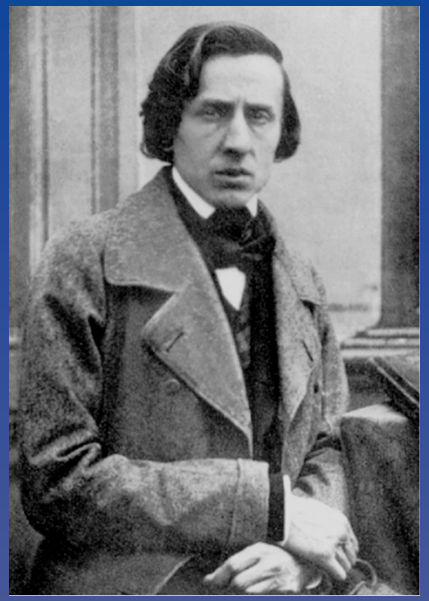
Chopin

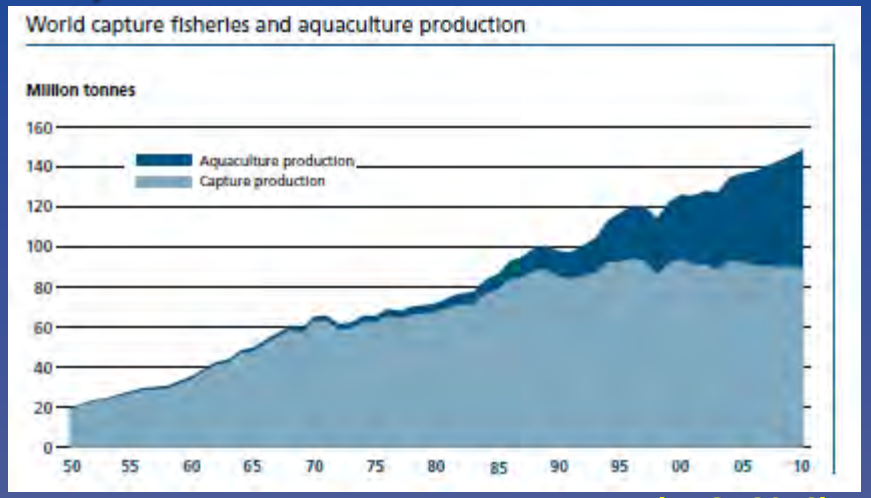


Integrated Multi-Trophic Aquaculture (IMTA): an overview of the concept, the Canadian experience and its potential for the Baltic Sea Region

T. Chopin and the IMTA team

Canadian Integrated Multi-Trophic Aquaculture Network (CIMTAN)
University of New Brunswick
Saint John, N.B., Canada

Renewed interest in IMTA was triggered by the fact that aquaculture, while being the world's fastest growing food production sector, is associated with environmental, economic and societal issues.



(FAO, 2012)

For the aquaculture sector to continue to grow, it will need to develop innovative and responsible technologies and practices.

We had the "Green Revolution" of the 1960s on land, but was it really "green"?

We thought the sea was so immense that we did not need to worry about fishery limits… but this is not always the case.

We had the "Blue Revolution" of the 1980s of aquaculture development at sea, but it is not always "green".

It is time to make the Blue Revolution greener and apply agronomic principles to aquatic environments.

>>> Turquoise Revolution

and

Aquanomy

Sustainable aquaculture should be ecologically efficient, environmentally benign, product-diversified, profitable and societally beneficial.

Integrated Multi-Trophic Aquaculture (IMTA) has the potential to achieve these objectives by cultivating

- in proximity,
- species from different trophic levels, and
- with complementary ecosystem functions,

in a way that allows

- one species' uneaten feed and wastes, nutrients and by-products to be recaptured and converted into fertilizer, feed and energy for the other crops, and
- to take advantage of synergistic interactions among species
- while biomitigation takes place.

Farmers combine the cultivation of:

- **fed species, such as finfish or shrimps,**
- **with extractive species,**
  - **such as seaweeds and aquatic plants, which recapture inorganic dissolved nutrients,**
  - **and suspension- and deposit-feeders, which recapture organic particulate nutrients,**

for their growth.

In this way, all the cultivation components have an economic value (harvestable and healthy seafood and value-added marine bio-based products), as well as a key role in recycling processes and in providing biomitigative services for the surrounding ecosystem.

