

## *Taking Integrated Multi-Trophic Aquaculture (IMTA) from the egg to the plate: Extending the IMTA approach*

By Thierry Chopin, Hamid Khoda Bakhsh and Stacy Murray

The concept of Integrated Multi-Trophic Aquaculture (IMTA) is not confined to open-water, marine systems using finfish for the fed component and seaweeds and invertebrates for the extractive component. It has to be conceived as an extremely flexible concept. It is the central/overarching theme on which many variations can be developed. Consequently, the principles of IMTA can also be applied to land-based, closed-containment and freshwater systems. What is important is that the appropriate co-cultured organisms are chosen at multiple trophic levels based on their complementary functions, as well as on their economic value.

So far, we have been working on developing IMTA for the seawater grow-out phase of Atlantic salmon aquaculture. However, if salmon spend between 1.5 to 2 years in seawater pens, it is after they have spent between 12 and 18 months in freshwater hatcheries. Consequently, it now makes sense to venture into developing IMTA in the freshwater/hatchery context.

### **Bringing freshwater IMTA (FIMTA) to land-based, closed-containment facilities: the salmon hatcheries and juvenile rearing facilities**

Freshwater IMTA (FIMTA) is the combination of animal aquaculture, microbial digestion and plant hydroponic cultivation (sometimes called aquaponics). Just like in saltwater operations, we consider the nutritional benefits of the water that has been used to grow fish. Rather than treating and releasing this water and wasting potential nutrients, wastewater becomes a source of irrigation water, nutrients and media for additional crops. From an environmental perspective, it is the same strategy of recapturing lost nutrients and energy and converting them into biomass of commercial value. Of course, the extractive species and infrastructures will be different from what we have developed so far at open-seawater sites.

FIMTA has several advantages over other recirculating aquaculture systems (RAS) and hydroponics, which needs to add fertilizers. FIMTA should increase water reuse, demand no extra farm soil and produce high yields of fresh, nutritious additional crops of commercial value in the form of vegetables, fruits, herbs, ornamentals and more. From a marketing perspective, it would be most

interesting to develop an overall system where salmon would be IMTA-produced from the egg to the plate.

It is also worth noting that the New Brunswick Department of the Environment is very interested in our initiative to develop FIMTA. At a time when the industry is moving toward a performance-based standard approach to freshwater aquaculture, FIMTA could be a very efficient strategy for effluent biotreatment of land-based facilities and could become an important component of the Environmental Management Program. In particular, using plants to extract phosphorus from effluent waters could prevent eutrophication and help farmers uphold water quality guidelines.

### **Adapting tropical aquaponics to cold-temperate FIMTA**

FIMTA is a relatively new concept to modern food production methods in the western world. However, such systems have been in existence for many centuries, being used by the Aztecs, in China and in Egypt. Fish and invertebrates grown in aquaponic systems have most often been organisms that spend their entire life cycle in tropical freshwater (e.g. tilapia, perch, catfish, crayfish and prawn). The integration of aquaculture and hydroponics cultivation has been examined extensively over the past three decades using a wide variety of system designs, plants, aquatic animal species and experimental protocols.

The innovation in our project is to develop FIMTA for Atlantic salmon and, consequently, will require selecting co-cultured organisms having 1) a low optimal temperature to be hardy and easy to grow, 2) evidence of being grown without soil, 3) appropriate nutrient absorption capacities at these low temperatures, and 4) a commercial value. It should pave the way for scaling up to the industrial level with our partner, Cooke Aquaculture Inc., who already owns large Atlantic salmon hatcheries and is always looking for improved nutrient management and commercial development strategies.

### **Feasibility study and pilot-scale system**

Over the last year and a half, a comprehensive field and laboratory feasibility study was conducted to investigate the potential for developing FIMTA systems for the Atlantic salmon hatcheries operated in New Brunswick by Cooke Aquaculture Inc. Both flow-through and recirculating facilities were assessed to design the



The FIMTA pilot-scale system operated at the University of New Brunswick in Saint John. Tanks with extractive species in the foreground; reservoirs of salmon hatchery effluent water in the background (photo credit: Thierry Chopin).



Some of the plants selected for growing and extracting nutrients at temperatures experienced in salmon hatcheries (photo credit: Thierry Chopin).

most appropriate systems, based on water quality, nutrient loading, flow and discharge characteristics, nutrient concentrations and bioavailability, temperature, light, space availability, plant candidate specific growth and absorption requirements and economic viability and markets. The analyses indicate that recirculating hatcheries are more valuable candidates for FIMTA systems than conventional flow-through hatcheries.

