CATCH THE LATEST IN FISHERIES

INFOFISH International

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Opening of the 17th INFOFISH World Tuna Trade Conference and Exhibition, 11-13 October 2022, Bangkok, Thailand

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AQUACULTURE//

By Sujit Krishna Das

The characteristics of a circular economy – elimination of waste and pollution, circulation of products and materials, as well as regeneration of nature – resonate with the principles of responsible aquaculture development. Upcycling nutrient systems (for example, using Bioflocculation Technology (BFT); Integrated Agri-Aqua systems (IAA); multi-sector integration (e.g. renewable energy/fisheries/aquaculture); recycling of dissolved and solid effluent materials; and increasing circularity in feed production, can contribute to responsible and sustainable intensification. Implementation of a circular economy therefore contributes to responsible development in the sector, for which a globally accepted framework already exists in the FAO's Blue Transformation Roadmap 2022–2030.

FISHING//

By Emilia Dyer and Martin Purves

While some fishing subsidies help in sustainable resource management, most have contributed to decimation of stocks by increasing the capacity of industrial vessels to overfish. Addressing this issue can have a number of benefits, of which the most important is to bring about truly sustainable fisheries which conserve the oceans and provide livelihoods for the small-scale sector. The International Pole and Line Foundation (IPNLF) says that the new World Trade Organization (WTO)'s agreement on harmful subsidies is a step forward, but it does not go far enough and that reforms to subsidies may be needed to make them more responsible and equitable.

FEATURE//

By Christopher Lord

A tuna processor in Latin America received reports from a major retailer in the UK regarding the detection of the DNA of an undeclared tuna species in cans of skipjack tuna. Regulations specify that canned tuna must be prepared from a single species. This article is based on a case study that details the investigation carried out by the processor and others with expertise in the science of DNA analysis. It suggests alternative origins of the undeclared DNA, offers methods to assure the buyer that the risk of undeclared species in canned tuna has been minimized, and proposes a strategy to resolve the issue satisfactorily for all concerned.

Moritz K Lehmann and Andrew Middleditch

The detection of vessels at sea that are not self-reporting their position using automated geolocation systems, i.e., dark vessels, poses a particular challenge to maritime domain awareness. Satellites have a unique advantage in dark vessel detection as they can scan larger ocean areas more often than any other surveillance technology. In this article, the science team of Starboard™ Maritime Intelligence reports insights from their dark vessel detection operations using optical, radio frequency and synthetic aperture radar satellite sensors. We found that an effective satellite dark vessel monitoring programme requires a multi-sensor approach and patrol assets should be available for verification and interrogation of dark targets. In conclusion, dark illegal fishing threatens the sustainability of fish stocks and the economy of nations relying on fisheries income, but evolving technology and the increasing number of satellites mean that satellite sensors are quickly closing the surveillance gap for large ocean areas.

By Firoza Buranudeen

Like those in western markets, Asian consumers have a preference for live or fresh/chilled fishery species and products, followed by frozen, canned and other forms. Excluding the category of live/fresh/chilled species from its purview, this article provides a glimpse into the market for popular fishery products in several Asian countries, giving examples and highlighting some reasons why some items sell better than others. Flavour localisation is a key determinant in whether a product, which may be selling well in Europe or the US, will be equally successful in Asia. How it is presented, prepared, or incorporated into evolving lifestyles, and yet forming a large part of the traditional cuisine and cultural norms in Asia is another important factor.

INDUSTRY PROFILE//

Co-Founder & CEO, SCALE.VISION

EVENTS//

FISHBYTES//

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The 17th INFOFISH Tuna Trade Conference and Exhibition ("Strengthening Resilience, Adaptability and Sustainable Growth in the Global Tuna Industry") was held from 11 – 13 October in the "tuna capital" of Bangkok, Thailand. Participating were more than 500 delegates, 43 speakers, and the Hon Ministers from Ecuador (HE Andres Arens Hidalgo), Fiji (HE Semi Koroilavesau), the Republic of Kiribati (HE Ribanataake Tiwau), the Republic of the Maldives (HE Dr Hussain Rasheed), and Papua New Guinea (HE Jelta Wong). In addition, 38 international companies showcased their equipment and services at their various booths. A review of the event can be found on pages 34 – 38.

In this edition of the INFOFISH International, we are pleased to bring to you two of the papers presented at that Conference, both of which showcase the kind of innovation that has become the hallmark of the global tuna industry. One article, based on an actual incident, investigates the inadvertent presence of environmental DNA in imported canned tuna, and proposes a strategy to minimise the risk of recurrence. Another article points to the effectiveness of optical, radio frequency and synthetic aperture radar satellite sensors in tracking dark vessels at sea.

Fishing, both legal and illegal, is the focus in an article by the International Pole and Line Foundation (IPNLF). Specifically, while acknowledging that the new WTO agreement on harmful subsidies is a step forward, the IPNLF asks if we can end, or reform harmful subsidies to make them more responsible and equitable. This same theme of responsibility is carried through in an article on circular aquaculture in which some of the key features are elimination of waste and pollution, circulation of products and materials, as well as regeneration of nature. The author states that implementation of a circular economy contributes to responsible development in aquaculture, for which a globally accepted framework already exists in the FAO's Blue Transformation Roadmap 2022–2030. A final article, asking "What do Asian consumers want?", looks at some popular fishery products in several Asian countries. It puts forward the view that flavour localisation and incorporation into traditional and evolving Asian cuisines are some main determinants for market success in the region.

This edition of the INFOFISH International also contains an Industry Profile of Erik de Laurens, who exemplifies the kind of quiet innovation that is occurring in global fisheries. Having stumbled upon a fish leather tannery in France more than a decade ago, he noticed a significant waste: fish scales. Today, his company produces environmentally sustainable stone-like material which can be used as tiles, amongst other uses.

In addition to the articles, we invite readers to also take a look at our regular categories such as Industry Notes, Market Trends, Commodity Updates, FishBytes, and Innovations.

And finally, since this is the last edition for the year, on behalf of all at INFOFISH, I take this opportunity to wish readers good health and cheer for the upcoming Christmas and year-end holiday season.

Happy reading!

Shirlene Maria Anthonysamy
Director, INFOFISH

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Resúmenes de los principales artículos

Si bien algunos subsidios a la pesca ayudan en la gestión sostenible de los recursos, la mayoría ha contribuido a diezmar las poblaciones de peces al aumentar la capacidad de sobrepesca de los barcos industriales. Abordar este problema puede tener una serie de beneficios, siendo el más importante el lograr pesquerías verdaderamente sostenibles que conserven los océanos y brinden medios de vida al sector de pequeña escala. La Fundación Internacional Pole & Line (IPNLF) dice que el nuevo acuerdo de la Organización Mundial del Comercio (OMC) sobre subsidios perjudiciales es un paso hacia adelante, pero no alcanza, y que se deberían reformar los subsidios para hacerlos más responsables y equitativos.

Un procesador de atún en América Latina recibió informes de un minorista importante en el Reino Unido sobre la detección de ADN de una especie de atún no declarada en latas de barrilete. Las regulaciones especifican que el atún enlatado debe prepararse a partir de una única especie. Este artículo se basa en un estudio de caso que detalla la investigación realizada por el procesador y otros actores con experiencia en análisis de ADN. Sugiere orígenes alternativos del ADN no declarado, ofrece métodos para asegurarle al comprador que se ha minimizado el riesgo de aparición de especies no declaradas y propone una estrategia para resolver el problema de manera satisfactoria para todos los interesados.

Las características de una economía circular (eliminación de desechos y contaminación, circulación de productos y materiales, así como la regeneración de la naturaleza) resuenan con los principios del desarrollo de la acuicultura responsable. El reciclaje de sistemas de nutrientes (por ejemplo, utilizando tecnología de bio-floculación (BFT); sistemas de agro-acuicultura integrada (AAI); integración multisectorial (por ejemplo, energías renovables/pesca/acuicultura); reciclaje de materiales disueltos y efluentes sólidos; y aumento de la circularidad en la producción de ración; pueden contribuir a una intensificación responsable y sostenible. Por lo tanto, la implementación de una economía circular contribuye al desarrollo responsable del sector, para el cual ya existe un marco aceptado mundialmente en la Hoja de Ruta para la Transformación Azul 2022-2030 de la FAO.

La detección de embarcaciones en el mar que no informan automáticamente su posición utilizando sistemas electrónicos de geolocalización, es decir, embarcaciones oscuras, plantea un desafío particular para la conciencia del dominio marítimo, ya que la pesca ilegal oscura amenaza la sostenibilidad de las poblaciones de peces y la economía de las naciones que dependen de los ingresos pesqueros. Los satélites tienen una ventaja única en la detección de embarcaciones oscuras, ya que pueden escanear áreas oceánicas más grandes con mayor frecuencia que cualquier otra tecnología de vigilancia. En este artículo, Starboard™ Maritime Intelligence informa sobre sus operaciones de detección de embarcaciones oscuras utilizando sensores satelitales de radar ópticos, de radiofrecuencia y de apertura sintética. Descubrimos que un programa satelital efectivo de monitoreo de embarcaciones oscuras requiere un enfoque de múltiples sensores y los activos de patrulla deben estar disponibles para la verificación e interrogación de objetivos oscuros. En conclusión, la tecnología en evolución y el número cada vez mayor de satélites significan que los sensores satelitales están cerrando rápidamente la brecha de vigilancia de grandes áreas oceánicas.

Al igual que los consumidores en los mercados occidentales, los asiáticos tienen preferencia por las especies y productos pesqueros vivos o frescos/refrigerados, seguidos de los congelados, enlatados y de otro tipo. Excluyendo la categoría de especies vivas/frescas/refrigeradas, este artículo ofrece un pantallazo del mercado de productos pesqueros populares en varios países asiáticos, brinda ejemplos y destaca algunas razones por las cuales unos se venden mejor que otros. La localización del sabor es un factor clave para determinar si un producto que puede venderse bien en Europa o EEUU tendrá el mismo éxito en Asia. La forma en que se presenta, prepara o incorpora a los cambiantes estilos de vida, a pesar de pertenecer en gran parte a la cocina tradicional y las normas culturales en Asia, es otro factor importante.

Rodrigo Misa

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Résumés des articles de fond

Si certaines subventions à la pêche contribuent à la gestion durable des ressources, la plupart d'entre elles ont contribué à la dégradation des stocks à travers l'augmentation de la capacité opérationnelle des navires industriels telle la surpêche. S'attaquer à ce problème peut avoir un certain nombre d'avantages, dont le plus important est de parvenir à une pêche véritablement durable qui préserve les océans et qui fournit des moyens de subsistance au secteur de la pêche artisanale. La Fondation "International Pole and Line" (IPNLF) affirme que le nouvel accord de l'Organisation Mondiale du Commerce (OMC) sur les subventions dommageables est un pas en avant, mais qu'il n'est pas assez contraignant et il faut des réformes nécessaires sur les s subventions pour le rendre plus responsable et équitable.

Un transformateur de thon d'Amérique latine a reçu un rapport d'un grand détaillant au Royaume-Uni concernant la détection de l'ADN d'une espèce de thon non-déclarée dans des boîtes de listao. Les règlements précisent que le thon en conserve doit être préparé à partir d'une seule espèce. Cet article est basé sur une étude de cas qui détaille l'enquête menée par le transformateur et d'autres personnes ayant une expertise dans la science de l'analyse de l'ADN. Le rapport met en exergue d'autres origines de l'ADN de thon non-déclaré, propose des méthodes pour rassurer l'acheteur que le risque d'espèces de thon non déclaré en conserve a été minimisé et propose une stratégie pour résoudre le problème de manière satisfaisante pour toutes les parties concernées.

Les caractéristiques d'une économie circulaire - élimination des déchets et la pollution, circulation des produits et des matériaux, ainsi que la régénération de la nature - riment avec les principes d'un développement responsable de l'aquaculture. Recyclage des systèmes d'éléments nutritifs (par exemple, à l'aide de la Technologie de Biofloculation (BFT) ; Systèmes Agri-Aqua intégrés (AAI) ; l'intégration multisectorielle (par exemple, énergies renouvelables/pêche/aquaculture) ; le recyclage des effluents dissous et solides ; et l'augmentation de la circularité dans la production d'aliments pour animaux peuvent contribuer à une intensification responsable et durable. La mise en œuvre d'une économie circulaire contribue donc au développement responsable du secteur, pour lequel un cadre accepté à l'échelle mondiale existe déjà dans la Feuille de Route de la FAO pour la Transformation Bleue 2022-2030.

La détection de navires en mer qui ne déclarent pas eux-mêmes leur position à l'aide de systèmes électroniques de géolocalisation, c'est-à-dire de navires suspects, pose un défi particulier à la connaissance du domaine maritime, car la pêche illégale menace la durabilité des stocks de poisson et l'économie des pays tributaires des revenus de la pêche. Les satellites ont un avantage unique dans la détection des navires suspects car ils peuvent balayer de plus grandes zones océaniques plus souvent que toute autre technologie de surveillance. Dans cet article, *Starboard™ Maritime Intelligence* rapporte des informations sur ses opérations de détection de navires suspects à l'aide de capteurs satellites optiques, de radiofréquence et de radar à synthèse d'ouverture. Nous avons constaté qu'un programme efficace de surveillance par satellite des navires suspects nécessite une approche multi-capteurs et que des moyens de patrouille devraient être disponibles pour la vérification et l'interrogation des cibles suspectes. En conclusion, l'évolution de la technologie et le nombre croissant de satellites signifient que les capteurs satellitaires comblent rapidement l'écart de surveillance pour les grandes zones océaniques.

Comme ceux des marchés occidentaux, les consommateurs asiatiques ont une préférence pour les espèces et les produits de la pêche vivants ou frais/réfrigérés, suivis des produits congelés, en conserve et autres formes. En excluant de son champ d'application la catégorie des espèces vivantes/fraîches/réfrigérées, cet article donne un aperçu du marché des produits de la pêche populaire dans plusieurs pays asiatiques, tout en donnant des exemples et en soulignant certaines raisons pour lesquelles certains produits se vendent mieux que d'autres. La localisation des goûts est un facteur déterminant pour savoir si un produit, qui peut bien se vendre en Europe ou aux États-Unis, aura le même succès en Asie. La façon dont le produit est présenté, préparé ou incorporé dans l'évolution des modes de vie, tout en formant une grande partie de la cuisine traditionnelle et des normes culturelles en Asie est un autre facteur important à prendre en compte pour pénétrer ce marché.

DIGRÉ Arriko Calice

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文 章 摘 要

虽然一些渔业补贴有助于可持续的资源管理，但大多数补贴通过增加工业船只过度捕捞的能力而导致种群的大量减少。解决这一问题可以带来一些好处，其中最重要的是带来真正可持续的渔业，保护海洋并为小规模部门提供生计。国际延绳钓基金会（IPNLF）表示，新的世界贸易组织（WTO）关于有害补贴的协议是向前迈进了一步，但还不够，可能需要对补贴进行改革，以使其更负责任和公平。

拉丁美洲的一金枪鱼加工商收到英国一家大型零售商的报告，称在鲣鱼罐头中检测到一种未申报的金枪鱼物种的DNA。法规规定金枪鱼罐头必须由单一品种制成。这篇文章是基于一个案例研究，即详细介绍了加工商和其他具有DNA分析科学专业知识的人员进行的调查。它建议了未申报DNA的替代来源，提供了向买方保证罐装金枪鱼中未申报物种的风险已被最小化的方法，并提出了一个令所有相关方满意地解决问题的策略。

循环经济的特点——消除浪费和污染，产品和材料的循环，以及自然的再生——与负责任的水产养殖发展原则产生共鸣。提升循环营养系统（例如，使用生物絮凝技术（BFT）；综合农业水系统（IAA）；多部门一体化（例如可再生能源/渔业/水产养殖）；溶解和固体废水的回收；以及提高饲料生产的循环性，可以促进负责任和可持续的集约化。因此，循环经济的实施有助于该行业负责任的发展，为此，在粮农组织的《2022-2030年蓝色转型路线图》中已经存在一个全球公认的框架。

在海上发现没有使用电子地理定位系统自我报告位置的船只，即黑暗船只，对海洋领域的认识提出了特别的挑战，因为黑暗非法捕捞威胁到鱼类资源的可持续性和依赖渔业收入的国家的经济。卫星在探测黑暗船只方面具有独特的优势，因为它们可以比任何其他监视技术更频繁地扫描更大的海域。在这篇文章中，StarboardTM海事情报部门报告了他们使用光学、无线电频率和合成孔径雷达卫星传感器探测黑暗船只的行动。我们发现，一个有效的卫星暗船监测计划需要一个多传感器的方法和巡逻设备应可用于核查和审讯暗目标。总之，不断发展的技术和越来越多的卫星意味着卫星传感器正在迅速缩小对大片海域的监测差距。

和西方市场的消费者一样，亚洲消费者更喜欢活的或新鲜的/冷藏的鱼类品种和产品，其次是冷冻的、罐装的和其他形式的。不包括活/鲜/冷的种类，这篇文章提供了一些亚洲国家流行的水产品市场的一瞥，给出了一些例子，并强调了一些项目比其他更好卖的一些原因。将欧美流行的产品风味本土化是决定一个产品在亚洲是否同样成功的关键因素。它如何被呈现，被预制，被融入到不断演变的亚洲生活方式中是一方面，而能否形成亚洲传统美食和文化规范的一部分是另一个重要因素。

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THE BEGINNING OF THE END FOR HARMFUL SUBSIDIES: IS IT WITHIN REACH?

By Emilia Dyer and Martin Purves

While some fishing subsidies help in sustainable resource management, most have contributed to decimation of stocks by increasing the capacity of industrial vessels to overfish. Addressing this issue can have a number of benefits, of which the most important is to bring about truly sustainable fisheries which conserve the oceans and provide livelihoods for the small-scale sector. The International Pole and Line Foundation (IPNLF) says that the new World Trade Organization (WTO)'s agreement on harmful subsidies is a step forward, but it does not go far enough and that reforms to subsidies may be needed to make them more responsible and equitable.

Credit: IPNLF

Decades of global fisheries subsidies, which often do more harm than good, have landed us in hot water, but after a long week of deliberations at the World Trade Organization's (WTO) 15th Ministerial Conference in June 2022, an agreement on harmful subsidies was finally reached.

This new agreement establishes some much-needed rules on how nations can allocate fisheries subsidies, but serious concerns remain about ongoing subsidies that provide an economic incentive for fishing to continue even when fish stocks are already declining and fishing is no longer profitable. So, why is it so important for fisheries and our ocean that we continue to work for the complete abolishment of harmful fisheries subsidies, and is the recent WTO agreement as positive as it seems on the surface?

The need to transform our food systems

Since humans first began to fish on any scale we have demonstrated an inability to take only what we need. The exploitation of global fish stocks ramped up dramatically with the introduction of motorised vessels, and this has been especially true since the 1950s, with global fishing capacity and effort more than doubling while the nominal catch per unit of effort (CPUE) has comparatively decreased. So in effect, an increasing number of larger fishing vessels are using more sophisticated equipment to chase and catch fewer fish. Obviously, such a situation is not sustainable.

The impacts of fishing on the ocean have been felt for decades, as we have polluted, damaged and fished beyond its limits, in many instances leaving behind altered ecosystems where marine organisms struggle to survive. Instead, our ocean is in danger of becoming a hot, acidic shell of its former self, dotted with dead zones, plagued by plastic and overfished beyond belief. We need to reverse the path we're on and transform our food systems. Truly sustainable fisheries need to help secure livelihoods and restore ocean life by stopping overfishing and destructive fishing practices. Seafood production systems need to play their part in protecting and restoring ocean biodiversity, making a hopeful future for today's and future generations possible.

Despite media coverage of plastic straws and bottles, the greatest threat to our ocean is industrial overfishing. We remove over 100 million tons of wild fish from the oceans every year, the majority of which are taken via destructive and non-selective fishing methods, such as bottom trawling, gill nets, and in tuna fisheries, the use of entangling drifting Fish Aggregating Devices (FADs). Abandoned, lost, or otherwise discarded fishing gear (ALDFG) is increasingly of concern with the continued catching of target and non-target species (such as turtles, seabirds and marine mammals); alterations to the benthic environment; navigational hazards; beach debris/litter; the introduction of synthetic material into the marine food web; the introduction of alien species transported by ALDFG; and a variety of costs related to clean-up operations and impacts on business activities.

Sealife easily become entangled in, or are killed by, drifting FADs as well as abandoned and discarded fishing gear

Subsidies make it easier to overfish

Small-scale fisheries, including responsible methods such as one-by-one tuna fishing, are increasingly being squeezed out of markets, outcompeted by highly subsidised, industrial vessels often using more destructive fishing methods. Now over two-thirds of the world's commercial fish stocks are either already fished at maximum levels or are overfished. Intense fishing pressure over many decades has led us to this point of oceanic decline in abundance and diversity of life. As a result, we now have to pump money into the industry in order to keep it afloat. This comes in the form of subsidies.

Government subsidies for fisheries can come in a number of forms and whilst some are helpful, such as promoting conservation and sustainable fishery management, many are socially and environmentally harmful. The most harmful are those which reduce the operating costs of industrial fleets and subsequently encourage them, or facilitate them, to overfish. How? It allows larger fleets to go out further, staying at sea longer, and catching more fish. For example, harmful subsidies include reduced fuel costs or support to increase capacity of a fleet. Recent research found at least 60% of subsidies to be socially and environmentally harmful, amounting to over USD 22 billion annually. These subsidies effectively mean that taxpayers are paying industrial boats to degrade the environment and to destroy the food security and livelihoods of vulnerable coastal communities around the world.

Subsidies therefore do more harm than good in a number of areas but addressing them can have a number of benefits. So what does this new WTO agreement do to facilitate the transition?

Supporting biodiversity

In propping up industrial overfishing, our current system facilitates further exploitation and biodiversity loss beyond the balance of the ecosystem. We are suffocating our ocean, at a cost to our pockets and our future. However, there is an alternative USD 22 billion dollars worth of destructive subsidies every year which could be our answer. If we can reallocate the harmful subsidies - those that increase fleet capacity and fund their extra effort to compensate for decades of overfishing, such as fuel subsidies - this money could be repurposed for positive reform.

A 2020 study by the Organisation for Economic Cooperation and Development (OECD) found that reversing biodiversity loss of recent decades across both land and sea would cost USD 78 - 91 billion per year globally. However, governments currently spend USD 500 billion annually on practices that are harmful to the environment. In other words, ceasing funding to activities that are harmful to the environment would provide 5 – 6 times the amount of funding we would need to reverse the impacts on biodiversity. Similarly, a study by the Paulson Institute highlights the redirection of harmful subsidies as key to changing our systems to those that support biodiversity rather than destroying it.

Increasing capacity can lead to overfishing

Subsidies financially support industrial fisheries in an ocean that they have depleted to such an extent that they now often

can't survive without them. A global study found that 54% of high seas fishing grounds would not be economically viable given current catch rates, unless the industrial fishing fleets exploiting these grounds were propped up by government subsidies. Essentially, subsidies which increase capacity and a fleet's ability to find fish, will encourage them to continue fishing at current catch rates, thereby further depleting global fish stocks. This, in turn, will result in the need to spend more money in the future to help fleets reach dwindling fish populations. Such a never-ending downward spiral that can only lead to disaster!

Subsidised industrial fleets have the capacity to overfish and crowd out the small-scale sector

Instead, ending capacity-related subsidies would limit the number of boats and the technology they're equipped with, reducing fleet expansions as they fish more in balance with the bounds of the ocean, putting less pressure on fish stocks. Recovering fish stocks have obvious financial and ecological benefits for people and the planet in the long run.

One of the greatest downfalls of the WTO agreement is that it fails to address this critical issue. There are no measures to stop subsidies which enhance capacity and, crucially, nothing to prevent building new vessels which target fish stocks like tuna, many of which are struggling under the immense pressure from industrial fleets.

