



Fisheries, the journal of the **American Fisheries Society**, published the second paper in a series dedicated to marine related Strategic Networks in Canada in its July issue. This time **the feature paper was on CIMTAN**. Integrated Multi-Trophic Aquaculture is on the cover page. The Table of Contents page has 5 lines summarizing very well what CIMTAN is about, and displays the Shawn



Robinson's well-known picture of mussels underwater. The 12 page paper presents the raison d'être of our network, its objectives and the research themes of the different projects within its three domains; it concludes with the benefits, applications and significance of the CIMTAN network approach.

The reference of the paper is:

[Chopin, T., MacDonald, B., Robinson, S., Cross, S., Pearce, C., Knowler, D., Noce, A., Reid, G., Cooper, A., Speare, D., BurrIDGE, L., Crawford, C., Sawhney, M., Ang, K.P., Backman, C. and Hutchinson, M., 2013 - The Canadian Integrated Multi-Trophic Aquaculture Network \(CIMTAN\) – A network for a new ERA of Ecosystem Responsible Aquaculture. *Fisheries* 38 \(7\): 297-308.](#)

Read the paper: for copyright reasons, this paper cannot be posted here, but you can contact Thierry Chopin (tchopin@unbsj.ca) and he will send you a copy for individual use.

Two CIMTAN funded papers were published recently on modelling the potential of blue mussels to extract salmon farm organic particulates and how this could affect organic loading and deposition in open-water IMTA.

(1) [Cranford P.J., Reid G.K. and Robinson S.M.C. 2013 - Open water Integrated Multi-Trophic Aquaculture: constraints on the effectiveness of mussels as an organic extractive component. *Aquaculture Environment Interactions* 4: 163-173.](#)

This study identified important constraints on the capacity of mussels to perform their intended role in IMTA systems that can only be partially addressed by optimizing system design. Mussels are currently the primary species employed worldwide in open water IMTA systems to extract waste organic particles (fish feed and feces) exiting fish pens. Available information on mussel feeding and digestion physiology was used to identify natural limitations on the capacity of mussels to capture these materials under various open water IMTA scenarios. Waste capture by mussels was shown to be highly inefficient because of the limited time they have to intercept particles in the water that flows past them. Intensive mussel stocking and spatially extensive mussel culture within IMTA systems could improve particulate waste capture to as much as 50%. Maximal waste extraction will ultimately be limited by the space available in IMTA farms for mussel culture. The paper also identified several other factors that limit the capacity of mussels to perform their intended role as an extractive species, including:

- (1) Effects on fish culture from flow reduction caused by the mussels and their holding structures will limit the size of the mussel component.



- (2) A large proportion of the mussel organic diet has to consist of waste particles (15 to 35% depending on the quality of natural food resources) for the mussels to absorb more organic matter from fish feces than they produce as mussel feces (*i.e.* a waste biomitigation requirement).
- (3) The efficient capture and extraction of fish farm particulates by high density mussel culture also results in the efficient depletion of natural seston, which makes up the majority of the mussel diet. Seston depletion causes mussel growth to become food limited, which results in relatively poor mussel crop production (tonnes per farm area per year) compared with lower density mussel culture. Maximizing waste extraction efficiency eventually results in a reduction in the profitability of the mussel component.

(2) [Reid G.K., Robinson S.M.C., Chopin T. and MacDonald B.A. 2013 - Dietary proportion of fish culture solids required by shellfish to reduce the net organic load in open-water Integrated Multi-Trophic Aquaculture: a scoping exercise with cocultured Atlantic salmon \(*Salmo salar*\) and blue mussel \(*Mytilus edulis*\). *Journal of Shellfish Research* 32 \(2\): 509-517.](#)

This study explored how mixed mussel diets could affect solid organic loading at an IMTA site. In addition to the potential consumption of fish culture solids (*i.e.* feces, feed "fines"), IMTA shellfish also consume natural particles (*i.e.* seston). Consumption of seston portions by shellfish means that some suspended solids that would otherwise drift by fish cages now have the potential for redirection to the benthos as indigestible seston components, egested in shellfish feces. This raises the issue as to what dietary proportion of fish culture solids, consumed by extractive species, results in an increase or reduction of net organic load. As a scoping exercise, a mathematical model was created, using known absorption efficiencies (fraction of organic material digested) of blue mussels (*Mytilus edulis*) on diets of seston and Atlantic salmon (*Salmo salar*) culture solids, to estimate the resulting organic fecal load of blue mussels on a mixed diet. The organic load from the mussel feces was added to the unconsumed load of salmon culture organics to determine the net IMTA organic load. The dietary proportion threshold (DPT) is the percentage of fish culture solids in an extractive species diet that results in no change in net organic load at an IMTA site. The DPT of salmon culture solids that must be exceeded for mussel culture to reduce the net IMTA site organic load is 14.5% for salmon feces and high-quality (high organic content) seston, 19.6% for salmon feces and low quality seston, 11.5% for salmon feed fines and high-quality seston, and 15.6% for salmon feed fines and low-quality seston. A net reduction of organic load occurs if the amount of salmon culture organics absorbed (digested) by mussels exceeds the organic fecal load produced by indigestible seston components. Changes in total particulate matter consumed by a mussel population or changes in the amount of salmon culture solids available did not change the DPT, although these factors did influence the magnitude of net organic load increases or decreases. Whether DPTs are achievable is a function of many biophysical parameters some of which are discussed in the above Cranford *et al.* paper. Knowledge of DPTs can be useful to frame expectations of nutrient mitigation and to assist in the interpretation of augmented growth and tracer data as a means to infer nutrient reduction potential.

