Center of Excellence for Water

Dr. Mahmoud Dawood

Associate Prof. & Post-doc researcher

Center for Applied Research on the Environment and Sustainability - AUC

Exchange, Training, and Scholarships Pillar activities are implemented in cooperation with:

Modern Aquaculture

Agenda

- Understanding the concepts and types of aquaculture systems
- Understand the concept of intensive aquaculture and fish farming
- Prospects and considerations of different aquaculture systems
- Integrated aquaculture systems
- Understand the concept of aquaculture in different water salinities
- Aquaculture in Egypt

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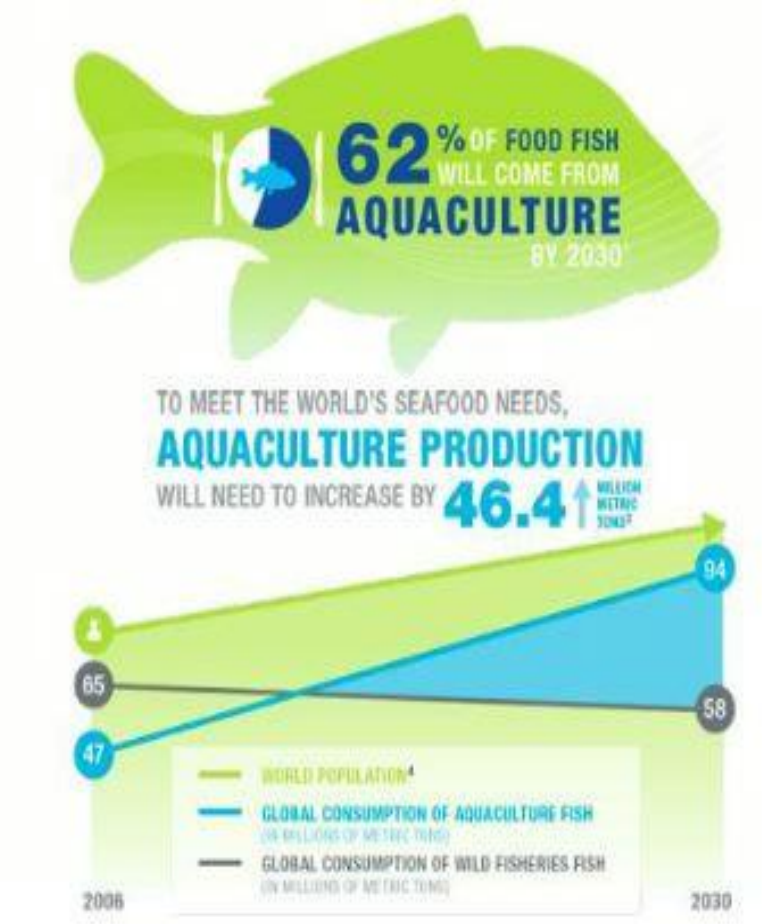
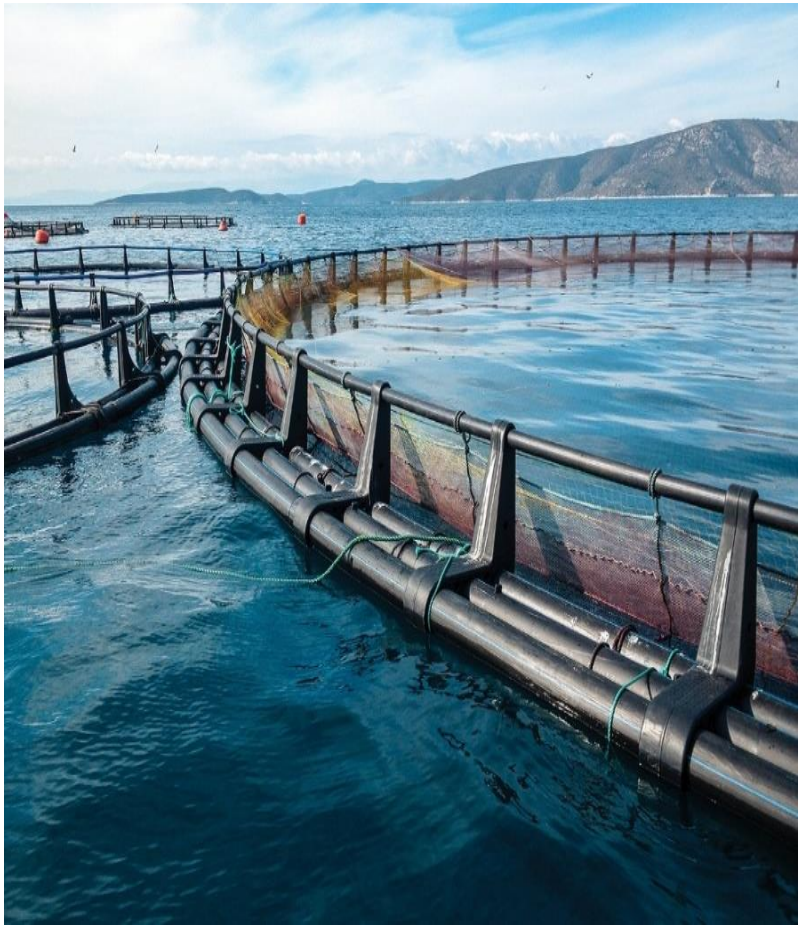
Aquaculture and Fisheries





أغنى 5 أثرياء تحت سن الثلاثين

* مليار دولار
* المصدر: فوربس
* تعود لـ 14 سبتمبر 2022

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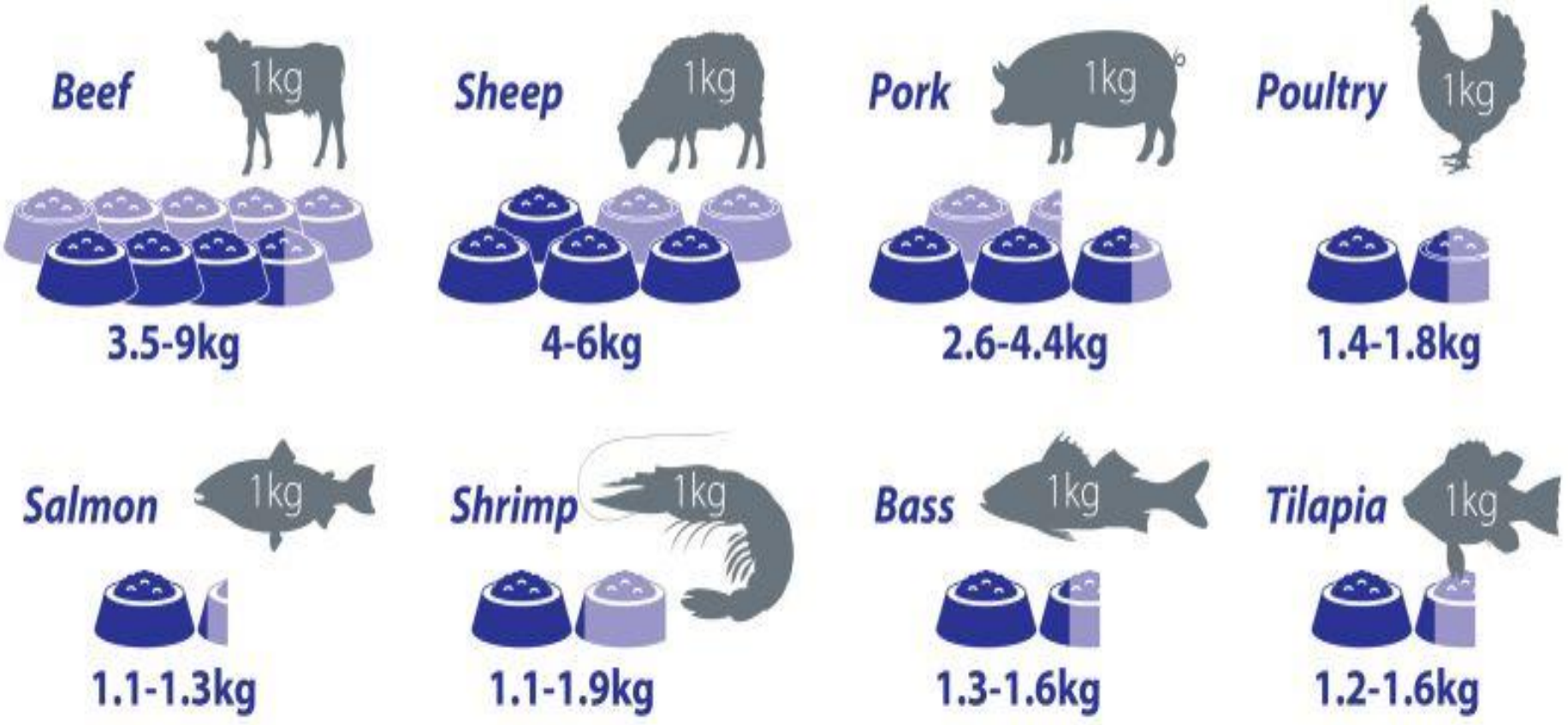
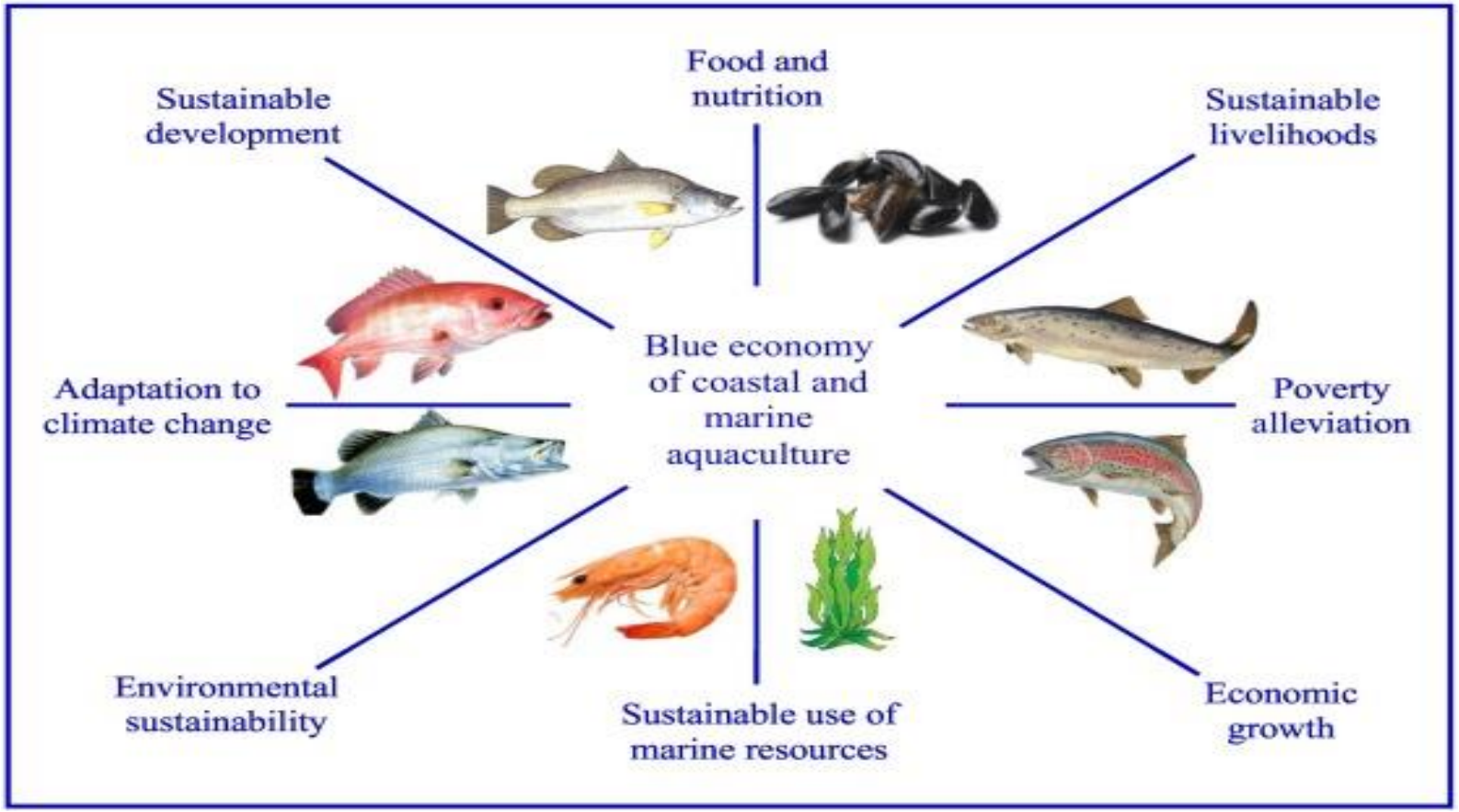
Feed conversion efficiency of aquatic farming vs. land-based farming