Equity: developing nations lose out

Subsidies, both harmful and beneficial, are distributed disproportionately in favour of industrial fleets of developed nations. More than 80% of subsidies are allocated to large-scale, industrial fleets of nations such as China, Japan, the EU, Korea, Russia and the US. In terms of subsidies per landed value, industrial fisheries receive twice as many subsidies per dollar landed than small-scale fisheries! After accounting for the difference in employees, the study found that an industrial fisher receives as much as 3.5 times more subsidies than a fisher involved in a small-scale fishery. There is obviously still a long way to go in terms of the equitable distribution of fishing subsidies.

This disproportionate distribution keeps small-scale fisheries, often based in low-income countries, on the back foot and allows dominant fishing nations to send more distant water fleets into the waters of remote coastal communities. Research has found that most fisheries subsidies are given out by developed nations but that the ecological burden of their fishing activities is concentrated in the waters of developing nations and small-island developing states. This means that low-income countries with more sustainable fishing methods are subjected to the consequences of overfishing without reaping any of the benefits of having caught so many fish previously, because resources in their region are being sold by other nations in other countries.

By ending harmful subsidies, and redistributing the funds, we could level out the oceanic playing field and give small-scale, low-impact fisheries a better chance in the markets. Unfortunately, the WTO agreement is yet to outline any guidelines for the equitable distribution of fishing subsidies, or how to reduce the impacts on developing, coastal nations.

Transparency and accountability

Transparency across industries is a driving force towards a more environmentally sustainable, equitable future. As an industry that operates largely out of sight, increasing transparency in fisheries is an essential component to moving forwards. This is especially true for fisheries operating on the high seas as these are considered a common good and no state owns these resources. Increased transparency will help to hold fisheries accountable for their operations, empowering consumers to make informed choices. Historically, there has been a heavy veil over fisheries subsidies and governments haven't been required to disclose information about them.

This is however about to change. One of the most positive outcomes of the new WTO agreement is that it improves transparency by mandating states to disclose the subsidies they grant to their fisheries. This is a significant step forward

as these increased levels of transparency, making more information publicly available, will help drive change and hopefully speed up the phasing out of many harmful subsidies.

The future can still be bright

We are all dependent on the ocean ecosystem, not least, the fishing industry itself. Therefore, ending harmful subsidies should be seen as an opportunity to redirect funds, which have previously been used to facilitate the over-exploitation of our oceans; instead investing these to manage our fisheries effectively and operate in balance with nature, rather than against it.

Redirecting these funds to improve global biodiversity makes clear economic sense, especially when you factor in what would happen if we don't begin to protect and restore ocean biodiversity. The crises of biodiversity loss and climate change share many of the same causes and solutions and need to be addressed concurrently. Recent analysis estimates that around half of global GDP (USD 44 trillion) is highly or moderately dependent on nature - the pivotal role that natural capital assets and ecosystem services play in ensuring social and economic prosperity. Turning away from harmful subsidies and redirecting these funds can enable new investments, benefitting fishing communities, national economies and marine ecosystems, and help transform our future. Instead of investing in over-exploitation, we should invest in the enforcement of international law on the high seas, research on the recovery of fish populations and the promotion of sustainable fishing practices, among other things.

Nature loss threatens our health and economies and it also undermines our efforts to tackle the climate crisis. Many governments and non-state actors are calling for a Nature-Positive future where food systems do not result in biodiversity loss, habitat degradation and high levels of carbon dioxide emissions, but instead help to protect and restore biodiversity, improve habitat resilience and remove carbon from the atmosphere. In doing so, we would reduce inequity in global food systems, promote sustainable fishing for the future and allow fish stocks to recover, ensuring that people around the world have access to sustainable food for generations to come.

Although the WTO has been kicking the 'harmful subsidy' can down the road for two decades, this new agreement does offer a glimmer of hope. Whilst important steps have been taken, and in future there will be greater clarity on how subsidies are allocated and spent, we still have a long road ahead to phase out all the harmful impacts of fisheries subsidies. The next step at the WTO will be for governments to fine-tune the details of the agreement at the next ministerial conference, possibly in late 2023, and to deal with some of the subsidies where agreement proved elusive. Indonesia, for instance, is pushing for the banning of state subsidies for fleets that operate on the high seas and for vessels that have switched their flag states. In tuna fisheries, the state subsidies that many distant-water fishing operations receive remains a serious issue that many feel undermines the long-term sustainability of these resources in the waters of coastal states.

Ultimately, what is needed are reforms to subsidies to make them more responsible and equitable. It's not clear what will happen next, but the harsh reality is that our oceans, food systems, and coastal communities may not survive another two decades of putting off the issue. The opportunity to transform our future is within reach and we all need to play our part in pushing for further momentum on the complete abolishment of harmful subsidies.

Call on your government to put their actions where their mouths are. It's time to deliver on meaningful legislation which ends and reinvests harmful subsidies to ensure a more just, equitable and sustainable future for all!

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Martin Purves *is a fisheries management and engagement specialist with over 20 years of field, government, consultancy, market and non-profit sector experience. He has been leading the work of the International Pole and Line Foundation (IPNLF) as Managing Director since 2016. Mr Purves started his career as a fisheries observer on fishing vessels, later also joining scientific cruises as a cruise leader, spending more than three years of his life on fishing vessels of all sizes in the Southern, Indian, Atlantic and Pacific Oceans. He gained further experience by working as a resource manager at the South African fisheries department where he represented his country at RFMO meetings. In between his stint as a government scientist and fisheries manager, and before establishing and leading the Marine Stewardship Council's (MSC) Southern Africa Programme for seven years, he worked as a fisheries consultant for MRAG and Capfish. The toughest job he ever did was to work as a fisherman in the Southern Ocean.*

Market Trends

SHRIMP

Global: Gorjan Nikolik, industry analyst, via *Undercurrent,* highlighted that for Ecuador's shrimp production, the country's supply is continuing to reach highs even as uncertainty in prices is seen. He added that Ecuador alone can create another 350 000 MT of additional global supply if the projection of 1.35 million MT harvest in 2022 is true. Moreover, the analyst mentioned that production has also increased in China, India, Viet Nam and Indonesia. Therefore, it is expected that the momentum of the global production in the first half will be carried into the second half as the seeding for harvest this August and September was made back in April and May.

Japan: Despite the strong season of shrimp consumption, demand for basic shrimp products for home cooking and ready-to-eat meals in the retail segment (supermarket and online) as well as the overall shrimp consumption in the foodservice sector is yet to pick up. Demand however, continues to remain steady post-COVID-19. Market and price instability continues following the uncertainties in the general economic situation and the threat of emerging COVID-19 variants.

USA: Consumer demand for shrimp in the retail and foodservice sector remained slower but constant and stable compared to other seafood products particularly salmon. This is however an unusual scenario during the summer season which is usually considered a very strong shrimp consumption period. Wholesale shrimp prices also remained relatively stable despite the high inflation and rising fuel prices due to political conflicts. According to some analysts, this indicates that demand is on par with the increasing supply of imported shrimp. Imports however, have slowed down in July due to the stockpiling of inventory.

India: India continues to be one of the top suppliers to the US market during the first seven months of the year despite a huge decline in export in the month of July by 21% against last year. During the Global Shrimp Forum, analysts said that the country's shrimp production would likely remain high as the country invests more into the sector. However, *vannamei* production is forecasted to drop to around 800 000 MT in 2022.

Vietnam: The spread of disease is affecting shrimp production in the country, causing raw material shortage. Processors are having difficulty to fulfill orders despite the higher prices offered. Moreover, the continued global inflation and the uncertainties in global shipping are further complicating matters for the shrimp industry in Vietnam.

Indonesia: Prices for *vannamei* rose in the West Java region across all sizes during the week of 5-11 September (week 36). The 30/40 counts increased for the first time in four weeks at USD 5.60/kg and USD 5.30/kg respectively. Counts 60, 80 and 100 also recorded increases. In addition, the same trend was observed in Central Java. *Source: Undercurrent News.*

Europe: Shrimp demand in Europe is not as good as expected during the summer months. Prices for large-sized shrimp for both farmed and wild (Argentine) are on a downward trend as supplies are up following low demand in the US market and cold storage holdings in the region are still considered good. However, supplies of middle and small sizes are getting tight as demand for both is increasing due to shifting of marketing focus to lower-priced products and value addition. *Source: EPR 7/2022.*

Argentina: In the first half of 2022, exports of frozen shrimp to the Russian Federation were recorded at only 658 MT from 4 203 MT, a decrease by 84% compared in the same period last year. The collapse was due primarily to the Russia-Ukraine conflict.

Moreover, export to main countries in Europe: Spain, Italy and France also decreased, by 35%, 54% and 39% respectively. During the reported period, there were high shrimp catches in the country, and because of the low demand in Europe, prices of Argentinian shrimp went down.

Asia/Europe: In Europe it is known that countries in Asia, particularly India, Vietnam and Indonesia are among the main suppliers of shrimp in the region. During the first half of the year, India's cumulative total export of shrimp to the world increased marginally by 1.42%, while Indonesia was up by 2.3%. During the review period, India recorded increases of shrimp exports to its main markets in Europe: Belgium (+34%), the Netherlands (+69%) and UK (+10.8%). Vietnamese supplies were also up for the Netherlands (+53.8%), Germany (+30%) and Belgium (+71.6%), and a similar growth trend was seen for Indonesian shrimp exports to the UK (+15.6%), the Netherlands (+28%) and Belgium (+230%).

TUNA

Japan: The unstable weather conditions during the typhoon season from mid-August to September continued to see a considerable decrease in landings for the daily auction at the Toyosu fish market for both fresh and frozen tuna. As a result, fetching prices also remained unfavourable during that same period. Demand is however expected to increase from October onwards with the coming festive holidays (Autumn Equinox).

Generally, consumers' buying power has been further impacted with the rising cost of goods and services, affecting demand for sashimi tuna for household consumption.

Thailand/Western Pacific: Fishing in the Western and Central Pacific Ocean is expected to improve with the ending of the 3-month FAD closure on the 30th of September. Delivery prices of frozen skipjack to Thailand (CFR) have risen sharply at USD 1 800/MT from USD 1 750/MT in late August due to the low supply as a result of the FAD closure.

USA: The year-to-date total imports of non-canned frozen tuna fillets increased by 45.5% for the January to July 2022 period at 30 800 MT compared to the previous year of the same period which was at 21 167 MT. This is by far the highest recorded figure since 2019. Supplies from the top ten exporters increased except for Canada (-15.1%). During this review period, Vietnam surpassed Indonesia (the USA's top importer since 2018) with a market share of 42.7% over 31.4%.

CANNED TUNA

USA: Total imports of canned and processed tuna for the January to July 2022 period totalled 135 745 MT in volume (8.2% increase) and about USD 693 million in value (10.5% increase) compared to the same period of the previous year. During this review period, imports from the top ten suppliers were higher except for Thailand (-1.6%), Indonesia (-17.1%), the Philippines (-26.3%) and Mauritius (-13.19%) compared to the same period in 2021. However, Thailand maintained its market share dominance at 43.6%, followed by Ecuador at 12.3% and Vietnam at 10.6%.

Thailand: The year-to-date total canned and processed tuna export for the January to July 2022 period was 299 474 MT in volume (+10.4%) and about USD 1 272 million in value (+18%) compared to the same period of the previous year. During this review period, export to Thailand's top ten markets remained higher for all except for Saudi Arabia (-21.4%), and Chile (-0.3%). The US market continues to be Thailand's main destination for canned and processed tuna with a 21.9% market share dominance over Egypt (14.4%), Australia (7.8%), Japan (7.7%) and Libya (7.2%).

FROZEN AND FRESH FISH

Tilapia

USA: During the first half of 2022, frozen tilapia imports increased by 18% at 74 591 MT compared to the same period in 2021. Both frozen fillet and whole product categories grew positively by 21.8% and 9.4% respectively. Among the main suppliers of frozen fillets, imports increased from China (+22.8%) and Indonesia (+24.5%), whilst for frozen whole, there were growths from Brazil (+320%), Thailand (+120%) and Vietnam (+58%). Although China and Taiwan's export of frozen whole tilapia declined, it was compensated by increases from new suppliers, particularly Colombia.

USA: Fresh/chilled tilapia fillet imports during January – June 2022 increased by 4.3% in volume and 13% in value compared to the same period in 2021. During this period, increases in exports were recorded from main suppliers, namely Brazil, Colombia, and Honduras, while Costa Rica, Ecuador and Mexico recorded decreases. The slight incline in the total imports of fresh/chilled tilapia fillets for the review period was primarily because of the increase of supply from Colombia. Demand for the product continues to grow following regular operation of hotels and restaurants as COVID-19 protocols were eased.

Pangasius

Vietnam: A Vietnam-based company has resumed exporting frozen pangasius to the US after leaving the market in 2014 due to the imposition of high antidumping duties on Vietnamese pangasius. With exports now resumed, the company has set the long-term goal of taking over 10% of the total US pangasius market.

USA: During the first half of 2022, imports of frozen catfish increased by 39% to 81 448 MT from 58 757 in the same period of the previous year. Frozen pangasius fillets continued to dominate imports with 93% market share. The total import of frozen catfish fillets was up by 39% with increased supplies from Vietnam (+40%) and China (+24%). With eased COVID-19 restrictions in the main supplying countries, particularly Vietnam, more raw materials were made available for processing and export. In addition, the current state of inflation in the country has increased demand for lesser-valued species, which has inevitably boosted higher demand for frozen catfish imports.

Salmon

China: During the first half of 2022, fresh Atlantic salmon imports (excluding fillets) decreased by 19.6% in volume at 20 967 MT but increased in value by 40% at 345 121 MT compared to 2021 of the same period. Inflation remains the main reason why there was a decline in imports from the main suppliers in Norway, Chile, Faroe Islands and Canada together with some COVID-19-related protocol implemented by China for exporting countries' products.

Norway: July was the best month of the year in terms of export value for salmon. Salmon exports were at 96 500 MT in volume and valued at USD 891.5 million. The relatively high prices saw salmon exports increase its value by 27% at USD 184.4 million compared to the same month last year, although

the volume was down by 5%. Main markets for Norwegian salmon were Poland, Denmark and France.

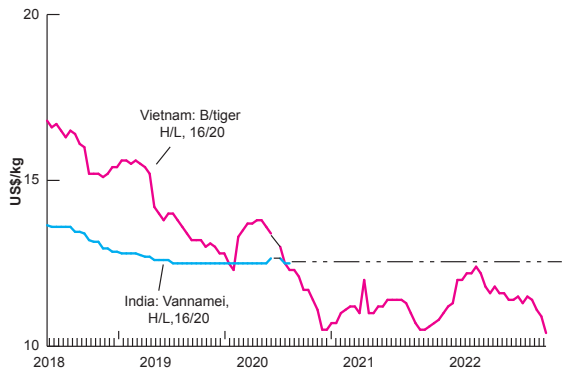
Asia: Imports of fresh/chilled salmon during January – June 2022 recorded decreases in the main markets. Despite a lower import volume (-20%), China continues to dominate the Asian market with imports of 20 967 MT and an increased value of 40% compared to the previous year of the same period. The Republic of Korea is still in second position followed by Thailand, Taiwan, and Japan, making up the top five in Asia.

Among the main importers in Asia, all recorded decreases in volume except for Indonesia, which increased by 31%. Due to inflation and other causes, the import value of fresh/chilled salmon in these Asian main markets increased. Demand for high value seafood like salmon slowly decreased because of price hikes although the hotel, restaurant, and catering services (HORECA) sector is now back to normal operation hours and capacity.

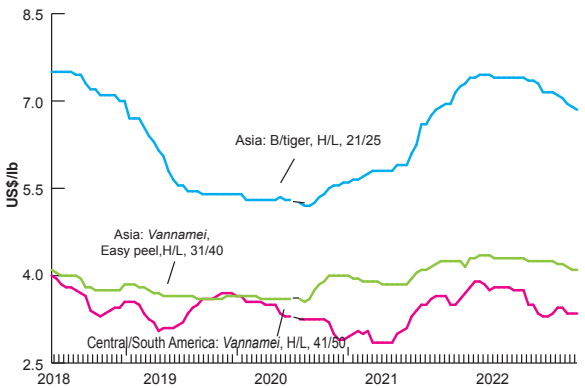
Japan: Imports of fresh/chilled salmon during the first half of 2022 decreased by 26% in volume but increased by 1.1% in value compared to the same period in 2021. Specifically, both Atlantic salmon and Pacific salmon declined by 26% and 25% respectively in terms of volume. There was a significant decrease in volume from the main supplier of Atlantic salmon, Norway, by 42.8%. Canada, on the other hand, increased its supply of Atlantic salmon to Japan by 40.6%; other suppliers of fresh/ chilled Atlantic salmon are Chile, Faroe Islands, and Iceland. The overall negative growth of fresh/chilled salmon imports during January – June 2022 was due to increase of prices following global inflationary pressures on salmon.

Price Trends

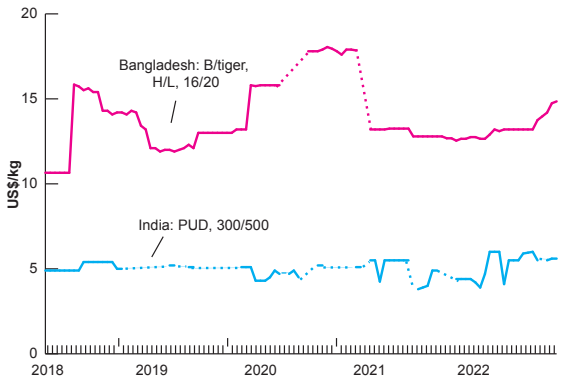
FROZEN SHRIMP, C&F JAPAN (US$/Kg)



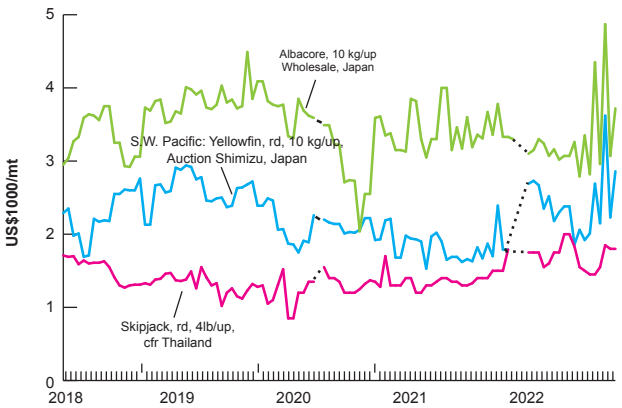
FROZEN SHRIMP, USA (ex-warehouse NY, US$/lb)



FROZEN SHRIMP, EUROPE (CFR, US$/kg)

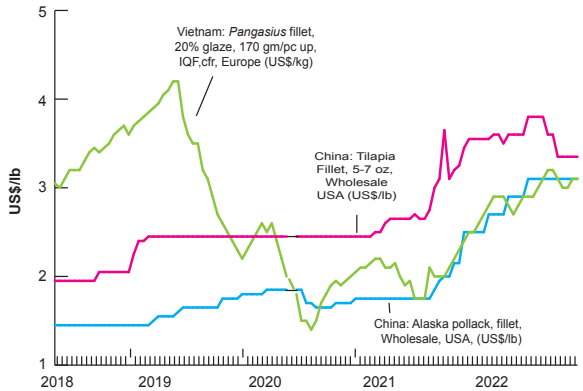


FROZEN TUNA (US$/MT)

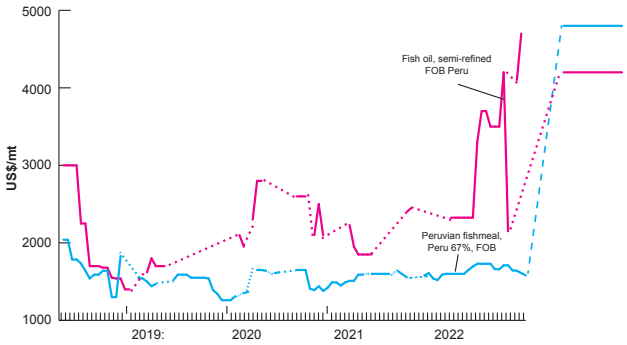


Price Trends • Cold storage holdings • import trends

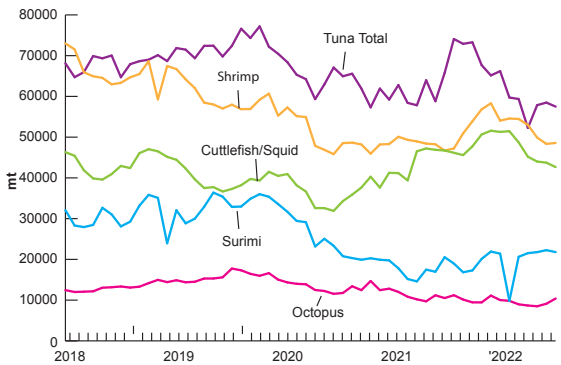
FROZEN WHITEFISH



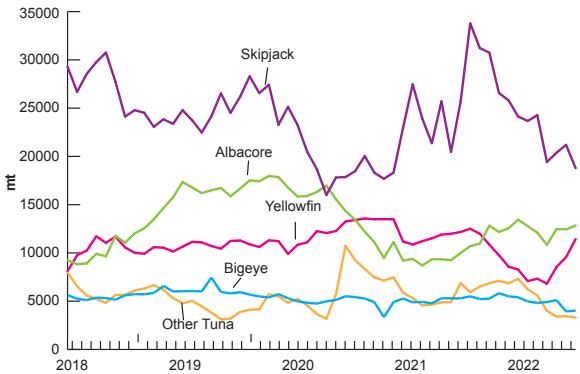
FISHMEAL/FISHOIL (US$/MT)



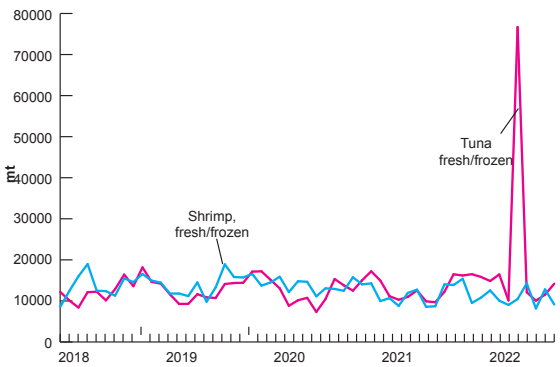
JAPAN COLD STORAGE HOLDING: SELECTED PRODUCTS (MT)



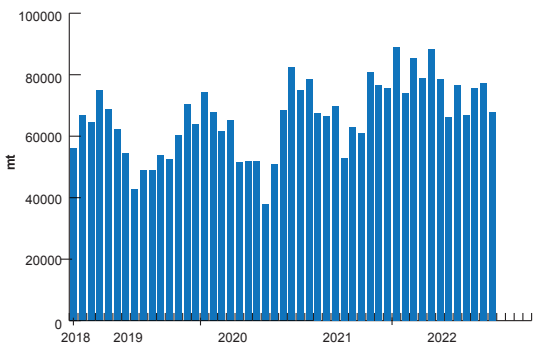
JAPAN COLD STORAGE HOLDINGS TUNAS (MT)



JAPAN: MONTHLY IMPORTS OF SHRIMP & TUNA (MT)



USA: Monthly SHRIMP Imports



CRAB

With the war in Ukraine having a major impact on the crab industry, the current state of play has been described as "lower supplies, shifting trade patterns and high prices" as a result of the imposed trade sanctions on the Russian Federation, the largest supplier of king crab and a major supplier of snow crab.

Supplies

In early April, the Department of Fisheries and Oceans Canada announced that the quotas for the 2022 snow crab fishery would be increased. The quotas and the increases vary from area to area, but all told, the total Canadian snow crab TAC for 2022 will amount to 50 470 tonnes, up by 32 percent compared to 2021. The fishery opened on 4 April.