Read the papers: for copyright reasons, these papers cannot be posted here, but you can contact Peter Cranford (Peter.Cranford@dfo-mpo.gc.ca) for the first paper, and Gregor Reid (Gregor.Reid@dfo-mpo.gc.ca) for the second paper, and they will send you a copy for individual use.



In April 2013 [see *CIMTAN Snippets* 3 (2)], *BioScience*, the journal of the *American Institute of Biological Sciences* (AIBS), published the following paper:

[Diana J.S., Egna H.S., Chopin T., Peterson M.S., Cao L., Pomeroy R., Verdegem M., Slack W.T., Bondad-Reantaso M.G. and Cabello F. 2013 - Responsible aquaculture in 2050: valuing local conditions and human innovations will be key to success. *BioScience* 63 \(4\): 255-262.](#)

In that paper, IMTA was cited as a biomitigative approach for the improvement of management practices to create more efficient and diverse aquaculture systems. It happened that Lesley Evans Ogden, a former wildlife ecologist turned freelance science writer, based in Vancouver, British Columbia, was interested in writing a paper on IMTA and pitched the idea to the Features Editor of *BioScience*, Beth Baker, who alerted her that a paper on responsible aquaculture was already in press. They convinced each other that a separate feature paper exploring IMTA more in depth would still be complementary and worthwhile. Subsequently, Lesley completed extensive interviews with Thierry Chopin (CIMTAN-University of New Brunswick, Canada), Alejandro Buschmann (Universidad de Los Lagos, Chile), Shawn Robinson (CIMTAN- Fisheries and Oceans Canada), Shaojun Pang (Institute of Oceanology of the Chinese Academy of Sciences, China), Jack Rensel (Rensel Associates Aquatic Sciences, USA), Stephen Cross (CIMTAN- Kyuquot SEAfoods Ltd.) and Frank Powel (Cooke Aquaculture Inc.) to write the following very comprehensive paper:

[Evans Ogden L. 2013 - Aquaculture's Turquoise Revolution – Multitrophic methods bring recycling to the seas. *BioScience* 63 \(9\): 697-704.](#)

Lesley has to be commended for a thorough search and for writing a paper that is both very instructive and pleasant to read (that is why she is a science writer!). It is also important to recognize the remarkable open mind of Beth, who accepted to publish "different kinds of images", hence allowing Lesley to cover the delicious dishes of IMTA products created by Chris Aerni, the Chef of the [Rossmount Inn](#), and the production of the dance performance "IMTA" by [Motus O Dance Theatre](#), in that way giving the holistic dimension of IMTA.

Read the article:

<http://www2.unb.ca/chopinlab/articles/files/Evans%20Ogden%202013%20Aquaculture%27s%20Turquoise%20Revolution%20BioScience.pdf>

You can also contact Lesley Evans Ogden (lesley@oggies.net), explore her website (<http://lesleyevansogden.com>) or follow her on Twitter @ljevanso.

IMTA has been in the news over the last two months

On July 8, 2013, the *New Brunswick Telegraph Journal*, and associated newspapers, produced a special *New Brunswick Business Journal* magazine on aquaculture and fisheries. In it, there was an article ("Fish farms getting their own ecosystems") written by Laura MacInnis, based on her interviews with Thierry Chopin (CIMTAN-UNB), and Nell Halse and Keng Pee Ang (Cooke Aquaculture Inc.).

Read the article:

<http://www2.unb.ca/chopinlab/articles/files/MacInnis%202013%20NB%20Business%20Journal.pdf>



Barb Rayner wrote an article ("Integrated Multi-Trophic Aquaculture could help fight against sea lice") in *The Saint Croix Courier*, on July 9, 2013.

Read the article:

<http://www2.unb.ca/chopinlab/articles/files/Rayner%202013%20IMTA%20could%20help%20fight%20against%20sea%20lice.pdf>

Mark J. Spalding, Kathryn Peyton and Ashley Milton wrote an article ("Sustainable ancient aquaculture") in *National Geographic Ocean Views*, on July 11, 2013. IMTA is mentioned in the article and recommended as a sustainable practice inherited from ancient aquaculture technology.

