

# Can tuna farming be sustainable ?

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# Tuna in the oceans

- There are 15 tuna species across five genera inhabiting Indian, Pacific and Atlantic Oceans, and the Mediterranean Sea; within these there are more sub-species. All belong to the Scombrida family.....
- There are 23 stocks of major commercial tuna species: 5 skipjack, 4 yellowfin,, 6 albacore, 4 bigeye stock, and 4 bluefin tuna stock
- Out of all types of tuna in the sea 5 are most popular (Skipjack, Albacore, Yellowfin, Bigeye and **Bluefin\_tuna**)
- Poor management with a lot of political governed decision is a major problem to tuna stocks; one-thirds of all types of tuna are fished at biologically unsustainable levels (FAO, 2020)



# Tuna market

- Japan has always been the primary market destination of cultured bluefin tuna
- About 80 to 85 percent of sashimi – grade bft (whether it's Atlantic, Pacific or Southern) goes to Japan
- **Concerns about sustainability- capture based aquaculture;**
  - the use of **wild caught fish** for aquaculture has been repeatedly questioned (*Metian et al., 2014*)\*
  - catching **wild juveniles** and raising them 18+ months to market size (**farming**) as to maximize commercial returns from the limited quota available (impact tuna population!)
  - **fattening** of larger size wild caught tuna 6+ months aiming to increase the fat content of their muscle desired by sushimi consumers, and supplying market at times when market bring optimal prices (*Miyake et al., 2010*)\*\*



Sources: \*Metian, M., Pouil, S., Boustany, A., & Troell, M. (2014). Farming of Bluefin tuna—reconsidering global estimates and sustainability concerns. *Reviews in Fisheries Science & Aquaculture*, 22(3), 184-192.

\*\*Miyake et al. 2010. Recent development in the tuna industry. FAO Fisheries and Aquaculture Technical Paper. No. 543. Rome, FAO. 2010. 125p.

# Tuna – Other markets

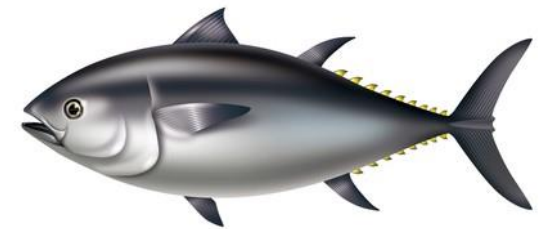
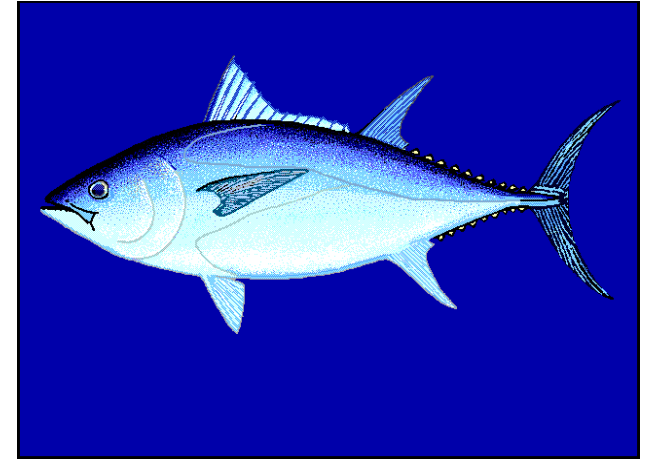
- The final bluefin tuna products (mainly as sushi and sashimi) continue to show a positive trend in consumption in Southeast Asia\*, and the United States of America
- Most appreciated seafood item in the EU with 3.14 kg consumed per capita/year
- The **global tuna market** reached US\$ 42.2 Billion in 2022. The market is expected to reach US\$ 50.2 Billion by 2028.
- Prices depending on the quality of the individual fish specimen.
- **Market is based on unsustainable catches**
- **Capture based aquaculture has developed significantly**



*\*China has shifted from being a net exporter to that of net importer of seafood! procts*