The main competitor for the Canadian snow crab fishery in the US market is the Alaska snow crab fishery, which has seen a dramatic cut in quotas, down by 88 percent for the 2022 fishery. Russian imports have in the past been another major competitor; these will likely be restricted as the United States of America has announced a ban on Russian imports of fish and fish products, set to come into force on 23 June.

Oregon Dungeness crab harvesters set a new record in January with landings of 14.7 million pounds (6 668 tonnes) just eight weeks into the season, with an ex-vessel value of USD 74.5 million. While it is still early days, it is expected that the record landings of 23.05 million pounds (10 455 tonnes) in 2017 will be surpassed. Ex-vessel prices averaged USD 5.48 per pound, which is considered to be high for the time of year.

Washington State has issued an emergency order in an effort to eradicate the European green crab *(Carcinus maenas)* in their waters. The European green crab is a small shore crab, with a natural range in the Northeast Atlantic Ocean along coasts from northern Africa to Norway and Iceland, and in the Baltic Sea. The crab is an effective predator, adept at opening bivalve shells. It preys on numerous organisms, and has been blamed for harming the softshell clam industry on the east coast of the United States of America, having decimated the industry in the Gulf of Maine.

California announced that all commercial Dungeness crab harvesting would cease along three quarters of the California coast for the months of April and May, in an effort to prevent the entanglement of humpback whales with the fishing equipment.

International trade

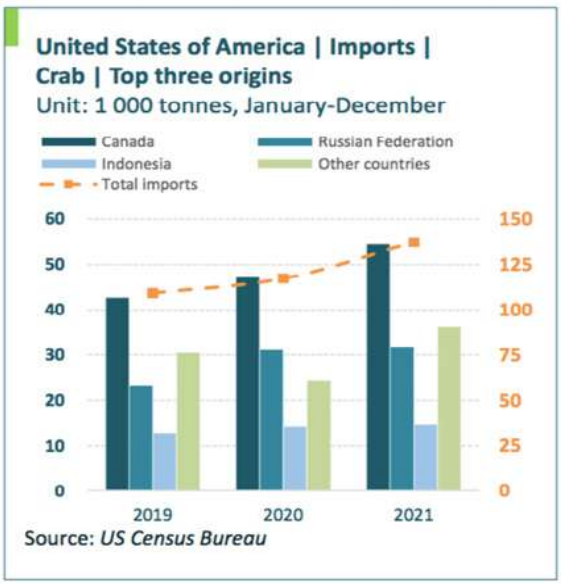
Global trade in crab picked up slightly in 2021 after a modest decline in 2020. Total imports grew by 12.8 percent to 418 470 tonnes. The main importers were the United States of America with 137 249 tonnes, up by 17 percent compared to 2021, and China with 85 165 tonnes, up by 25.7 percent.

The largest supplier to the United States of America was Canada, which accounted for 40 percent of the volume of imports, followed by the Russian Federation (23 percent of total) and Indonesia (10.6 percent of total).

While the market for live Russian crab has shrunk somewhat due to trade restrictions, observers perceive this change to be limited by the relatively small size of the European market for live king crab and snow crab. Even so, Russian exporters have had to re-direct shipments to other markets.

Europe is a major market for Russian frozen snow crab and king crab. In 2021, 57 percent (USD 929 million) of frozen Russian snow and king crab went to the Netherlands for consumption in Europe or re-export to other markets. This trade is now in jeopardy as European countries have imposed sanctions on trade with the Russian Federation. The situation may open an opportunity for Norwegian crab exports, although the country is currently a relatively minor player in the global snow and king crab industry.

The value of US imports of blue swimming crab *(Portunus pelagicus)* increased dramatically in 2021 as unit prices for imports shot up. During 2021, US imports of both blue and red swimming crab amounted to 30 231 tonnes, of which 47 percent came from Indonesia. The value of these imports has increased dramatically, from USD 448.5 million in 2020 to USD 845.4 million during the first eleven months of 2021.



The turbulence in the market has had a marked impact on crab prices. The majority of prices have skyrocketed, as the Russian Federation, the largest global supplier, is no longer able to export to western markets. In Canada, industry

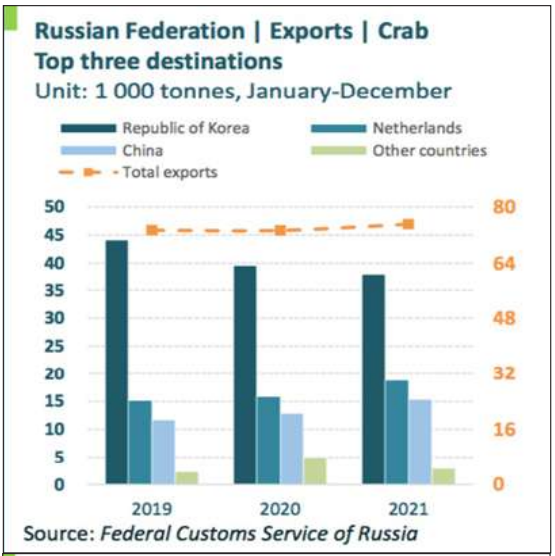
spokespersons are saying that prices need to be reduced in order to keep trade flowing. Canada is the second largest supplier of king crab and snow crab to the US market, after the Russian Federation. Imports from the Russian Federation account for 30 percent of all the snow crab and 90 percent of all the king crab imported through the major port of Seattle.

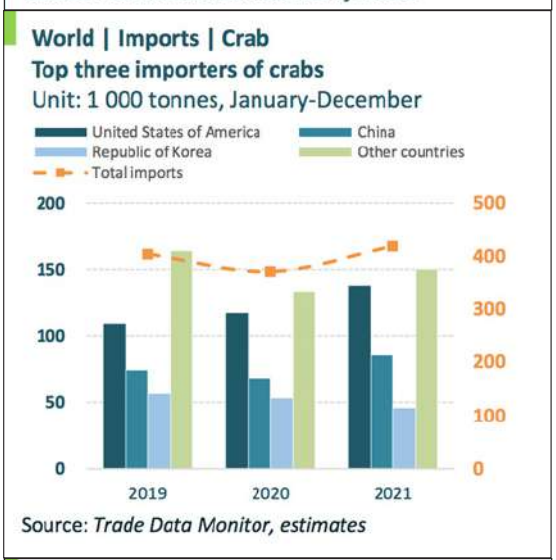
Russian exporters have diverted shipments of crab that would normally be destined for China and western markets because of the ban on Russian imports in many western countries and the closure of some important Chinese ports. These have been largely redirected to the Republic of Korea and prices for both snow crab and king crab in the Republic of Korea have plummeted. While most Korean consumers previously found these delicacies unaffordable, they are now buying king crab and other crab products from the Russian Federation in great volumes. Thus, a market in the Republic of Korea is developing for these products; it remains to be seen if the market will be able to sustain itself if prices were to return to previous levels.

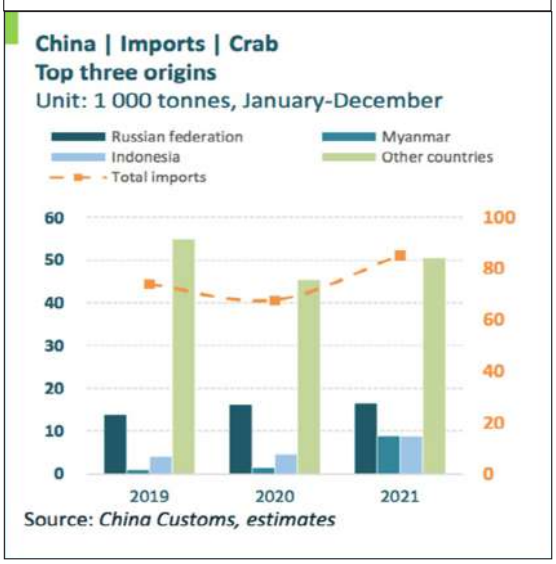
Outlook

It appears that the global market for crab will remain turbulent for some time to come. The supply situation for king crab and snow crab will remain difficult as Russian supplies are cut off from western markets and the Alaskan quota has been drastically reduced. For the time being Russian crab is being diverted to countries that have not yet imposed trade restrictions on Russian exports, such as China and the Republic of Korea.

There is sustained and growing demand for crab in the global market. Prices have shot up in most markets and will probably remain high unless something happens to dampen demand.







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WIDE RANGE OF PRODUCTS

ENVIRONMENTAL DNA (eDNA) IN CANNED TUNA: HOW DOES IT AFFECT THE INDUSTRY?

By Christopher Lord

A tuna processor in Latin America received reports from a major retailer in the UK regarding the detection of the DNA of an undeclared tuna species in cans of skipjack tuna. Regulations specify that canned tuna must be prepared from a single species. This article is based on a case study that details the investigation carried out by the processor and others with expertise in the science of DNA analysis. It suggests alternative origins of the undeclared DNA, offers methods to assure the buyer that the risk of undeclared species in canned tuna has been minimized, and proposes a strategy to resolve the issue satisfactorily for all concerned.

A major UK retailer reported the presence of another species in canned skipjack tuna chunks in brine. "We have detected skipjack *(Katsuwonus pelamis)* tuna as expected in both the chunks and the flakes but also a signal for another species of tuna in the flakes." The buyer shared the Certificates of Analysis from Eurofins Food Testing UK Ltd. The Certificate states that a "mixture of *Katsuwonus pelamis* (skipjack tuna) and *Thunnus spp*" were detected in the flakes of the sample analyzed, but no method was specified. After some discussion, it was determined that the testing conducted used specific real-time PCR DNA analysis[1,2].

In this case, it is most likely that *Thunnus spp* was *Thunnus albacares* or yellowfin tuna, since 85% of *Thunnus* species processed at this facility are yellowfin tuna. The balance is *Thunnus obesus* or bigeye tuna.

One of the most common reasons for food fraud is economic gain where the supplier substitutes a cheaper material for a more expensive one. However it should be noted that yellowfin tuna from the Eastern Tropical Pacific (ETP) is of considerably more value than skipjack tuna, especially since yellowfin is MSC-certified. Since the beginning of 2021, the price of yellowfin has averaged approximately 70% higher than skipjack, or about USD 1000 per ton more, so economic fraud does not make sense in this case[3].

[1] *Botti, S. and E. Giuffra. Oligonucleotide indexing of DNA barcodes: identification of tuna and other scombrid species in food products. 2010. BMC biotechnol 10(1):1-7. https://doi.org/10.1186/1472-6750-10-60*

[2] *Servusova, E. and Z. Piskata. 2021. Identification of Selected Tuna Species in Commercial Products. Molecules 26(4):1137. https://doi.org/10.3390/molecules26041137*

[3] *Lord, Christopher W.; personal communication. [protech1993@live.com]*

Why is this a problem?

The primary concern of the buyer is compliance with the species declared on the label and with Council Regulation (EEC) No 1536/92, which specifies that preserved tuna must be prepared exclusively from fish of one of the species listed in the annex and that different species may not be mixed in the same container[4].

This regulation also defines chunks and flakes as "fragments of flesh, the initial muscle structure of which is maintained". It does not mention DNA, which raises the question of whether the presence of the DNA of an undeclared species, without evidence of this species in the initial muscle structure of the flesh, constitutes non-compliance with this regulation.

It should also be noted that awareness of mixed species is still high in the UK processed food segment because of the horse meat scandal of 2013. This scandal came to light as a result of DNA analysis in Ireland, which sparked the trend towards analyzing DNA in food products[5,6].

Presumed guilty!

While the buyer has avoided saying that the presence of this undeclared species could be intentional, the implication is that it is due to some sort of carelessness or lack of process control. In other words, "you are probably not being dishonest, but you are certainly incompetent". Either way… guilt has been presumed.

Courtroom experts refer to this as the "CSI effect," whereby juries, schooled by television police procedurals, needed only to hear those three magic letters—DNA—to arrive at a guilty verdict[7].

Old-school DNA analysis, like qualitative PCR with species-specific primers, is easy to understand; either the DNA profile is found in the sample, or it is not. With DNA mixtures and trace DNA, the results can be ambiguous and difficult to understand, sometimes even for the experts.

Risk assessment analysis findings

After a full investigation, the supplier responded, "Although fragments of cooked flesh are collected from the cleaning tables and trays when changing species… traces of a previously worked species could possibly be found in the following batch on the same line". The supplier/processor implemented a few corrective actions to strengthen existing mitigation measures, aimed at improving cleaning and training personnel. A risk assessment of the process was reconducted.

To investigate the risk of fraud, there should be a measurement of the vulnerability or likelihood of it happening at various stages – procuring raw materials, packaging, and processing – and the severity of the impact should it happen to occur. The factors focused upon in the analysis process can include the following:

- Traceability
- Storage
- Calibration of instruments
- Hygiene and sanitation
- Information

Meanwhile a severity analysis considers three important aspects that are related to one another:

- Is a health risk?
- Is it an economic risk? and/or
- Will it have a negative impact on public opinion?

The overall risk assessment is made up of the combination of these two scores. In the particular case of this supplier/processor, both vulnerability and severity were low, so the overall risk rating was the lowest possible.

Audit

A virtual audit of the processing plant was conducted with the buyer and the control measures and risk assessment were accepted. It was agreed to conduct DNA analysis to verify their effectiveness.

Analysis

As agreed, the processor sent samples of canned skipjack tuna chunks in water to a laboratory testing company, eurofins Germany, for DNA analysis, which identified the DNA of *Thunnus spp.* in every sample of skipjack tuna, without exception. These results were perplexing, as all assessments inside the plant showed that the process was well-controlled and that the risk of mixing undeclared species was minimal.

Sometimes it is best to simply shut down and start over, which is what the processor elected to adopt when faced with this paradox. In other words, they decided to validate the results from the process and from the lab.

[4] European Economic Community (EEC). 1992. Council Regulation (EEC) No 1536/92 (Common marketing standards for preserved tuna and bonito). Available at: https://eur-lex.europa.eu/legal-content/EN/ALL/?uri=CELEX%3A31992R1536 Accessed 18 December 2021.
[5] Equus. 2017. Burgergate: What does the news of horse meat in British and Irish supermarkets mean to American horses. Available at: https://equusmagazine.com/blog-equus/burger-horse-meat-abattoir-knackery-slaughter/ Accessed 8 October 2022
[6] The Guardian. 2013. Horse meat scandal wipes £300m off Tesco's market value. Available at:https://www.theguardian.com/business/marketforceslive/2013/jan/16 horse-meat-tesco-market-value-shares Accessed 7 Oct 2022.
[7]Starr, D. 2022. The Bias Hunter. Available at : https://www.science.org/doi/pdf/10.1126/science.adc8720 Accessed 8 October 2022.

Hazard analysis

The Guide to Preventing Fraud in the Food Industry[8] is an excellent tool aimed at operators that already have their HACCP system and prerequisite programmes in place, follow good manufacturing and hygiene practices, but need support to include the risk of food fraud. It frames the development of a food fraud prevention system in an HACCP-style, which makes it easy for processors to comprehend, as all exporters to the UK and EU are familiar with HACCP.

Per this guide, the processor conducted a hazard analysis based on the process flow diagram of their HACCP plan. The Terms of Reference (ToR) of the analysis were changed from "Food Safety" to "Food Fraud"; specifically, undeclared species in canned tuna. The process was divided into two general parts, in separate locations: (i) receiving and cold storage; and (ii) fish preparation and processing. Mitigation measures for raw and cooked fish differ in that (i) raw fish are easily segregated by their morphometric characteristics; and (ii) cooked fish depend more on the identification and control of the containers in which they are placed.

The mitigation measures identified by the hazard analysis were very similar to the criteria of the vulnerability analysis conducted previously. They included:

- Chain of Custody: vessel documents, electronic recording of lot details;
- Personnel training at receiving morphometric segregation of species;
- Incoming materials inspection with positive release;
- Planning and scheduling by species and lot all through the process;
- Hygiene: Personnel trained to wash at prescribed intervals;
- Sanitation: lines, equipment and accessories washed at prescribed intervals;
- Identification of bins, trolleys and trays (colour code);
- Personnel training at processing: Chain of Custody (CoC) species segregation;
- Permanent ink jet can code (CoC);
- Material balance reconciliation; and
- Finished product evaluation with positive release.

The analysis indicated that the hazards at the process steps where whole round fish may be mixed and where fragments of cooked flesh may be mixed, are well controlled by the current mitigation measures, and are not likely sources of the undeclared DNA of *Thunnus spp* in the finished canned product.

Laboratory validation

The processor contacted Applied Food Technologies, Inc. (AFT) in Alachua, Florida, for assistance. AFT has been a loud voice in support of industry against media reports of mislabeling and claims its internal testing has shown much lower mislabeling rates[9].

DNA bar coding[10], used frequently in fish fraud cases, is most effective for determining a species from fresh or mildly processed tissue, but not as reliable for highly processed products, such as canned tuna, which undergo a high-temperature sterilization process. AFT was one of the first US labs to put mini-barcodes to practical use, enabling more accurate testing of processed tuna.

Over a period of a few months, the processor sent samples of canned tuna, frozen-cooked tuna loins, and whole-round raw tuna to AFT for DNA analysis. The DNA of both *Katsuwonus pelamis* and *Thunnus spp.* was detected in all canned, frozen-cooked, and raw skipjack tuna samples with the 100 base pair amplicons from species-specific primers . In other words, the results from AFT corroborated the original results from eurofins in Germany. In the meantime, risk assessment, vulnerability (hazard) analysis, and mitigation measures had been updated by the processor/supplier, reviewed/approved by the buyer and the importer. All this led to the conclusion that the identified process steps where whole round fish or fragments of cooked flesh may be mixed, are well-controlled and are not likely sources of the undeclared DNA of *Thunnus spp* in the finished canned product.

Hazard analysis – assessing adventitious DNA

But if the process is not the source of the undeclared DNA, then it must have come from somewhere else. The question is where? In this case study, the original hazard analysis focused on the mixing of whole fish at receiving and cold storage and the mixing of fragments of flesh during preparation and processing, as the possible sources of the undeclared DNA. In a second hazard analysis, the processor focused on other possible sources of undeclared DNA.

When considering potential sources of adventitious DNA, imagine the ocean as basically a "soup" of its resident species' genetic material, cast off in the form of metabolic wastes,

[8] Premiumlab. 2018. Guide to preventing fraud in the food industry. Available at: https://www.interregeurope.eu/fileadmin/user_upload/tx_tevprojects/library/file_1603105162.pdf Accessed 31 January 2022.

[9] Carman, T. 2022. Subway tuna lawsuit still hangs over the chain after judge's ruling. Available at: https://www.washingtonpost.com/food/2022/07/12/subway-tuna-lawsuit-amended/ Accessed 8 October 2022.

[10] Hebert, P. D. N., A. Cywinska, S. L. Ball and J. R. DeWaard. 2003. Biological identifications through DNA barcodes. Proc R Soc Lond B Biol Sci. 270(1512):313-321.

Table 1: Possible sources of DNA contact

Process Step	Fish-to-fish	Environment	Equipment	Personnel	Observations
Free swimming		✓			Adventitious DNA in the sea
Catching	✓		✓		Contact with fish & equipment
Brailing	✓		✓	✓	Contact with fish, equipment & hands
RSW Chill	✓	✓			Contact with fish & circulated sea water
Brine Freezing	✓	✓	✓		Contact with fish & circulated brine
Brine Storage	✓	✓	✓		Circulated brine prepared from seawater
Unloading	✓		✓	✓	Contact with fish, equipment & hands
Transport	✓		✓		Contact with fish & equipment
Sorting	✓		✓	✓	Contact with fish, equipment & hands
Cold storage	✓	✓	✓		Circulated air environment
Thawing	✓	✓	✓		Circulated water environment
Evisceration	✓		✓	✓	Contact with fish, equipment & hands
Racking	✓		✓	✓	Contact with fish, equipment & hands
Cooking		✓	✓		Common steam environment
Conditioning		✓	✓		Circulated mist environment
Deheading			✓	✓	Contact with hands & trays
Skinning			✓	✓	Contact with hands, utensils & trays
Cleaning			✓	✓	Contact with hands, utensils & trays
Fish filling			✓	✓	Contact with hands & filling equipment
Can Closing					No further species mixing of DNA

scales, skin, hair, etc., into their surrounding environment. Collectively, these are referred to as environmental DNA (eDNA), which is genetic material that is shed by organisms through the loss of skin, hair, scales, fluids, and faeces. It can be isolated by filtering water and used to monitor the distribution of species through time and space using sensitive molecular tests. The rapid growth of eDNA-based monitoring reflects its ease and cost-effectiveness compared to physical survey methods[11,12].

There is an inordinate number of opportunities for eDNA to enter the flow, and once it's present, there are four basic ways that this DNA can be transferred: (i) Fish-to-fish contact; (ii) Different fish in contact with the same environment; (iii) Different fish in contact with the same equipment, tools, accessories, and utensils; and (iv) Different fish in contact with the same personnel (Table 1).

After harvest, the fish are chilled in refrigerated seawater, the same "soup" they live in; and then frozen and stored in brine also prepared from seawater. They have contact with each other, and with common equipment from capture through cold storage. They also have contact with common personnel on board, in port and at receiving.

While thawing at the processing plant, the fish share a common circulated water environment. Thereafter they have contact with each other at the preparation and processing stages (cooking, cooling, chilling and canning) where they also come in contact with common equipment, accessories and utensils at preparation, processing, and canning; as well as common personnel who handle the fish during the whole process.

Table 1 lists the vulnerable process steps and identifies how the adventitious DNA may enter the flow, but there is something missing: what about control measures and corrective actions?

- How to prevent fish of different species from schooling together in the sea?
- How to avoid fish-to-fish contact in the purse seine net during catching?
- How to stop freezing fish in circulating brine on board the fishing vessel?
- How can we avoid the personnel from handling different fish during unloading?
- How to prevent circulated air in the cold store from passing through bins of different fish?
- How can personnel at the processing stage wash their hands after handling every fish?
- How can we wash fish contact surfaces in the process area after every fish?
- How do we clean the filling machine after each can?

It becomes clear that the processor has no control measures to prevent these things from happening and, without control measures, there are no corrective actions.

Environmental DNA metabarcoding

Environmental DNA (eDNA) metabarcoding is a novel method of assessing biodiversity wherein samples are taken from the

[11] Francisco P. Chavez , Markus Min, Kathleen Pitz, Nathan Truelove, Jacoby Baker, Diana LaScala-Grunewald, Marguerite Blum, Kristine Walz, Charles Nye, Anni Djurhuus, Robert J. Miller, Kelly D. Goodwin, Frank E. Muller-Karger, Henry A. Ruhl, Christopher A. Scholin. 2021. Observing Life in the Sea Using Environmental DNA. Oceanography 34(2):102–119, https://doi.org/10.5670/oceanog.2021.218.

[12] Ruppert, K. M., R. J. Kline, and M. S. Rahman. 2019. Past, present, and future perspectives of environmental DNA (eDNA) metabarcoding: A systematic review in methods, monitoring, and applications of global eDNA. Glob. Ecol. Conserv. 17, e00547.

