On nutrition:

1. Given that the nutritional value of alternative seafood is diverse and may differ from that of conventional seafood, is there a need for labeling to inform consumers?

   The inherent nutritional value of plant-based seafood and cell-based seafood varies across product type and production method. Most companies in this space, however, are looking to develop nutritionally similar or superior products as compared with conventional counterparts, especially because seafood is often seen as a food with many health benefits.

2. Can alternative seafood potentially provide the same health benefits as normal seafood and if so how can this be ascertained?

   Since cell-based seafood is comprised of the same cell types as conventional animal seafood muscle tissue, products may be able to match or exceed the nutritional profile of their conventional counterparts. This is mainly reliant on the cell culture media formulation as the cells will accumulate nutrients from the media similar to the way fish accumulate nutrients from their diets.

3. Aren't we producing more 'processed' food in these processes, but we're told to reduce the amount of processed food we eat? More salt, different fats?

   Health implications regarding the number of ingredients (which can include binders, colorants and preservatives) and the degree of processing of plant-based replacements have raised concern. Plant-based seafood companies are aware that there is currently limited evidence of the health effects of their products, so they are striving for transparency and simplicity in their recipes.

   Nutritional outcomes will likely vary based on the inputs and types and degree of processing, especially of the plant-based seafood, and need to be further investigated. To ensure and communicate the nutritional value of these products, the development of transparent, consistent certification and labeling will also need to occur.

   Since there is more control at each step of production, plant- and cell-based seafood can also be uniquely developed with specific nutrient profiles that complement local diets and address nutrient deficiencies expected in the consumer base. Further research exploring optimal nutrient profiles and the nutritional potential of alternative seafood would need to inform these decisions.

4. How do you see this trend in seafood alternatives fitting in with the "slow food" movement and idea of eating better and reconnecting with the environment where our food comes from?

   The essence of slow food is food prepared in accordance with local culinary traditions, typically using high-quality locally sourced ingredients. Both plant- and cell-based seafood can try to embrace the philosophy by, for example, using locally-sourced ingredients (vegetables, grains and fungi produced locally; cells isolated from indigenous seafood species and multiplied in local production facilities) to either produce a plant-based or cell-based seafood analog and to prepare and serve it using local culinary traditions. For example, one company in Southeast
Asia is piloting the culture of fish maw – swim bladder tissue – to be incorporated into local cooking.

On sovereignty:

5. A question to all panelists: what is the cost of producing alternative seafood and what will happen to the millions of artisanal fishers globally who depend on capture fishing both inland and inshore?

As of now, there is no commercial production of cell-based seafood and until that happens we can do little more than speculate on prices, but it is likely to be around $20 per kg, which is much higher than all but the most expensive of fishes, such as bluefin tuna. Plant-based seafood production costs are much lower. Given the projected growth of the sectors, however, our report concluded that there is unlikely to be any real impact on artisanal fishers, at least in the next decade. However, we also identified as a priority the need for more research on this.

6. The innovation is exciting, but what about the 'who controls things' question, especially if products from multinationals enter markets and outcompete locally produced seafood from smaller-scale producers, esp in lower-income countries? Will small-scale manufacture ever be possible to maintain a mix of seafood livelihoods (esp for both small-scale producers and processing plant workers)?

A range of production and distribution models might be pursued here. It is probably desirable to have a distributed production base, and for both plant and cell-based seafood, it is possible to develop these anywhere, including in urban centers. As with burgers, multinationals may decide to launch a range of standardized alternative seafood products targeted at global fast-food markets. However, there may also be scope for local, joint venture, or franchise operations that bring indigenous plant- and cell-based food analogs of much valued local products to market. The scale of such operations will very much depend on profitability; a mix of jobs is also likely.

7. Do we have any idea of how capital intensive the Alt seafood processes? It will be out of reach of a smallholder if it is capital intensive.

Cell-based seafood production is capital intensive, and although costs will fall as technologies and operational management improve, it will probably always remain comparatively capital intensive. Plant-based seafood production can be much less capital intensive depending on the desired product attributes but may require significant investment in the processing equipment/facility.

Other solutions:

8. Hi Malcolm - thank you for your interesting presentation. Will gene editing help produce seafood under climate change conditions and do you think this will be acceptable to consumers in those countries suffering most from climate change?