# Bluefin – the most prized tuna

- Three species of bluefin tunas (bft) – Atlantic, *Thunnus thynnus*; Pacific, *T. orientalis*; Southern, *T. macoyii* are farmed in floating sea cages in the Mediterranean, Mexico and Japan, and Australia
- Bluefin tuna is regarded as the best and most expensive because of their taste, fat, and the protein balance
- Atlantic bluefin tuna is the largest, 4+ m in length and up to 700 kg in weight, and it is believed to live up to 40 years; tuna with the greatest commercial interest, inhabiting W and E Atlantic, and Mediterranean; they carry out trans-oceanic migrations for feeding and reproduction
- **Purse seine (large nets) is most used capture system**
- **Number of tuna harvested is regulated by quotas**

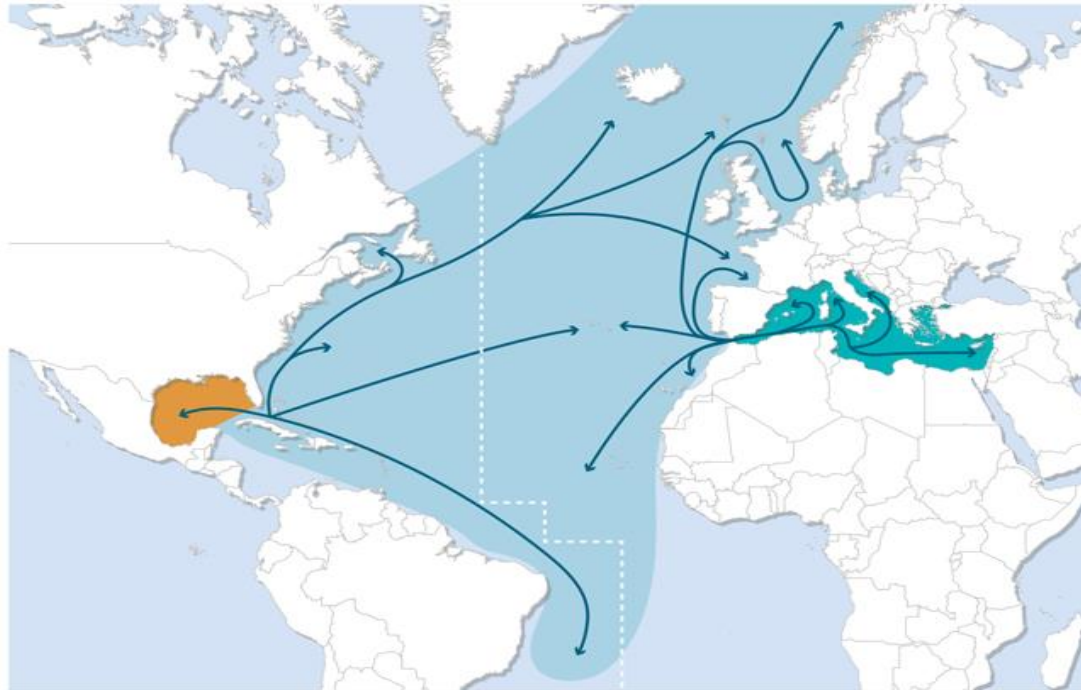


# Atlantic Bluefin Tuna – two populations

Figure 1

At Least 2 Populations of Atlantic Bluefin Tuna: Highly Migratory and Highly Mixed

Western and eastern bluefin mix to feed but separate to breed



Two populations of bluefin—western and eastern—crisscross the Atlantic to feed and return home to spawn.

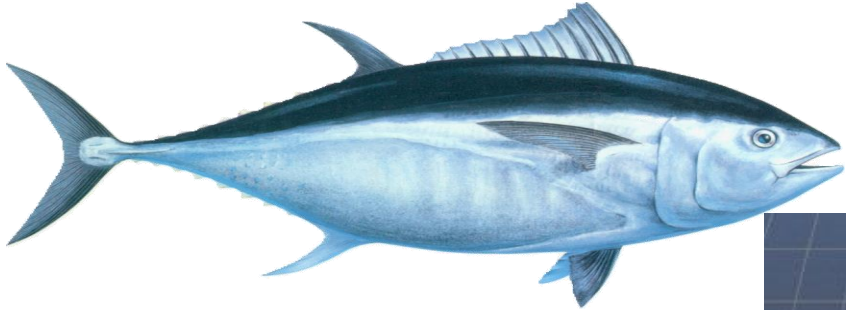
■ Atlantic bluefin historic range    ■ Main western spawning area    ■ Main eastern spawning area  
-- East-west management boundary    — Migration routes