Food and nutrition
Sustainable development
Sustainable livelihoods
Blue economy of coastal and marine aquaculture
Adaptation to climate change
Poverty alleviation
Environmental sustainability
Sustainable use of marine resources
Economic growth

Advantages of Aquaculture

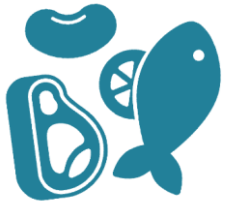
Fastest growing food production system

Alternative of capture fisheries

Supply the increasing human populations of food demand

Produce more food fish

kept the overall price of fish down



Important source of animal protein

Challenges of Aquaculture

Genetic changes by introduced species

Disease outbreaks impact production

Ensuring livelihood of local communities

Don't compromise the needs of future generations

Don’t destroy ecological balances

Main producers of Aquaculture

Top 5 Countries in the World

China

India

Bangladesh

Indonesia

Vietnam

Top species in world aquaculture

Japanese kelp

- *Laminaria japonica*
- 11 174 505 tones

Common carp

- *Cyprinus carpio*
- 4 129 100 tones

Grass carp (= white Amur)

- *Ctenopharyngodon idellus*
- 5 519 487 tones

Cupped oysters nei

- *Crassostrea spp.*
- 4 905 215 tones

Silver carp

- *Hypophthalmichthys molitrix*
- 4 704 673 tones

Whiteleg shrimp

- *Penaeus vannamei*
- 4 456 603 tones

Gracilaria seaweeds

- *Gracilaria spp.*
- 4 311 040 tones

Japanese carpet shell

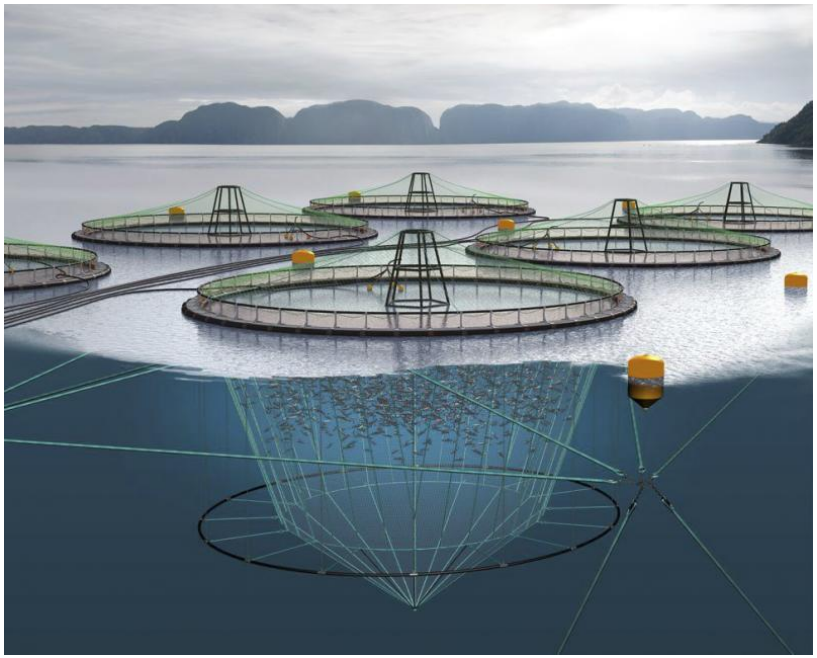
- *Ruditapes philippinarum*
- 4 228 206 tones

Nile tilapia

- *Oreochromis niloticus*
- 4 130 281 tones

Types of aquaculture systems

Water-based systems



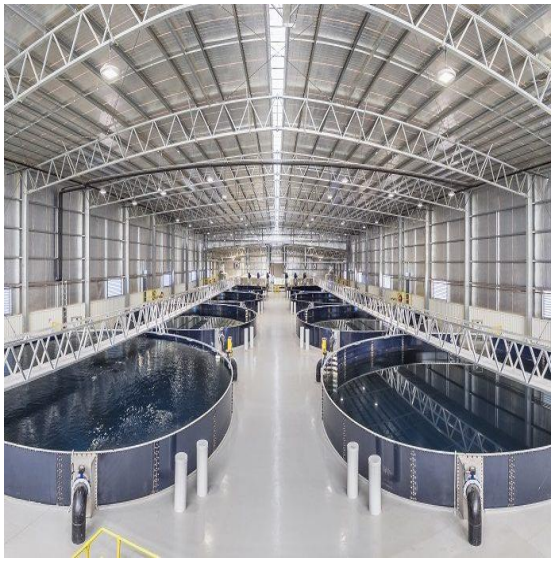
Cages

Pens

Types of aquaculture systems

Land-based systems

Rainfed ponds



Tanks

Raceways

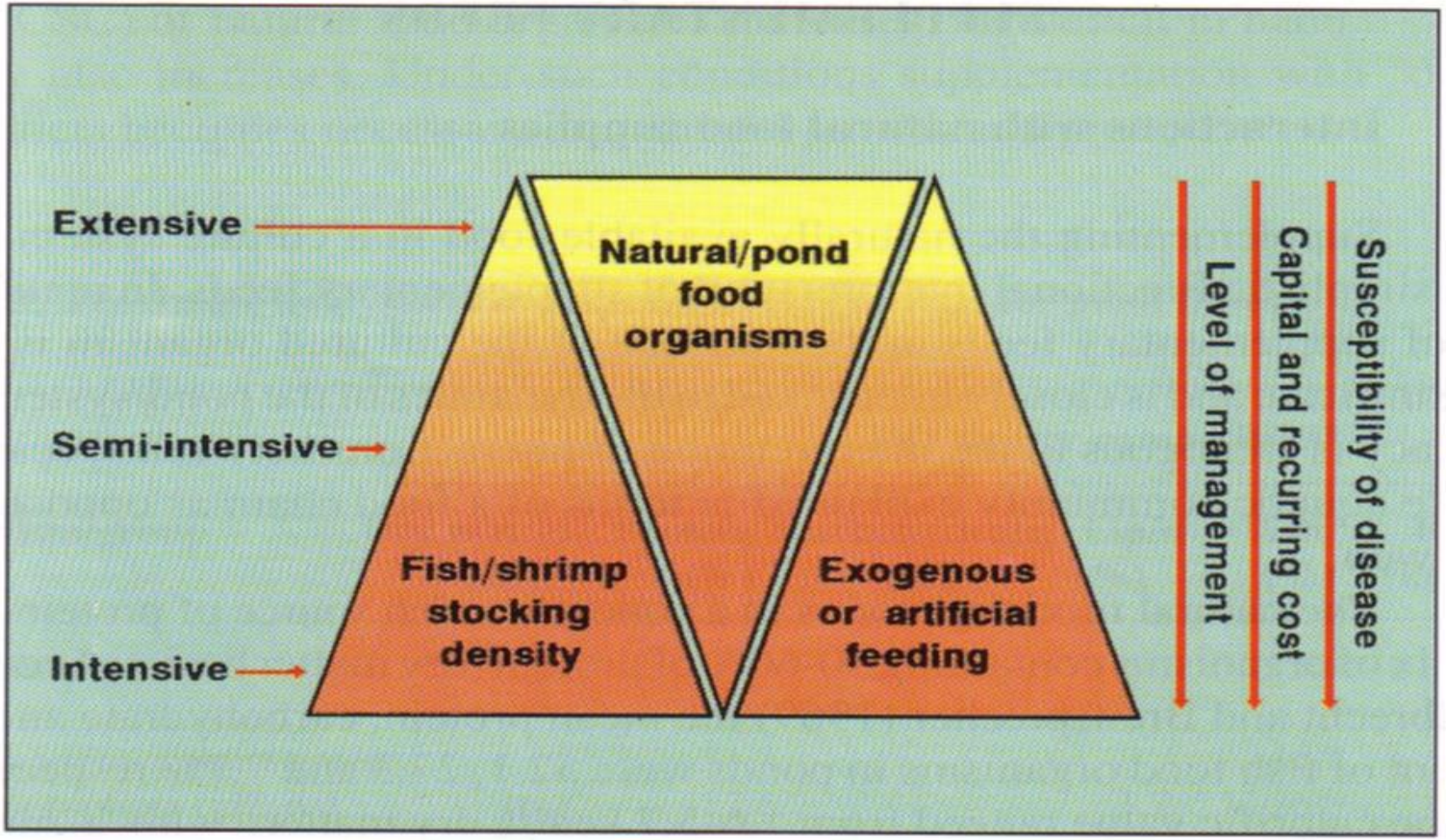
Types of aquaculture systems

Extensive

Semi-Intensive

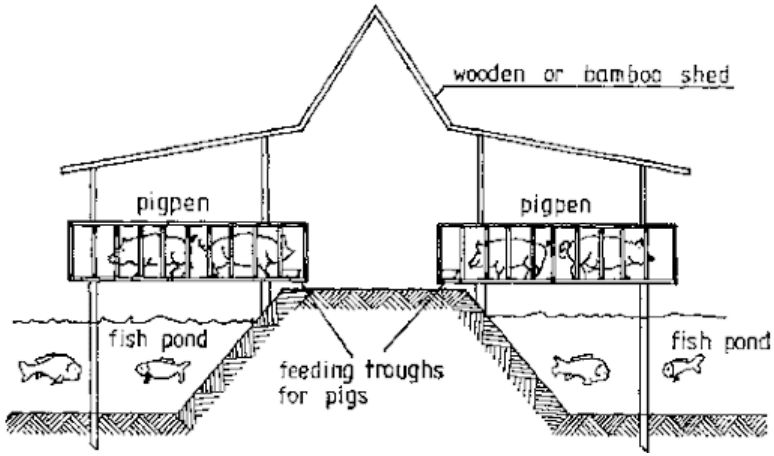
Highly Intensive

Hyper-Intensive


Extensive
Semi-intensive
Intensive
Natural/pond food organisms
Fish/shrimp stocking density
Exogenous or artificial feeding
Level of management
Capital and recurring cost
Susceptibility of disease