Comparing the evolution of agronomy and aquanomy

Agriculture: 6.3 billion tons, 82% plants and 18% animals
Aquaculture: 78.9 million tons, 76% animals and 24% seaweeds
Mariculture: 37.1 million tons, 51% seaweeds and 49% animals

However, 98.9% of seaweed aquaculture is concentrated in 7 Asian countries (China, Indonesia, The Philippines, South Korea, North Korea, Japan and Malaysia).

>>> If aquaculture is to make a major contribution to the efficient and responsible food production systems of the future, far more production and applications of inorganic extractive seaweeds and aquatic plants, and organic extractive animals, must be developed in a more evenly distributed manner throughout the world.

The aim is to engineer a new ERA of aquaculture systems (Ecosystem Responsible Aquaculture) for increased:

- environmental sustainability
(ecosystem services and green technologies for improved ecosystem health),

- economic stability
(improved output, lower costs, product diversification, risk reduction and job creation in coastal and rural communities), and

- societal acceptability
(better management practices, improved regulatory governance and appreciation of differentiated and safe products).

In this way, some externalities of fed monoaquaculture are internalized, hence increasing the overall sustainability, profitability and resilience of aquaculture farms.

The IMTA concept is extremely flexible

- IMTA is the central/overarching theme on which many variations can be developed.

- IMTA can be applied to open-water or land-based systems, marine or freshwater systems, and temperate or tropical systems.

- What is important is that the appropriate organisms are chosen at multiple trophic levels based on their complementary functions in the ecosystem, as well as for their economic value.

- Integration should be understood as cultivation in proximity, not considering absolute distances but connectivity in terms of ecosystemic functionalities.

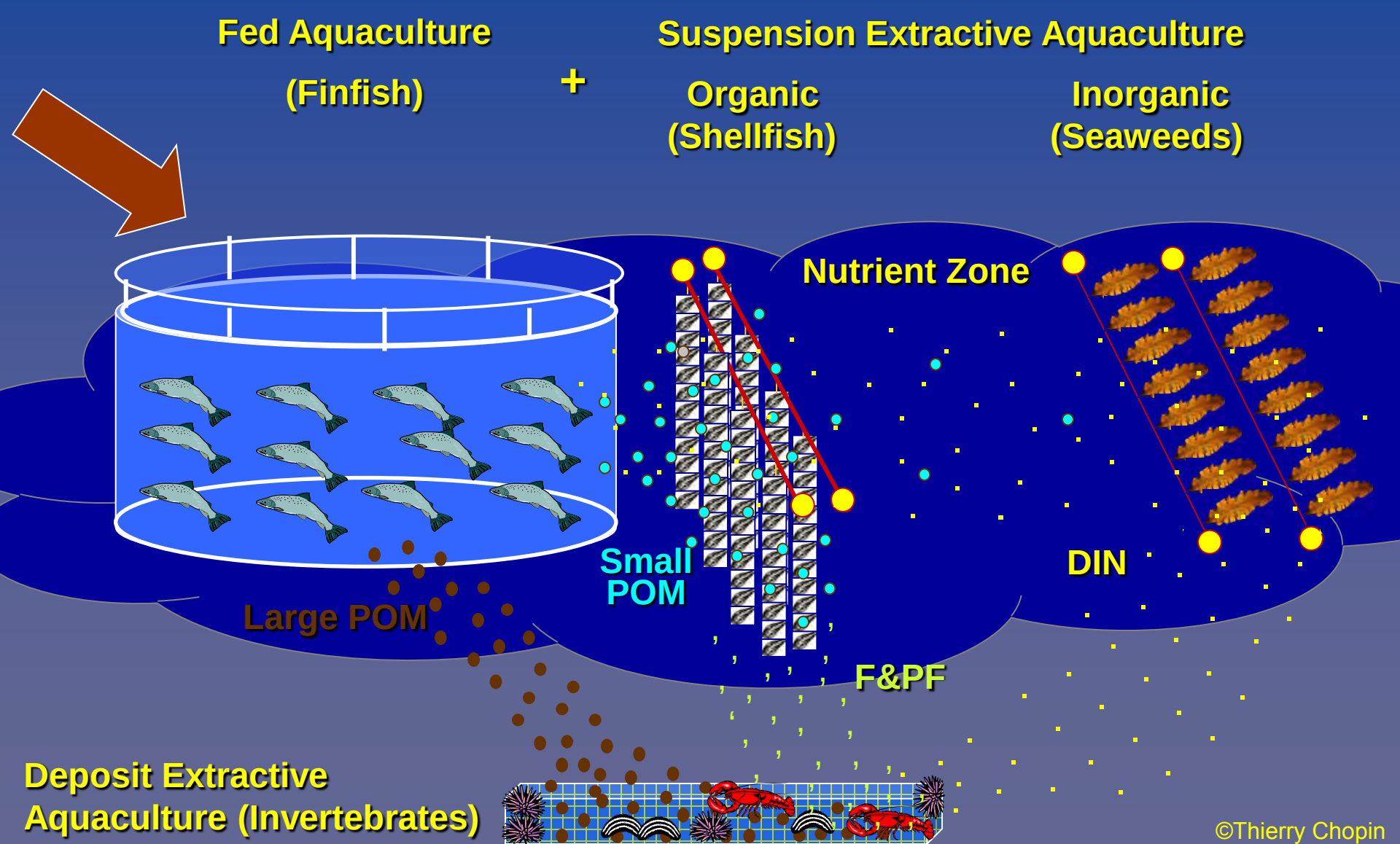
It should be made clear that in the minds of those who created the acronym "IMTA" in 2004, it was never conceived to be viewed only as the cultivation of salmon, kelps, blue mussels and other invertebrates in temperate waters and within a few hundred meters.