Source: Jean-Marc Fromentin and Joseph E. Powers, "Atlantic Bluefin Tuna: Population Dynamics, Ecology, Fisheries and Management," *Fish and Fisheries* 6 (2005): 281-306

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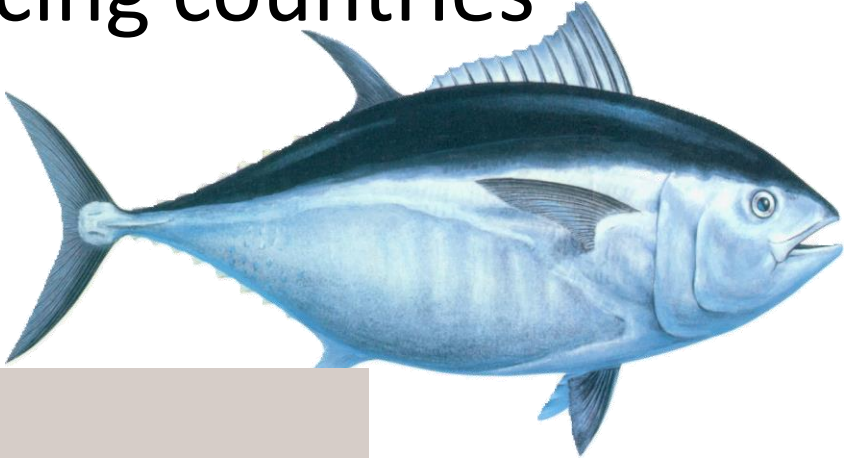
- Sexual maturity of Western-bft tuna is reached at the age of 5-8 years, while Eastern bft maturity is reached at 3-4 years
- Bft may release from 5 to 30 million eggs spawning occurs close to surface, from May to August
- Hatched larvae are 3mm, grow at the rate of 1 mm per day

# Aquaculture practices and producing countries



**Fattening:** 4 to 6 months

+25% to 50%



**Farming:** 18 to 30 months (Croatia\*)

400% to 700%



\*Signiificant success un raising bluefin tuna juveniles in Croatia has advanced knowledge in tuna farming technology