Types of aquaculture systems

Integrated farming systems



Livestock-fish

Agriculture & fish dual use aquaculture

Integrated aquaculture production system

Integrated aquaculture (aquaponics)

RAS (recirculated aquaculture system)

Intra-basin running water system (IBRS)

Bioflocs (BFT)

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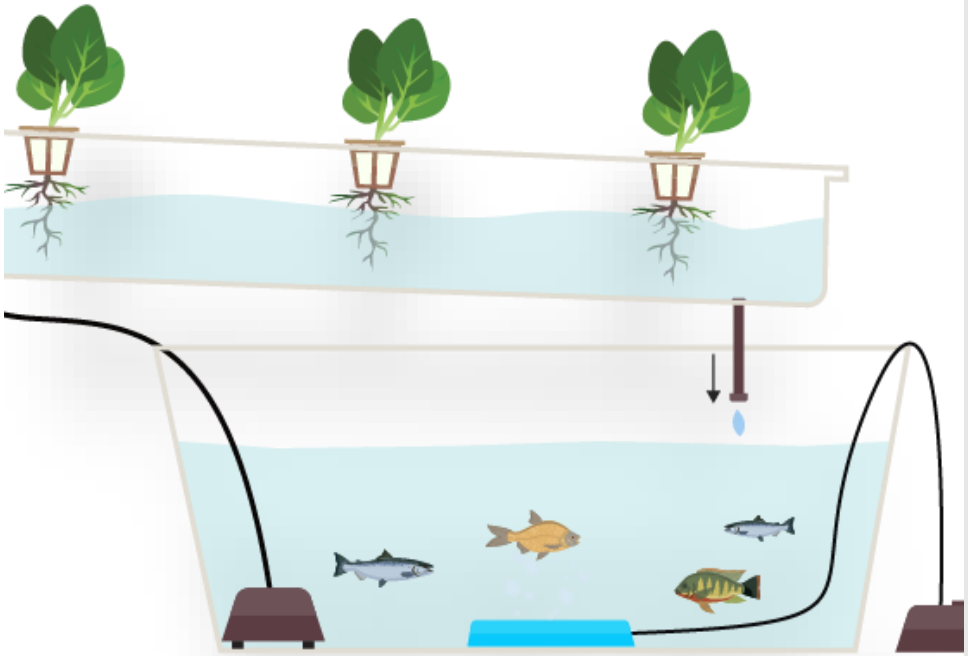
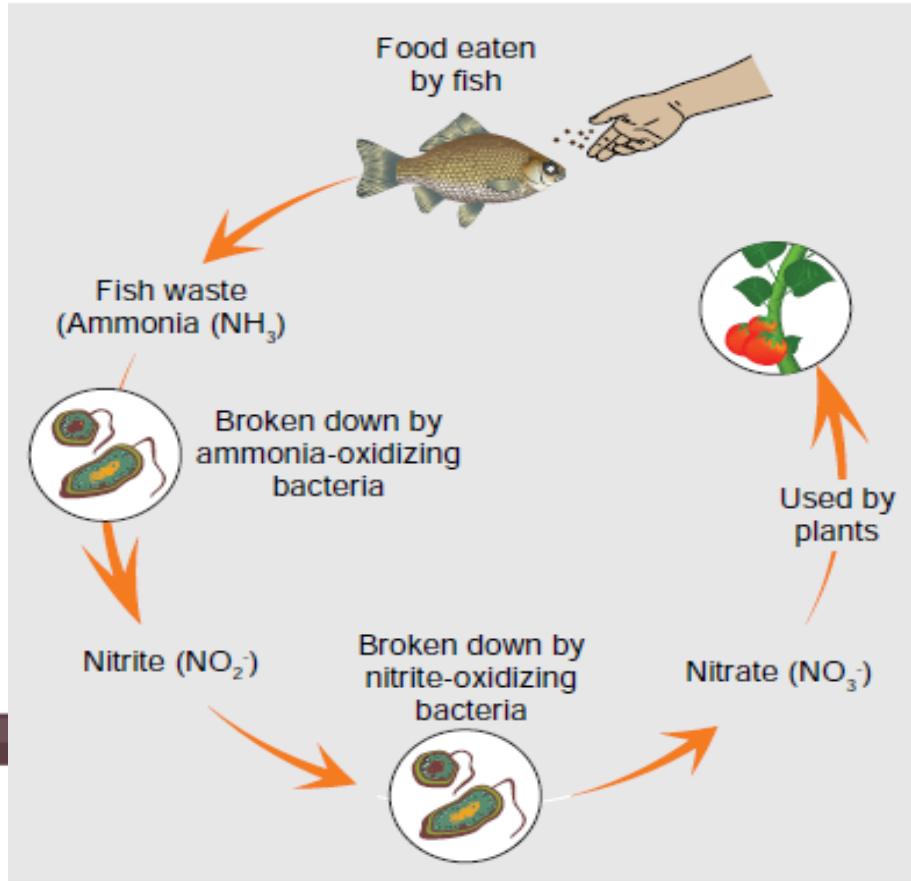
Aquaponics

Aquaculture + Hydro**ponic**





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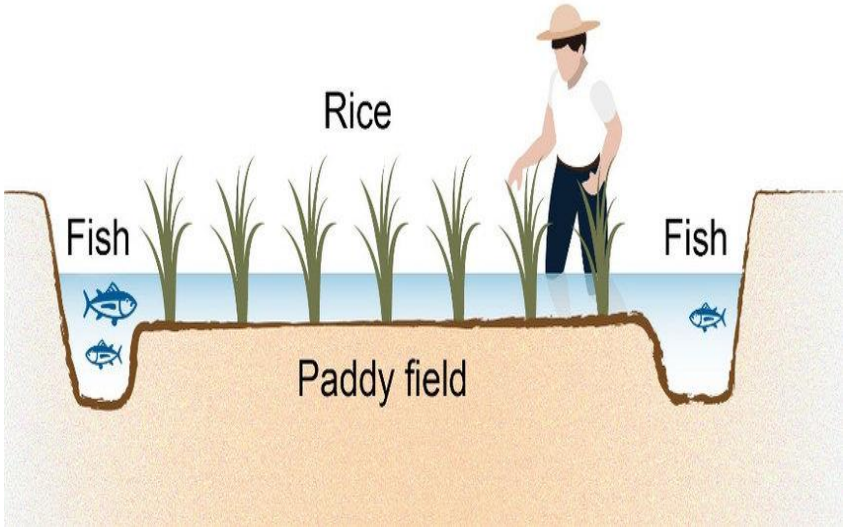


Ponds

Integrated pond systems

Technological Advancements

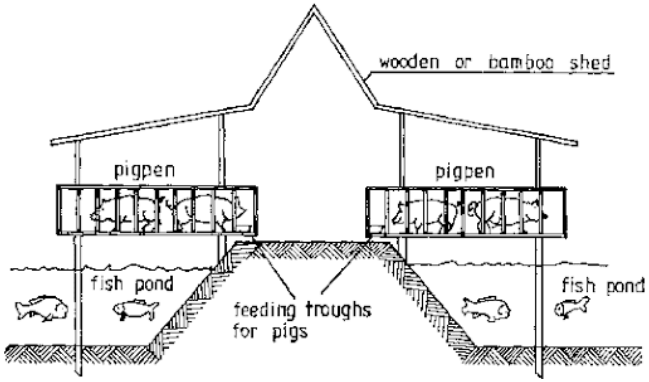
Conventional pond systems' problems

Water shortage is a controlling factor in many countries

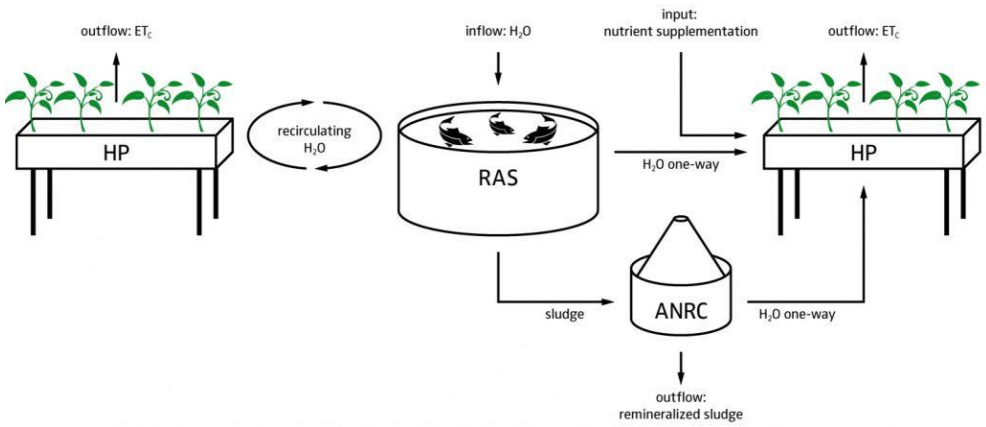
Aquaculture is ineffective usage of fresh water – in warm, dry countries

Technological Advancements

Integration of aquaculture into other systems



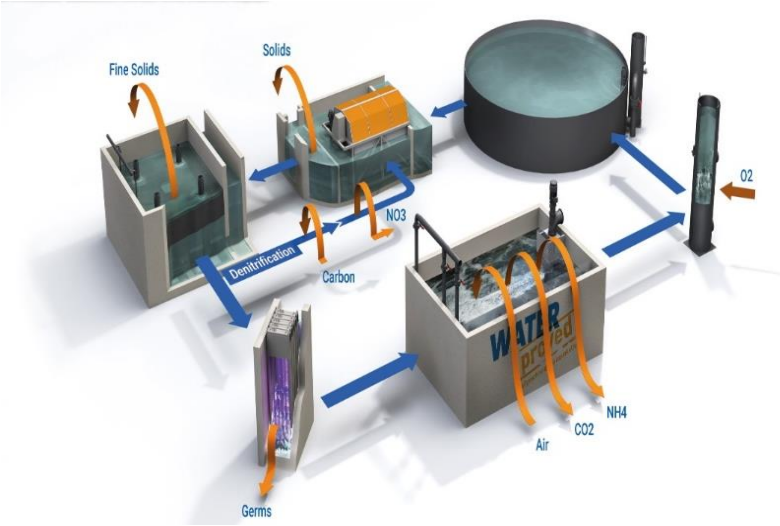
Integration of livestock and aquaculture