Table 2: Fish genera that were found in fish holds of Ecuadorian vessels

Order	Family	Genus	Species (Common Name)
Acanthuriformes	Scianenidae	-	-
Beloniformes	Exocoetidae	*Exocoetus*	*Exocoetus volitans* (two-wing flying fish)
"	Hemiramphidae	*Oxyporhamphus*	*Oxyporhamphus Micropterus* (bigwing halfbeak)
Carangiformes	Carangidae	*Seriola*	*Seriola rivoliana* (longfin yellowtail)
"	"	*Chloroscombrus*	*Chloroscombrus orquesta* (Pacific bumper)
"	"	*Decapterus*	*Decapterus macrosoma* (shortfin scad)
Gadiformes	Merlucciidae	*Merluccius*	*Merluccius productus* (North Pacific hake)
Istiophoriformes	Istiophridae	-	-
Scombriformes	Scombridae	*Acanthocybium*	*Acanthocybium solandri* (wahoo)
"	"	*Auxis*	*Auxis rochei* (bullet tuna)
"	"	"	*Auxis thazard* (frigate tuna)
"	"	*Katsuwonus*	*Katsuwonus pelamis* (skipjack tuna)
"	"	*Sarda*	*Sarda orientalis* (striped bonito)
"	"	*Euthynnus*	-
"	"	*Thunnus*	-
Tetradontiformes	Balistidae	*Canthidermis*	*Canthidermis maculate* (rough triggerfish)

environment via water, sediment, or air. The DNA material is extracted and then amplified using general or universal primers in polymerase chain reaction (PCR); and sequenced using next-generation sequencing (NGS) to generate millions of reads.

A paper entitled "Characterizing Industrial & Artisanal Fishing Vessel Catch Composition Using Environmental DNA" by Demian Willette, et al., hit "close to home"[13]. The authors of the paper used forensic environmental DNA (eDNA) metabarcoding to profile fish species composition on industrial fishing vessels in Ecuador. In the process, they identified more than a dozen genera of fish from the brine in the fish holds (Table 2).

Forensic environmental DNA (eDNA) metabarcoding identified more than a dozen genera of fish from the brine or meltwater in the fish holds on industrial and artisanal fishing vessels in Ecuador (Demian Willette et al).

[13] *Willette, D. A., G. Navarrete-Forero, Z. Gold, A. M. D. Lizano, L. Gonzalez-Smith, and G. Sotil. 2021. Characterizing Industrial and Artisanal Fishing Vessel Catch Composition Using Environmental DNA and Satellite-Based Tracking Data. Foods. 10(6):1425. https://doi.org/10.3390/foods10061425*

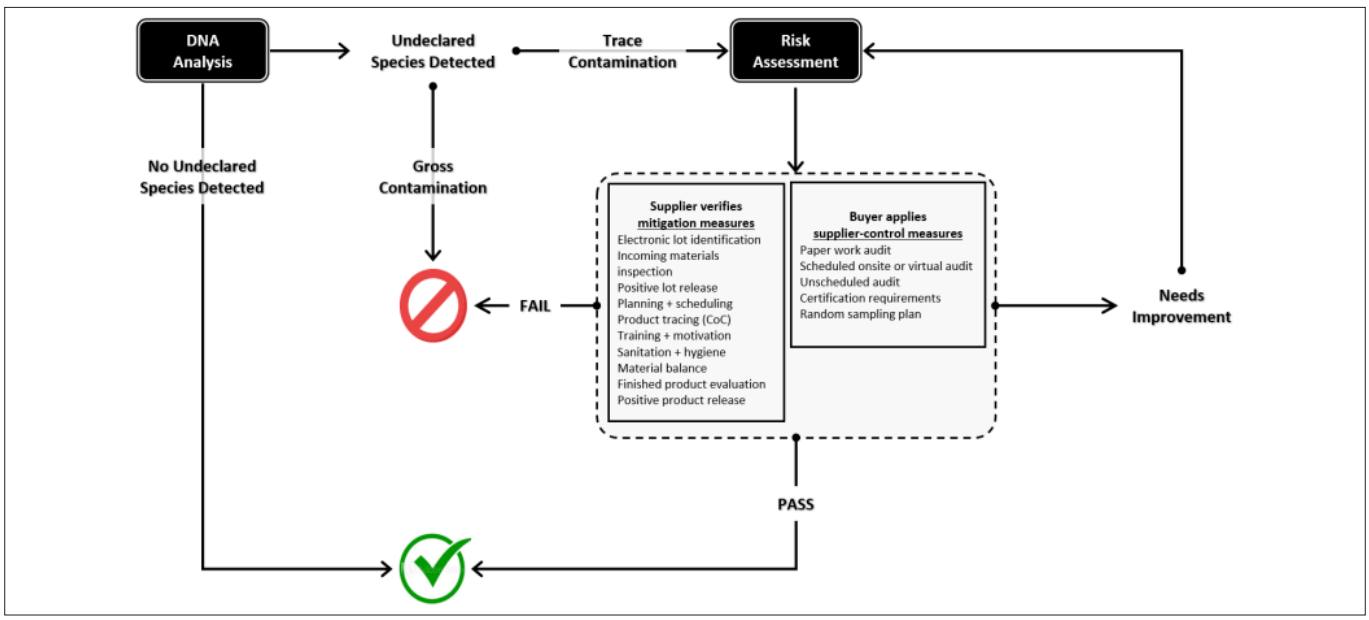
The processor contacted Wilderlab, a DNA testing lab based in Wellington, New Zealand, that specializes in metabarcoding for environmental testing[14]. The basic package consists of six assays (primer sets). They use the Illumina iSeq 100 to process up to four million DNA reads per run. With kits from Wilderlab, the processor sampled the water in which the fish had been thawed. Almost all (99.6%) of the sequences identified were specified in the Annex to (EEC) No. 1536/92[15]. The most likely inference is therefore that adventitious eDNA of multiple species accompanies the fish into the processing plant.

Quantitative metabarcoding for canned tuna

The same assays can be used to identify fish species present in canned tuna. A trial was conducted using the brine from canned tuna to provide an overview of the contents of the can. Metabarcoding targets short DNA fragments, ideal for this purpose, as these are more likely to still be present in the can after the canning process. Although still in the trial stage, quantitative metabarcoding of food has excellent potential[16].

In the context of fraud prevention, all tuna processors who export to the EU/UK must develop a Food Fraud Prevention System based on BRCGS[17,18] and/or IFS Guidelines[19].

[14] *Wilderlab. https://www.wilderlab.co.nz/*
[15] *European Economic Community (EEC). 1992. Council Regulation (EEC) No 1536/92 (Common marketing standards for preserved tuna and bonito). Available at: https://eur-lex.europa.eu/legal-content/EN/ALL/?uri=CELEX%3A31992R1536 Accessed 18 December 2021.*
[16] *Lust, B. https://www.wilderlab.co.nz/*
[17] *British Retail Consortium. 2017. Available at: Understanding-VulnerabilityAssessment-BRC-2017.pdf (siroccoconsulting.com) BRC Accessed 7 Oct 2022.*
[18] *Safefood 360 - Methods & Models for Conducting Risk Assessments Under the BRC Standard. Available at: https://www.ifsqn.com/fsf/ Risk%20Assessment%20Under%20BRC.pdf Accessed 21 January 2022.*
[19] *International Featured Standards. 2022. Available at: IFS_Guideline_Product_Fraud_Mitigation_V2_EN.pdf (ifs-productintegrity.com) Accessed 7 October 2022.*



Protocol for minimizing the risk of species fraud in canned tuna

Conclusions

The increasing sensitivity achievable by DNA tests means that it is possible to detect extremely low levels of DNA from other undeclared species, even when processors are adhering to good hygiene and manufacturing practices. Even where equipment has been thoroughly and properly cleaned, a few individual molecules of DNA might remain and could be detected as a trace-positive result by sensitive DNA tests[20,21]. For this reason, the need to consider exculpatory evidence is greater than ever.

A second conclusion that can be drawn in this case study is that the process is not the likely source of the DNA of *Thunnus spp* mixed in the finished canned product. It is well-established that the DNA of a variety of species accompanies the fish onto the fishing vessel, and then into the processing plant. There are no control measures to control adventitious DNA[22], hence the presence of undeclared environmental DNA (eDNA) in processed tuna products is "technically unavoidable". If DNA analysis is conducted, it must be able to distinguish between trace and gross contamination.

Finally, in criminal investigations, forensic DNA is just one of many types of evidence. Investigators also look at additional evidence such as: motive, weapons, alibis, etc. When looking at food authenticity, investigators should also look at multiple lines of evidence, e.g., results of audits, third-party auditor reports, plus the overall relationship with the supplier. In addition, DNA testing should be considered as one more piece of evidence within the context of the investigation[23]. When multiple lines of evidence tell a consistent story, investigators can be assured that undeclared DNA is not the result of intentional fraud or poor process control. DNA analysis thoughtfully used in conjunction with traditional techniques is therefore a powerful tool and provides the foundation of a healthy relationship between buyer and supplier.

[20] *Food Standards Agency. 2014. Report of the investigation by the food standards agency into incidents of adulteration of comminuted beef products with horse meat and DNA. Available at: https://www.reading.ac.uk/foodlaw/pdf/uk-13014-horse-meat-summary.pdf Accessed 9 October 2022.*

[21] *Shaer, M. 2016. The False Promise if DNA testing. Available at: https://www.theatlantic.com/magazine/archive/2016/06/a-reasonable-doubt/480747/ Accessed 8 October 2022.*

[22] *Primrose, S. B. 2019. Chapter 1: The Role of DNA Analysis in the Determination of Food Authenticity, in DNA Techniques to Verify Food Authenticity: Applications in Food Fraud, pp. 1-11 https://doi.org/10.1039/9781788016025-00001*

[23] *Penacino, G., Sala, A., and Corach, D. Are DNA tests infallible? In International Congress Series (Vol. 1239, pp. 873-877). Elsevier. Available at:https://www.isfg.org/files/463140944080a67924e5eabe5d233f69c07f3270.02005587_657502477377.pdf Accessed 8 October 2022.*

Mr Christopher W. Lord *got into the tuna processing industry in Samoa after serving as a Peace Corps volunteer. He became the first locally-recruited manager and, after 45 years, is still in the industry. After years of working in managerial positions, he decided to share his skills globally and started Pro-Tech International, a consulting firm specializing in tuna processing, based in Bangkok, Thailand.*

Mr Lord has collaborated with tuna processors in the Pacific, Indian Ocean, and the Southeast Asian and Latin American regions. He has worked successfully with people of diverse cultures in various organizational structures. Most assignments have involved assisting prospective processors with factory design, staff training, and start-up or helping existing processors to improve process efficiency and effectiveness. He has a long history of training local staff to assume positions of authority. In recent years, he has co-authored ten research papers for scientific journals.

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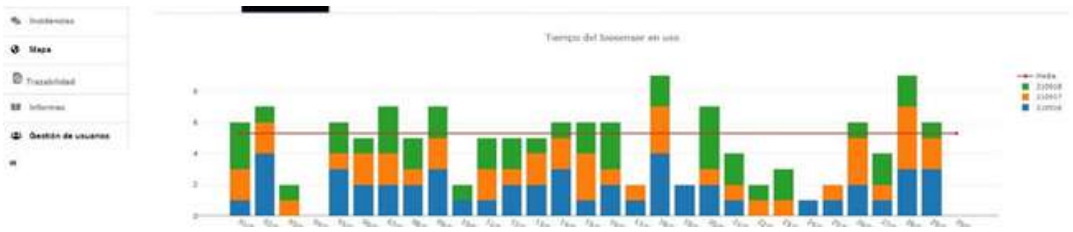

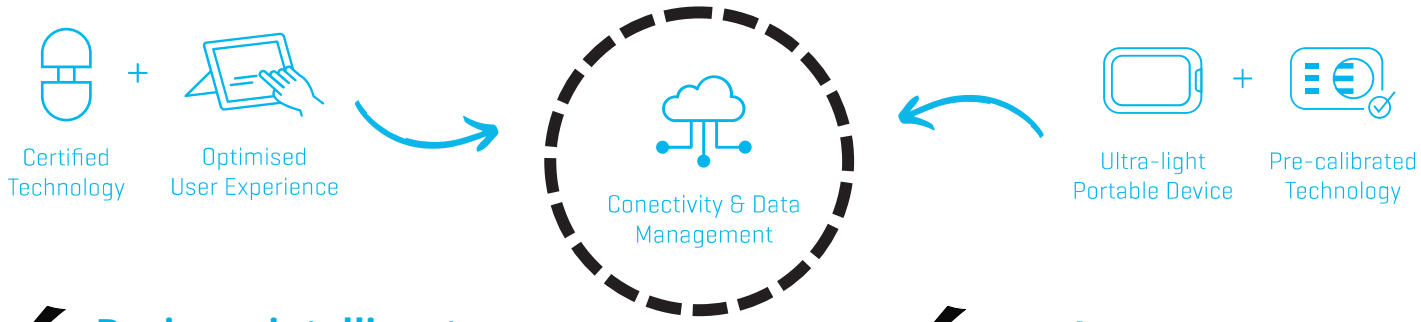

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INFOFISH speaks to …
ERIK DE LAURENS

Co-Founder & CEO, SCALE.VISION

While still a Master's student at the Royal College of Arts (London), in 2011, you had presented a project called The Fish Feast, where you exhibited several stone-like items made only from fish scales: swimming goggles, spectacles, beakers, and a water dispenser. Why fish scales? What was the inspiration behind that idea?

EDL As a product designer, you are highly dependent on the industrial health of your country. The knowledge and knowhow of the existing companies will determine the extent of what you can design. A healthy innovative industry means good novel products. Yet, at that time in France, I was, rather powerlessly, witnessing an increase of factory closures and relocations.

Events such as these are not only a great loss for a country's industrial identity, but they are also social tragedies. Hundreds of families become suddenly out of revenue. Some will be able to relocate themselves, but most are bound to stay in their region with years of valuable experience that are now useless. I was really affected by this situation. I wondered if there was maybe a way in which we could root industrial knowhow to a region, so it wouldn't make sense to do it anywhere else than in the said region.

There is an industry which works that way. The food industry has generated a number of long-lasting businesses which are bound to the region they belong to. Champagne is a product which can only be produced in the Champagne region, Normandy, and Camembert is almost inextricable from another. So, I looked at this industry for inspiration. In my research, I stumbled onto a fish leather tannery based in France. I found fascinating that this activity which is at the end of an enormous industry has one waste: scales, and I thought that would be a good starting point. Fish scales are somewhat like bones which were used in the past to produce goods. The fishing industry is also suffering and adding value to a waste would ultimately help fishermen. Fishing is also an activity that is widespread and practised around the world, so the project could help a lot of people.

After months of research, I was able to produce these first items which show the tremendous potential for this discarded and overlooked resource.

SCALITE tiles are so versatile that they are now used, for example, as part of furniture, to cover walls, and in-store displays.

This stone-like material, which you named SCALITE, is promoted by Scale.Vision (the company that you subsequently co-founded) as being ocean-friendly and completely environmentally sustainable. Without going into the patented specifics of the process, could you briefly explain what goes into its production? Is the end-product fully recyclable?

EDL SCALITE is slightly different than the early prototypes in the sense that we transform the raw scales into a powder before we compress them into sheets, much like cement tiles are made. We use eco-friendly dyes to give the material colours. Then comes the finishing stage during which we sand the sheets to reveal SCALITE's extraordinary texture.

SCALITE is 100% recyclable because we use nothing else than scales (no added resin). All our off-cuts and byproducts are fed into production in a completely circular way.

As not all processing facilities have equipment which is specific for de-scaling and separation of by-products, where do you obtain sufficient supplies of the scales and what is the approximate cost of the raw materials?

EDL Not all processing facilities have equipment, indeed. Scales are not easily accessible, but we have had some luck. Some species lose their scales naturally when dead. In this case, scales are a real problem as they clog sinks and pipes. There,

solutions to extract them have been devised to make the resource available. Some species have large scales which are undesirable in a consumer product, so they are better scaled.

Cost depends; byproducts and wastes can't be disposed of by processors. Getting rid of them has a cost, so some are happy to give the scales to us as long as we organize their collection, while others will want some money. The exact price is a negotiation. The project always intended to bring more wealth to the whole industry. What we don't want is that fishermen start fishing for scales.

What species of fish is best suited for processing of its scales into SCALITE, and why?

EDL All species are suitable. They are all made of the same molecules though in variable proportions. Some have more mineral and require a pretreatment. We found that freshwater fishes tend to produce a stronger material than saltwater fishes; but at the same time, saltwater fish SCALITE tend to be easier to manufacture.

According to the Scale.Vision website, SCALITE is now available as marble-like tiles in various dimensions, and that they have found use in interior design applications such as feature walls in buildings. How do they compare with traditional tiles in terms of cost, durability, and water resistance?

EDL We are still learning a lot from this groundbreaking material. Obviously, the environmental credentials of SCALITE are the main arguments in favour of this material. It is biosourced, non-toxic to marine ecosystems, emits no VOCs, is recyclable and biodegradable. It requires little energy to produce compared to other similar materials. SCALITE is also naturally non-flammable, whereas other materials need harmful and toxic charges to meet these criteria. Its scratch resistance and hardness are also better than that of conventional solid surface materials. Many more properties are being looked into and we're confident that it will continue to show its advantages.

Apart from business growth, and viewing the production of SCALITE through a global and inclusive lens, do you see a possibility of collaboration with small-scale fishers and fish workers which could help them to enhance their livelihoods and at the same time, reduce fisheries byproduct wastes? Placed within context, the small-scale sector comprises the vast majority of fishers and fish workers around the world, particularly in Asia.

EDL SCALE has always had a strong social agenda. Helping small communities of fishermen and smaller-scale businesses making the most of what they fish is what we are about.

Two challenges need to be overcome before this can happen on a large scale. The first is that small businesses are typically scattered around territories, and this makes accessing and collecting more difficult; the second challenge is that raw scales rot very quickly if not stored properly or cleaned and dried carefully. Today we're finding that the drying of scales is where subcontractors are missing. If we want to collect from small businesses, we would need to set up a network of centralized drying plants sited close to fishing communities.

This is part of our future developments but for now, we seek to validate market interest with partners who can supply large volumes of scales.

And in closing, the late American inventor Thomas Edison was reported to have said: "To invent, you need two things: A good imagination and a pile of junk." While science and scientists are the source of much useful knowledge, what other attributes would you consider to be important in driving innovation and creativity?

EDL Being able to look at the overlooked with a novel and imaginative glance is definitely an attitude leading to innovation, and one that I have used much in my work.

Often though, I think our lack of imagination comes from a sterile compartmentalizing of knowledge fields. Finding bridges between unrelated fields is another method that has often led me to find novel solutions.

With the use of eco-friendly dyes, these SCALITE tiles have aesthetic appeal and can be used in interior design.

MORE FROM LESS: TOWARDS MORE CIRCULAR AND RESPONSIBLE AQUACULTURE

By Sujit Krishna Das

The characteristics of a circular economy – elimination of waste and pollution, circulation of products and materials, as well as regeneration of nature – resonate with the principles of responsible aquaculture development. Upcycling nutrient systems (for example, using Bioflocculation Technology (BFT); Integrated Agri-Aqua systems (IAA); multi-sector integration (e.g. renewable energy/fisheries/aquaculture); recycling of dissolved and solid effluent materials; and increasing circularity in feed production, can contribute to responsible and sustainable intensification. Implementation of a circular economy therefore contributes to responsible development in the sector, for which a globally accepted framework already exists in the FAO's Blue Transformation Roadmap 2022–2030.

Off-shore mariculture in China.

The total global production of aquatic animals and algae in 2020 was estimated at 214 million tonnes, while their combined sales value is about USD 406 billion[1]. Animal aquaculture production reached 87.5 million tonnes (a new high) and the total amount for human consumption (excluding algae) touched 157 million tonnes. The value of international trade of fisheries and aquaculture products was recorded at USD 151 billion and the total population employed in the primary sector of fisheries and aquaculture is about 58.5 million (of whom 21 percent are women). As a region, Asia contains the most fishers and fish farmers (84 percent), and the largest number of fleets (2.68 million vessels, about two thirds of the global fleet).

The world population will be around 9.8 billion in 2050 and 11.2 billion in 2100[2]. Hence, we need to produce more food from less natural resources (e.g., energy, water and land) for the increased number of people. To further progress the sustainability of aquaculture operations, it is vital to re-think some of the common approaches and habits, and one possible alternative venue would be to embrace the 'circular aquaculture bio-economy framework' as a key for the sector's long-term sustainable development. This type of approach aims to minimize food wastes, as well as recycle and reuse products, thus reducing the environmental impactof producing raw materials (Colombo and Turchini 2021).[3]

There are no concrete definitions of what constitutes a circular economy. Like sustainability, which can be defined more easily in terms of what is not sustainable, the circular economy is defined in terms of its opposite to a linear economy. The idea is to replace the current linear economy of "take, make, consume, dispose" and replace that with a

[1] *FAO. 2022. The State of World Fisheries and Aquaculture 2022. Towards Blue Transformation. Rome, FAO. https://doi.org/10.4060/cc0461en*

[2] *https://www.un.org/en/desa/world-population-projected-reach-98-billion-2050-and-112-billion-2100*

[3] *Colombo and Turchini, 2021. Aquafeed 3.0: creating a more resilient aquaculture industry with a circular bioeconomy framework. The Reviews in Aquaculture, Volume 13 Issue 3, Pages 1156-1158. https://doi.org/10.1111/raq.12567*

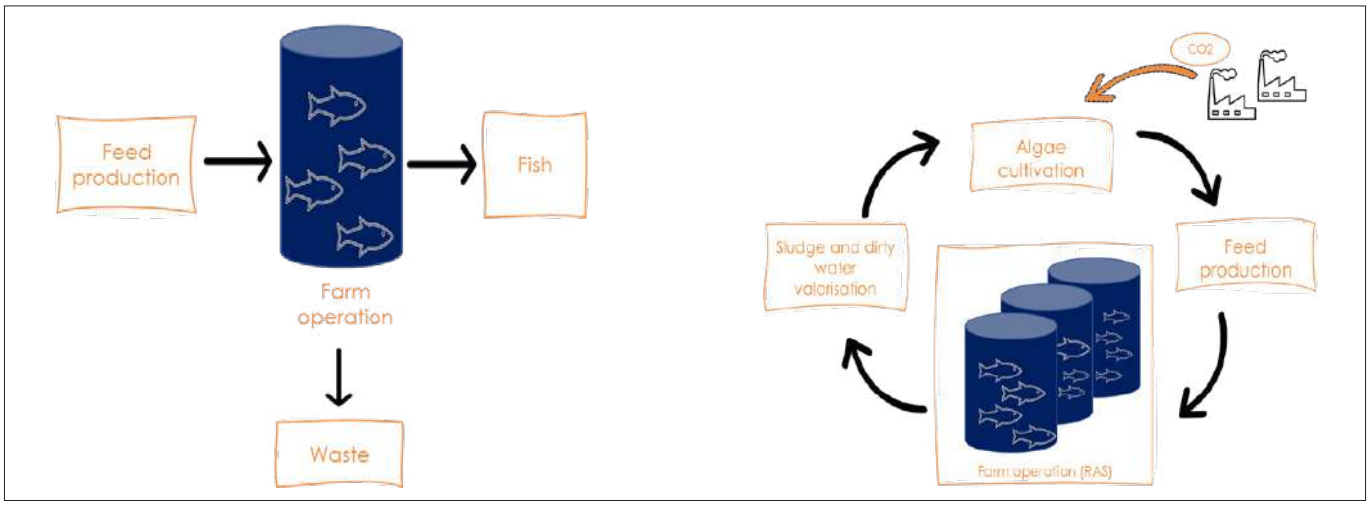

Figure 1: From linear to circular. *Credit: iFishIENCi Project.*

circular model based on the 4Rs strategy of "Reduce, Reuse, Recycle, Recover."[4]

A circular approach in aquaculture helps to identify new value chains for the valorization of specific waste (dirty water, sludge) from different production systems, leading to zero-waste target and value creation. Smart breeding and strain selection might support the optimization of feeding efficiency and will ensure growth in global aquaculture production as well as fulfill protein demand in developing countries. (Policy Recommendations from iFishIENCi Project).[5]

Principles of a circular economy

Circularity in aquaculture is very broad and encompasses a variety of different concepts. In a food production system like aquaculture, the definition needs to address the strengths of circularity considering, but not limited to, the importance of biological flows within aquaculture production systems. Traditional integrated agriculture-aquaculture systems as practiced in Asia take advantage of synergies among farm components to efficiently recycle and reuse nutrients.