Read the article:

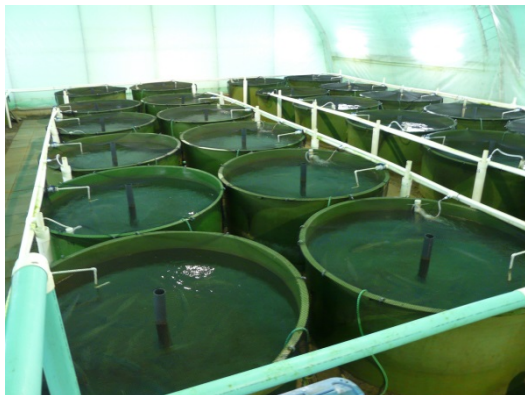
<http://newswatch.nationalgeographic.com/2013/07/11/sustainable-ancient-aquaculture/>

In the spring/summer 2013 issue of *Global Young Academy Connections*, Rees Kassen, of the University of Ottawa, wrote an article entitled "Who speaks for science? The view from Canada". Rees Kassen described that, when it comes to dealing with pressing societal issues, scientists and politicians can sometimes be worlds apart and he discussed how it can be possible to bridge the gap between the two cultures. The presentation "Towards a more sustainable and diversified aquaculture" by Thierry Chopin at the "Bacon and Eggsheads Breakfast" series for Parliamentarians, in Ottawa, in October 2012, is highlighted as an example.



Read the article: <http://www.globalyoungacademy.net/gya-publications/gya-connections>

Brian Mendel wrote an article ("Aquaculture firm to expand") in *The Chronicle Herald*, on August 19, 2013. Brian Mendel covered **Cooke Aquaculture Inc.**'s projects of building a new hatchery, opening a processing plant and expanding a feed mill operation in Nova Scotia, Canada. Chuck Brown, communications manager, explained that "Our reliance on fish ingredients has actually gone down quite a lot in the last 10 years. We've been able to reduce the amount of fish that goes into our feed by about 70 per cent. We are finding suitable replacements for the fish ingredients like poultry byproducts and even seaweed, in feeding trials. We grow seaweed at some of our sites. In turn, we're able to put some of that seaweed into our fish feed. It's still a bit of an experimental project right now but it's looking promising."



Read the article: <http://thechronicleherald.ca/business/1148555-aquaculture-firm-to-expand>



Thierry Chopin was on the television documentary “Le saumon” of the Société Radio Canada (SRC) show *Bleu, le magazine de la vie maritime* presented by Normand Latour.

Watch the television documentary:

<http://www2.unb.ca/chopinlab/av/content/BleuRadioCanada.wmv>

The large green tide phenomenon occurring in the Yellow Sea was back in the news this summer after journalists sent spectacular pictures of the beaches in Qingdao, China, around the globe.

Harold Thibault, journalist at one of the most influential French newspapers, *Le Monde*, correctly reported on the phenomenon after doing some careful research and interviewing Thierry Chopin, who has worked on the issue for several years with his colleague, Shaojun Pang, from the Institute of Oceanology of the Chinese Academy of Science (IOCAS; see CIMTAN Snippets 3 (6) from December 2012). Thierry Chopin also exchanged several emails with Andrew Jacobs of the *New York Times* to explain that it is important to understand the problem from its origin, because, if we want to resolve it, we better combat it at its source.



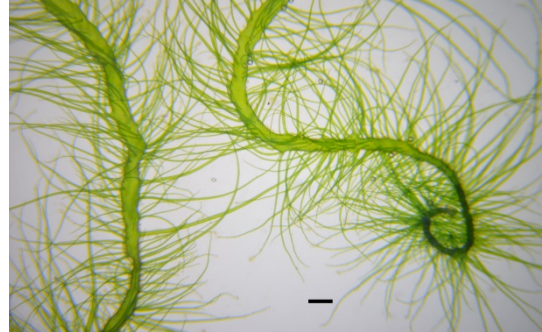
The cultures of nori (the red seaweed *Porphyra*, now called *Pyropia*) in the Jiangsu Province are maybe an amplifying step, but they are not the origin. To find it, one has to go “upstream” and search for the answer, looking not only in marine waters, but at the coastal zone in its entirety: coastal zone management is complicated and one needs to look at the coastal zone from both a terrestrial and a marine perspective. The Chinese have developed huge coastal pond systems (they can easily be seen on Google Earth). Chinese aquaculture evolves very rapidly, mostly driven by economics, cultivating the species with the highest return: it was shrimp, then sea cucumber and now the freshwater crab is the latest fashion with a burgeoning middle class.