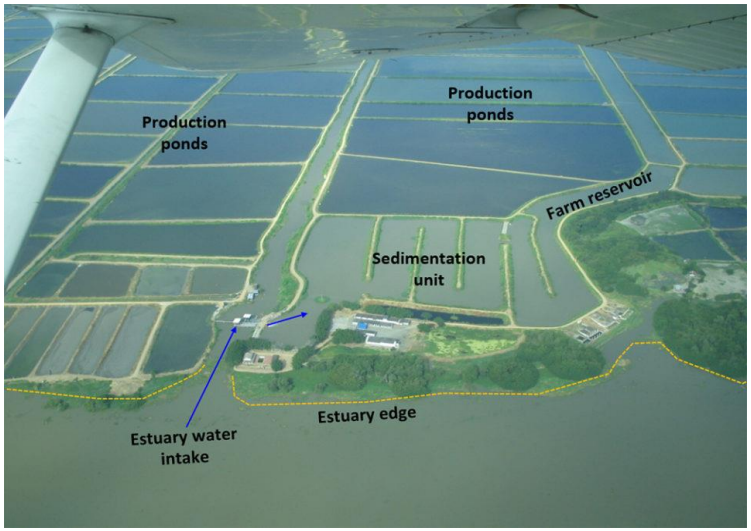
Decoupled-RAS system

Types of aquaculture systems

Recycling systems



High control enclosed systems



More open pond based recirculation

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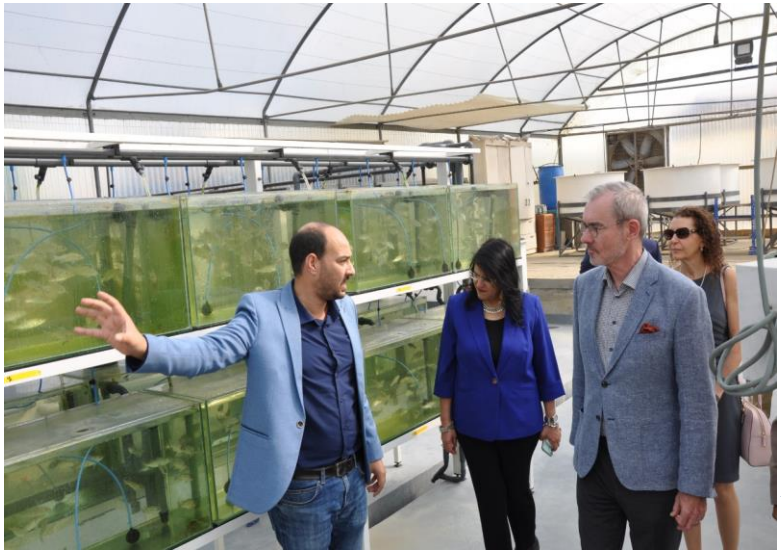
1 kg of fish feed 30%



32 g
Ammonia

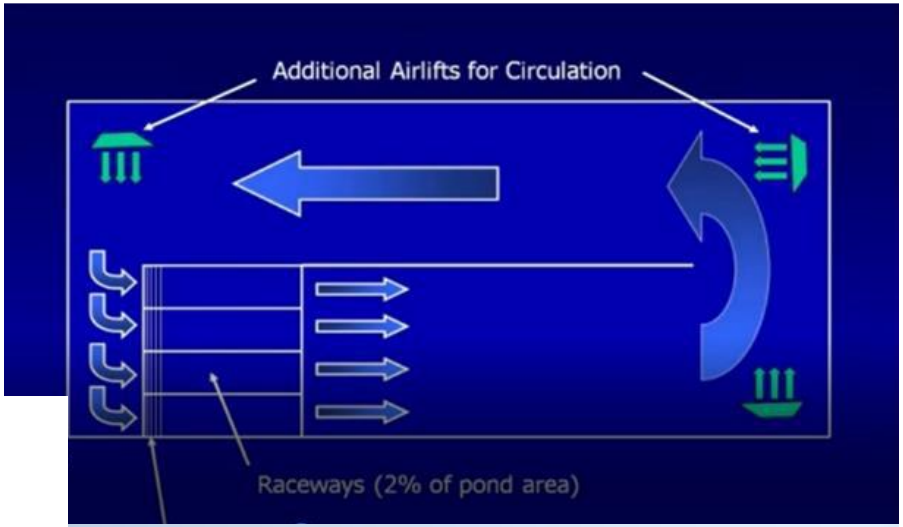
87 g
Nitrate

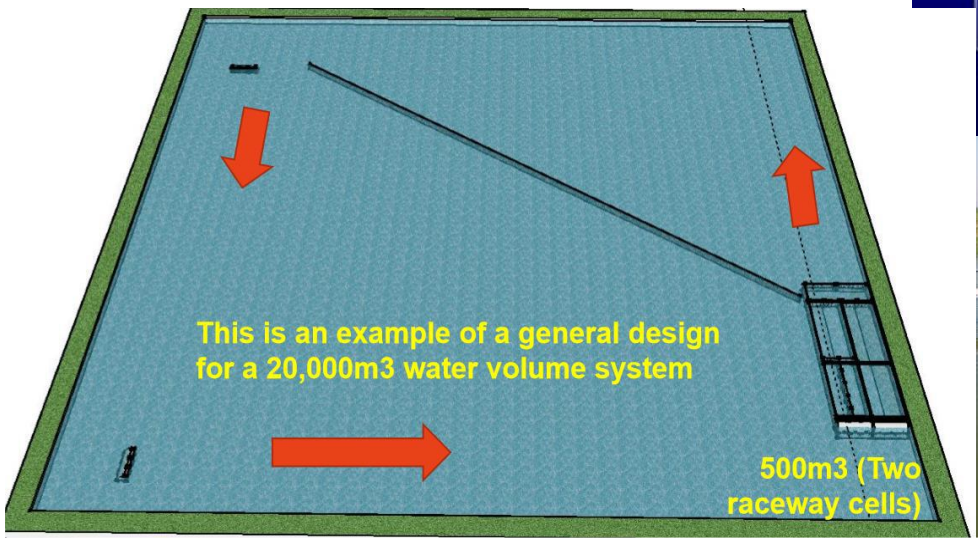
5 g
Phosphate

Types of integrative farming

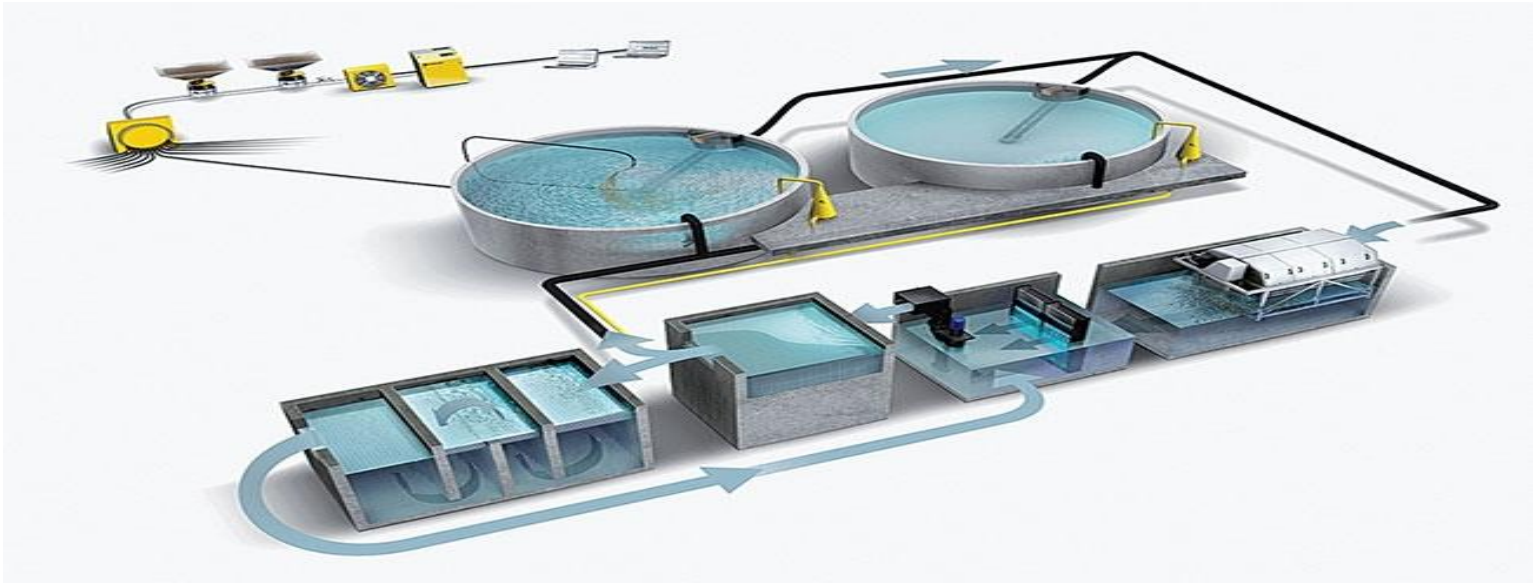
Intra-basin running water system (IBRS).

- Developed at Auburn University
- To grow American catfish
- Grow Grass carp in China
- Fixed system
- Floating system

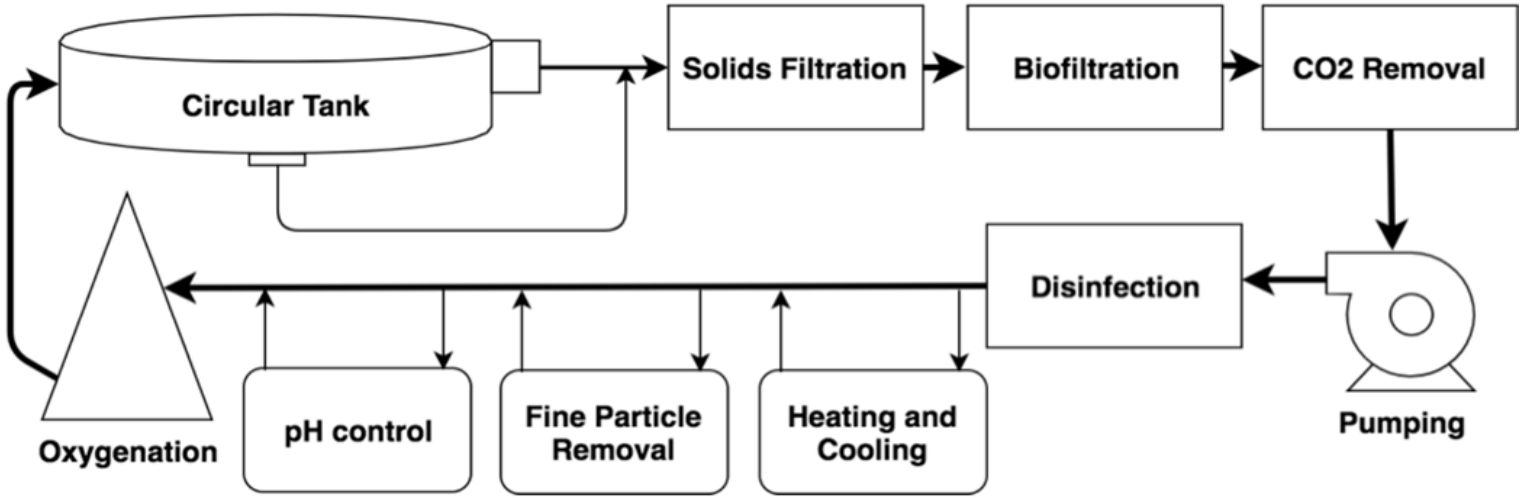




Recirculation systems



RAS system



A flow chart for the various water treatment processes needed in a recirculating aquaculture system, by AndyyParadise, licensed by CC BY-SA 4.0