Circular economy principles reduce waste, increase efficiency and support more sustainable systems. By reducing waste, the value extracted from the natural resources is increased. In other words, we get more, using less. This is particularly important as we aim to feed an ever-growing population. Life-cycle analyses (LCA) are often used to measure the environmental impact of a value chain. An LCA typically measures the total carbon footprint of the product, considering all the raw materials and processes used to create that product from inception to sale. When circular economy principles are included, an LCA shows dramatic decrease in environmental impacts.

Within circular economy (Fig 1) the value of the products, materials, and resources last within the economy for as long as possible, which aims to minimize waste generation. The circular economy as it may be applied to aquaculture, aims to produce renewable biological resources, facilitating a conversion of these resources and waste streams into value-added products, such as food, feed, biobased products and bioenergy (Policy Recommendations from iFishIENCi Project)[5].

According to the Ellen MacArthur Foundation,[6] *"the circular economy is a system solution framework that tackles global challenges like climate change, biodiversity loss, waste, and pollution".* It is based on three principles, driven by design: Eliminate waste and pollution, Circulate products and materials (at their highest value) and Regenerate nature.

National policies advocating circular economy

Bohnes et al., 2021[7] compared the national aquaculture policies of Norway and Singapore and proposed a step-wise framework to assess the national environmental impacts from aquaculture industries with a prospective and systemic approach. Starting from identifying policy-based national

[4] *https://www.was.org/articles/Editors-Note-The-Circular-Economy-Concept-and-Aquaculture.aspx*
[5] *Policy Recommendations for a More Circular Aquaculture Report 2022, Published by H2020 iFishIENCi (Intelligent Fish feeding through Integration of Enabling technologies and Circular principles), Pages 1-16*
[6] *https://ellenmacarthurfoundation.org/topics/circular-economy-introduction/overview*
[7] *Bohnes, F. A., Hauschild, M. Z. Schlundt, J., Nielsen, M., Laurent, A., 2021. Environmental sustainability of future aquaculture production: Analysis of Singaporean and Norwegian policies. J. Aquaculture 549 (2022) 737717, 1-16. https://doi.org/10.1016/j.aquaculture.2021.737717*

targets, the methodology relies on economic equilibrium modeling to develop realistic future-oriented scenarios of the aquaculture sector, and couples them with life cycle assessment principles. To evidence its operability, the researchers applied the framework for both the countries. The researchers also observed that feed production and usage are important drivers of impacts, hence calling for new and more environmentally-friendly feed options. Their results additionally showed that the development of aquaculture following existing governmental policies may not directly reduce greenhouse gases emissions and hence, not support climate change mitigation objectives.

How circularity can contribute to sustainable and responsible intensification

Integration of production systems to upcycling nutrient systems

Bioflocculation Technology (BFT) has so far been recognized for its eco-friendly bioremediation process and cost-effectiveness. In BFT, two groups of bacteria build up biofloc in the culture system i.e., autotrophic bacteria (nitrogen cycle bacteria that convert nitrogenous wastes to ammonia, nitrite and nitrate) and heterotrophic bacteria (such as *Lactobacillus* and yeast that use up nitrates upon addition of a carbohydrate such as molasses). The system provides a stable culture medium where the toxic materials are neutralized, the floc is eaten by the shrimp and fish, FCR is improved, and zero water discharge is gained.[8] When waste waters have a C/N ration ≥ 10, BFT can reduce ammonium concentration about 20 percent faster than nitrification and is about 30 percent more economical than conventional biofilters. BFT is of appropriate nutritional value for the cultivation of zooplankton, shrimp, red Nile Tilapia and mussels and could reduce feed costs.[9] Microalgal-biofloc sludges can be obtained through solid-liquid separation or air floatation and further upcycled through vermicomposting using Polychaetes.[10]

Similarly, integrated polyculture systems have strong potential in valorizing added-value byproducts from farm effluents through nutrient upcycling and increasing harvestable biomass. Biofloc and RAS (Bio-RAS), The Mixotrophic™ System, Integrated Multi Trophic Aquaculture (IMTA), In-Pond Raceway System (IPRS), Combined Intensive and Extensive (CIE) Aquaculture and polyculture fish production systems use the similar bioremediation strategy with low water and energy requirements.

Integration of Agriculture-Aquaculture or agro-ecological aquaculture

Rice-fish farming started more than 2 400 years in China and more than 1 500 years in India. It is now recognized as a 'Globally Important Agriculture Heritage System' (GIAHS). There is a wide range of Integrated Agri-Aqua systems (IAA) in Asia, Africa, Europe, South America and Central America. Small-scale IAA has great potential in meeting the nutritional needs of the poor, being an income source with minimum risk. The level of skills is fairly low, unlike pond management.

SRAS (Solar RAS), ELIAS (Ecological Intensification of Aquaculture Systems), Aquaponics and Photovoltaic Aquaculture (PVA) are examples of innovative integration between agriculture-aquaculture for water and energy efficiency, and as well as climate-smart farming. There are some species integration systems also available in China like kelp-scallop-sea cucumber (IMTA), shrimp-crab, shrimp-fish (spatial and temporal planning), fish-fowl, fish-pigs, fish-amphibians (based on consumer demand). Ecosystem Approach in Aquaculture (EAA) like Aqua-Silviculture in mangrove areas also becoming popular in some countries.

Integration of multiple sectors (Renewable energy-fisheries & aquaculture- tourism)

Due to ongoing fuel crises and the increasing demand for energy and other natural resources, scientists are trying to bring innovative solutions to tackle these challenges in a coordinated and combined way. Multisectoral integration for renewable energy production (wind or waves), offshore engineering (oil, gas and other marine resources including minerals), aquaculture production (offshore mariculture) and tourism (establishment of marine parks, recreational fishing etc) can bring huge benefits for countries, reduce the carbon footprint and contribute immensely in the circular blue economy.

China developed aquaculture park to integrate hatcheries, farms, feed mills and processing plants which are located in the same compound. These aquaparks might be useful for new aqua entrepreneurs and investors to understand the sustainable food production systems. Aquaculture students might be interested in the parks for further research and development. Moreover, the site can be treated as a tourist spot for visitors.

[8] *Sujit Krishna Das, 2021. Technological Trends and Innovations in Aquaculture. INFOFISH International Magazine, Issue No. 6/2021. Pages 53-58*

[9] *Camilla et al. 2022. Nutrient recycling and circular economies can support sustainable intensification of aquaculture, part 1, Article published in Global Seafood Alliance dated 9 May 2022*

[10] *Camilla et al. 2022. Nutrient recycling and circular economies can support sustainable intensification of aquaculture, part 2, Article published in Global Seafood Alliance dated 16 May 2022*

Recycling of dissolved and solid effluent materials

An article published in the *Responsible Aquaculture Advocate* by Camilla et al., (2022) described how circular economies and nutrient recycling can contribute in responsible aquaculture through "Dissolved and solid effluent materials, Recycling of wastewater solids and wastewater dissolved nutrients and Processing of seafood byproducts".

RAS and raceway systems can produce waste waters with high concentrations of solids and nutrients, which can be useful resources if treated effectively. To evaluate reuse options realistically, discharge rates must be considered. RAS, for example, has lower water exchange, produces effluents at 1 000 times lower compared to raceways and which are more concentrated compared to ponds and cages. The paucity of cage effluents studies urges a more careful and standardized method for monitoring compound concentration, to allow better comparison across systems. In ponds and cages, efficient management of solids can make use of significant quantities of reusable biomass and maximize production through in-situ nutrient upcycling with polycultures and multi-trophic systems.

By increasing circularity in feed production

Circularity in feed production was clearly explained in a research article published in *Reviews in Aquaculture* by Koushik et al., 2022.[11] Optimization, and not just increased productivity, of land, animals and energy is the way ahead. Embarking on this challenge, we need to reset our thinking and focus more about resource efficacy and how to utilize most materials considered as waste. This means a paradigm shift towards circularity (de Boer and van Ittersum 2018). Some of the key issues raised in the article are presented below for interested readers:

- ***Plants are the basis of a circular system*** – plant-enriched diets have been used as a protein source for growth; carbohydrate source for protein-sparing; prebiotic and probiotic pre-cursor for gut microbiota; and phyto-immunostimulants for disease resistance (Reverter et al., 2020). The meta-analysis by the researchers confirmed the overall efficacy of plant supplementation in fish feed but it also unraveled some ignorable negative responses in growth and feeding efficiency or high heterogenicity in responses of immunity parameters. Hence, to overcome these problems, researchers suggested that the search for alternatives must go on; not only alternative species but also alternative culture, harvesting, processing and even alternative application techniques.

- ***Inedible byproducts recycled into the food system*** - seafood processing operations generate large volumes of waste streams such as filleting waste, unpreferred dark muscles of fish, or unused skin, head, frames etc (Siddik et al., 2020). The authors highlighted the potential of valorizing these waste streams through fish protein hydrolysates (FPH). Agboola et al., 2020 emphasized that yeast perfectly fits into a circular plan as it provides mannan-oligosaccharides (MOS) and β-glucans from cell walls. Siddike et al., 2020 underlined that bioactive peptide fractionation using the enzyme alcalase from *Bacillus licheniformis* as a circular source, is most effective.

- ***Circularity increases feed and food safety risk*** – while pursuing circularity it is often not easy to recycle waste, as, for example, an important concern is the transmission of diseases (Melo-Bolivar et al., 2020 and Knipe et al., 2020). The authors identified the recycling of autochthonous facultative anaerobes in the gastrointestinal tract of fish as a future research priority. They state that agriculture and aquaculture should not continue as isolated sectors; they must be responsive to each other's needs to achieve increased circularity.

'Policy Recommendations for a more Circular Aquaculture Report 2022" from the iFishIENCi Project provided some important recommendations for circularity in aquaculture, some of which I have highlighted for readers' better understanding:

- New feed formulations should consider resource efficiency principles in the manufacturing process (novel energy-intensive process, etc);

- Circular feed ingredients and supplements should get priority plant-based, insect-based protein (Fig 2); microbial protein and algal protein/oil etc) rather than linear feed ingredients (fish meal and fish oil);

- Locally available ingredients and feed supplements should be mapped out;

- Nutrient credits for aquaculture companies should be explored to recover nutrients through valorization of effluent and waste (including IMTA: Fig 3); Aquaculture wastes (effluent and sludge) can be valorized and waste water can be reutilized for irrigation and street cleaning;

- Review of national legislations to support circularity in aquaculture;

[11] *Koushik et al 2021. Triggering Circularity in Aquaculture – an introductory virtual issue. Reviews in Aquaculture (wiley.com)*

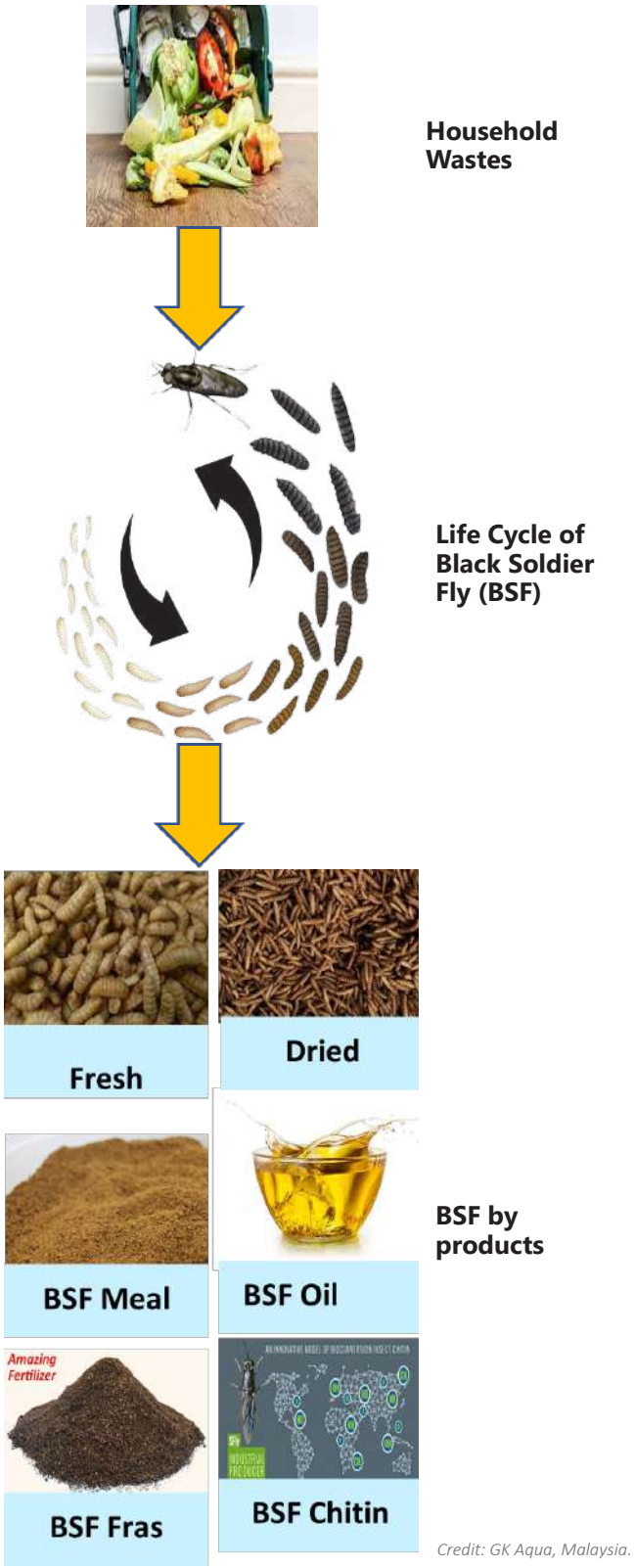

Figure 2: Insect-based protein (BSF Meal) production by using household wastes.

- Facilitate agriculture-aquaculture cooperation; and
- Redesign future aquaculture projects addressing unique issues at co-creative and cross-sectoral levels.

Major challenges and opportunities

The Commonwealth Scientific and Industrial Research Organisation (CSIRO) recently published a report entitled *Risks and Opportunities for the Blue Economy*[12] which resembles similar challenges for circularity in aquaculture. Some of them are listed here:

- There might be potential competition with the renewable energy-fisheries and aquaculture-tourism sectors;
- Interactions with the local environment with regard to renewable energy, marine engineering and aquaculture production;
- Social (policy) considerations of new development including obtaining a social license to operate and impacts on local communities from emerging industries;
- Dearth of national legislations supporting circularity in aquaculture; and
- Limited aquaculture R & D and investments considering multi-sectors and multi-stakeholders.

Conclusions and recommendations

Despite some challenges, a circular economy has obvious benefits in the race to grow more food from less resources. The ravages of climate change cannot be reversed overnight but we can still act to prevent further potential hazards from climate change through innovations. Priority should be given to establishing responsible aquaculture for future generations to come.

National policies on circular economy will contribute to responsible aquaculture development through the Blue Transformation - Roadmap 2022–2030 initiated by FAO. A coordinated effort by the regulators, government and non-government multi-stakeholders can support actions (through the Advocacy Coalition Framework) to make aquaculture more circular.

[12] *Risk and Opportunities for the Blue Economy; https://blueeconomycrc.com.au/wp-content/uploads/2022/08/Risks-Opportunities-for-the-Blue-Economy.pdf*

In this regard, circularity in aquaculture will help us to:

- Prevent habitat degradation including damage to mangrove ecosystems;
- Preserve biodiversity and protect natural integrity;
- Promote traceable and sustainably-sourced aquaculture feed ingredients;
- Encourage better fish health management and promote fish welfare through reducing stress and minimizing chemical inputs;
- Safeguard strict management of aquaculture wastes and utilization of wastewater;
- Reduce the carbon footprint while encouraging responsible use of natural resources;
- Protect the wellbeing and livelihoods of indigenous and local communities while operating aquaculture farms and adhering to labour law and better practices;
- Ensure traceability throughout aquaculture value chains; and
- Achieve the Sustainable Development Goals (SDGs) of the UN as well as the objectives of FAO's Blue Transformation framework.

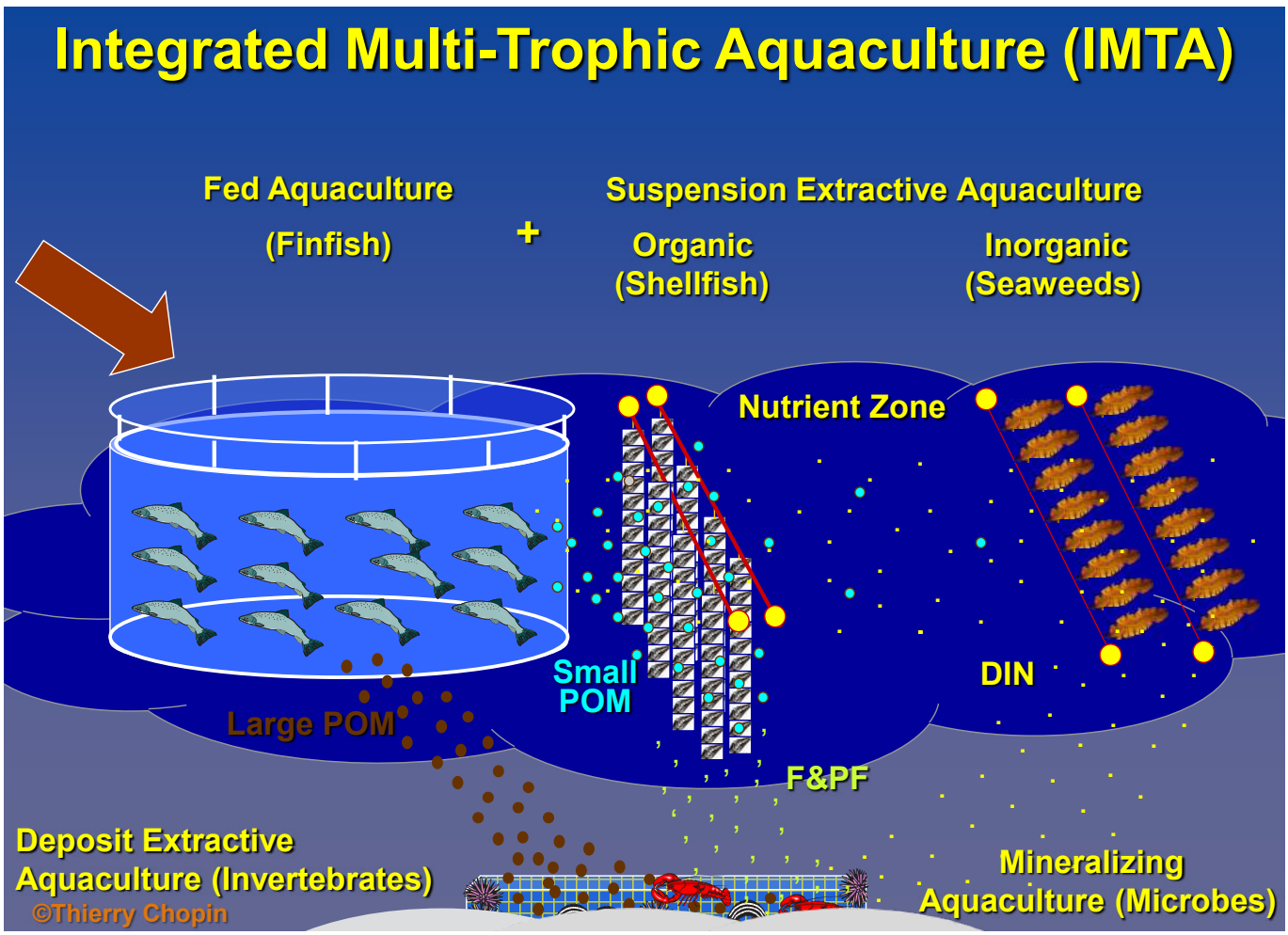

Figure 3: Fed and Non-fed aquaculture within the Integrated Multi-Trophic Aquaculture (IMTA) and flow of nutrients. e.g., Particulate Organic Matters (POM).
Credit: Thierry Chopin, Canada.

Being the Technical Officer at INFOFISH, Sujit Krishna Das provides technical advisory and consultancy services to the INFOFISH Member Countries while keeping abreast of new technological developments within the fisheries and aquaculture sector. He is also passionate about Responsible Aquaculture and FAO's Blue Transformation Framework. Mr Das contributes articles for the INFOFISH International magazine regularly and is responsible for the publishing of two newsletters, The Fish Inspector (FI) and The Fishing Technology Digest (FTD), of which he is the Editor. He can be reached at sujit@infofish.org

The 17th INFOFISH World Tuna Trade Conference and Exhibition (TUNA 2022) was held at the Shangri-la Hotel in Bangkok, Thailand from 11th – 13th October 2022. With the theme ***'Strengthening Resilience, Adaptability and Sustainable Growth in the Global Tuna Industry'***, about 520 industry leaders, experts and policy makers from 47 countries, convened to reflect and network on the current challenges and opportunities being presented to the global tuna industry in a constantly changing and disruptive business environment.[1]

The official welcome and opening address for TUNA 2022 was delivered by **Mr Somchuan Ratanamungklanon,** Deputy Permanent Secretary, Ministry of Agriculture and Cooperatives, Thailand. There were also special addresses delivered by the Conference Chairperson **Mr. Neil Bohannon,** Group Director Seafood from the Princes Group in UK and the Honorable Ministers from Ecuador **(HE Andres Arens Hidalgo)**, Fiji **(HE Semi Koroilavesau)**, the Republic of the Maldives **(HE Dr Hussain Rasheed)**, and Papua New Guinea **(HE Jelta Wong)**.

In the Keynote Address, **Mr. Juan Corrales,** CEO, Tri Marine International, USA, reflected on the conference theme. He said that tuna consumption patterns highlighted a direct correlation with good health and nutrition and that fishing as an industry provides a much-needed protein and solution for global food security. Good ocean management, continuous improvement, a people-first approach, putting the Blue Economy to the fore and collaboration with all stakeholders, are critical to a resilient, adaptable and sustainable industry.

[1] *A review of the Exhibition is contained in the "Equipment & Supplies" pages in this edition of the INFOFISH International.*

Session 1: Industry updates: Adapting to the new global trade reality

Mr. Narin Niruttinanon, Vice President, of Thai Tuna Industry Association (TTIA) in Thailand (TTIA) on the topic of 'Thai Tuna Industry Updates: Adapting to the new global trade reality', spoke to the importance of TTIA's emphasis on policy, ethical practices and labour guidelines as part of its industry norms. These considerations are critical to maintaining industry standards and TTIA continuing to operate as a transparent, responsible and sustainable player in the industry and globally. On the topic of 'Latin America: Ecuador's tuna industry during the pandemic', **Ms. Monica Maldonado,** Executive Director of the Ecuador Association of Tuna Processors and Exporters (CEIPA), said that Ecuador's tuna industry is resilient and the second largest tuna exporting country after Thailand. She highlighted that CEIPA works to improve competitivity, based on sustainable fishing and social sustainability. The emphasis on certification and a 'traffic light' approach remains integral to this in changing lives and transforming the region. Under the topic 'Europe: Business Resilience into the new global context', **Mr. Roberto Alonso,** Secretary General, ANFACO-CECOPESCA, Spain, provided an overview of the EU tuna industry, production and consumption trends and patterns. He spoke to the need to reactivate demand, give value to the category, have a more stable legal framework, ensure a constant supply of raw materials, and ensure a level playing field in the market. It is also essential for the EU to promote sector innovation based on digitalisation, sustainable production and growth. **Mr. Erik Hempel** (Director of Communications, The Nor-Fishing Foundation, Norway) speaking to the state of 'The Indian Ocean Tuna Industry' highlighted an industry that represents 23% of overall industry production at 1.8 million tonnes. He said that the transfer of knowledge to national fisherman and operators to phase out foreign operations has had limited success and that the balance of trade continues to remain in terms of countries in the Indian Ocean exporting raw materials or semi-processed products to the EU and other western countries.