To feed the juvenile freshwater crabs, rotifers (live preys) need to be cultivated. To obtain massive quantities of rotifers, the ponds need to be enriched. The Chinese use an old method with “fermented chicken manure” (FCM). This recycling method, which is not a bad idea in itself, becomes a problem because of the scale at which it is now practiced (50,000 tons are estimated to be applied annually). That develops an eutrophicated environment ideal for the blooming of green seaweeds. The ponds release their effluents,



loaded with propagules of the green seaweed *Ulva prolifera* (the person who gave it that name must have had premonitions!). The propagules are “inoculating” a unique and very large mudflat, which extends up to 90 km into the sea. This mudflat is really a “green tide incubator”. The propagules overwinter there in the sediments. In the spring, when temperatures increase and longer days provide more light, the propagules germinate into filaments. These filaments, like all seaweeds, photosynthesize, *i.e.* they release oxygen and the bubbles of oxygen are trapped within the filaments, which become buoyant and reach the surface. More light, more proliferation and large mats start to form. Pushed by the predominating currents and winds, these huge mats move NW or N towards the Shandong Province and, depending on the year, are washed ashore (when it reaches Qingdao, everybody talks about them) or stay offshore (and are much less talked about... out of sight, out of mind!). Curiously, when drifting to the N during summer, this huge green biomass may suddenly collapse and disappear. This sporadic aspect complicates the development of economically viable applications from what remains an unwanted “manna”.



The green seaweed, *Ulva prolifera*, responsible for the green tides in the Yellow Sea (scale bar = 1 mm; photo credit: Shaojun Pang).

Pyropia net infrastructures can trap *Ulva prolifera* filaments, as any substrates/obstacles in the sea,



and they can participate in increasing their growth/biomass, but they are not responsible, *per se*, for green tides. One has to address the problem at its origin but that becomes complicated because one starts to get involved with economic and political issues. We emphasized, in a previous paper, the need for early management actions in the sequence of events leading to the recurrent and massive green tides in the Yellow Sea. For a truly integrated management of the coastal zone, reduction in nutrient inputs, and control of the effluents of the coastal animal aquaculture pond

systems, are needed in the land-based operations. If the green tides are to be managed, and, hopefully, reduced or eliminated, their development needs to be stopped at the sources on land, not at intermediate steps on the radial intertidal mudflat, when it is already too late for preventing their massive blooming.

This is, in fact, a much bigger problem that China will have to confront soon: its development of the coastal zone, agriculture, aquaculture, and other industrial activities, in the name of economic development and of having to feed a huge human population, but nutrients need to be managed. We have mentioned several times in our IMTA papers, the so-called “duality of nutrients”, which, in one way, are useful and needed for the ecosystem to work, but which can become pollutants at high concentrations. Nutrients





are vital, but we need them in moderation. In fact, this large green tide phenomenon is an illustration of a case of a missed opportunity for large scale coastal IMTA. Seaweeds can be an excellent tool for nutrient bioremediation. When they are desirable and cultivated species, everything is fine; when they are nuisance species and we do not know what to do with them, everything is bad. The argument can be made that all these green seaweeds are, in fact, providing ecosystem services: they recapture nutrients from the marine ecosystem and, if harvested, they contribute to removing nutrients from the marine ecosystem.

From all the above, it is easy to understand why the problem is not that easy to solve, especially with so many stakeholders, and their many different reasons for being at the table to try to find solutions.

Read the article:

"En Chine, la mer Jaune devient la "mer verte"" ("In China, the Yellow Sea becomes the "Green Sea") by Harold Thibault, in *Le Monde*, on July 8, 2013.

<http://www2.unb.ca/chopinlab/articles/files/Thibault%202013%20Le%20Monde%20Green%20tid es%20in%20Qingdao%20compressed.pdf>

Thierry Chopin was invited by Emeritus Professor **Lam Toong Jin** to be one of the two keynote speakers at the **Singapore's inaugural Aquaculture Industry Engagement Day**, hosted by **Republic Polytechnic** and jointly organized with the **Tropical Marine Science Institute (TMSI)** of the **National University of Singapore (NUS)**. The conference was held on August 2, and was attended by approximately 150 people from research institutes, government agencies and the aquaculture sector.

Thierry Chopin gave a presentation entitled "**Integrated Multi-Trophic Aquaculture (IMTA): an environmentally, economically and societally responsible aquanomic practice**". The second keynote speaker, **Noam Mozes** (Head of the Mariculture Division of the Department of Fisheries and Aquaculture of the Ministry of Agriculture and Rural Development of Israel) gave a presentation entitled "**Research and development of Recirculating Aquaculture Systems (RAS) and Integrated Aquaculture – Limitations and opportunities based on practical experience and engineering considerations**". If one considers that RAS is a variation on the overarching IMTA theme, in which the extractive component is the microbial part of the system, the solution for Singapore may be a combination of both approaches.