https://www.youtube.com/results?search_query=recirculating+aquaculture+system

Application and Feasibility

Recirculation systems

Minimum water demand

Reduced water discharges

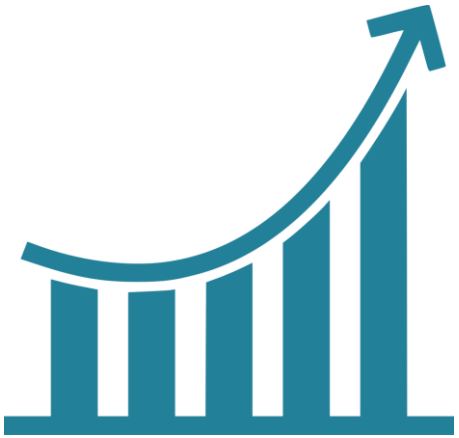
Limited space demand

High capital costs

Exclusion of predators & climatic events

Application and Feasibility

Fish cage systems



Increasing globally

High cost of feeds

Shortage of fish seed

Application and Feasibility

Inshore-nearshore cage farms

Reduce nutrient & organic loading

Contribute to stock enhancement

Long term potential for culture based fisheries

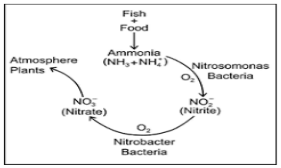
Making better nets

Better knowledge about mortality

Better feeding regimes

Biological filter

NH_3 —(1 ½ O_2, Nitrosomonas)→ NO_2 —(1 ½ O_2, Nitrobacter)→ NO_3



DEFINITIONS

NH_3–N = unionized ammonia nitrogen (ammonia)

NH_4^+–N = ionized ammonia nitrogen (ammonium)

TAN = NH_4^+–N + NH_3–N

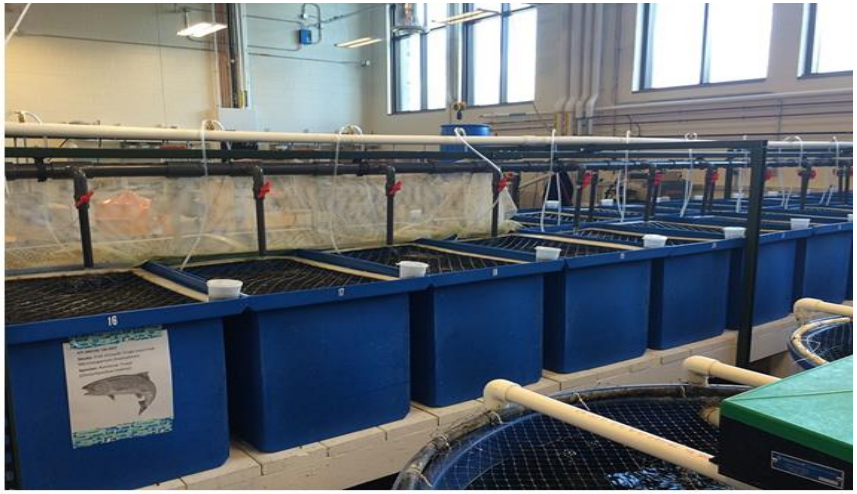
NO_2^-–N = nitrite nitrogen

NO_3^-–N = nitrate nitrogen

Bio-filter. By CARES - AUC

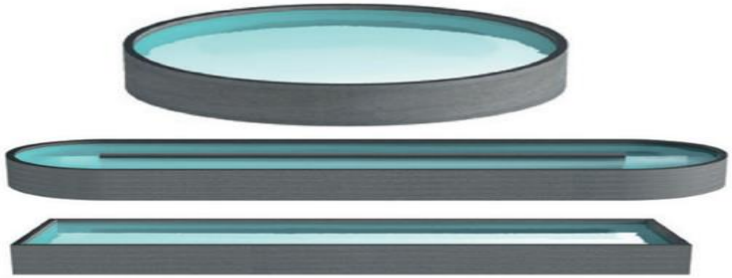
Different MBBR media, by CARES - AUC

Recirculating Aquaculture System, by Narek75, Licensed by CC BY-SA 4.0



Recirculating Aquaculture System, Narek75, licensed by CC BY-SA 4.0

RAS indoor facility located in VSU Randolph Farm, by Narek75, Licensed by CC BY-SA 4.0

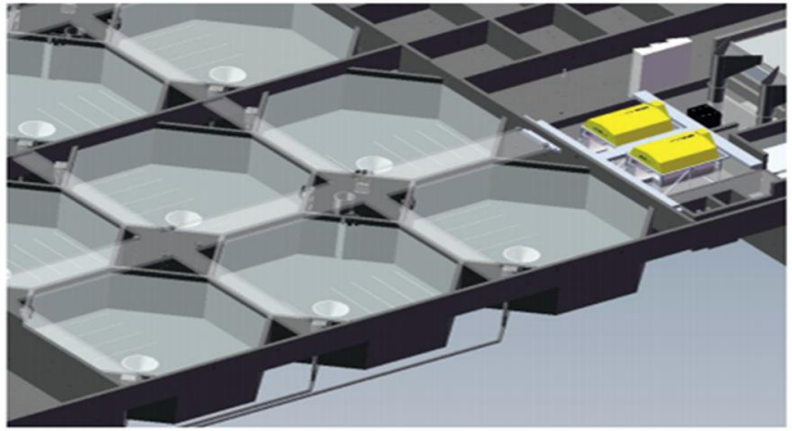


Circular tank, D-ended raceway, and raceway type. From "A guide to Recirculation Aquaculture", by Jacob Bregnballe, FAO & EUROFISH, 2015

https://www.evoqua.com/en-GB/articles/uv-in-recirculating-aquaculture-systems/

Aquaculture pond Water inlet by CARES - AUC

http://photos.prnewswire.com/prnfull/20160928/412741



An example of octagonal tank design in a recirculation system saving space yet achieving the good hydraulic effects of the circular tank. From "A guide to Recirculation Aquaculture", by Jacob Bregnballe, FAO & EUROFISH, 2015

Water Quality

Water Quality Parameters of Interest to Aquaculture Include:

- Salinity
- Dissolved oxygen
- CO_2, pH, alkalinity, hardness
- Dissolved and particulate organic matter
- Total solids, suspended inorganic particles, and turbidity
- Nitrogen
- Phosphorous
- Sediment quality (especially Redox Potential)
- Temperature

Organism type	Temperature (°C)	pH	Ammonia (mg/L)	Nitrite (mg/L)	Nitrate (mg/L)	DO (mg/L)
Warm water fish	22-32	6-8.5	<3	<1	<300	4-6
Cold water fish	10-18	6-8.5	<1	<0.2	<300	6-8
Plants	16-30	5.5-6.5	<30	<1	-	> 3
Bacteria	14-34	6-8.5	<3	<1	-	4-8

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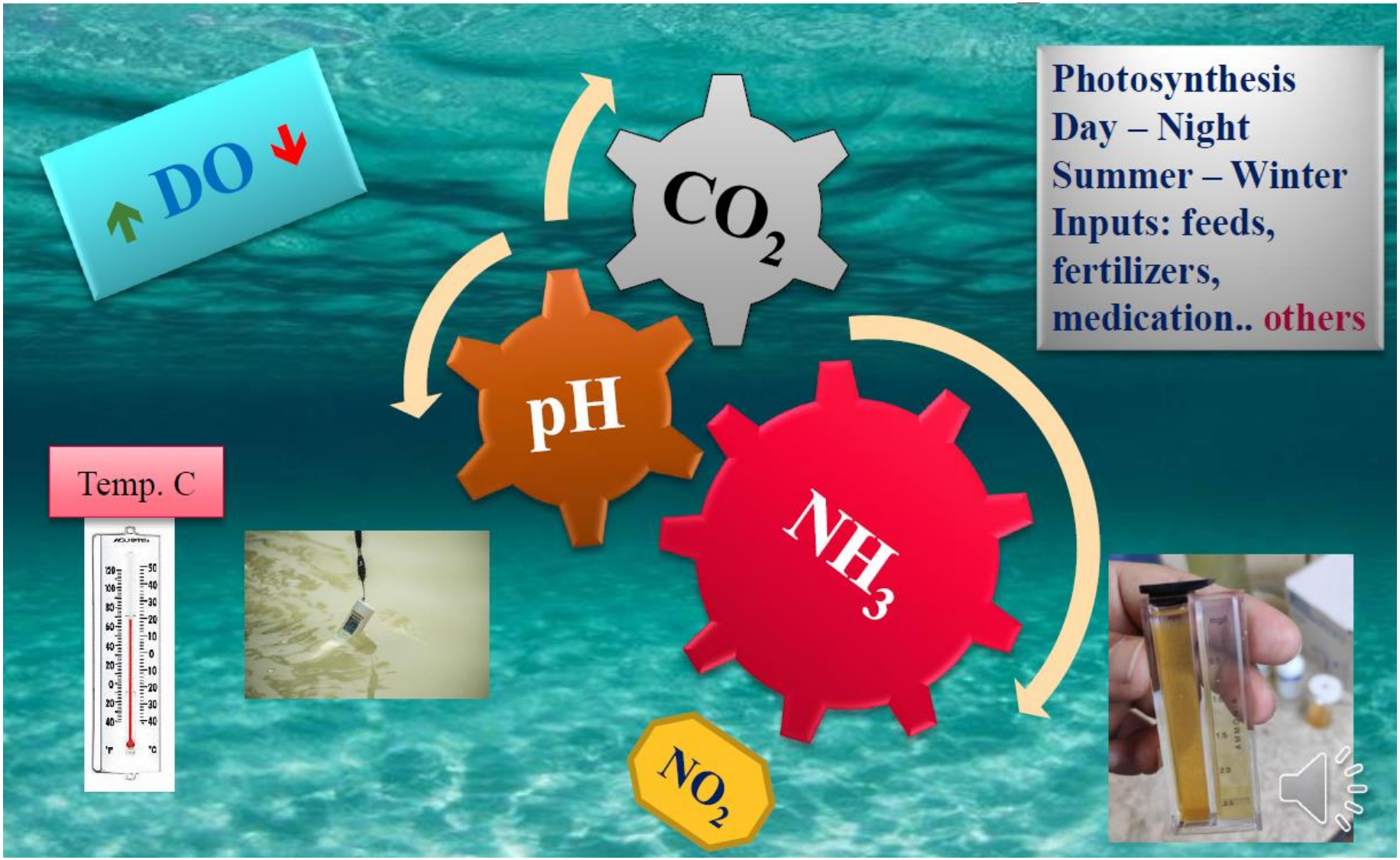