Session 2: Industry updates: Revisiting sustainability

Ms Susan Jackson (President, International Seafood Sustainability Foundation (ISSF), (USA) made a presentation on 'Transparent accountability across tuna fisheries' and how ISSF's continued

global collaborations, marine research projects and advocacy efforts to identify and promote best practices in tuna and ocean conservation with fishers, tuna companies, and RFMOs, remain fundamental to these efforts. **Mr Husen Amru Mohamed Rashad** (Chairman, Maldives Industrial Fisheries Company (MIFCO), Maldives, on the topic 'Building connections: the human story of the Maldives Way from hook to plate', highlighted that sustainability is very intertwined with the human condition and wellbeing. In the Maldives, fishing is not just about economy, it is about the very core of Maldive society itself and that adding value to local fishermen and local industry, means bringing technology (and traceability) closer to the fishermen. **H E Andres Arens Hidalgo** (Vice Minister of Fisheries and Aquaculture, Ecuador) speaking to the 'Industry's role in sustainability from the Government's perspective', highlighted the role of industry in driving sustainability as strategic partners with the Government, the leveraging of technology as an enabler in digital traceability and sustainability, and transparent policies underpinned by stakeholder participation. **Dr Sangaa Clark** (CEO, Parties to the Nauru Agreement (PNA) Office, Republic of the Marshall Islands), under the topic 'The tuna industry in the Pacific- Parties to the Nauru Agreement (PNA),' provided an overview of the work and progress that PNA has made and how the Vessel Day Scheme (VDS) has been a successful example of cooperation by member states in maintaining the WCPO tuna stock status at sustainable levels, increasing revenue, growing jobs in the sector and increasing contributions to local economies. **Mr Neil Bohannon** (Group Director Seafood, Princes Group, UK) spoke on the industry's role in sustainability and how Marine Stewardship Council (MSC)-certified tuna as a mark of sustainability, has increased substantially since 2017 in several core markets including the USA, Netherlands, and Germany. If industry as a collective can support a cohesive and clear sustainability message that is identified, understood, and valued by consumers, this can act as a powerful demand pull on the whole supply chain to continuously improve. On the topic of 'Women in the Western and Central Pacific Ocean tuna fisheries', **Prof. Kate Barclay,** (Professor International Studies and Global Societies, University of Technology Sydney (UTS), Australia), pointed out that progress on gender equity needs collaboration by multiple stakeholders, including in industrial firms employing people, and regional bodies and national governments responsible for policy and regulation.

Session 3: Overview of global tuna resources and supply

Ms Stefania Vannuccini (Senior Fishery Officer (Statistics), Team Leader – Statistics Team (NFISS), Fisheries and Aquaculture Division, FAO, Italy) provided an overview on 'Global tuna production and trade trends' and highlighted FAO's emphasis on a 'blue transformation'. She said that coordinated global capacity building programmes are needed to improve fisheries and develop aquaculture sustainably in regions with larger needs.

On the topic of "Tuna stock health and sustainability (challenges and issues)" **Mr Feleti P. Teo, OBE** (Executive Director, Western and Central Pacific Fisheries Commission (WCPFC), Federated States of Micronesia) spoke on 'Tuna stocks health in the Western and Central Pacific Ocean: Strategic challenges and issues' and highlighted that bigeye, yellowfin, skipjack, and South Pacific albacore tuna stocks have been well-managed, attributed to the application of fish aggregating devices (FADs) closures, purse seine effort limits and longline bigeye catch limits. **Mr Gerard Domingue** (Compliance Manager, Indian Ocean Tuna Commission (IOTC), Seychelles), speaking on "Towards sustainable tuna fisheries in the Indian Ocean", highlighted the work of the IOTC in the sustainable management of 16 tuna and tuna-like species in the Indian Ocean. With a focus on yellowfin tuna stock which is currently considered overfished, a two-pronged approach has been undertaken through effort control (limit of active dFADs per vessel) and output control (catch limit for qualifying members). The conundrum between stronger management measures and the aspiration of developing coastal States to participate in this fishery is proving to be a significant challenge. **Mr Steve Adolf** (Research & Consultancy Sustainable Fishery and Ocean Policies) in his presentation on 'Paradigm change in global tuna sourcing management? Stakeholders and the current way of decisión-making in sustainable global tuna governance', pointed out that only six out of 23 major commercial tuna stocks that need assessment are avoiding overfishing and maintaining the target stock biomass. The uncomfortable truth right now is that we are still not sufficiently capable of managing our stocks in a sustainable way. **Dr Tom Pickerell** (Executive Director, Global Tuna Alliance, UK) on the topic of 'The Global Tuna Alliance (GTA): Supporting the delivery of SDG14 through supply chain advocacy and action via a 5-year strategy', spoke on GTA's 2025 Pledge Towards Sustainable Tuna (25PST), focused on transparency and traceability, environmental sustainability and social responsibility. The 25PST includes very rigorous progress reporting, including annual reports, RFMO review, self-reporting and third party audits.

Session 4: Tuna markets and marketing: Embracing changes

In his special address, **Dr Audun Lem** (Deputy Director, Fisheries and Aquaculture Division, FAO) spoke on the 'Impact of raw material prices on global tuna trade'. While international trade is increasingly important and emerging markets are importing ever more tuna, external pressures, including inflation, fuel and freight costs, are forcing prices higher. The industry has remained resilient, despite the disruption of the pandemic and other global shocks.

(i) Canned /processed tuna: Retail and catering trade

Mr Henk Brus, (CEO, Pacifical B.V., Netherlands) spoke on the 'European market for canned tuna 2022', and how preferences and "perceptions affect the way tuna is marketed", distributed and consumed within Europe. This includes varied dietary lifestyles (i.e. plant-based diets) and the negative perceptions of the tuna industry. There is a need for more active messaging on tuna as being a healthy meal option, better-priced and environmentally friendly. On the topic 'Middle East and North Africa (MENA) tuna market, post-COVID: The new era', **Mr. Arnab Sengupta** (Deputy CEO, J.M.B International, Thailand) highlighted the región as a dynamic market with growth potential. It has attracted the attention of many European national brands, with introduction of salad tuna and other value-added products. Canned tuna solid and chunks are the key products that are favoured. **Mr Dario Chemerinski** (Business Director, SSP-Selecting Strategic Partners, Brazil) on 'Post-COVID-19 New era in Latin America: The rise of tuna and the surprising case of Brazil', pointed to the development of vaccines in 2021 as the turning point for improvement. Post-COVID-19, consumption of canned tuna has

risen but mainly for middle and upper classes. One recommendation is that governments in Latin America should provide a safety net for the lower-income groups; for example, reduce the import tariffs on food, including tuna.

(ii) Changing landscapes

On the topic of 'WTO fish subsidies agreement, implementation and potential impacts for the tuna sector', **Mr David Vivas Eugui** (Head, Ocean Economy and Fisheries, UNCTAD, Switzerland) pointed out that the WTO Fish Subsidies Agreement (FSA) has important transparency obligations and a politically-delicate sunset clause (an "expiry date"). There is also a need to address subsidies that contribute to over-capacity and overfishing while considering new challenges such as carbon dioxide emission levels and small-scale artisanal fishers' needs. **Ms Fatima Ferdouse** (International Expert in Fishery Trade and Markets, Malaysia) on the topic 'Tuna trade in Asia: Diversity and opportunities' highlighted that the post- COVID-19 recovery in demand for fresh and frozen tuna (non-canned) has been faster compared with canned tuna. A deeper analysis on this trend will be useful for regional exporters of higher-value tuna (fresh and frozen). **Ms Le Hang**, Communications Director with the Vietnam Association of Seafood Exporters and Producers (VASEP) speaking to the topic "Changing landscape in Vietnam on tuna markets and marketing', stated that Vietnam exports tuna (mainly loins and steaks) to more than 100 markets, with the top destination being the US (nearly 50% in 2021) followed by the EU. Challenges include the lack of raw materials, the IUU yellow card that affects exports to the EU and the US Seafood Import Control Program (SIMP). **Mr Adolfo Valsecchi** (CEO, Generale Conserve S.p.A, Italy) on the topic 'Market adaptability and innovation at the retail level in the EU market' stated that market adaptability and innovation is the winning mix, especially if the cost of a tuna meal for a family is between USD 10-12 per time. He predicts that canned tuna consumption will grow by 2-3% per year for the EU, US, Australia, Saudi Arabia, and Japan, driven by product innovation and price value. Asia and Central as well as South America will probably see a faster growth rate of 3-8% per year.

Session 5: Sustainable supply chain and logistics

On the topic 'Shipping tuna: Impacts of high freight costs on raw tuna/raw material and processed tuna trade', **Mr Thue Barfod** (Global Head of the Fish & Seafood Segment, Maersk Hong Kong) stated that global reefer trade has grown consistently at 3.3% in 2021 year-on-year. He added that stretched supply chains continue to be vulnerable to disruptions; low unemployment rates and changing demographics in the US and Europe make it difficult to attract the necessary workforce and talent; bunker costs are increasing due to rising fuel demand; and there are also geo-political challenges. Digitalisation as well as better communication on potential disruptions are necessary. **Mr Luciano Pirovano** (Global Sustainable Development Director, Bolton Food, Italy) spoke to 'Strengthening Resilience, Adaptability & Sustainable Growth in our Supply Chain' and how 'Partnership is our Leadership' is the principle driving strategic partnerships between Bolton Food and other organisations in promoting a more sustainable sector. On the topic "Effectiveness in maintaining European Union policy in fighting Illegal, Unreported and Unregulated fisheries (IUU): post-COVID-19, new challenges and future objectives', **Mr Roberto Cesari** (Head of Unit, DG MARE – B4, IUU Fisheries Policy Directorate for International Ocean Governance and Sustainable Fisheries, European Commission) spoke on maintaining EU policy in fighting IUU. Useful approaches include using the Catch Certification Scheme and cooperation with third countries, failure of which may result in the issuance of red or yellow cards. New challenges are related to transshipments, port controls and open registries as well as encouraging countries to adopt internationally-accepted frameworks such as the Port State Measures Agreement (PSMA). The role of the private sector in cooperating with anti-IUU initiatives is also important.

Session 6: Market adaptation and technological innovation towards a sustainable tuna fishery

(i) E-commerce innovation

Dr Radika Kumar (Adviser Infrastructure Policy – Digital, Trade, Oceans and Natural Resources Directorate, The Commonwealth Secretariat, UK) in speaking to 'Leveraging digital infrastructure in the fisheries sector' highlighted that during the pandemic, markets with tech advantage could recover better and cater to the increased demand for seafood. However, the efficacy of digital infrastructure is impacted by factors such as network coverage, enabling basic infrastructure and spectrum allocation. Recommendations include strengthening local seafood systems linking small-scale fishers, processors and distributors; setting up safety net programmes for small-scale fisheries; and investing in social and capital networks for digital access to platforms for trading. On the topic 'ESG and sustainability in fisheries, a new vision in Latin America' **Mr Antonio Guerra Autrey** (CEO, GrupoMar, Mexico) reminded the Conference that consumers are concerned about healthy seafood without harming the environment. He spoke about GrupoMar's increased sales of pouched tuna in Mexico, through Tuny, a digital brand that promoted creative content during the pandemic, and utilised QR codes on cans for redirecting to landing pages. He added that the company will continue to focus on developing sustainable options, and digital platforms in positive messaging, and felt that they would appeal to consumers to whom ESG is important. **Mr Kazuhiro Shimura** (Group Creative Director, Dentsu, Japan), spoke to how only a handful of artisans in Japan can tell the quality of tuna by looking at a cross section of the tail, but to be trained in this skill takes about 10 years. Hence the usefulness of TUNA SCOPE, a mobile app which grades the quality of frozen yellowfin and bigeye while work is ongoing to adapt it to other forms and species.

(ii) Technological innovation

On the topic 'Smart oceans, sustainable oceans', **Mr Gabriel Gomez Celaya** (General Manager, Marine Instruments, Spain) provided an overview of the technological developments, products and services that Marine Instruments has developed for the sector. As examples, he mentioned the M3iGO satellite buoy which is the first in the market in employing artificial intelligence, as well as the autonomous Tuna Drone which can take off and land on the move, has a 10-hour operating time, a range of 18 nautical miles, carries a full HD video, and has zero emissions. The presentation by **Dr Moritz Lehmann** (Senior Scientist, Starboard Maritime Intelligence, New Zealand) on "How technological innovation

is helping to monitor IUU and other illegal activities" was on the security applications of new technologies and how satellite technologies allow for better coverage and detection modes to discover non-reporting vessels through the Starboard Maritime Intelligence operational platform.

Session 7: Technology and innovations for a safer, secure and sustainable tuna industry

In a Special Address on 'Blue Food revolution: Balancing demand, supply and sustainable tuna stock', **Ms Eva van Heukelom** (Partnership Manager, Global Sustainable Seafood Initiative (GSSI), Netherlands) highlighted a main challenge in balancing supply and demand with sustainable and responsible management. The main messages are that inclusivity and clear pathways for improvement are key for a more sustainable tuna sector; and that connecting local and global actors, reliance on trusted codes and guidelines, as well as collective action ("creating a common language") can drive the sector towards the goal of the UN 2030 Agenda.

(i) How smart technology is supporting sustainable fishing

Mr Pedro Vigil Diaz (Global Sales Director, SATLINK S.L. (Spain) on the topic 'Electronic monitoring for sustainable technology: edge-computing for automatic capture detection in real time' spoke on how using AI to achieve real-time automation capture detection, can be a game-changer for bycatch avoidance and sustainability in fisheries from environmental, social, and economic perspectives. He said that the EM tools developed by the company bring faster processing capabilities, higher quality images and unlimited satellite connectivity that allow fishers to make automated fishing reports. Speaking to the topic 'Innovation & process improving: Quality control system', **Mr Antonio Bustamante** (Manager, BIOLAN Southeast Asia, Thailand), highlighted how the implementation of digital tools for quality monitoring, and the integration of production lines with analytical tools, can improve traceability, accessibility, connectivity, and better management of the analysis process along the supply chain. Some of the digital tools developed by the company are the portable BIO 7000 and the desktop BIO 3000. On the topic 'Environmental DNA (eDNA) in canned tuna: How does it affect the industry?', **Mr Rick Heroux** (Chief Operating Officer of Eurofish, S.A) addressed the problem of environmental DNA (eDNA) in canned tuna, based on a case study involving a major UK retailer who reported finding traces of another tuna species (yellowfin) rather than the 100% skipjack that was expected. Risk assessment and vulnerability analysis schemes which aim to build confidence in the supply chain, may provide the assurance needed. **Mr Angel Martinez** (Commercial Director, Zunibal, Spain) on 'The path to sustainability for global tuna fishing through artificial intelligence and technology' highlighted that the company has developed AI tools which aim for features such as improved biomass estimation, target species identification, fishing zone identification, and buoy trajectory predictions. An example is the company's echo-designed buoy, which is the first of its type on the market. On the 'Origin of the Smart Brine Viewer or "SBV": Salt content measurement for new market opportunities and quality in the fishing industry', **Mr Gildas Bodilis** (President, OLEN, France), posited that currently, brine salinity in freezing processes is measured using a densimeter but this method has limitations when the brine contains an increasing amount of organic matter, and the salt content decreases due to absorption by the fish. OLEN has developed a Smart Brine Viewer (SBV) which allows for tighter control over the traditional brine freezing process through closer monitoring of the salt content and temperature of the liquid. In 'Adding value to tuna Fishery Improvement projects (FIPs)', **Mr Iain Pollard** (Senior Consultant, Key Traceability Ltd., UK) pointed out that markets want tuna sustainability and that FIPs are a suitable vehicle for working on new and evolving sustainability activities. Issues such as climate impact, carbon footprint, and human rights are becoming just as important as environmental sustainability.

(ii) What's next in social accountability and sustainability?

On the topic 'Labour standards on fishing boats: a problem looking for a home', **Mr Francisco Blaha** (Independent Consultant, New Zealand) highlighted that while the global fisheries industry has charted many advances in management and technology; and several international policies exist such as the ILO's C188, there is almost no framework that looks after the people whose voices will never be heard publicly. He asked who is looking after their welfare and interests, including to ensure that they are paid what they are worth. **Mr Martin Purves** (Managing Director, International Pole & Line Foundation (IPNLF), UK) speaking to 'How can tuna safeguard people, planet and prosperity?', pointed out that fishing has an impact upon ocean biodiversity, causes plastic pollution linked to ALDFG; and is also linked to human rights abuse and harmful subsidies. The IPNLF invites partners to join its "Reimagine Tuna" initiative which is led by ocean leaders from business, civil society, and international organisations in a global multi-stakeholder partnership. **Mr Bubba Cook** (Western and Central Pacific Tuna Programme Manager, WWF, New Zealand) on the topic 'Growing concerns among banking and financial institutions' drive for greater due diligence and scrutiny of fishing investments', expounded on how financial institutions are increasingly concerned that their investments in fishery businesses must not contribute to IUU or unethical fisheries, in line with Sustainable Blue Economy Finance Principles developed by the European Commission, WWF, the World Resources Institute (WRI) and the European Investment Bank (EIB).

On 'What's next in social accountability and sustainability at the Marine Stewardship Council (MSC)', **Mr Bill Holden** (Senior Tuna Fisheries Outreach Manager, MSC, Australia) explained the MSC's current policies on labour, the eligibility requirements for all certificate holders, requirements for at-sea certificate holders, and land-based Chain of Custody certificate holders. The MSC is working on creating a roadmap for a social policy, and that opportunities exist for stakeholder engagement in the development of the MSC's new labour policy which will be published on 26th October, with an implementation date of May 2023. Speaking on the topic of 'Satellite and CCTV monitoring, augmented reality audits and marine biodiversity offsets: Sustainable seafood certification according to Friend of the Sea', **Mr Paolo Bray,** (Founder and Director, Friend of the Sea (FOS), Italy) updated the Conference on the developments and initiatives that FOS has incorporated into its programmes. These include post-audit satellite monitoring of approved FOS vessels to verify compliance with requirements such as those related to MPA, legal transshipment at sea, fishing season and area limits, and social accountability. **Mr Marcelo Hidalgo** (Sustainability and CSR

Director, Fishing Industry Association, Papua New Guinea) speaking on 'Human rights in tuna fisheries: Group certification experience of PNG tuna fleet', recounted the group certification experience of the PNG tuna fleet starting from a commitment made in 2018 by the Fishing Industry Association (FIA) to implement a Responsible Sourcing Policy that includes, among other things, a focus on crew welfare, labour, social responsibility, and human rights at sea. The presentation used the group certification of FIA PNG as a case study on how to prepare a fishing company for social rights and human rights certification. On the overarching theme of 'Social sustainability in fishing: Why is it controversial?' **Dr Julio Morón** (Managing Director, OPAGAC/AGAC, Spain) asked the question: Why is social sustainability in fishing controversial? He pointed to the fact that only 20 countries have so far ratified the ILO's C188 and that even some globally-recognized sustainability schemes are not, or are slow in, fully addressing social sustainability. He said that there are several initiatives which are well thought-out such as the collaboration between the GSSI and the Sustainable Supply Chain Initiative (SSCI), but that despite the industry itself asking for social sustainability policies, implementation in practice remains low.

The 17th World Tuna Trade Conference and Exhibition (TUNA 2022) ended on the 13th of October. In his closing remarks, **Mr Neil Bohannon,** Chair of the Conference, applauded the high-level participation and contribution of the world-class speakers and representatives of the industry, who made the event a very engaging and successful one.

Ms Shirlene Maria Anthonysamy, Director of INFOFISH, said that a clear message that had surfaced over the three days of the Conference and which also resounded in a closed-door Ministerial Roundtable that was held, was that the global fisheries industry needs to communicate better. "When we do not communicate our positions as tuna stakeholders, our sustainability initiatives and our successes, we simply open ourselves up to being the target of misinformation and negative publicity. This not only affects us here, but also the small-scale and artisanal fishers whose role in providing the fish is often under-recognised, but whose voices must be heard." She added that a special session on communication might be held in response to this identified gap.

The Director ended by thanking Mr Somchuan Ratanamungklanon, Deputy Permanent Secretary, for officiating the opening on behalf of the Minister of Agriculture and Cooperatives, Thailand; and to the Hon Ministers from Ecuador, Fiji, Kiribati, Maldives and Papua New Guinea for gracing the occasion. She also thanked the Conference Chairs Mr Neil Bohannon (Group Director Seafood at Princes UK) and Mr Chanintr Chalisarapong (President, Thai Tuna Industry Association), co-organisers Thai Tuna Industry Association and the entire team of the Department of Fisheries, Thailand, for their unwavering support throughout the preparation leading up to the Conference. A big thank you went to the Conference collaborators FAO, WCPFC, IATTC, IOTC, ICCAT, WTPO, ANFACO CECOPESCA, Atuna.com, and the media partner Undercurrent News, as well as the sponsors Marine Instruments, MIFCO, Baader, Biolan, Ensis, Olen and FDO.

In the middle is Mr Somchuan Ratanamungklanon, Deputy Permanent Secretary, Ministry of Agriculture and Cooperatives, at the Department of Fisheries' booth.

Mr Juan Corrales, CEO of Tri Marine International (USA), delivering the Keynote Address.

AQUACULTURE

Collaboration with the Netherlands

Bangladesh – The Daily Star reports that the Dutch government has teamed up with some Bangladeshi companies (Aftab Bahumukhi Farms, Gemini Sea Food, Nutreco, Viqon, and LightCastle Partners) to ensure sustainable growth of the country's aquaculture sector.

The initiative, called FoodTech Bangladesh, is a four-year cooperation agreement between the parties, in which the joint investment is EUR 6 million co-financed by the Netherlands Embassy in Bangladesh. Headed by Larive International, the collaboration will see the establishment of three centres of excellence in Sylhet, Khulna, and Cox's Bazar to introduce and demonstrate different types of improved and more sustainable techniques for fish breeding and cultivation.

Research and trials with on-farm products such as feed additives, aqua specialties and antibiotic replacers will be conducted, while over 1 600 local fish breeders and farmers will receive training at the centres of excellence and via online courses. In addition, the partnership will upgrade an aquafeed line in Dhaka to increase the availability of domestically produced specialised fish feed.

Data center using waste heat to farm eels

Japan – A business venture in Hokkaido called the White Data Center (WDC) is collecting snow from the streets of Bibai, using it to cut air-conditioning costs

The Japanese are said to consume about 50 000 tonnes of eel per year

and reduce carbon dioxide emissions while cooling servers and networking equipment that operate around the clock. As the process increases the snowmelt's temperature rises to 33 degrees and the warmed liquid is used for growing eel.

A Kobe company called Kobe Unagi Tansui provided WDC with the 1 700 elvers (juvenile eels) that it released into tanks in February 2022, and provides the technical knowhow as well. Eels normally require warmer climates than Hokkaido, but WDC believes that the heat produced by its servers will keep the tanks at the required temperature. The eels will be sold at 250 grams or larger after a grow-out period of 7 – 12 months. Farm-grown eels are sold at upwards of USD 100 per kg at wholesale, or for USD 90 per dish in restaurants. The Center plans to grow 300 000 eels per annum by 2023.

Kota Honma, a WDC director and chairman of the Bibai Nature Energy Research Association, said that "The northernmost region where eels live in the wild is Aomori Prefecture. Eel farming has not been carried out in Hokkaido. We want to market Hokkaido-produced eels cultured in a hygienic indoor environment.