The island city-state of Singapore is at a crossroad. When it came to existence in 1965, the human population was at 1.87 million; as of 2012, it has reached 5.31 million people [3.28 million being citizens and 2.03 being permanent residents or foreign workers/students ("expats")]. The island country is made up of 63 islands. There are ongoing land reclamation projects, which have increased Singapore's land area from 581.5 km² in the 1960s to 704 km² today; it may grow by another 100 km² by 2030. Some projects involve merging smaller islands to form larger, more functional islands. Urbanisation has eliminated most primary rainforest on the main island. There are only about 250 acres of farmland remaining in Singapore. Most of the water is imported from Malaysia. Consequently, water and food security and self-sufficiency are major concerns for the Singapore government. The Singapore's Agri-Food & Veterinary Authority (AVA) aims to raise the proportion of locally produced fish to 15% of total fish consumption, from the current 7%.



Hanging Gardens



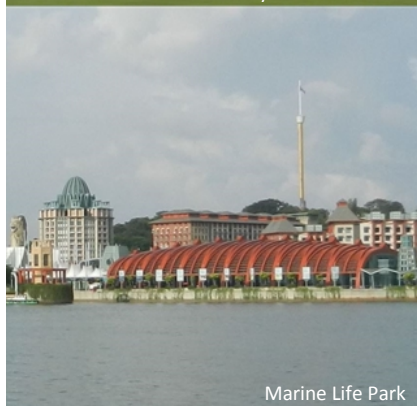
Cricket and Marina Bay Sands



Garoupa Sarma



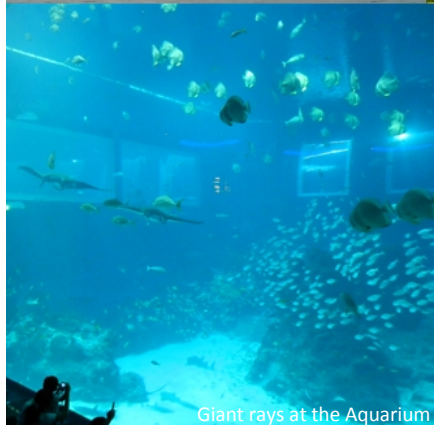
Singapore at night from the Ku Dé Ta Bar



Marine Life Park



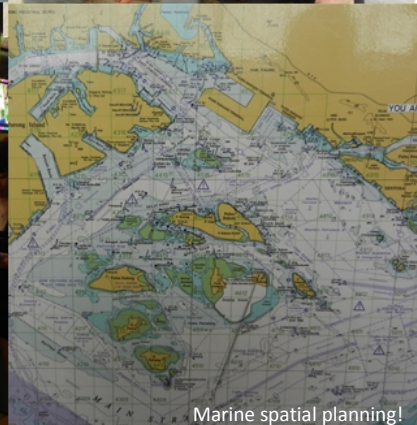
Great thinkers!



Giant rays at the Aquarium



Local hawker food fair



Marine spatial planning!



Peaceful St. John's Island

IMTA at TMSI



St. John's Island Marine Laboratory

AVA Marine Aquaculture Center



Singapore sea farm

Singapore harbour



Inside the Dome



Singapore harbor front



The Cloud Forest Dome



Photovoltaic trees



Marina Bay Sands at night



Supertree Grove at night



Hanging gardens at the airport



As the government is looking at reducing the country's dependence on imported fish for consumption, it is turning to both academia and industry players to find solutions for aquaculture development. This is, however, not that simple. In the North, the Straits of Johor is highly polluted, the water flow has been reduced and oxygen levels are generally low. In the South, lies the world's second-busiest port (after Shanghai) in terms of shipping and cargo tonnage handled and containerised traffic; it is also the world's busiest port for transshipment traffic and ship refuelling. There is, consequently, not much space left for aquaculture. On land, there is also not much space left and real estate deals seem much more profitable in this burgeoning city with some most astonishing architectural designs.

IMTA could be a solution, but it will require some major out of the box thinking. One thing which always strikes the traveller to Singapore is how green the city is and how the facades of buildings are used as cascades of hanging gardens. This green vision was imparted by the first Prime Minister of Singapore, Lee Kuan Yew [was he inspired by the hanging gardens said to have been built in Babylon (presently near Hillah in Iraq) on the Euphrates river, under the Neo-Babylonian king Nebuchadnezzar II (605-562 BC), or the well-documented hanging gardens built in Nineveh (presently Mosul) on the Tigris river, under the Assyrian king Sennacherib (704-681 BC)?]. To this day, Singapore is still harboring luxuriant facades, covered with vegetation, which are said to provide oxygen to the city-state and to cool its buildings in a city just 137 km north of the Equator. These principles being accepted by Singaporeans, we could translate, in present day language, that this urban vegetation provides ecosystem services and that would not be a gigantic leap to then think of the ecosystem services provided by the extractive component of IMTA. Consequently, what needs to be imagined are urban (or peri-urban) and vertical IMTA farming systems in which the vegetation would not only provide ecosystem services paired with aesthetic values, but would also combine food production of vegetables with fish and invertebrates. A new variation on the overarching IMTA theme and a new acronym: VIMTA, for vertical IMTA!