# Bluefin tuna aquaculture

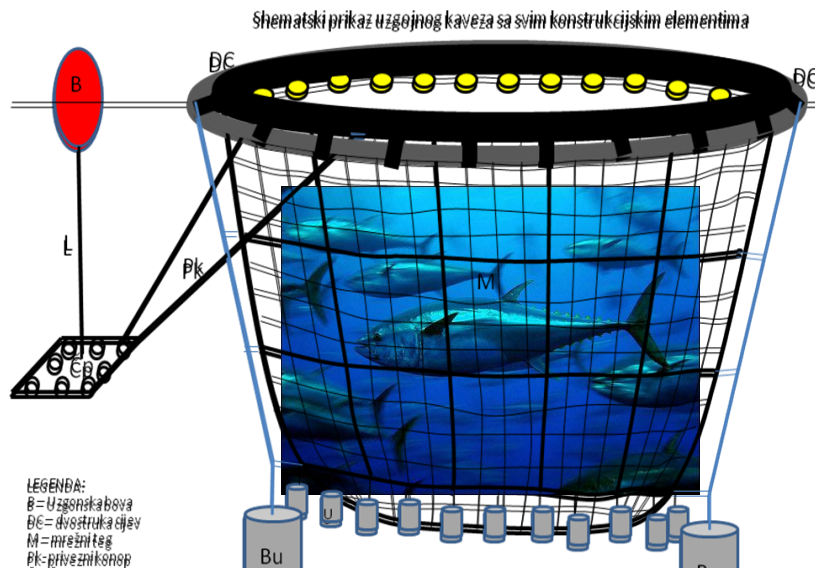
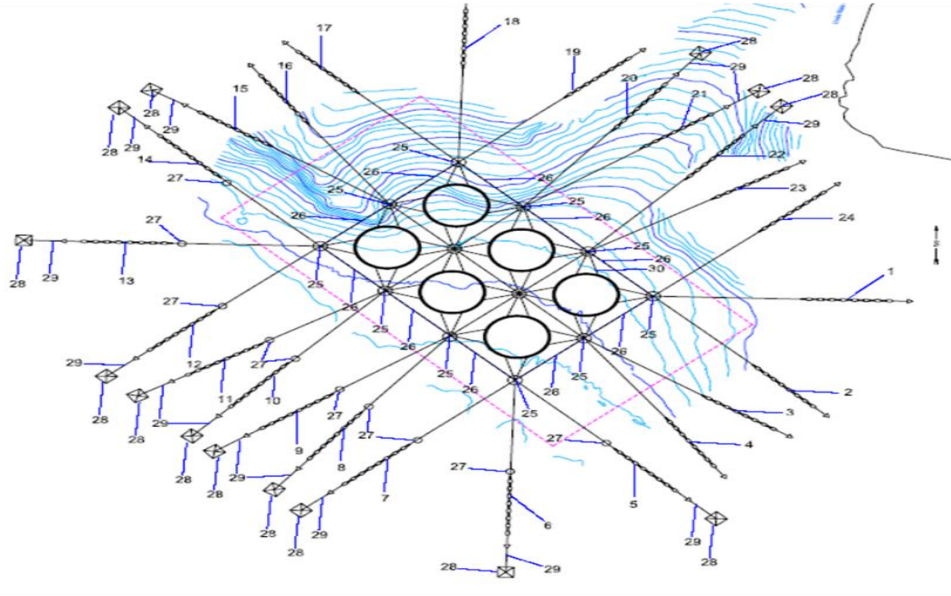
- Tuna aquaculture is not driven by food demands but by its economic benefits
- Circular floating net cages 30-80m in diameter with net depths ranging from 15-30m
- Mixed diet composed of variety of small pelagic fish; overfeeding is a common practice
- To much criticism regarding farmed tuna FIFO\* (Fish In-Fish Out)
  - 15 to 20 weight units of wild (defrosted) fish for one weight unit of cultured large fish, and 10 – 15:1 for smaller fish; so bft aquaculture is thus a net consumer of marine protein

\*Efficiency at which aquaculture converts unit of wild fish into a unit of cultured fish

Tacon, A.G.J. and M. Metian, 2008. Global overview on the use of fish meal and fish oil in industrial compounded aquafeeds. Trends and future prospects. *Aquaculture* 285:146-158.