Why *monodon* will rebound in Asia

An interesting take on global *monodon* farming was presented by Robins McIntosh (senior vice president of CP Foods and shrimp farming expert) at the Global Shrimp Forum recently. He explained that when shrimp farming started in Asia in 1985, black tiger was sourced from wild broodstock and wild PLs but because of low growth rates, it was replaced by imported whiteleg shrimp *(L. vannamei)* which is now the main cultivated species. In the meantime, CP Foods decided to domesticate black tiger.

Starting by establishing an SPF programme, CP brought in as much genetic variation as possible from around the range of the species. After about nine years, they were able to start a selection programme at their breeding centre in Thailand. After the 14th generation, McIntosh was able to chart how survival rates have risen from around 30 percent to 85 percent. "With this domesticated *vannamei* we've reversed the downward trend," he said, explaining that global production of the species had fallen from 700 000 tonnes in 2004, to 300 000 tonnes in 2018, before rising to 500-600 000 tonnes today.

He added that the main countries to have capitalised on the new domesticated strains of *monodon* include China, Thailand, Vietnam, India, Malaysia, Bangladesh and Madagascar, and that the key advantage of black tiger is that the species is tolerant to both EMS/AHPND and EHP.

Seafood self-sufficiency by 2030

Saudi Arabia – Seafood self-sufficiency is expected to be achieved by 2026 in Saudi Arabia, according to Ali Al-Sheikhi, CEO of the National Fisheries Development Programme. In addition, the growth in the fish farming sector is expected to push the overall value of fish exports to USD270 million per year. Furthermore, under its Vision 2030 which involves the diversification of economy away from oil, the government wants to boost aquaculture production in the kingdom from the current level of around

80 000 MT to 300 000 MT in 2025 and to 600 000 MT by 2030.

Its plans stipulate that around 450 000 MT of fish are to be produced by marine cage farms in the Red Sea and the Persian Gulf. The rest should be provided by recirculating aquaculture systems (RAS) farms built across the country. Overall, the potential of the Saudi fish farming industry is estimated to be close to 1 MT per year.

One of the main reasons for scaling up the growth of its aquaculture production is to bolster demand in the domestic fish market. Consumption currently stands at 11 kg per capita, which is about half of the world average. Furthermore, and similar to other countries in the Middle East, Saudi Arabia depends heavily on food imports, purchasing roughly 80% of all the food it consumes from abroad, including the lion's share of the 300 000 MT of fish it consumes annually.

Currently, fish farmers in Saudi Arabia primarily raise whiteleg shrimp *(Penaeus vannamei),* Nile tilapia *(Oreochromis niloticus),* Asian sea bass or barramundi *(Lates calcarifer)* and gilthead sea bream *(Sparus aurata).* To fully meet the domestic demand, these farmers need not only to increase output but also expand the product range.

FISHING

Ministerial and industry roundtable on sustainable tuna fisheries

A closed-door Ministerial and Industry Roundtable was held in conjunction with the 17th INFOFISH World Tuna Trade Conference and Exhibition (TUNA 2022) which took place in Bangkok, Thailand, from 11 – 13 October 2022 with the theme *'Strengthening Resilience, Adaptability and Sustainable Growth in the Global Tuna Industry'.* Present were the Honorable Ministers from leading tuna producing and exporting nations Ecuador (HE Andres Arens Hidalgo), Fiji (HE Semi Koroilavesau), The Republic of Kiribati (HE Ribanataake Tiwau), The Republic of Maldives (HE Dr Hussain Rasheed), Papua New Guinea (HE Jelta Wong) and Thailand as the host country.

The Roundtable was moderated by Dr Simon Funge-Smith, Senior Fishery Officer, Food and Agriculture Organization of the United Nations (FAO). Representatives of international and regional organisations and the tuna industry were also invited to

attend the Roundtable, including Dr Chanintr Chalisarapong, President, Thai Tuna Industry Association; Mr Narin Niruttinanon, Vice President, Thai Tuna Industry Association; Ms Eva van Heukelom, Partnership Manager, Global Sustainable Seafood Initiative (GSSI); and Ms Praulai Nootmorn, Executive Advisor on Fishery Management, Department of Fisheries, Thailand.

A media statement issued after the roundtable had the approval of all the Hon Ministers and representatives of the Government of Thailand, the key points being that they:

• Committed to develop their commercial tuna fisheries sector guided by the aims of the United Nations' Sustainable Development Goals;

• Emphasised the need to communicate more effectively on the success of the tuna sector in meeting expectations on sustainability as well as to showcase that the industry is dynamic and embraces innovation and information technology;

• Recalled that during the COVID-19 crisis, tuna fed both domestic and international markets; and although a valuable and nutritious product, tuna remains under-appreciated in the market;

• Called for the reduction of import tariff imposed by developed countries such as US and EU, that are the final destination for tuna products imported from processing countries that have obtained tuna raw materials from sustainable fisheries. This is to encourage and enable developing countries, especially developing Pacific Island countries, which are making the effort in tuna sustainable fishing, to use the difference for the improvement of their local fishery communities' livelihood and for adaptation to climate change;

• Expressed concern that initiatives to close the oceans to fishing can unfairly impact livelihoods and economies dependent upon tuna fisheries, while not addressing the effective conservation and management of highly migratory species such as tuna;

• Urged countries, especially island nations, to work together to mitigate the effects of climate change on fisheries production and food security, and to prepare for the future impacts of climate change on the oceans and tuna fisheries;

• Reaffirmed their commitment to combat IUU fishing and implement the Agreement on Port State Measures to Prevent, Deter and Eliminate Illegal, Unreported and Unregulated Fishing (PSMA) and the Voluntary Guidelines on Transhipment; strengthen implementation of catch documentation schemes as well as strengthen monitoring, control and surveillance (MCS);

• Welcomed major bilateral and multilateral international partnerships between tuna producing and exporting nations and the industry to minimise the entry of illegally caught fish into markets;

• Committed to strengthen collaboration and support for Regional Fishery Management Organizations to support their mandate for fishery resource management and initiatives to combat IUU fishing;

• Stressed the need to improve data collection and reporting, monitoring control and surveillance; and

• Emphasised that sustainable fishery management is an effective conservation measure, particularly for highly migratory species such as tuna.

Global Fishing Watch signs MoU with PNG

Papua New Guinea – On 11 October in conjunction with the 17th INFOFISH World Tuna Trade Conference and Exhibition (TUNA 2022) in Bangkok, Thailand, the National Fisheries Authority (NFA) of Papua New Guinea signed a Memorandum of Understanding with Global Fishing Watch. Under the terms of the partnership, all 50 vessels from the Fishing Industry Association (FIA) will share their vessel tracking data, which will complement the already-existing automatic identification system, or AIS, data that appears on Global Fishing Watch's map. This additional layer of information will help strengthen vessel compliance and increase the transparency of its seafood supply chain.

"Our tuna fishery is one of the largest in the western and central Pacific Ocean and represents a key source of protein for more than 9 million people in Papua New Guinea," said Justin Ilakini, Managing Director of the NFA. "With support from Global Fishing Watch's monitoring technology, we can strengthen enforcement, contribute

Justin Ilakini, MD of the NFA, holds up the MoU.

to regional collaboration to eliminate illegal fishing and also demonstrate our commitment to promoting food security and the blue economy", he added.

Sylvester Pokajam, FIA Chairman said that "Our members want to know they are doing the right thing when it comes to responsible tuna sourcing, and by making fishing activities visible on the Global Fishing Watch map, they can help demonstrate compliance and add real value to their fishing operations."

Handline fishers benefit from IPNLF project

Oman – The International Pole and Line Foundation (IPNLF) reports on its website that it joined forces with its member Seafood Souq to conduct a pilot project using IPNLF's Fisheries Improvement Toolbox. This collaboration focused on targeted improvements in one-by-one tuna operations introducing high-quality, sustainably caught Omani tuna as an alternative source for the global seafood market with Seafood Souq providing a direct route to global buyers via their digitised seafood marketplace.

Omani tuna is, more often than not, sold for a domestic market rather than exported internationally, but it holds huge potential. One of the challenges faced by this fishery was developing the techniques to provide the highest quality tuna product ("grade-A") to meet the demands of international buyers. In the global market, high quality tuna for sushi and sashimi is often bought from longline, rather than small-scale fisheries using low-impact techniques like handline. However, this doesn't necessarily have to be the case.

This project has seen an increase in product quality, reduced waste, reduced environmental impact and supports better economics for the local fishers and the region by expanding their horizons beyond the shores of the Omani market.

Protecting migrant labour rights

Indonesia – The government is working on signing agreements with other countries to improve protection of its citizens working in those countries' fishing industries and on their vessels. Indonesia is thought to be the largest source of labour in the global fishing fleet, but for the moment, its fishers are not adequately protected against labour abuses. Many have related incidents of overwork, withholding of wages, debt bondage, as well as physical and sexual violence.

In May 2021, the Indonesian government signed an agreement with the South Korean government, addressing

key issues such as recruitment and placement mechanisms, protection of the labour rights of Indonesians working on board South Korean coastal fishing vessels larger than 20 tons, and a dedicated training centre for Indonesian fishers. Indonesia is the largest source of workers in the South Korean fleet, followed by the Philippines, Vietnam and Myanmar. According to reports, the Foreign Ministry is now seeking similar agreements with Taiwan and China, with the latter's fishing fleet accounting for nearly as much activity in distant waters as the next four top countries combined.

This move follows the issuance of an earlier government decree aimed at boosting the protection of Indonesian deckhands working aboard foreign commercial and fishing vessels. Ratified on 8 June 2022, the decree is designed to streamline the recruitment and placement process of Indonesian migrant deckhands, and improve measures to protect their labour rights. It is applicable to foreign commercial and fishing vessels, including distant-water boats. The new decree also includes working scheme and condition standards based on the ILO's Convention 188.

MARKETING

Export performance January – August 2022

China – *Food World* reports that according to China's customs statistics, in August, the country's export of aquatic products was USD 1.8 billion, a year-on-year increase of 1.68% while the export volume was 301 900 tons, a year-on-year decrease of 2.80%.

In the first 8 months of 2022, China's total exports of aquatic and marine products reached USD 15 billion, a year-on-year increase of 13.56%; and the export volume was 2.4058 million tons, a year-on-year increase of 2.66%.

In terms of markets, in the first 8 months, the top ten countries/regions in China's export of aquatic products were Japan, the United States, Thailand, South Korea, Malaysia, Hong Kong, China, Taiwan, the Philippines, Vietnam, and Mexico, which together accounted for 74.37% of the export value.

Thai Union partners with The ISH Food Company

Credit:ishfood.com

Thailand – Giant seafood producer Thai Union and its subsidiary Chicken of the Sea Frozen Foods have announced a partnership with a US plant-based seafood maker, The ISH Food Company. The latter, whose flagship product is Shrimpish, will use Thai Union and Chicken of the Sea's marketing and distribution channels for its sustainable seafood products.

The announcement is part of Thai Union's SeaChange® commitment, which includes measurable steps to foster sustainable solutions across their business. "We are excited to expand our reach within the alternative protein space through this alliance with The ISH Food Company," said Maarten Geraets, Thai Union Managing Director for Alternative Proteins. "Our corporate venture business arm has been working closely with innovative alternative protein start-ups as we increase our attention and investment in sustainable seafood alternatives."

Exports continue to grow despite challenges

India – In August, The Hindu newspaper reported that India is likely to register around 14 percent growth in exports of seafood products valued at close to USD 8.86 billion in 2022-23. The country had shipped marine products worth USD 7.76 billion in FY-22.

According to KN Raghavan, Chairman, MPEDA (Marine Products Export Development Authority), India had witnessed a 30 percent growth in exports of seafood products during FY22 over FY21 on the back of a steadily growing demand. The growth was despite challenges surrounding logistics and container freight issues and concerns over antibiotic residue and sustainable practices raised from certain key markets including Japan, the EU and the US.

He said that export of seafood products has grown by nearly 15 percent at USD1.99 billion in value terms during the first quarter of this fiscal, over the same period last year. "We have a target of touching exports of around USD8.86 billion during this year and we are on the path to achieving that. We have a target of touching close to USD14 billion exports by FY25".

What do Asian consumers think of alternative seafood?

Singapore – The Good Food Institute APAC reports on its website that it recently conducted a survey to learn what would motivate consumers in Singapore, Thailand, Japan, and South Korea to choose plant-based or cultivated seafood instead. The key take-aways from the survey were:

- Consumers see many potential upsides to alternative seafood products, including a guaranteed lack of mercury and other heavy metal contamination, which was identified as the leading benefit of alternative seafood in all four countries.
- The second leading food safety and health benefit considerations in Singapore and Japan were alternative

seafood's absence of microplastics and reduced risk of foodborne illness, respectively. In South Korea and Thailand, the second leading food safety and health benefit considerations were a low risk of foodborne illness and richness in omega-3s—an attribute that has become increasingly popular among leading alternative seafood producers in Asia, North America, and Europe.

• Respondents in Thailand were the most enthusiastic about alternative seafood among the four surveyed countries.

However, the study found that while local consumers are curious about trying alternative seafood dishes, they will accept no compromises on the taste, texture, or health benefits of alternative seafood for the sake of increased sustainability. Some consumers also expressed skepticism that plant-based or cultivated products can deliver the "freshness" and "naturalness" that they believe conventional seafood does.

Exports rebound, but some countries still maintain import measures

Japan – The annual Fisheries White Paper released by the Fisheries Agency covered the Basic Fisheries Plan for FY 2022 which was formulated in March 2022. Japan's strategy for growth in aquaculture is focused on increasing exports of yellowtail, seabream, scallops, and cultured pearls. Additionally, the Fisheries Agency is trying to help deal with the economic decline of fishing villages by promoting seafood-related tourism, such as recreational fishing. Increased mechanisation and introduction of information and communications technology are also being promoted.

The COVID-19 pandemic resulted in a shift in public consumption patterns in Japan from eating out to eating at home. Across Japan, demand is increasing for home-use frozen foods that can be stocked, are easy to cook, and are convenient. Consumers also purchased more seafood online in response to the pandemic. In terms of exports, Japan's seafood exports decreased in 2020, but rebounded in 2021, again due to COVID-19-related fluctuations in demand in destination countries.

The white paper also reviewed the lingering impacts of the Great East Japan Earthquake which happened on 11 March, 2011 in Fukushima. The Agency has been working to try and get countries that still have bans on seafood from the region to lift them, citing Japan's system for preventing foods exceeding safety levels for radioactivity from entering the market. This past June, the UK lifted restrictions on Japanese food products related to radionuclides, but China, Republic of Korea, Taiwan, Hong Kong, and Macau all retain import measures on Japanese food.

More dependence on seafood imports

EU – The European Fish Processors and Traders Association (AIPCE-CEP) says that self-sufficiency levels for seafood in the EU are sinking to an historic low. Its annual report points to two key factors being the UK's withdrawal from the European Union and lower catches by the EU's own fleet. The UK was a major source of farmed fish, including Atlantic salmon, for the EU market.

Of the total supply of 12.5 million metric tonnes in 2021, imports accounted for 9 million metric tonnes, or 72%, while the EU's domestic supply dropped to 3.5 million metric tonnes. For 2022, AIPCE is forecasting a further 7% decline in total supply, with both imports and domestic production weakening.

The report states that although the worst direct effects of the Covid-19 virus appear to have eased, many related supply chain issues such as high cargo costs, have hindered a return to pre-pandemic trading conditions. In addition, the Russia-Ukraine crisis has resulted in unprecedented energy price increases. It also says that "analysis shows that third country imports are ever more important to meet consumer demand."

TRACEABILITY & SUSTAINABILITY

Fully sustainable tuna sourcing by 2025

UK – International food group Princes has announced an ambitious roadmap to source and sell 100% of its UK Princes branded tuna from Marine Stewardship Council (MSC)-certified sustainable fisheries by the end of 2025. The roadmap includes three key milestones, which will see Princes increase MSC-labelled tuna products to 25% by the end of 2023, 50% in 2024 and 100% by the end of 2025. Achieving the 100% milestone represents 75 million cans (11 000 tonnes) of MSC-certified tuna per year under the Princes brand – meaning the amount of certified sustainable tuna available in the UK will increase by five times, based on current volumes.

Source fisheries will include newly MSC-certified fleets, in addition to the Group's existing MSC-certified suppliers. Princes has been supporting Fishery Improvement Projects (FIPs) for over five years, with many of these now maturing and meeting MSC standards. Last year, Princes also announced it had reached its goal of reducing Indian Ocean yellowfin tuna sourcing by 50% on 2017 levels, a year ahead of its 2022 deadline, to support the long-term sustainability of the stock.

Interactive tool to track global initiatives

The Conservation Alliance for Seafood Solutions, with support from Seafood 2030, called together a diverse Working Group of 15 Global Hub members working across different stakeholder groups and a team of programme developers and mapping experts, to co-design an interactive tool called SeaHive.

SEAHIVE

This was in response to stakeholders' calls for a mechanism to track the efforts and experts across the movement to increase opportunities for collaboration, while also providing a visual analysis of the responsible seafood movement, both geographically and topically.

Participation in SeaHive is open to all who are engaged in the responsible seafood movement, including individuals from NGOs and seafood businesses, human and labour rights experts, consultants, government representatives, funders/investors, coalitions, and beyond. The roll-out of this project will be phased, with SeaHive initially open to Global Hub Members in July 2022, followed by a public launch in November 2022.

WORLD

FAO called upon to better protect welfare of fishers

Three major tuna processors, the Bolton Group, Bumble Bee, and Tri-Marine, with the seafood industry groups of Fedespesca, SEA Alliance, and the Hong Kong Sustainable Seafood Coalition have signed a call to action asking for a mechanism by the FAO to reduce fisher mortality by improving data collection and analysis of labour-related accidents. They were joined in this initiative by several NGOs: Earthworm, ADM Capital Foundation, ClientEarth, the Fishing Industry Association Papua New Guinea (FIA PNG), Friend of the Sea, FishWise, the Global Seafood Alliance, and the Teng Hoi Conservation Organization.

Many of the signed organizations are already advocating for ratification and implementation of key international agreements to improve fisher safety and welfare. These include the IMO Cape Town Agreement, the ILO Work in Fishing Convention, the FAO Port State Measures Agreement, and the International Convention on Training, Certification, and Watchkeeping for Fishing Vessels Personnel.

Seafood trade expected to rebound

Netherlands-based Rabobank expects global seafood trade to continue to rebound for the rest of the year, with markets such as the US and Europe having fully recovered from the pandemic, while China is slowly returning to pre-pandemic import levels.

In its latest report, "Global Seafood Trade: The Growing Influence of a decade's Winners," Rabobank highlighted that seafood is the most traded animal protein, and its trade has grown to five times the size of the pork trade and more than 3.5 times the size of the beef trade. Novel D. Sharma, analyst at RaboResearch, and Gorjan Nikolik, senior global specialist, noted that US consumer eating habits are shifting toward seafood, which Rabobank attributes to millennials focusing on healthier protein options, as well as aging baby boomers.

To meet the growing demand, the United States is increasingly relying on imported seafood, especially high-quality varieties, such as shrimp, salmon, lobster and crab which are listed as "beneficiaries" of the increased demand for seafood in the United States.

The United States ranks second in global seafood imports, with imports of USD 28 billion in 2021, up USD 10 billion from 2013, according to Rabobank. While current imports have slipped from their 2021 peak, they will recover over the next two to three years.

Release, November 2022

The Pacific Tuna Forum is back – lock in the 06-07 of September 2023

INFOFISH and its partners are very pleased to announce that the **8th Pacific Tuna Forum** is back and that this premier event on the global Tuna calendar will be held from the **06-07 September 2023** in *Amazing* **Port Moresby, Papua New Guinea.**

The event will provide industry players within the region and beyond, with the timely opportunity to convene on the state of the play of the Tuna industry and the significant potential for further business growth and investment in this exciting industry and region, that is the Western and Central Pacific. To request for further information on the Pacific Tuna Forum 2023 kindly refer to the following link **http://ptf.infofish.org**

The **8th Pacific Tuna Forum 2023** is jointly organized by I**NFOFISH**, the **National Fisheries Authority (NFA)** of Papua New Guinea, and regional organizations in the Pacific.

Tuna industry players eyeing the Western and Central Pacific region are warmly invited to participate in this unique event.

Lock in the dates **06-07 September 2023** and look out for more details that will be provided in the months ahead.

SATELLITE DARK VESSEL DETECTION FOR MARITIME DOMAIN AWARENESS

Moritz K Lehmann & Andrew Middleditch

The detection of vessels at sea that are not self-reporting their position using automated geolocation systems, i.e., dark vessels, poses a particular challenge to maritime domain awareness. Satellites have a unique advantage in dark vessel detection as they can scan larger ocean areas more often than any other surveillance technology. In this article, the science team of Starboard™ Maritime Intelligence reports insights from their dark vessel detection operations using optical, radio frequency and synthetic aperture radar satellite sensors. We found that an effective satellite dark vessel monitoring programme requires a multi-sensor approach and patrol assets should be available for verification and interrogation of dark targets. In conclusion, dark illegal fishing threatens the sustainability of fish stocks and the economy of nations relying on fisheries income, but evolving technology and the increasing number of satellites mean that satellite sensors are quickly closing the surveillance gap for large ocean areas.

Illegal, unreported and unregulated (IUU) fishing undermines national and regional efforts to conserve and manage fish stocks, threatening marine biodiversity and communities relying on fisheries resources for food security and livelihoods.

Introduction

For fisheries operators, an accurate knowledge of ships in the vicinity, environmental conditions, and the location of fishing areas are essential for safe and legal conduct. Likewise, this situational awareness is indispensable for monitoring, control, and surveillance of fishing activity by governmental or regional fisheries management organisations.

Maritime domain awareness (MDA) is the effective understanding of anything associated with the maritime domain that could impact security, safety, the economy, or the environment. MDA encompasses many types of intelligence, but a fundamental requirement is knowledge of the locations of vessels at sea and information pertaining to their journey, such as their destination and the activities they are engaged in.

Fisheries-related vessel activities such as gear setting, steaming, and encounters for transshipment or resupply make up a significant fraction of maritime traffic. For example, in an area of the western equatorial Pacific north of Papua New Guinea, a quarter of vessels transmitting their positions are fishing boats (Figure 1).

Regulations of the International Maritime Organization require most large vessels to be equipped with automatic identification system (AIS) transponders providing geoposition and ship identification. Many small vessels, including recreational craft and fishing boats, are also AIS equipped voluntarily or because of regional regulatory requirements. AIS transmissions are received globally through networks of shore- and satellite-based receivers and are commercially available. This makes AIS an important component of MDA activities.