On August 3, some of the participants of the Conference went to [Artichoke Café & Bar](#), owned by Chef **Bjorn Shen** who is committed to using locally grown/raised/produced food and ingredients. A delicious Garoupa Sarma was served: grouper barbequed in vine leaves with lemon and Israeli couscous. The fish was provided by **Shannon Lim** and **James Norris** from [OnHand Agrarian](#), which is a company starting an IMTRAS (Integrated Multi-Trophic Recirculating Aquaculture Systems) business.

On August 4, Thierry Chopin and Noam Mozes visited the [Singapore Aquarium \(Marine Life Park\)](#) in the Resort World on Sentosa Island. There could be a great educative mission for the aquarium, whose Director of Education and Conservation, **Biswajit Guha**, spoke positively about aquaculture meeting marine conservation needs during the conference. On August 5, they visited St. John's Island (a peaceful heaven where the skyscrapers and city noises are left on the northern horizon). They visited the [St. John's Island Marine Laboratory](#), part of TMSI, and the [Marine Aquaculture Centre](#), part of AVA.

Singapore is a fascinating place. However, the success of its blossoming formula since its creation in 1965 is not without challenges, which were very well summarized by Professor Peter Ng, the Director of TMSI:

"Singapore is both land and resource scarce, and this presents a unique problem for local aquaculture and our researchers. Good science underpinned by good business sense will be the hallmarks of a successful and sustainable aquaculture programme. Only then can there be real food security. Producing huge quantities of cheap fish, and just of a few kinds, is not enough. We need



quality as well as diversity, and we must encourage the local industry to play an active role in producing seafood for Singapore, by making it economically viable”.

Read the articles:

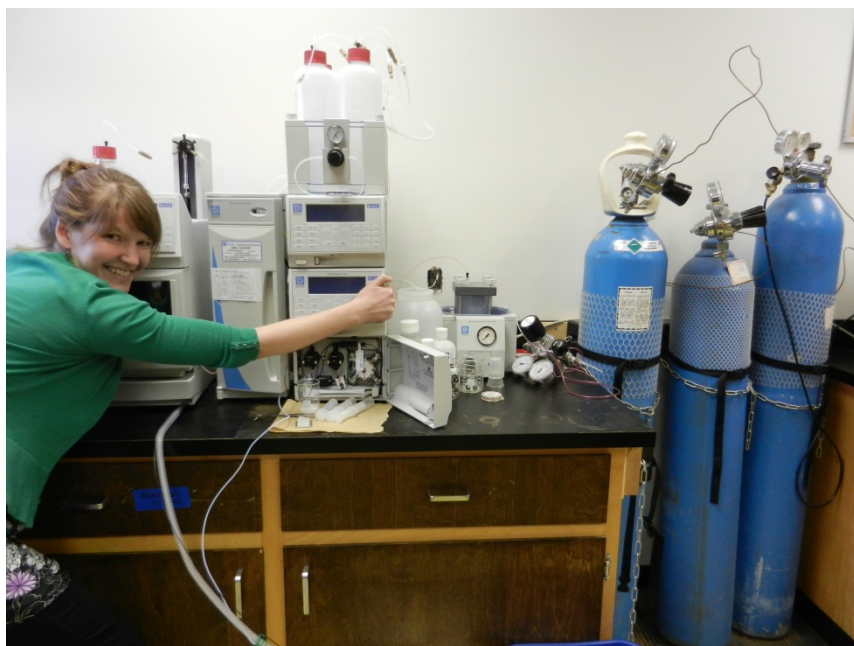
- “Aquaculture Industry Engagement Day 2013” by *Republic Polytechnic of Singapore*, on July 31, 2013.

http://www.rp.edu.sg/Aquaculture_Industry_Engagement_Day_2013.aspx

- “Republic Polytechnic hosts Singapore’s inaugural Aquaculture Industry Engagement Day” in *eFeedLink*, on August 5, 2013.

<http://www.efeedlink.com/contents/08-16-2013/96adebca-0559-4cae-a87c-81ff4e684cb3-b505.html>

Ellen Campbell recently defended her MSc thesis entitled “**Total nitrogen and free amino acid contents in the brown seaweed, *Saccharina latissima*, at an Integrated Multi-Trophic Aquaculture site and in wild populations in the Bay of Fundy, Canada**” (under the supervision of **Thierry Chopin** at UNB Saint John). While not supported by CIMTAN, Ellen’s thesis very much supports the work on seaweeds carried out by project D1P2.