This is only one of the variations and the IMTA concept can be extended to very large ecosystems like the Yellow Sea.

This also means that IMTA variations include:

- integrated agriculture aquaculture (IAA)
- integrated fisheries aquaculture (IFA)
- integrated silviculture (mangrove) aquaculture (ISiA)
- integrated green water aquaculture (IGWA)
- integrated biofloc aquaculture (IBFA)
- integrated temporal aquaculture (ITA)
- integrated sequential aquaculture (ISA, also called partitioned aquaculture, PA, or fractionated aquaculture, FA)
- sustainable/sustained ecological aquaculture (SEA)
- aquaponics or freshwater integrated multi-trophic aquaculture (FIMTA)
- integrated peri-urban aquaculture (IPUA)
- integrated food and renewable energy parks (IFREP).

Integrated Multi-Trophic Aquaculture (IMTA)



IMTA is based on a very simple principle:

The solution to nutrification

is not dilution...

but extraction and conversion

through diversification

Fed component of IMTA: salmon

Inorganic component of IMTA: seaweeds

- *Saccharina latissima*
  - previously *Laminaria saccharina*
  - *Saccharina* means sweet
  - similar to other *Saccharina* and *Laminaria* for the Oriental market
  - sold as "*kombu*"

- *Alaria esculenta*
  - *esculenta* means succulent
  - similar to *Undaria* for the Oriental market
  - sold as "*wakame*"

From R&D to C

Organic component of IMTA: mussels and other invertebrates

Mussels: from biofouling to value-added co-cultured species

Additional Biofilter Species

A major rethinking is needed regarding the definition of an “aquaculture farm”.

>>> How does it work within an ecosystem?

>>> Considering it in a broader context of Integrated Coastal Zone Management.

Ecosystem services should represent financial incentive tools to encourage mono-aquaculturists to contemplate IMTA as a viable aquanomic option to their current practices.

The value of the ecosystem services provided by the extractive components of IMTA systems will have to be recognized and accounted for.

>>> Introducing the concept of "nutrient trading credits" (NTC), similar to carbon trading credits (CTC)

For example: seaweeds 19.0 million tons US$5.7 billion

Composition	NTC
0.35% N	US$10-30 kg^{-1}
0.04% P	US$4 kg^{-1}
3.00% C	US$30 t^{-1}

>>> Ecosystem services: at least US$712.5 million to US$2.043 billion

***i.e.* as much as 35.8% of their present commercial value.**

We will have to change our attitudes and business models to evolve from the

one species - one process - one product approach

to the emerging concepts of

- integrated food and renewable energy parks (IFREP), and

- integrated sequential biorefinery (ISBR).

Wind farms could become the pivotal anchoring systems of open ocean IMTA farms