# Tuna aquaculture technology



# Tuna aquaculture – impact on marine ecosystem

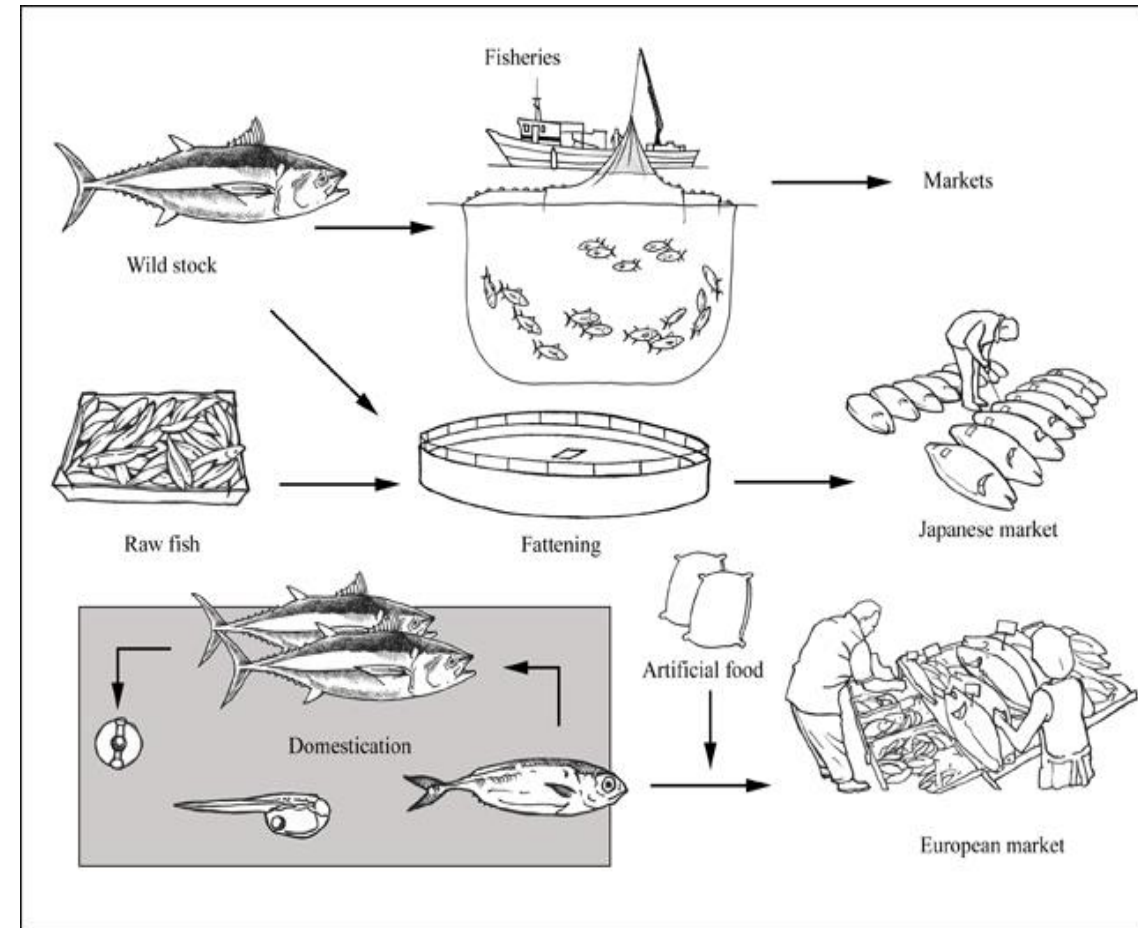
- Feeding tuna with baitfish - a significant depletion of the **pelagic stocks**
- Capture based tuna aquaculture has been contributing to an **overexploitation of the natural tuna populations;**
- Overfishing of small pelagic fishes as feed with high FC rates and related farm management problems (purchasing, transporting, storage,, and distribution of baitfish)
- **Introduction of potential pathogens with imported forage fish combined with overfishing of small pelagic populations may impact the entire marine ecosystem**
- Accumulation of uneaten feed –fish on the seabed
- Visible impact on bottom habitat in the vicinity of tuna cages\*; sediment organic carbon and nitrogen at distance 200m, and significant increase of sediment organic nitrogen 1.5 km away...



Mangion et al., 2013. Influence of tuna penning activities on soft bottom macrobenthic assemblages. Marine Pollution Bulletin, 70(1-2):164-174 <https://doi.org/10.1016/j.marpolbul.2013.12.021>

# Tuna aquaculture - current state

- This, economically viable business is often regarded as „environmentally inefficient“
- Since the mid 1990s, the expansion of tuna farming in the Mediterranean Sea has been accompanied by wide spread concerns about the environmental impact
- Tuna aquaculture have to undergo technological adaptation to reduce FCR ratio by using alternative feed ingredients in the diet (plant based protein, fish and animal by products (by at least 50 percent)
- There is general agreement that the future of bluefin tuna aquaculture will be directed by two vectors: (1) on the controlled production of fingerlings, and (2) the substitution of baitfish with artificial diet



Sources: \* Duarte CM, Holmer M, Olsen Y, Soto D and others (2009). Will the oceans help feed humanity? Bioscience 59:967–976

Figure: Production Cycle of *Tunnus thynnus*. FAO 2023. *Thunnus thynnus*. Cultured Aquatic Species Information Programme. Text by De la Gándara, F.. Fisheries and Aquaculture Division [online]. Rome.