Ellen Campbell hugging the Dionex ion-exchange chromatography system for the last time, after successfully defending her MSc thesis (note: Ellen did not have this special relationship with the equipment everyday (!); photo credit: Thierry Chopin).

One of Ellen’s major achievements is to have developed a reliable method for the separation, identification and quantification of free amino acids in kelp tissues. The reliable “lab-horse”, the Beckman 6300/7300 amino acid analyzer, ceased to be produced several years ago and it has been difficult to correctly measure amino acids ever since. Ellen devised a new technique combining high-performance liquid chromatography (HPLC) and a second ion-exchange column. The Dionex ion-exchange chromatography system, bought with the support of the [New Brunswick](#)

[Innovation Foundation](#), achieves the separation of amino acids in an underivatized form, eliminating the need for time-consuming post-column derivatization. However, the technique needed several adaptations to further improve the performance of the system and to customize it for the analysis of seaweed tissues to avoid interferences by non-target compounds. Integrated pulsed amperometric detection (IPAD) was used for the detection and quantification of amino acids, the profiles of which are poorly documented in the available literature on seaweeds.



The abstract of Ellen's thesis is given below:

Fish aquaculture operations contribute nitrogen to the ecosystem from feed and fish waste. Seaweeds respond to nitrogen concentration changes by taking up ambient nitrogen and storing it for subsequent growth. Seasonal variations in total nitrogen and free amino acid contents were investigated in the kelp, *Saccharina latissima*, cultivated at an Integrated Multi-Trophic Aquaculture (IMTA) site and from three naturally occurring beds. A reliable method was devised for the separation/identification/quantification of 16 free amino acids in kelp tissues. IMTA kelps had higher total nitrogen content than wild kelps in July; frill tissues had higher total nitrogen content than central tissues in April/May/June. Lysine was the most abundant free amino acid in April/May/July; alanine the most abundant in June. In spring, free arginine was higher in frill tissues; free aspartic acid and glycine were higher in central tissues. Free glutamic acid, aspartic acid, asparagine, and histidine were positively influenced by salmon aquaculture proximity.

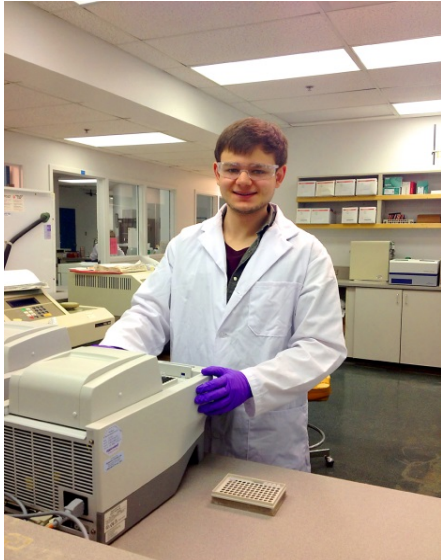


Combining sport fishing and shark research: tagging a porbeagle shark before it is released back into the Bay of Fundy and tracked (photo credit: Nicole Leavitt).

Nicole Leavitt is a CIMTAN MSc student working with **Gregor Reid** (project D1P8) on the green sea urchin, *Strongylocentrotus droebachiensis*, as a candidate for the deposit feeder niche in Integrated Multi-Trophic Aquaculture (IMTA) systems. She is also the daughter of **Chris** and **Carolyn Leavitt**, who operate *Sea Fox*, the vessel of the [St. Andrews Sport Fishing Company](#), and she has been the conduit to bringing sport fishing, whale watching (through their other operation [Island Quest Marine](#)) and shark research together. Instead of just fishing for porbeagle sharks (an endangered species often mistaken for the iconic great white shark), they partnered with Dr. **Steve Turnbull**, from **UNB Saint John**, who tags the porbeagle sharks to track them and learn more about their biology in the Bay of Fundy and in their voyage between Georges Bank and Newfoundland. Tourists participate in all the exhilarating action and take great pride in being part of this conservation effort. According to Steve Turnbull "Nicole is amazing and I am so thankful for this partnership. They are a great organization to be involved with. It is a great link and it does border on the edge of ecotourism with the research component added to it. None of this would be happening if not for Nicole."