Gene or Genome editing can target a range of traits that might help aquaculture in regions subject to climate change (such as faster growth, resistance to disease, heat and salinity tolerance), some of which can’t be readily addressed through selective breeding. However, according to the European Court of Justice genome editing results in the production of Genetically Modified Organisms (GMOs) and to date, there has been little appetite for GMOs by consumers, including fish GMOs, in many parts of the world.

9. What are the prospects of expanding nonfish plant and animal farming in the marine waters?
The potential is significant, but it depends on local/national market demand for farmed seaweed and shellfish, the abundance of coastal marine resources and the needs of other users. Coastal marine environments are increasingly congested and contested. Countries must develop strategic coastal zone plans that take account of competing demands from conservation, tourism, fishing and industry, as well as how coastal marine seaweed and shellfish farming can help meet SDG targets.

10. Peru has been working on anchovy powder as a direct human consumption product (rather than the indirect route through fishmeal and oil for aquaculture and pig production). Small pelagic short-lived fish need to be caught and used as they will otherwise be a lost resource - what do the panelists think about this concerning ALT-Seafood? (Note: Here in Peru, alternatives are being evaluated to replace anchovy flour in the production of feed for aquaculture, since the over-exploitation of anchovy will leave us without this species in less time than expected and would also allow us to use the anchovy more for direct human consumption than indirect consumption. Hello from Peru :))

11. Improving food and nutrition security can be achieved in many ways, including the adoption of rights-based approaches, better education about food and nutrition, improved intra-family division of food (prioritizing pregnant and lactating female household members) and improved access to nutritious foods (improved economic access, food markets, transport infrastructure). If it is decided that increased economic access to nutritious foods is the solution (e.g. food banks, food for work programs) then the issue arises of whether plant- and/or cell-based seafood products are cost-competitive to other food-based solutions (e.g. dried fish, fish powder, nutrient supplement powders). For WorldFish, it remains to be determined what the potential and feasibility are of plant- and cell-based seafood to provide cost-effective solutions to food and nutrition security in comparison with other food-based solutions.

12. Hi Dave and panel, Jeppe Koldig here. Why assume that wild production from the oceans is exhausted? We are fishing on trophic levels 4-5, which is 2 levels higher than on land. There are lots of potential by harvesting lower in the aquatic food chain. The oceans are producing biomass as the terrestrial hemisphere.

There is indeed considerable scope for harvesting seafood at lower trophic levels. However, as has long been observed, we prefer to eat species at the top of the aquatic food web, which as you rightly say contrasts with human consumption of food from terrestrial environments. There have been numerous attempts, for example, to persuade Peruvians and Chileans to eat more of the fish harvested from their coastal waters instead of turning it into fishmeal and fish oil, but with little success. This is not to say that more couldn't be done, of course. A second somewhat more contentious point is that planktonic crustaceans assume a large part of the role of grazers that on land are occupied by large herbivores such as deer or elephants. In other words, while aquatic and terrestrial environments may indeed support similar levels of biomass, the marine environment may support smaller biomass of herbivores per unit area that can be directly harvested as human food (i.e. fish, etc.) than terrestrial environments.

12. Although I appreciate the research into these new and alternate methods of food production (seafood and meat surrogates) in general but aren't there easier ways to increase our global food output? Currently around 1/3 of globally produced food (pre-and post-consumer) are wasted or lost...33%, with an estimated financial worth of 990 billion US$ ...reducing this waste/loss would more directly contribute to global food security instead of highly intensified and energy-intensive ways of food production, no?

We agree that alt seafood may not be the quickest way to increase our global food output, and that loss and waste play a major role in this discussion. Altseafood may be better seen
as a shift in production method, albeit for regions that can afford it, that may alleviate some pressure on coastal or other fragile aquatic ecosystems.

On markets:

13. Thank you, Malcolm. However, I find this is very much supply-driven. I will send comments by email.

There would appear to be a growing market for these products, especially among consumers in high and middle-income countries. The products address issues of animal welfare and food safety and environmental concerns. This view is shared by many of the big food producers.

14. To what extent is the tourism market feeding the demand for more seafood that is adding to the weight of meeting this growing demand by looking at alternative seafood production? any comments please as the tourism market is intense and contributes to the GDP.