# Foreseeable future

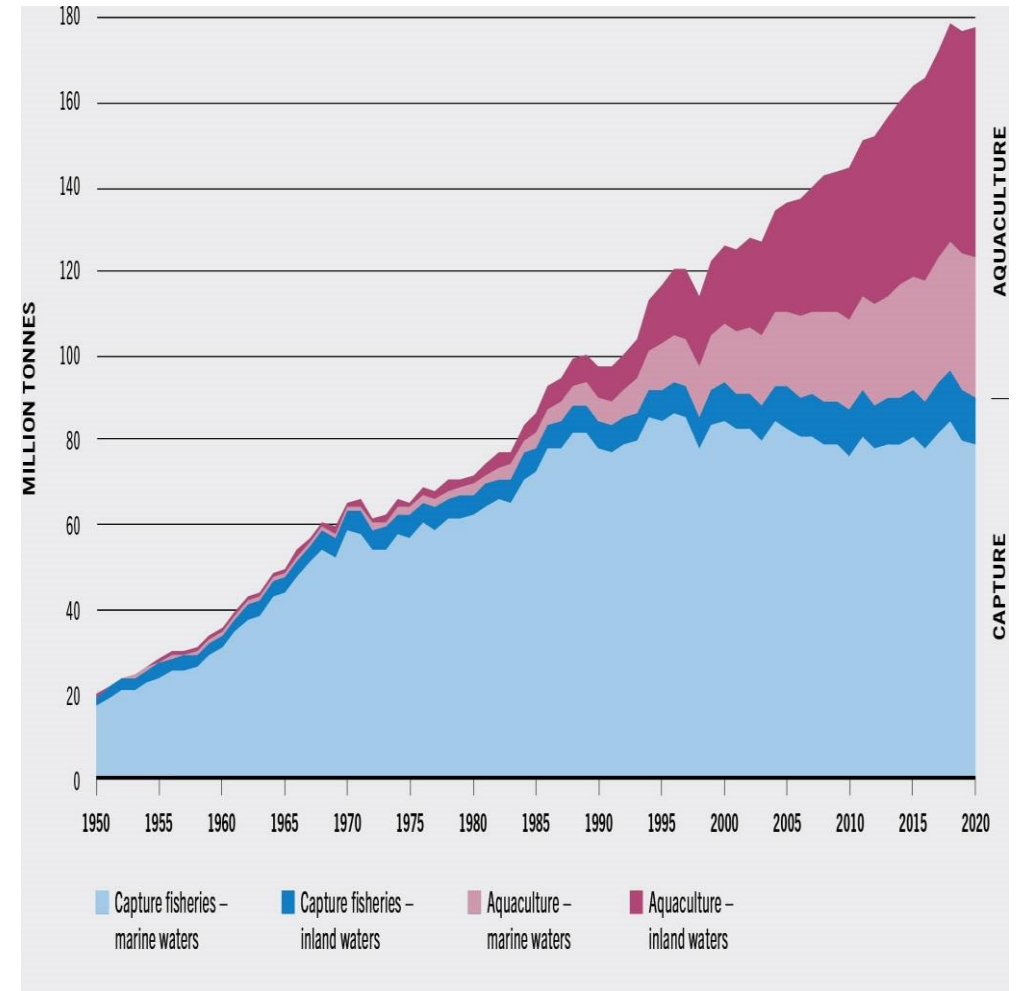
- Capture fisheries production is stagnating, and not expected to increase
- Marine aquaculture is expected to expand, thus an increased pressure on wild stock continue
- Most of the principal pelagic stocks are overfished, and currently subjected to an Ecosystem-based Management as to ensure sustainability in the future managed using
- Mediterranean catch is declining; European pilchard continue to be fished outside biologically sustainable limits\*
- Small pelagic would be best used for direct human consumption rather than fish feed
- The challenge for industry will be to decrease its reliance on wild fish as feed\*\*
- Aquaculture should reduce its fishmeal and oil use to lessen its dependency on small wild fish important to the integrity of marine food webs and food security for the poor in many coastal areas
- Fishmeal and fish oil shortages for use in aquaculture feed will result in a limit on production in the future if goals to lessen their use in feeds are not met\*\*

Sources:

\*FAO. 2022. *Blue Transformation - Roadmap 2022–2030: A vision for FAO's work on aquatic food systems*. Rome. <https://doi.org/10.4060/cc0459en>;

FAO. 2021. *GFCM 2030 Strategy for sustainable fisheries and aquaculture in the Mediterranean and the Black Sea*. Rome