To our knowledge, FIMTA for the early freshwater stages of Atlantic salmon has never been attempted successfully in an academic setting or by an industrial company. This is the reason why we are now conducting experiments with a temperature and light controlled pilot-scale system at UNB in Saint John to understand the bio-technical remediation of Atlantic salmon hatchery effluents and the management of the dynamic system in a simplified manner. Nutrient recovery and abatement scenarios, as a function of the fish/extractive species ratio and scalability, will be calculated. Not only the intrinsic value of the biomass, but also the

ecosystem services rendered, and the value of the FIMTA step in eco-certification schemes and public perceptions regarding the acceptability of aquaculture operations, will be considered.

The use of IMTA kelp biochar as an aquaponic medium for seedling development and plant support is also being examined. Using IMTA kelps in the FIMTA system, as a locally produced and renewable resource, would develop another interesting loop in the approach to

recycling, which is closely linked to the overall IMTA concept.

We will then look at the optimization at a larger scale for commercial adoption and implementation at hatcheries.

From left to right: Hamid Khoda Bakhsh, Stacy Murray and Thierry Chopin contemplating their first production. It will soon be time to think of which salad dressing to prepare! (photo credit: Adrian Hamer).



## Net gains at GMG

### New netting materials offer strength and durability

By Chuck Brown, Communications Manager

The crew at GMG Fish Services in St. George really are living in a material world as they continually search for netting innovations that will help make Cooke Aquaculture's containment systems stronger and longer lasting.

The cage and net systems have been in constant change over the past 30 years and it's certain that will continue as technology continues to improve. The most recent change has the potential to revolutionize the GMG net loft in St. George, NB, a facility that tracks and maintains some 4,200 nets in the Cooke system. In a given year, GMG could repair as many as 2,500 nets.

Some new netting materials have been appearing on Cooke farm sites over the past year and it's looking like they are going to help change the way GMG does business.

"We have two new materials we're working with now – one is called Star and one is called Sapphire Ultracore," said Ronnie Gullison, the net shop manager who oversees the repair and testing of almost 2,500 nets a year at the shop.

Both of the materials are imported and arrive at GMG ready for inspection and installation at the farm. That means GMG's business is moving away from making nets from scratch and more toward maintenance. With

thousands of nets in the system, there's plenty to keep the GMG team busy.

Both the Star and Sapphire UC nets are being used as containment nets and predator nets. They are gradually being deployed to replace nylon nets which are being decommissioned and recycled.

The Star and Sapphire UC materials have several appealing features. They are highly resistant to abrasion and UV damage and they have zero slackness or shrinkage – they remain tight and hold their form well. Both are stronger than nylon and they are a slicker material that helps prevent seaweeds and mussels from growing on them. In order to protect nylon netting from growth, it was dipped in an anti-foulant paint at GMG – a process that will soon be history.

Both Star and Sapphire UC nettings are working well with some other new technology – robotic net washers. Deployed right on site, the robotic washers come in two forms – a manual washer and a remote control version, known as a RONC.

The net washers clean working nets with no need to remove them from the cages. They quickly and efficiently knock growth off of the nets, an essential process in farming that improves oxygen flow to the fish in the cage. Before the new systems, nets had to be removed for thorough cleaning several times during a farm's grow-out period. The newer material nets will only have to be changed once – when the smaller-meshed smolt nets are



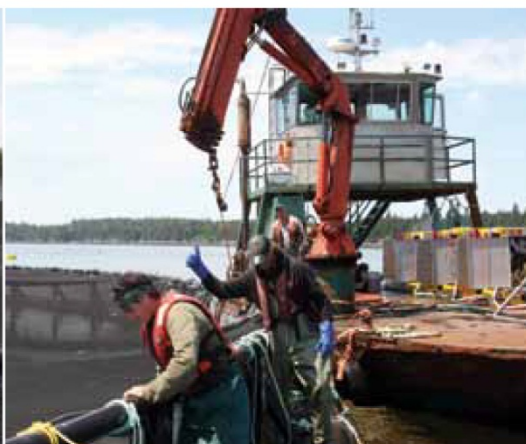
Juliet Araro works on a new predator net using new Sapphire Ultracore netting material. The new netting has a steel fibre core to give it added strength and to deter predators.

removed and larger-meshed market nets are installed.

There's another major strength with the new material. The Sapphire Ultracore gets its name because of what's inside the twine. At the heart of the netting are stainless steel fibres that not only add strength but are an excellent repellent for predators such as seals.

"It would be like us biting into a piece of aluminum foil," Ronnie said. "They don't like it very much."

Some of the new Star and Sapphire UC nets are already installed on our farms and robotic washers are in heavy use throughout Atlantic Canada and Maine. Innovation and improvement have been part of the Cooke Aquaculture story and modern netting materials are proving to be a new and exciting chapter.



New net cleaners like this one are being used to clean nets without the need to remove them from the cage. This manual version can be operated by a three person crew using a pulley system to move the net washer around a cage. Another version is operated by remote control. Both systems are proving to revolutionize net cleaning and maintenance at Cooke Aquaculture.