To be honest we cannot readily say. However, it is undoubtedly a factor.

15. Preliminary surveys in the U.S. seem to show very different consumer attitudes towards plant- versus cell-based seafoods. I’ve heard one estimate that ~40% of consumers would substitute some of their conventional seafood with cell-based options once they are available (which indicates a potentially very large market shift). Are any of the panelists seeing this level of consumer interest in their countries or study locations?

The available literature and media describe a similar level of interest in wealthier Asian countries/markets (Singapore, China) and some European countries (UK, Netherlands) but we are yet to see this interest (and that may be from a lack of data collection) in LMICs. Plant-based seafood (and plant-based alternatives in general) seem to have a wider reach, especially in younger generations.

16. This is interesting to meet diverse consumer demand. The population is growing and the potential to increase fisheries production is limited due to limitations in water availability and climate change. In short term will affect the fisheries sector but in the long term can replace some of the market shares.

There are indeed limitations to the expansion of seafood production by conventional means for the reasons you give. However, it remains a moot point as to whether alternative seafood will expand to fill the growing gap between seafood supply and demand or whether wealthier consumers will consume alt seafood in addition to rather than instead of conventionally caught or farmed seafood. The rapid growth of aquaculture production over the past thirty years had no impact on the consumption of fisheries products.

On scaling:

17. How will the advances made in terrestrial alternative meats affect progress with alternative seafood?

I think on two counts. First, if it is done right it is likely to help grow public acceptance of such plant- and cell-based foods and thus to develop markets. Second, I think there will considerable cross-over of technology – the development of cost-effective large-scale bioreactors, cell culture media and scaffolding for cell-based products and processing technologies for plant-based products. However, to some extent, the latter depends on attracting more funding for fundamental, open-source research, something that to some extent is hampering both sectors right now.
18. Hello from the Netherlands, Wageningen University. Question for the panelists: how would plant-based seafood scale up sustainably? For example, the Plant-Based Seafood Co. and its 'shrimp' use konjac (an East/Southeast Asian plant). Scaling up production will require land to grow this so how will environmental impacts be mitigated? Follow up: many of these products are geared towards affluent, Western customers, e.g. previously mentioned plant-based shrimp costs USD 28 for 25 'shrimp' so this does not address the acute impacts and needs of communities who depend on fish/seafood as part of their food security.

There is potential to use crops that are already being produced for different industries (e.g. approximately 98% of soy production is used for animal feed), but this is only possible if we see a transition is what we produce. Scaling up sustainably will also likely require governmental oversight and involvement.

Alternative seafood products likely will not be readily accessible for some time in LMICs, so will not directly contribute to food and nutrition security here. But once these products become more comparable with their conventional counterparts, and the appropriate value chains and governance are in place, we can hope that alternative seafood will be one method of increasing access and stability of seafood supplies. Alternative seafood may also indirectly impact food and nutrition security -- this hope centers on the idea of reducing pressure on coastal or impacted fishing grounds that traditional fishing communities rely on, but again the time to impact we are looking at is potentially quite long.

Answered live:

19. One perspective missing is that of the market - does the market want these products? Trond Bjornadl

There would appear to be a growing market for these products, especially among consumers in high and middle-income countries. The products address issues of animal welfare and food safety and environmental concerns. This view is shared by many of the big food producers.

20. What timeline do you see for the rollout of plant- and cell-based seafood? When will it replace 50% of the seafood products in stores?

Plant-based seafood production is increasing quite rapidly, albeit from a very small base. No cell-based seafood production is likely for another couple of years but may grow readily. Price remains the greatest determinant, as well as flavor and other attributes.

The timeline for replacing 50% is likely to be many decades … if ever!

21. How can we be sure ingredients used in alternative seafood products are responsibly sourced?

For cell-based seafood, the cells used are almost by definition sustainably sourced - stem cells, muscle cells, etc. However, there may be issues over what goes into the growth media, which may be covered by licensing.

For plant-based, plant-based materials used are products already deemed safe to eat - crops, mycoproteins, etc. Many producers would like to source a wider range of plant materials but some, especially marine plants, have yet to be licensed as safe for human consumption so at the moment aren’t used.
Ingredients are listed on the packaging. For those with concerns about the environmental issues surrounding certain crops, then labeling should help you avoid products containing these ingredients.