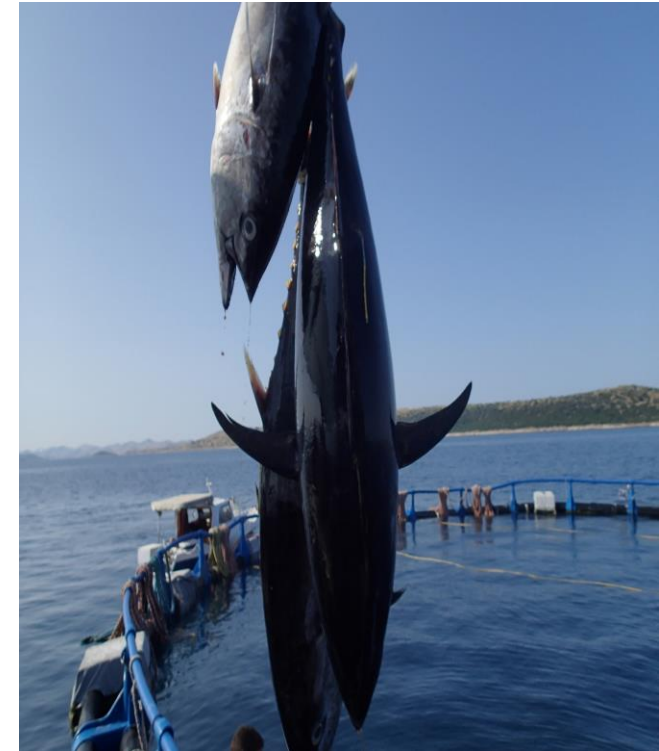
\*\*Smith A.D.M. et al. 2011. *Impact of fishing low-trophic level species on marine ecosystems*. *Science* 333:1147-1150



Note: Excluding algae, aquatic mammals crocodiles, alligators, Caimans, (FAO 2022)

# Fully farmed tuna - an important concept in today's food supply chains

- As of 2018. Japan has imposed restriction on any further expansion of tuna farming using wild juveniles; opportunities for fully farmed tuna!
- After first success reported by Kinki University (now Kindai) in 2002, and first sales in 2004th thanks to improved survival rate, improved growth rates and disease resistance artificially produced juveniles enabled a real tuna aquaculture
- Japanese technology use marker-assisted breeding programs based on genomic and mitochondrial DNA analysis conducted on carefully selected breeders held in floating cages; to overcome problem of fat content during maturation triploidy is induced \*
- Several companies including Maruha Nichiro, Kyokuyo, and Feed One targeting market of Asia and Europe
- Fully farmed tuna in Japan is around 15% higher than regular farmed wild tuna
- Combining artificial hatching with the use of artificial complete diet create a more sustainable tuna aquaculture\*\*



ASC\*\* (Aquaculture Stewardship Council) certified tuna is expected soon (no certified tuna yet!)

\*Sawada, Y. and Agawa, 2016. Genetics in Tuna Aquaculture. In: Advances in Tuna Aquaculturee-From Hatchery to Market. Academic Press, p. 323-332