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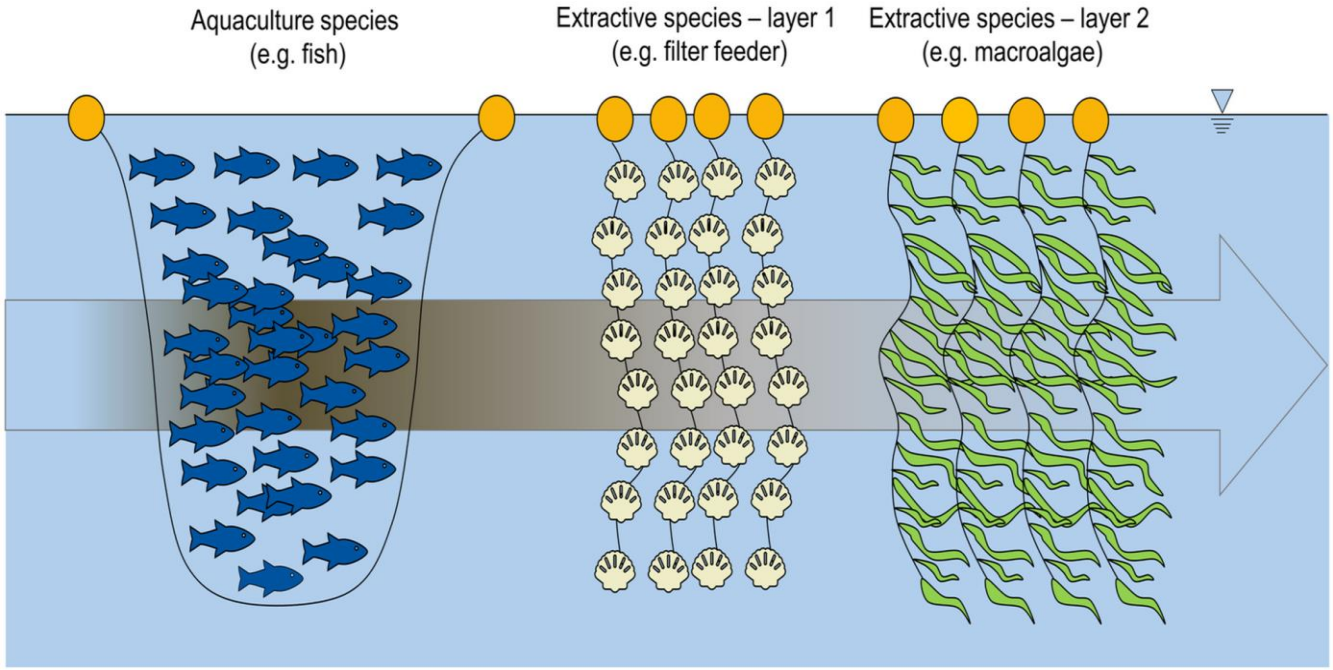
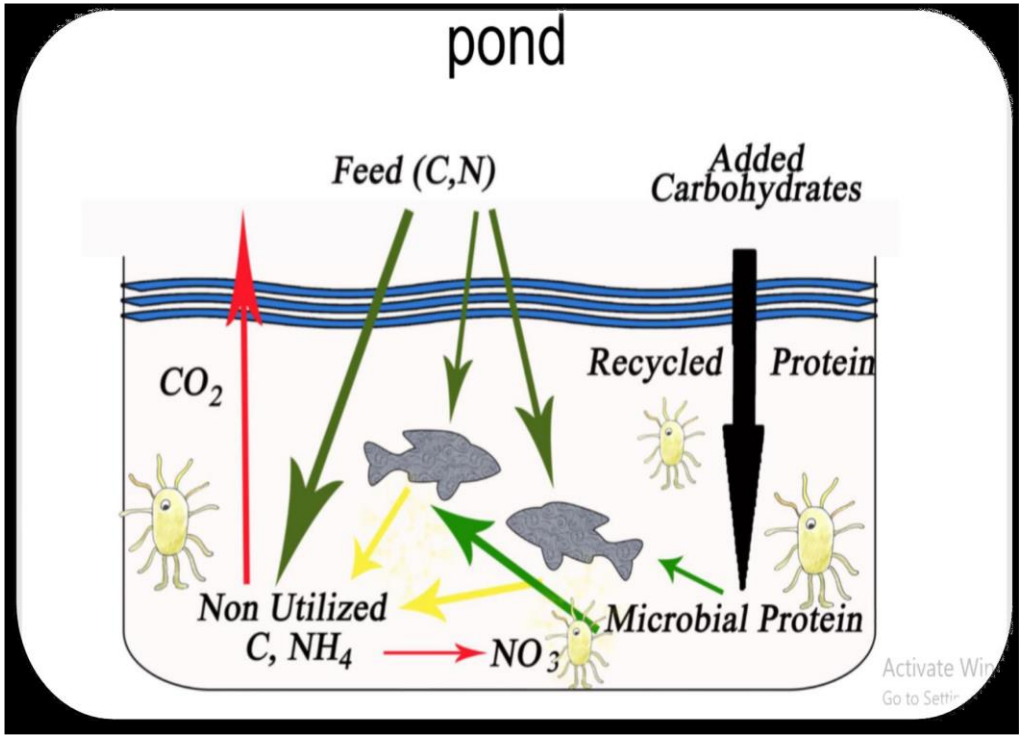
Potential of innovative marine aquaculture techniques to close nutrient cycles



Example of an Integrated Multi-Trophic Aquaculture (IMTA) in the open sea. A fish aquaculture produces waste, which is transported downstream by a current to two extractive species, which clean the nutrient-rich wastewater stream.

Reviews in Aquaculture, First published: 28 December 2022, DOI: (10.1111/raq.12781)

Biofloc


pond
Feed (C,N)
Added Carbohydrates
CO_2
Recycled
Protein
Non Utilized C, NH_4
NO_3
Microbial Protein

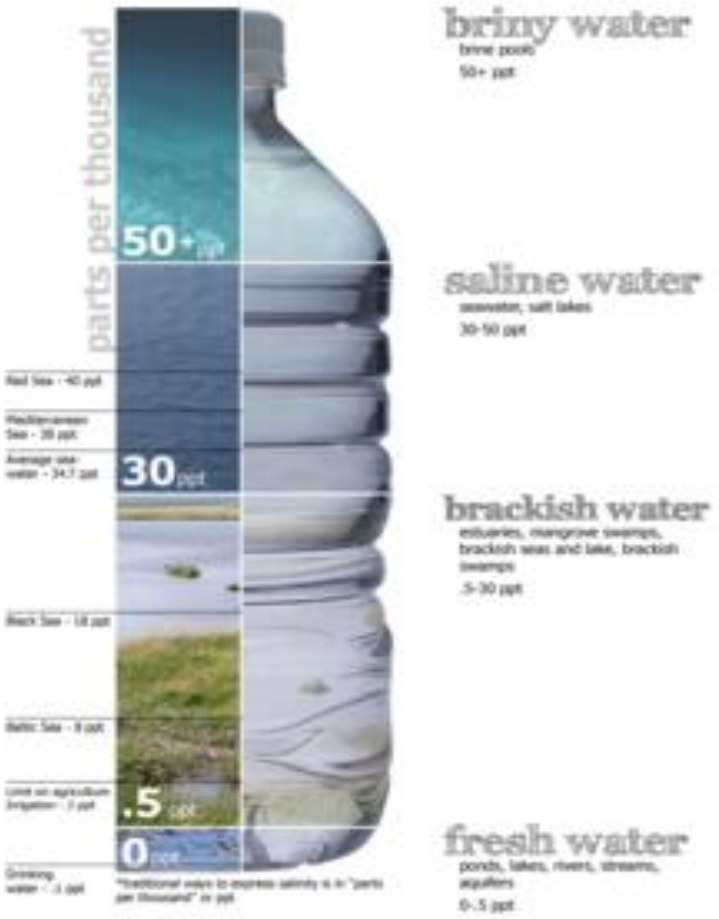
Colombo, S.M., Roy, K., Mraz, J., Wan, A.H., Davies, S.J., Tibbetts, S.M., Øverland, M., Francis, D.S., Rocker, M.M., Gasco, L. and Spencer, E., Towards achieving circularity and sustainability in feeds for farmed blue foods. *Reviews in Aquaculture*. https://onlinelibrary.wiley.com/doi/full/10.1111/raq.12766

Aquatic ecosystem classification (by water salt concentration)

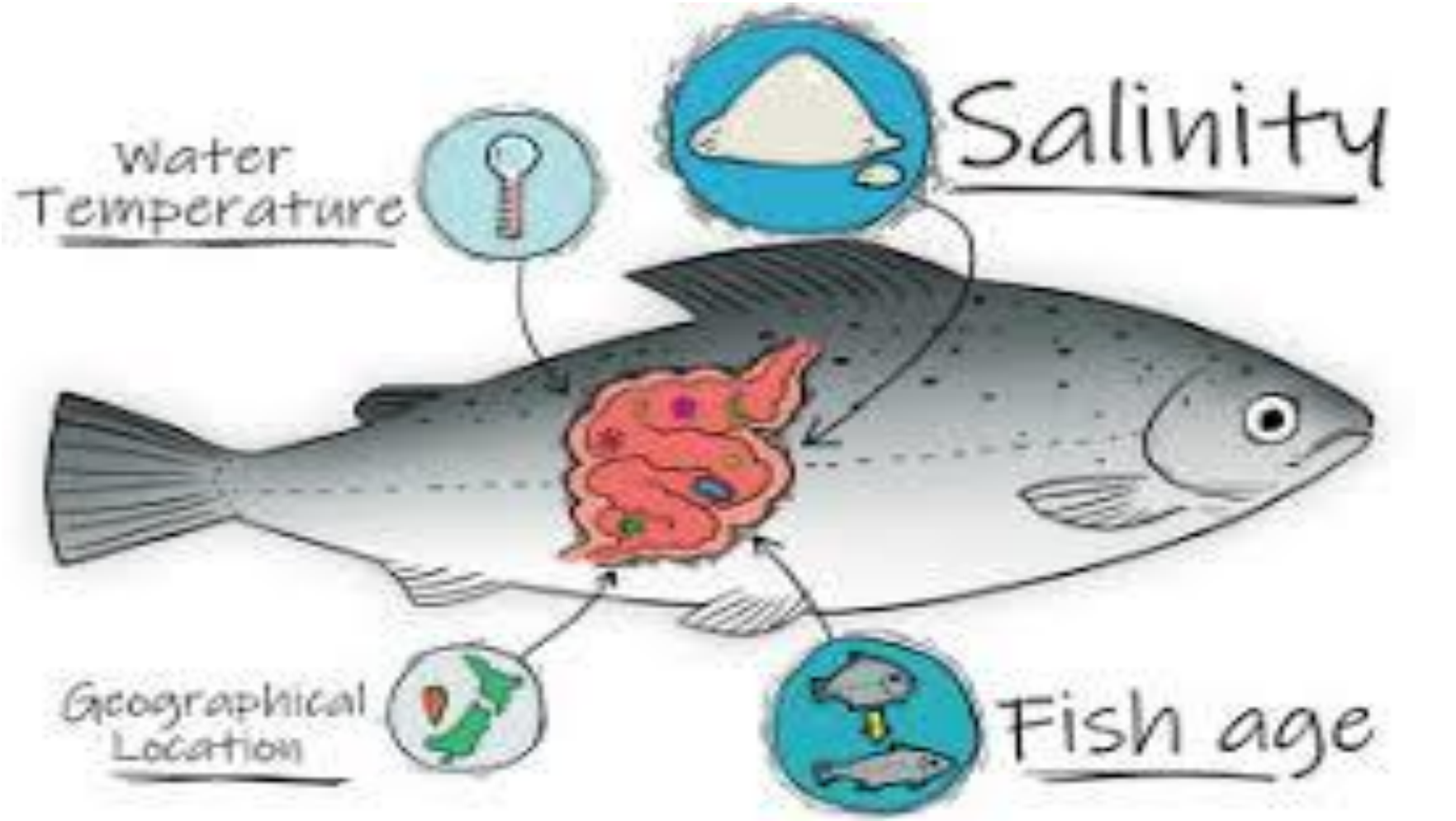
freshwater: < 0.5 mg/L (ppt)

