Manual for marine IMTA production, health, biosecurity and welfare.

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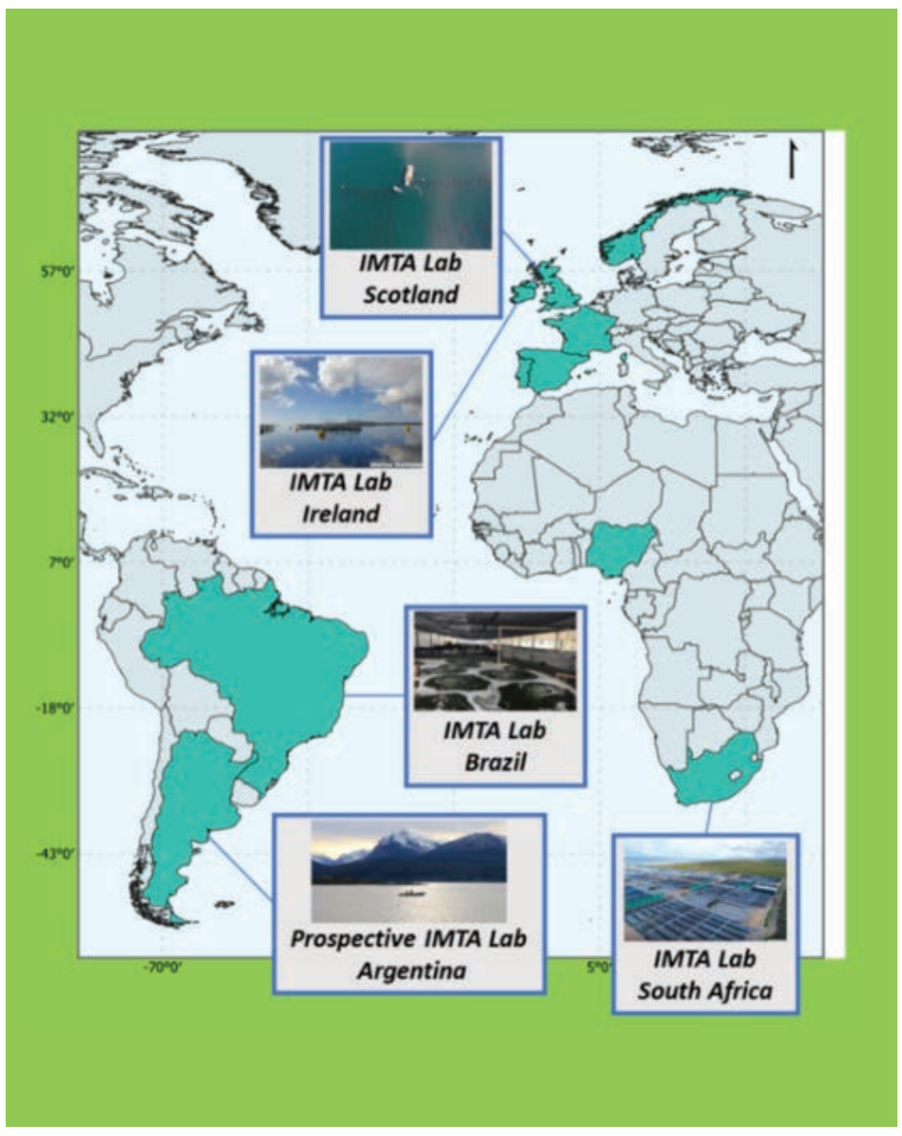

IMTA is defined as the farming of aquaculture species from different trophic levels, and with complementary ecosystem functions in the same area or at the same site. This type of integrated culturing allows one species' uneaten feed, waste, and nutrients to be recaptured and converted into fertilizer and feed for the other aquaculture species. The combination of fed aquaculture species (e.g., finfish or shrimp) with extractive aquaculture species, which utilizes the dissolved inorganic nutrients (e.g. seaweeds) and suspended particulate organic nutrients (e.g. suspension and deposit-feeders such as bivalves, urchins, sea cucumber) enhance growth in this type of system. IMTA aims to aid ecological balanced systems to improve environmental sustainability, enhance ecosystem services, boost economic stability by increasing biomass, lowering costs, providing product diversification, reducing risk, and creating jobs in rural communities while advancing societal acceptability.[1]

ASTRAL gathered four IMTA 'labs' including open-water (Ireland and Scotland), land-based pump-ashore with partial (50 %) recirculation (South Africa) and recirculation 'biofloc' land-based (Brazil) systems and one prospective IMTA lab (Argentina), focusing on a regional challenge-based perspective, including fish, mollusc, echinoderm, crustacean and algae species.

Three ASTRAL production manuals have been created that detail the cultivation techniques for each of the species trialled during ASTRAL. The Three IMTA systems described include an open-water IMTA system, a land-based pump ashore system and a RAS Biofloc system. The ASTRAL species included fed and extractive species of fish, seaweeds, molluscs, echinoderms and crustaceans.

[1] Chopin, T. (2013). Aquaculture, Integrated Multi-trophic (IMTA). In: Christou, P., Savin, R., Costa-Pierce, B.A., Misztal, I., Whitelaw, C.B.A. (eds) Sustainable Food Production. Springer, New York, NY. https://doi.org/10.1007/978-1-4614-5797-8_173

1. Open Water IMTA

Open water IMTA, as carried out in the ASTRAL project in IMTA lab Ireland and IMTA lab Scotland, refers to species production at sea with mooring structures in place to anchor the growing structures to the seabed. This type of system is continuously exposed to the environmental conditions including wind and wave action.

Species cultivated: Atlantic salmon *(Salmo salar)*, Cleaner fish *(lumpfish Cyclopterus lumpus, Ballan wrasse Labrus bergylta)* Atlantic wakame *(Alaria esculenta)*, sugar kelp *(Saccharina latissimia)*, oarweed *(Laminaria digitata)*, furbelows *(Sacchoriza polyschides)*, King scallop *(Pecten maximus)*, native oyster *(Ostrea edulis)*, European lobster *(Homarus gammarus)*, spiny sea urchin *(Paracentrotus lividus)*, sea cucumber *(Holothuria forsakli)*.

2. Land-Based IMTA

Land-based IMTA carried out in the ASTRAL project refers to species production in either recirculating inshore biofloc systems or land-based pump ashore systems with partial water recirculation. Recirculation of water enables more control of certain physical and chemical parameters in production systems, including temperature, dissolved oxygen, pH, and nutrients, with the level of independence from the ambient environment dependent on the extent of the recirculation and geographic location.

Species cultivated: Abalone *(Haliotis midae)*, Sea lettuce *(Ulva lacinulata)*, Collector sea urchin *(Tripneustes gratilla)* and Cape sea urchin *(Parechinus angulosus)*.

3. RAS Biofloc IMTA System

The Biofloc laboratory operates as a land-based IMTA system within a greenhouse, utilizing full recirculation approach and cultivating various species. The super-intensive production in Biofloc system serves as a sustainable and biosecure alternative to traditional intensive culture systems. Biofloc consists of uneaten feed, faeces, secretions, and their associated algal, bacterial, and microplankton communities.

Species cultivated: marine shrimps *(Litopenaeus vannamei)*, tilapia *(Oreochromis niloticus)*, oysters *(Crassostrea gasar)*, halophyte *(Salicornia neei)* and macroalgae *(Ulva lactuca)*.

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The ASTRAL project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No. 863034