\*\*Certifying environmentally and socially responsible seafood

# Manufactured feed – the requirements

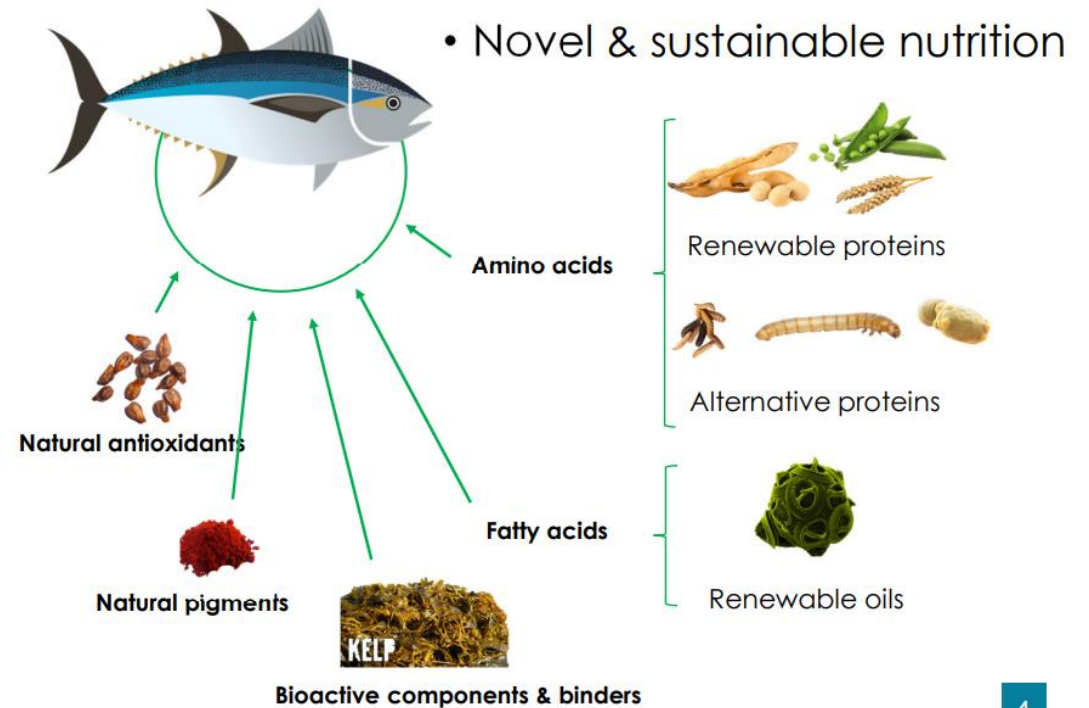
- Semi-moist pellets should be readily accepted
- Easy to store
- Easy to handle
- Stable in water
- Flexible in terms of ingredient composition
- Efficiently digested
- Cost effective



Photo: Courtesy A. Buentello

# FEEDING TUNA AS A CARNIVOROUS FISH - SUSTAINABLY

- Artificial complete diet has been developed to feed farmed tuna not only in Japan, but Australia, USA, EU
- Manufactured diet made from sustainable, renewable ingredients reduces the amount of fish meal and fish oil in feed by tenfold
- Range of plant sources, animal and fish by-product and microbial products were tested with an increasing success
- Anti-nutritional factors in plant products may be inactivated and protein content enhanced
- Tuna has the enzyme machinery necessary for the endogenous production (biosynthesis) of PUFA\*
- The nutritionally dense soy-based diet improves feed conversion rates (4:1), survival rates improved, reduces waste and improves meat quality
- Successful plant-based feeding demonstration by Sustainable Kinetics (a commercial branch of IU/USA) in Spain and Malta have farmers to consider the adoption of sustainable tuna feed



\*Betancor, M.B. et al. 2020. Molecular and functional characterization of a putative *elov14* gene and its expression in response to dietary fatty acid profile in Atlantic bluefin tuna *Thunnus thynnus*). *Comp. Biochem. Physiol., Part B. Biochem. Mol. Biol* 240. Art. No:110372gh

# Hatch to harvest - sustainable tuna farming

- Both Europe and USA has benefited from Japanese experiences in successful tuna propagation
- Aiming to domesticate these species several EU funded projects were performed ([DOTT](#), [REPRODOT](#), [SELFDOTT](#))
- To demonstrate the feasibility of the reproduction of bluefin tuna in captivity [Spanish IEO](#) developed land based an infrastructure for controlling the reproduction of the bluefin tuna
- EU co-funded company [NEXT Tuna](#) to provide sustainable source of tuna juveniles
- [Ichthus Unlimited \(IU\)](#) set up the first bluefin tuna hatchery in San Diego area, North America, and the third in the world





# Instead conclusion

With more than **2000 years of farming**, aquaculture become an important industry in global protein supply

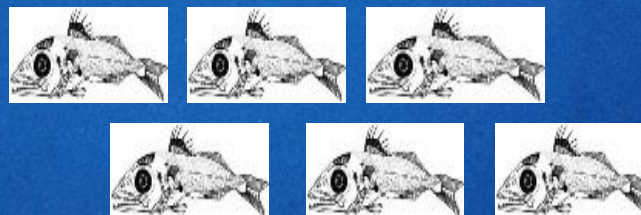
**600** aquaculture species were recorded (FAO, 2020), but **12 provided 87%** of total world production

It is believed that full success of further aquaculture development will be **species dependent**

Tuna farming industry has made significant biological and technical advances in recent years, but is still **strongly dependent on catches** as a source of livestock

**Tuna aquaculture** have to undergo technological adaptation if an economically viable business will be regarded sustainable and enviromnetally efficient





Thank you