Read the article:

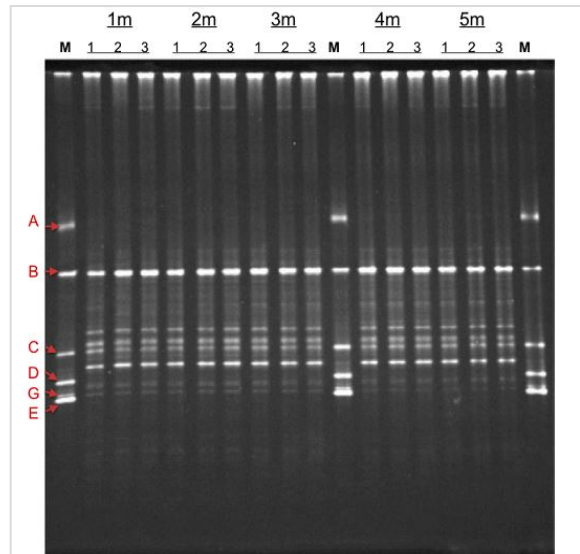
<http://www.cbc.ca/news/canada/new-brunswick/story/2013/07/09/nb-shark-fishing-research-standrews.html>



Eric Manuel about to initiate a Polymerase Chain Reaction (PCR), one of the first critical steps in performing Denaturing Gradient Gel Electrophoresis (DGGE; photo credit: Ben Forward).

Eric Manuel graduated from the Biology-Chemistry program at the University of New Brunswick's Fredericton campus this past April. Eric was born and raised in a small suburban area just outside of Bathurst, New Brunswick, called South Tetagouche. Throughout his first few years of university studies in Biochemistry, he developed an interest for research. It was after his third year, in 2011, that he was offered a position as a CIMTAN summer student research assistant working under Dr. Ben Forward's supervision in the department of Food, Fisheries and Aquaculture (FFA) at the Research and Productivity Council (RPC) in Fredericton. Although he knew little about aquaculture and marine bacteria, Eric saw this as an exciting opportunity to learn something new. Much of the first summer was devoted to learning about marine bacteria, devising and testing sampling techniques, bacterial culture, and adapting a molecular biology based method used to profile bacterial communities, called Denaturing Gradient Gel Electrophoresis (DGGE), for use in the marine environment. This latter technique was used together

with standard culture to spatially profile bacterial communities in water surrounding an aquaculture site in Kyuquot Sound, British Columbia. Eric returned for the summer of 2012 to apply DGGE to spatially and temporally profile bacterial communities at a salmon farming site in the Passamaquoddy Bay, New Brunswick. Eric decided to carry on this work through the fall and winter of his final year as the focus of his senior Honours research project, which he successfully defended in April 2013. Surprisingly, his work on the project showed that very little spatial and temporal variation existed in the bacterial community surrounding the study site. These results have helped to contribute to CIMTAN project D1P3 lead by Dr. Shawn Robinson at the St. Andrews Biological Station that seeks to quantifying the role of microbes in the nutrient recycling of organic material from IMTA sites. Eric is now attending the St. Thomas University Education program and is applying to attend medical school for fall 2014.



Bacterial profiles illustrated via DGGE of surface layer water samples collected in July at an aquaculture site in the Bay of Fundy. 1-5m: Depth of collection. 1-3: Triplicate samples. M: Marker. A-G (red): Marker identifications. Virtually no variation in bacterial community profiles is observed in the topmost surface layer. Each band represents a different bacterial species from the water sample (photo credit: Eric Manuel).

First CIMTAN member quote of the month: "Continuing my work for CIMTAN as a senior research project has been an amazing learning experience. Not only was I given the opportunity to learn an awesome technique (DGGE), I was also able to apply my skills in molecular biology to a field that was completely new to me." (*Eric Manuel, CIMTAN Honours student*).



Kimberly Irwin with a sablefish (black cod) at the Kyuquot SEAfoods Ltd. IMTA site on Vancouver Island, British Columbia (photo credit: Stefan Crampton).

As a graduate of McGill University's School of Environment, **Kimberly Irwin** has always been interested in sustainable development and environmental issues. Prior to beginning graduate studies, she worked in the environmental non-profit sector with a focus on coastal zone management. Kimberly is currently a master's candidate at Simon Fraser University's School of Resource and Environmental Management. She is a member of the D3P1 project led by Dr. Duncan Knowler, which focuses on economic and financial analyses of IMTA in Canada. She is currently conducting a non-market valuation of changes to the coastal environment that could arise from IMTA adoption in British Columbia. In order to obtain these values, she has created a discrete choice experiment, which will be administered via an online survey of the British Columbian public. This survey will determine what British Columbians are willing to pay for improvements to the

marine environment surrounding salmon farms. It will also determine whether British Columbians would support changes to government policy to encourage more sustainable technology adoption in aquaculture. This research provides an important component in determining the overall change to social welfare that could arise from IMTA adoption, and will therefore provide justification for public and private investment into IMTA in the province.

Second CIMTAN member quote of the month: "CIMTAN has allowed me to work on a truly collaborative and interdisciplinary research topic. My own work has benefited substantially from having access to experts in natural and social sciences through our national strategic network." (*Kimberly Irwin, CIMTAN MRM candidate*).