estuarine (brackish) water: ppt

seawater: ppt (average, 35 ppt)



https://slideplayer.com/slide/4214157/


Water Temperature
Salinity
Geographical Location
Fish age

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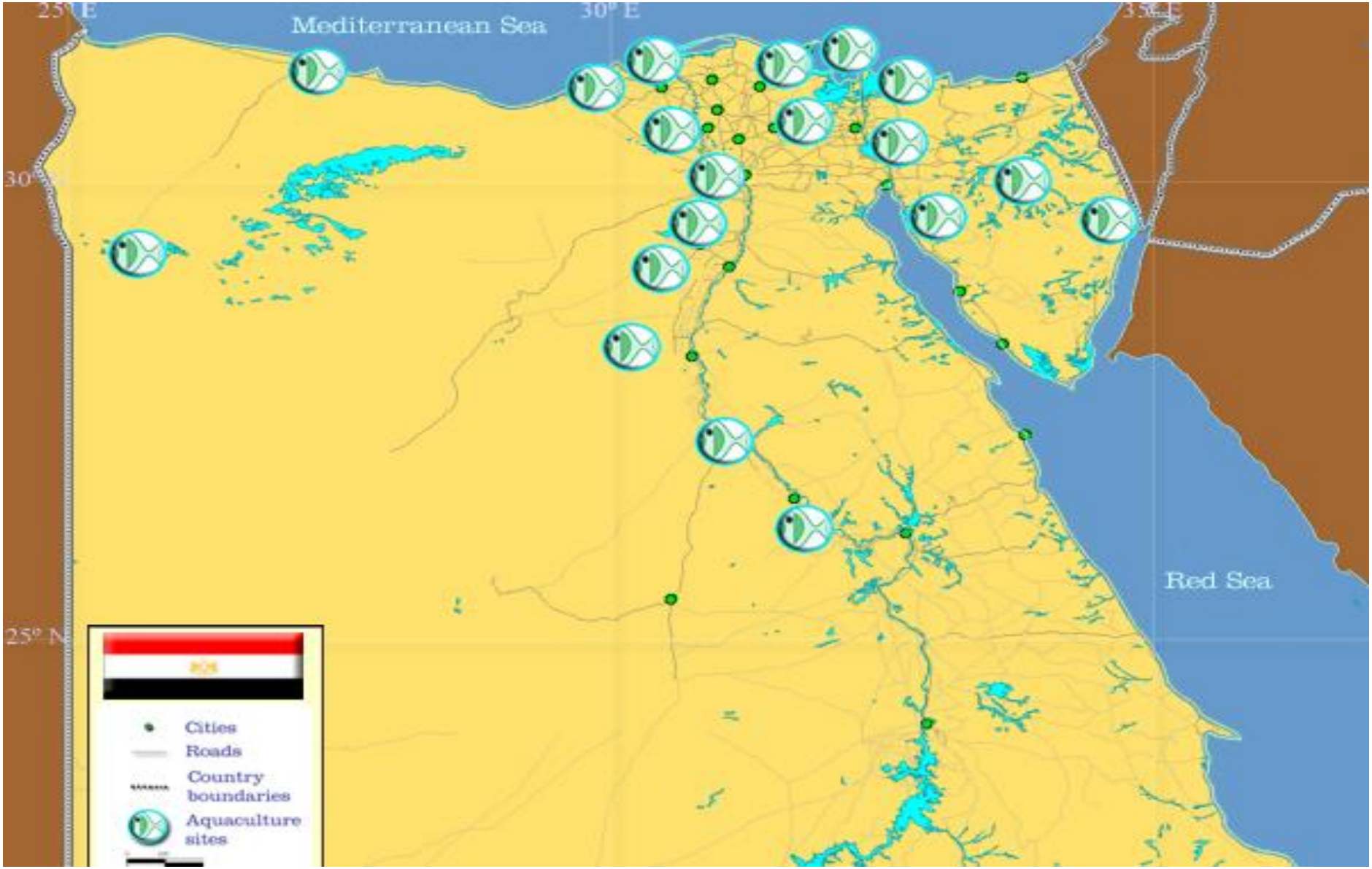


TABLE 5
INLAND WATERS CAPTURE PRODUCTION: MAJOR PRODUCING COUNTRIES

Country	Production (average per year)			Production				Percentage of total, 2018
	1980s	1990s	2000s	2015	2016	2017	2018	
	(million tonnes, live weight)							
Top 25 Inland water capture producers								
China	0.54	1.46	2.11	1.99	2.00	2.18	1.96	16
India	0.50	0.58	0.84	1.35	1.46	1.59	1.70	14
Bangladesh	0.44	0.50	0.86	1.02	1.05	1.16	1.22	10
Myanmar	0.14	0.15	0.48	0.86	0.89	0.89	0.89	7
Cambodia	0.05	0.09	0.34	0.49	0.51	0.53	0.54	4
Indonesia	0.27	0.31	0.31	0.47	0.43	0.43	0.51	4
Uganda	0.19	0.22	0.33	0.40	0.39	0.39	0.44	4
Nigeria	0.10	0.10	0.21	0.34	0.38	0.42	0.39	3
United Republic of Tanzania	0.25	0.29	0.30	0.31	0.31	0.33	0.31	3
Russian Federation	0.09	0.26	0.22	0.29	0.29	0.27	0.27	2
Egypt	0.12	0.23	0.27	0.24	0.23	0.26	0.27	2
Democratic Republic of the Congo	0.13	0.17	0.23	0.23	0.23	0.23	0.23	2
Brazil	0.20	0.18	0.24	0.23	0.22	0.22	0.22	2
Mexico	0.10	0.11	0.11	0.15	0.20	0.17	0.22	2
Malawi	0.07	0.06	0.06	0.14	0.15	0.20	0.22	2
Thailand	0.10	0.18	0.21	0.18	0.19	0.19	0.20	2
Philippines	0.26	0.19	0.15	0.20	0.16	0.16	0.16	1
Viet Nam	0.11	0.14	0.21	0.15	0.15	0.16	0.16	1
Pakistan	0.07	0.13	0.12	0.13	0.14	0.14	0.14	1
Chad	0.05	0.08	0.08	0.10	0.11	0.11	0.11	1
Iran (Islamic Republic of)	0.01	0.09	0.07	0.09	0.09	0.10	0.11	1
Kenya	0.09	0.18	0.14	0.16	0.13	0.10	0.10	1
Mozambique	0.00	0.01	0.02	0.09	0.10	0.10	0.10	1
Mali	0.07	0.09	0.10	0.09	0.10	0.11	0.09	1
Ghana	0.05	0.06	0.08	0.09	0.09	0.09	0.09	1
Top 25 producers	**4.01**	**5.86**	**8.08**	**9.79**	**10.01**	**10.53**	**10.64**	**89**
Total all other producers	**1.69**	**1.19**	**1.19**	**1.36**	**1.36**	**1.37**	**1.38**	**11**
All producers	**5.70**	**7.05**	**9.27**	**11.15**	**11.37**	**11.91**	**12.02**	**100**
Inland water captures, by region								
Asia	2.87	4.17	5.98	7.30	7.44	7.90	7.95	66
Africa	1.47	1.89	2.34	2.84	2.87	3.00	3.00	25
Americas	0.56	0.54	0.58	0.57	0.60	0.58	0.63	5
Europe	0.28	0.43	0.36	0.43	0.44	0.41	0.41	3
Oceania	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0
Others[1]	0.51	–	–	–	–	–	–	0
World total	**5.70**	**7.05**	**9.27**	**11.15**	**11.37**	**11.91**	**12.02**	**100**

[1] Includes the Union of Soviet Socialist Republics.
SOURCE: FAO.

