain of foods

Thank You

Tusen takk
Tack så mycket
Muchas gracias
Muito obrigado
Shukran jazilan
Mahalo nui loa
Terima kasih