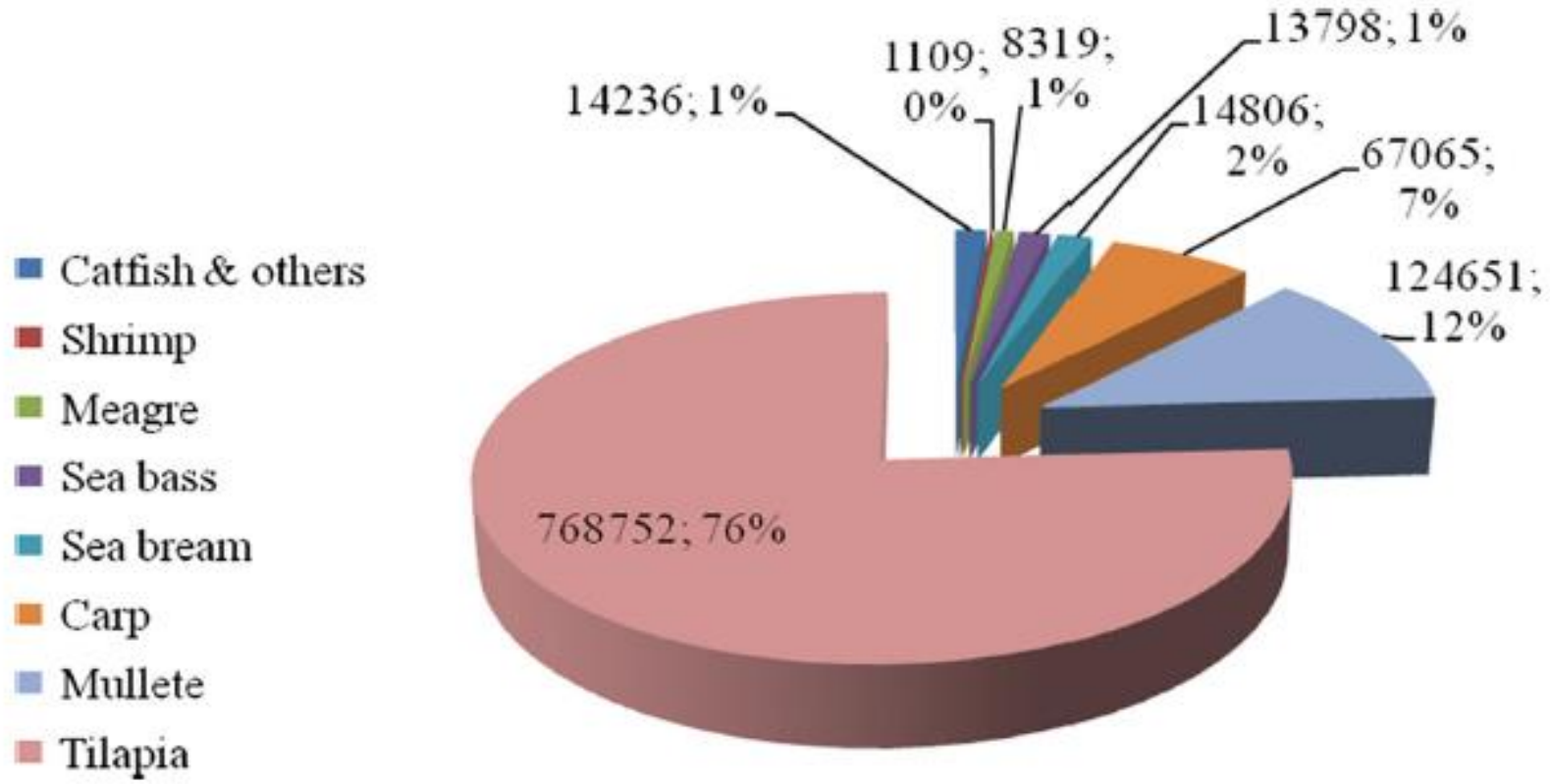
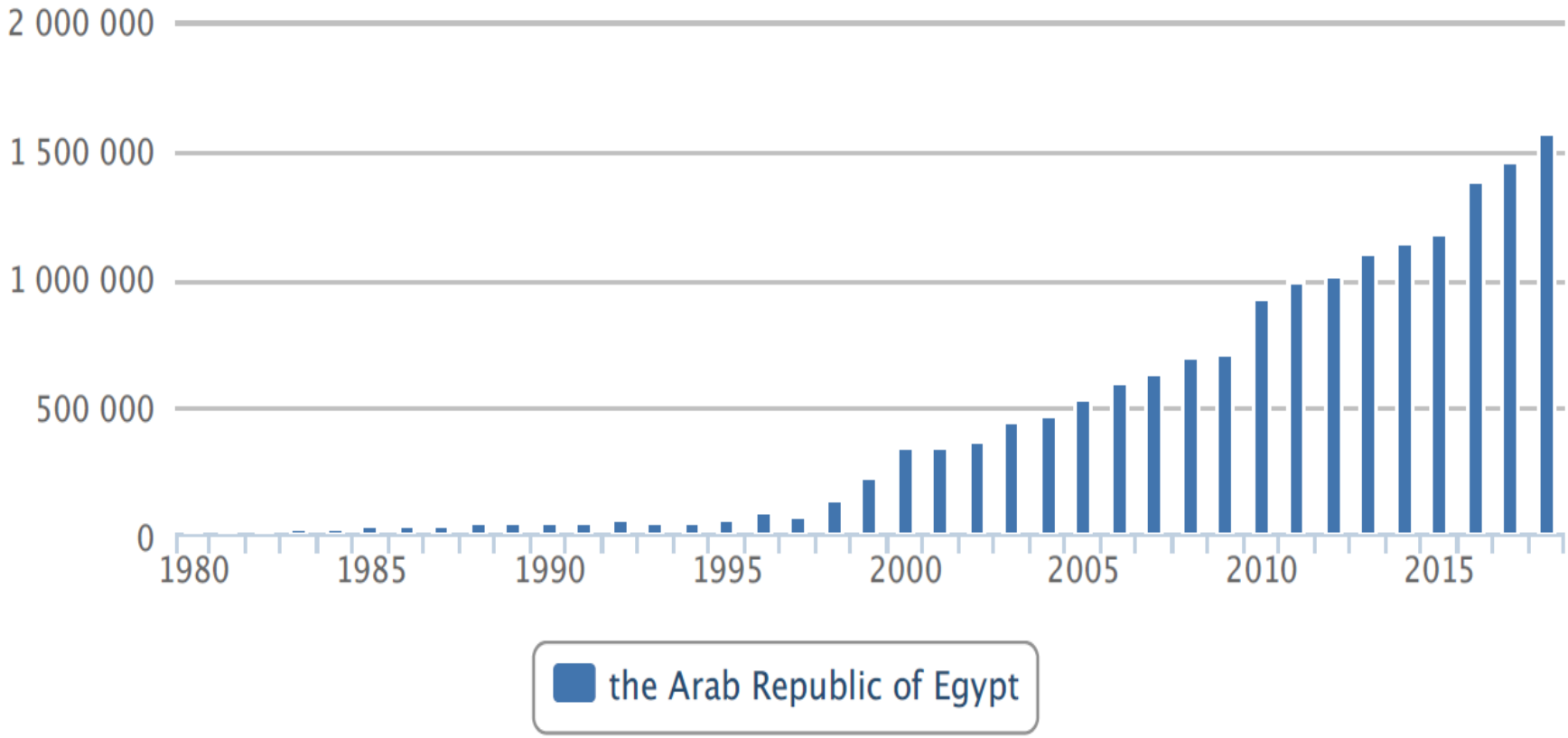


Fig. 2 Features of aquaculture production (GAFRD 2012; CAPMAS 2012)

Table 3 Area and production of private fish farms (temporary) by fish group/MT during 2012

Governorate	Area/ feddan	Production						Total
		Meager	European sea bass	Gilthead seabream	Carp[a]	Mullets nei	Tilapia nei	
Kafr El Shaikh	61,400	–	–	–	19,897	11,940	183,063	214,900
Daqahlia	221	–	–	–	151	34	478	663
Sharkia	25,000	–	–	–	121,813	3866	61,477	77,526
Damietta	35,000	2859	4230	4009	1754	3881	3217	19,950
Port Said	50,000	–	–	–	–	50,410	99,590	150,000
Ismailia	1500	–	–	–	300	1200	1500	3000
Total	173,121	2589	4230	4009	34,285	71,331	349,325	466,039

Total aquaculture production for the Arab Republic of Egypt (tonnes)
Source: FAO FishStat



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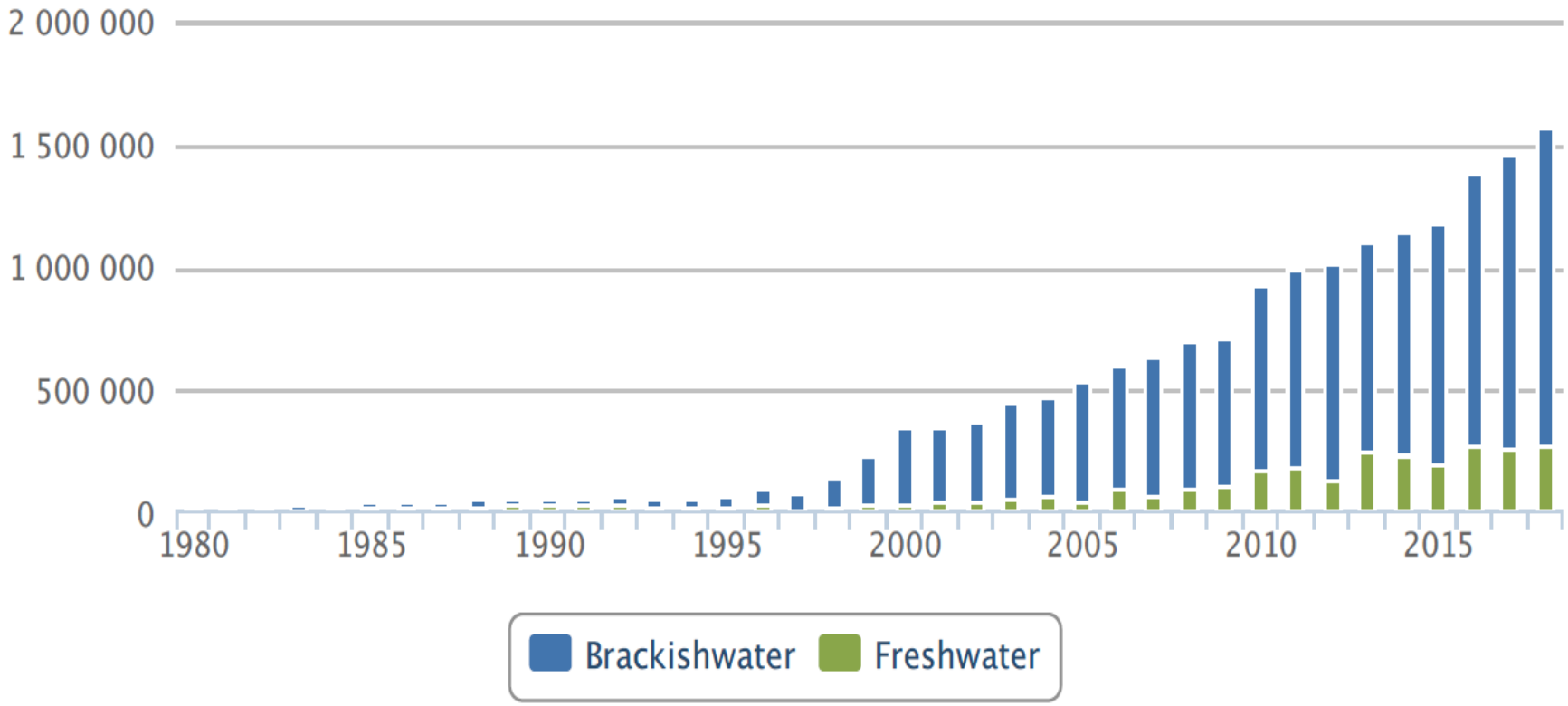
Aquaculture production by culture environment the Arab Republic of Egypt (tonnes)
Source: FAO FishStat



Egypt’s ambition of constructing the largest fish farm in the Middle East is materializing on the international coastal road in the Berket Ghalioun area in the Metoubas locality, in Kafr al-Sheikh.

The National Fish Farming Project is to be built on an area spanning 2,750 feddans, costing LE 1.7 billion.

Egypt’s aqua-cultural production ranks seventh in the world, according to the FAO, and ranks first in Africa in fish production.

In 2016, Egypt produced 1.5 million tons of fish, according to the General Authority for Fish Wealth Development. In the same year, it imported 236,000 tons of fish, worth 16 percent of total fish production.

The project consists of a hatchery for fish and shrimp on an area of 17 feddans with a capacity of 20 million fish and two billion shrimp. On top of this, a marine farm will produce up to 3,000 tons of fish per cycle, a shrimp farm 2,000 tons, and a freshwater fish farm will produce up to fish 2,000 tons per cycle.

The project will also include a research and development center on an area of 700 square meters, a marine fish feed plant on an area of 1,500 square meters with a production capacity of 120,000 tons annually, a shrimp feed plant on an area of 570 meters with an annual production capacity of 60,000 tons, and a foam factory on an area of 1,200 square meters to produce fish and shrimp containers.

Further, an ice factory will be built on an area of 450 meters, with a production capacity of 40 tons of crushed ice each day, and 20 tons of ice blocks for freezing fish and shrimp.

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Dankie Gracias
Спасибо Thank You
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Köszönjük Terima kasih
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Kiitos Täname teid 谢谢
شكراً Tak
感謝您 Obrigado Teşekkür Ederiz
Σας Ευχαριστούμ 감사합니다
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Bedankt Děkujeme vám
ありがとうございます
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