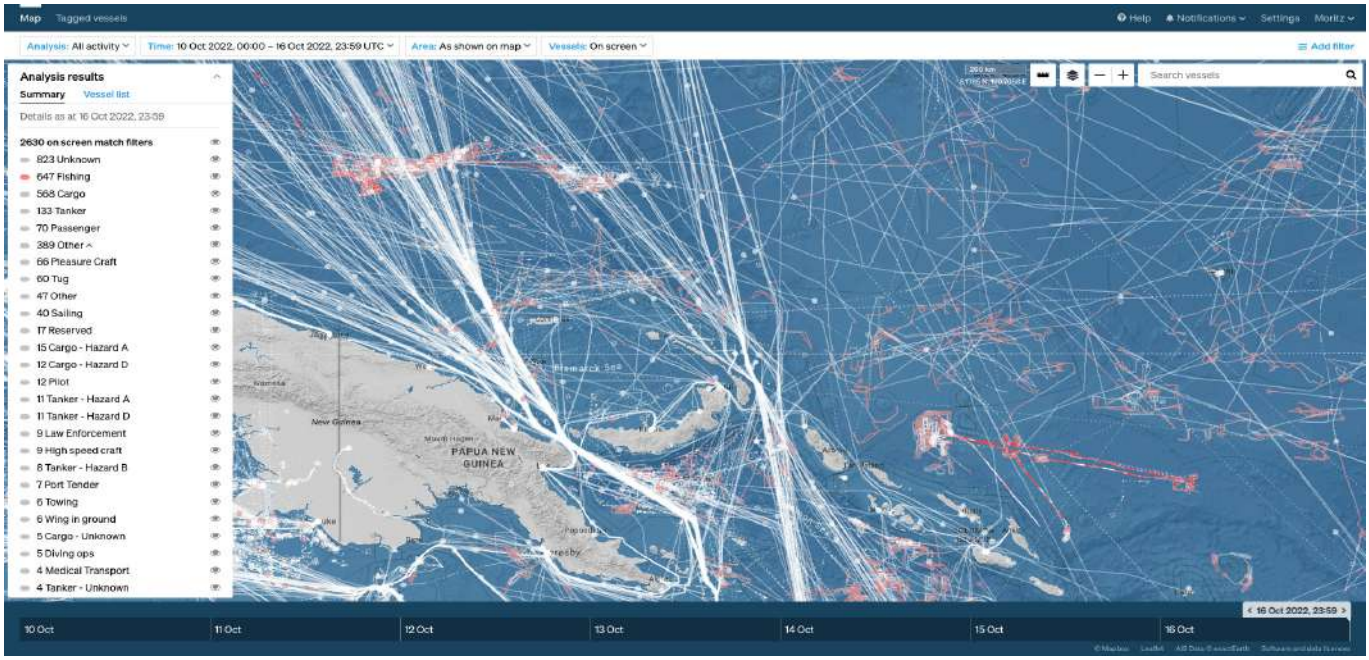

Figure 1: *Ship tracks of 2,630 vessels over six days in an area northeast of Papua New Guinea are shown in this screenshot of Starboard™ Maritime Intelligence. A quarter (647) of these vessels are fishing boats (shown as pink dots and active fishing is drawn as pink tracks). Starboard is a web-based MDA platform that displays and analyses global vessel positions in real time; vessel behaviour analytics and filters allow users to focus on vessels that matter to them. Long vessel tracks help analysts understand behaviour at sea and a vessel's relationship to other ships.*

Some fishing vessels are not required to be fitted with AIS transceivers, but most countries and many regional fisheries organisations require fishing vessels active in their jurisdictions to be operating vessel monitoring system (VMS) transponders. Similar to AIS, VMS provides geolocations at set time intervals and other identifying information. However, VMS data is not public, but exclusive to the governing organisation.

A difficult challenge for MDA is to detect and monitor vessels that don't report their positions, so-called dark vessels. Vessels may go dark because of technical failures of position transponders, gaps in coverage by signal receivers, or because they have been turned off purposefully by vessel operators. Finding a dark vessel in the vastness of the ocean, combined with the physical limitations of line-of-sight results in the proverbial "needle in a haystack" problem.

For example an average human standing at sea level can observe an area of about 70 km^2, with Earth's curvature obscuring anything below the horizon about 5 km away. Observing from a 20 m lookout increases this area to about 800 km^2. In general, the same distance rules apply to radar installations used for maritime domain awareness, as well as for airborne remote sensing. For example, for a surveillance aircraft flying at 0.8 km altitude, the horizon is about 100 km away yielding a survey area of 32,000 km .

As the viewing radius increases with the observer's altitude, satellite observations have a unique advantage: they can potentially observe vast areas of the ocean repeatedly. But all satellite sensors have specific limits to the size of the area that can be scanned (Figure 2), thresholds for the size or type of objects, and orbital dynamics dictate the timing and frequency of scanning opportunities.

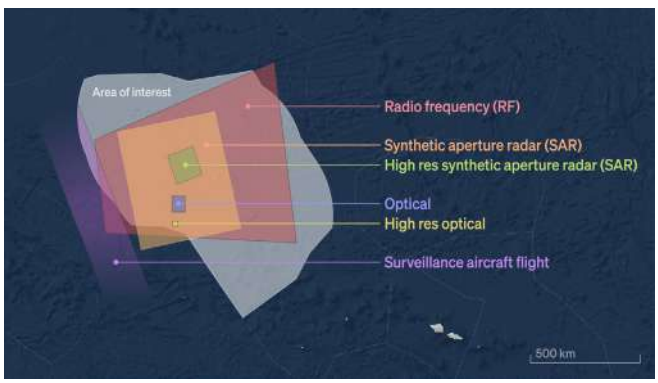

Figure 2: *The spatial footprints of observation technologies to detect vessel activity at sea in relation to the size of the exclusive economic zone of Tuvalu (irregular grey area, 750,000 km^2).*

In this article we describe our experiences from conducting numerous satellite surveillance campaigns at Starboard. We illustrate how satellites can support comprehensive monitoring of significant ocean areas both during operations where dark targets can be investigated by patrol assets, and for enhanced MDA over extended time periods. We first describe the advantages and limitations of three types of satellite sensors that are often used for vessel detection.

Satellite vessel detection

Most Earth observation satellites orbit our planet at altitudes between 300 to 1,000 km (low-Earth orbit) and scan the surface of our planet daily using a variety of different sensors. Three fundamental classes of sensors are routinely used for vessel detection: optical imagers, synthetic aperture radar (SAR), and radio frequency (RF) geolocation.

Optical imagers

Satellite-borne optical imagers produce the pictures of Earth's surface that are commonly known as 'satellite images'. The detection of vessels in satellite images is possible within the size limits given by pixel resolution. For example, vessels of 30 m length are visible in an image with 10 m pixel resolution (Figure 3a) and better pixel resolution is needed for smaller boats (Figure 3b).

Optical data is available for free from satellites operated by large space agencies such as NASA and the European Space Agency (ESA). Such satellites cover large portions of the planet routinely, and images have a resolution of 10 m or more per pixel. Commercial providers offer better resolution images from about 0.3 m per pixel, but typically do not acquire data continuously. This makes it necessary to order images in advance so that satellites can be tasked to acquire data at certain times in areas of interest.

There is generally a tradeoff in coverage (imaging footprint) and pixel resolution. For example, ESA's Sentinel-2 acquires data in continuous strips over land and coastal areas with 290 km swath width at 10 m pixel resolution, while PlanetScope images have a 25 by 16 km footprint at 3 m resolution. In other words, the resolution requirements to detect vessels simultaneously limits the maximum coverage area, so that 'you need to know where to look', which is often not applicable in the open ocean. An additional requirement for optical sensors is the need for a cloud-free view. Together, these limitations mean that optical imagers are of limited use for vessel detection at mission-critical times and areas of interest.

Figure 3a: *Vessels visible in 10 m resolution data from the Sentinel-2 satellite in Funafuti lagoon, Tuvalu, from 27 March 2021. The image swath has a width of 290 km. The four vessels visible in the lagoon have a length of 30 m or longer.*

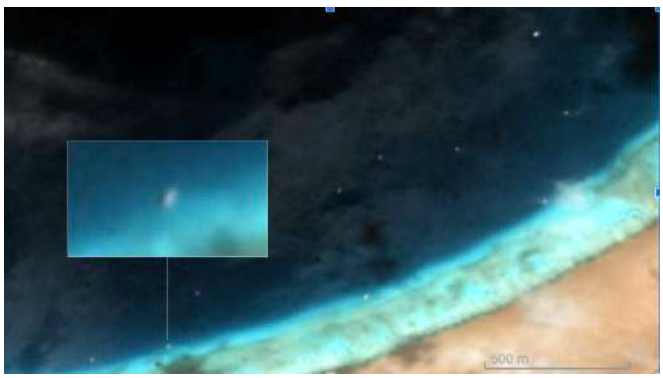

Figure 3b: *Optical image of the North Minerva Reef taken by a PlanetScope satellite with a footprint of 25 × 16 km at 3 m resolution from 21 October 2019. At least 10 sailing yachts are visible as diffuse white points.*

Synthetic aperture radar

Satellite-based synthetic aperture radar (SAR) systems transmit microwave radiation and then measure echoes received from the backscattered signal. By utilising longer wavelengths than optical systems, radar is able to penetrate clouds with minimal distortion. This enables measurements to be made in all weather conditions which is a significant advantage for most marine environments.

Satellite	Sentinel-2	PlanetScope	SPOT	SkySat	Pléiades
Operator	ESA	Planet	Airbus	Planet	Airbus
Pixel resolution	10 m	3 m	1.5 m	0.5 m	0.5 m
Imaging footprint	290 km swath	25 × 16 km	60 km swath	24 × 7 km	20 km swath
Return period	5 days	Almost daily	Almost daily	Daily	Almost daily
Tasking			✓	✓	✓

Table 1: *Information on a selection of satellites with optical imagers suitable for the monitoring of maritime domains (in order of decreasing footprint size).*

A number of different SAR satellites are available, providing both free and commercial imagery over regions from 25 to 225,000 km^2 at spatial resolutions between 0.35 and 50 metres. Some of the SAR satellites that have been used for ship detection include (in order of decreasing swath width):

- **Radarsat-2:** Canadian commercial C-band radar satellite with a dedicated large-scale ship detection acquisition mode at 450 km swath width; this satellite must be tasked to acquire data in areas of interest.
- **Sentinel-1:** ESA C-band radar satellite providing freely available data through the Copernicus Programme; Sentinel-1 scans land and coastal oceans at 250 km swath width and can not be tasked.
- **TerraSAR-X/TanDEM-X:** Twin satellite X-band constellation by the German Aerospace Centre; scanning modes for ship detection include ScanSAR at 100 km swath width and Wide ScanSAR at 270 km swath width.
- **ICEYE:** Finnish space startup offering tasking of its SAR constellation with a range of acquisition modes at a swath width of 5 to 100 km.
- **Capella:** Space startup company providing high-resolution SAR data at a swath width of 5 km. Capella achieves short revisit periods through a growing constellation of small satellites.

There are very few satellites available that can deliver large-area SAR imagery with suitable resolution for vessel detection. A system that has demonstrated good results for large ocean regions is the Radarsat-2 satellite. Using the Ship Detection (DVWF) mode, Radarsat-2 can cover an area of about 225,000 km^2 with a pixel size of 20 metres (Figure 4). The minimum size of a typical metal-hulled vessel that can be reliably detected from Radarsat-2 images in DVWF mode is approximately 30 metres.

The selection of the system and operating parameters is critical in order to optimise vessel detection capabilities. A SAR image (Figure 4) is a reflectivity map where the intensity of the backscattered signal is dependent on the physical properties of the reflecting surface. Surfaces that are relatively flat and smooth, such as the ocean, reflect the transmitted energy away from the satellite; this results in dark areas within the SAR image. Rough and complex surfaces, such as a vessel, reflect energy back to the satellite, providing a greater return at the radar receiver; this results in bright spots within the SAR image. Other bright structures are caused by oceanographic and meteorological conditions. Separating out spots of high signal intensity that might represent ships from this noisy background is a processing-intensive task.

Radio frequency geolocation

Recent developments in satellite technology for maritime domain awareness have focused on methods to detect and geolocate vessels from their radio frequency (RF) emissions. The main source of RF signals on ships are navigational radars, powerful beacons that sweep beams of RF energy around the horizon at a rate typically between 20 and 60 times per minute. Most vessels whilst at sea will have one or more navigational radars continuously operating, emitting strong pulses in the S- and X-bands. Other types of RF emission may also occur, such as the use of VHF for radio communications.

RF emissions from navigational radar propagate into space where satellites can detect them. If the angle-of-arrival at the satellite is measured, then the location of the emitter can be derived, to within some limited accuracy. Such data collections are made during a short interval (a few seconds) when a satellite in low-Earth orbit is making an overpass. The main advantage of RF geolocation over SAR imaging is that a larger area can be covered, generally at a lower cost. As such this is a promising new, albeit still maturing, technology. Some of the commercial companies providing RF detection products include (in alphabetical order):

- **HawkEye 360:** US geospatial analytics company using a constellation of small satellites to collect and geolocate RF signals for commercial use. The RF data collected includes UHF and VHF radio communications, X- and S-band marine radars, and L-band mobile satellite devices.
- **Kleos Space:** Luxembourg-based startup launching satellites for RF detection. Initially concentrating on the geolocation of VHF communication devices with plans to expand to marine navigational radars in the future.
- **Unseenlabs:** French company offering a radio frequency monitoring service using satellites. The RF data collected includes X- and S-band marine radar signals.

Dark vessel detection

The process of dark vessel detection starts with processing of the satellite data to reveal targets that could be ships. Data from optical and SAR satellite acquisitions are georeferenced images that have to be processed through feature detection algorithms to discern characteristic anomalies from the image background (Figure 4). RF scans on the other hand are processed by the data provider to deliver a list of geolocations of the radar emitter and their emission characteristics (Figure 5). While this is convenient, it does not allow assessment of the raw data background in case of suspected false detections.

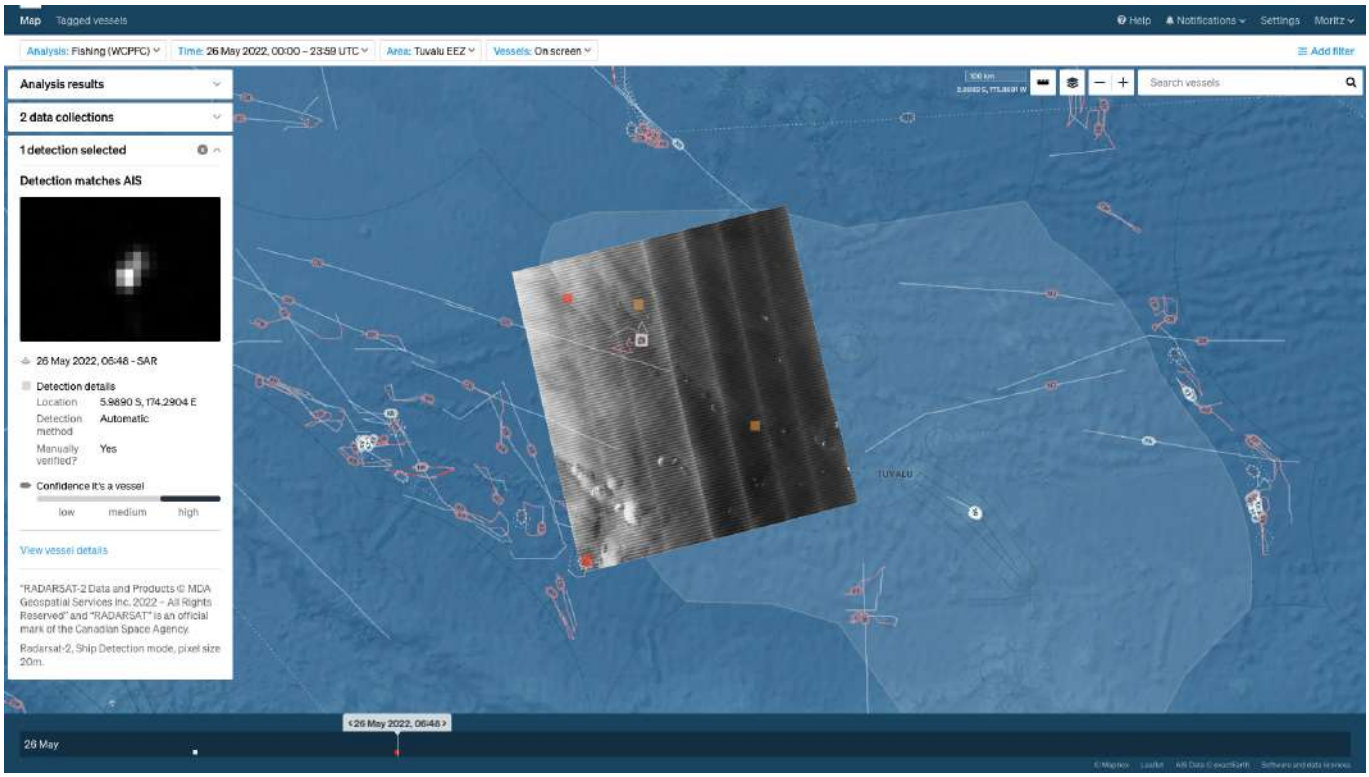

Figure 4: *Starboard screenshot displaying the intensity map from the Radarsat-2 scan over the Tuvalu EEZ on 26 May 2022 at 6:48 UTC. Vessels identified in the SAR data are shown as squares: white for matches to a vessel transmitting its location on AIS, red for a dark detection. Orange squares mark unmatched detections of medium confidence, i.e., where patterns in the SAR data are ambiguous. The image chip in the panel on the left shows a contrast-enhanced magnification of the SAR data around the AIS-matched detection. Ship tracks over 24 hours are shown as white lines, or pink if the vessel is engaged in fishing activities.*

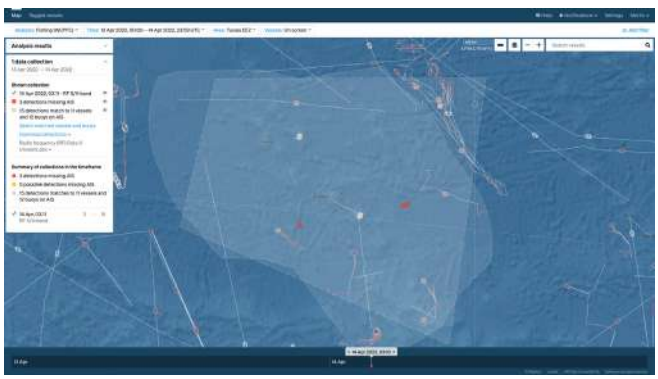

Figure 5: *Starboard screenshot of the Unseenlabs RF satellite scan on 14 April 2022 at 3:10 UTC over the Tuvalu EEZ. RF detections that are matched to a vessel transmitting its location on AIS are shown as white squares. Red squares are unmatched detections which are potentially dark vessels.*

The second step is matching satellite detections against known AIS and VMS ship positions. This matching has to take into account inherent uncertainty around the satellite-derived positions and possible gaps in the vessel track. For RF data, we consider a match to be a ship with an AIS message from within 5 km of the satellite detection. SAR data has better location accuracy than RF and we consider a match between a SAR detection and an AIS location within 1 km.

The end result is that satellite scans yield a list of detections matched to known vessel locations and a list of unmatched detections. As satellite sensors and processing techniques have the potential of creating false positives, i.e., making a vessel detection where no vessel is present, a dark satellite detection must be qualified as a 'possible' dark vessel, or a 'dark detection' unless it is independently verified to be a ship, for example by patrol assets.

The Starboard platform automates vessel detection processes, matching of satellite detections against known ship locations, and delivery of results to the end user. This means that actionable information is available almost immediately upon delivery of the satellite data, which is especially important when satellite acquisitions are in support of coordinated maritime patrol operations.

Case study: Dark vessel detection in the Tuvalu EEZ

In December 2021, the Starboard science team began to work with the Tuvalu Fisheries Department (TFD) on a long-term dark vessel detection programme of the nation's 750,000 km^2 EEZ. The work was as part of a pilot project under the World Bank-funded Pacific Islands Regional Oceanscape

Program (PROP) and included both routine data acquisitions, randomised over time and coverage area, as well as intensified acquisitions in support of patrol ship and aircraft operations. The TFD-Starboard team decided to task both SAR and RF detections to compare the different detection technologies and investigate optical imagery when the opportunity arose.

A total of 50 RF scans from Unseenlabs (Figure 6) and 10 Radarsat-2 acquisitions were tasked for this project adding to a total survey area of 25 million km^2. The team decided in favour of more RF scans as they cover a larger area and cost less per acquisition than SAR. Upon receipt of the data from the satellite provider, the Starboard platform processed the data, matched detections to known vessel locations, and served the result to the web-based user interface (as seen already in Figures 4 and 5). Over the course of the programme, approximately 700 vessel detections were made in satellite data, most of which could be matched against vessels via known geolocations based on AIS and VMS transmissions. These matches indicated that the positional accuracy of satellite detections is excellent, with geocoordinates of RF detections typically within less than one kilometre of the ship location, and SAR detections within 500 metres.

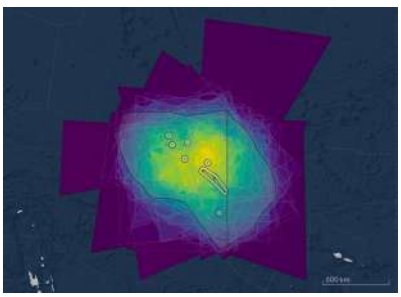

Figure 6: *Footprints of 50 RF scans over the Tuvalu EEZ from December 2021 to July 2022. Brighter colours indicate higher density of cumulative coverage.*

Both types of satellite data can produce false positive and false negative detections. We found that SAR data was very unlikely to miss ships over 30 m length (false negative), but noise in the data may be falsely interpreted as a ship (false positive). RF scans may miss ships that are not operating their radar, or when the rotating emitters are pointing away from the satellite at the time of data capture.

The large number of dark RF detections was unexpected. Radar sources that may not be transmitting AIS or VMS include yachts and pleasure craft, military ships and even aircraft, whose weather radar operates in the frequency range detectable by Unseenlabs. However, we suspect that there were a number of false positive RF detections. We carried out a detailed investigation of RF detection statistics over time and found changes in the broad characteristics of the data supplied to us during the project timeframe.

The insights gained from this surveillance campaign prove that the technology is evolving and limitations in the capabilities of the currently available commercial systems are being addressed.

Conclusion

Satellite sensors that can detect vessels at sea cover areas larger than any other surveillance technology in a single scan and can provide approximately daily global coverage. It is now easier than ever to order and quickly obtain satellite data at a fraction of the cost of ship or aircraft reconnaissance. Satellites have already become a regular tool to learn about the patterns of dark vessel activity, and to support fisheries monitoring, control and surveillance operations where the intelligence is used to direct surface and air patrol assets.

Satellite technology is also improving and expanding rapidly. Over the past year or so, more than a dozen new commercial vessel-detection satellites have been launched, and we expect dozens more before the end of 2023. This means that satellite sensors are quickly closing the surveillance gap. But the availability of a variety of sensing technologies, each with inherent advantages and limitations, requires careful planning of satellite campaigns. In our experience, an effective satellite dark vessel monitoring programme requires technical knowledge, close collaboration with regional experts, and flexibility to adapt to changing maritime traffic patterns and patrol asset availability.

At Starboard, we certainly foresee a future where global satellite surveillance provides continuous verification of ship locations at sea that is independent of self-reported positions. Space technology has already made it much harder to hide within the expanse of the open ocean and ubiquitous software platforms such as Starboard will continue to evolve to reveal suspicious activity, provide safety for those making their living at sea, and help to protect marine ecosystems.

Dr. Moritz Lehmann *is an oceanographer and remote sensing scientist who likes to squeeze every little bit of knowledge from ship tracks and vessel behaviour at sea. He leads Starboard's biosecurity research and supports operations against illegal, unreported and unregulated fishing using satellite dark vessel detections. Moritz is a well-published scientist and a skilled communicator. His work has been featured in several interviews for radio, newspapers and TV.*

Dr. Andrew Middleditch *is a research scientist at Starboard with a background in mathematics and oceanography. He has spent much of his career in ocean radar research, developing signal processing algorithms for the measurement of currents and waves. Andrew currently works on Starboard's dark vessel product, which focuses on the use of synthetic aperture radar (SAR) and radio frequency (RF) satellite technologies to detect non-reporting vessels.*

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WHAT DO ASIAN CONSUMERS WANT?

By Firoza Buranudeen

Like those in western markets, Asian consumers have a preference for live or fresh/chilled fishery species and products, followed by frozen, canned and other forms. Excluding the category of live/fresh/chilled species from its purview, this article provides a glimpse into the market for popular fishery products in several Asian countries, giving examples and highlighting some reasons why some items sell better than others. Flavour localisation is a key determinant in whether a product, which may be selling well in Europe or the US, will be equally successful in Asia. How it is presented, prepared, or incorporated into evolving lifestyles, and yet forming a large part of the traditional cuisine and cultural norms in Asia is another important factor.

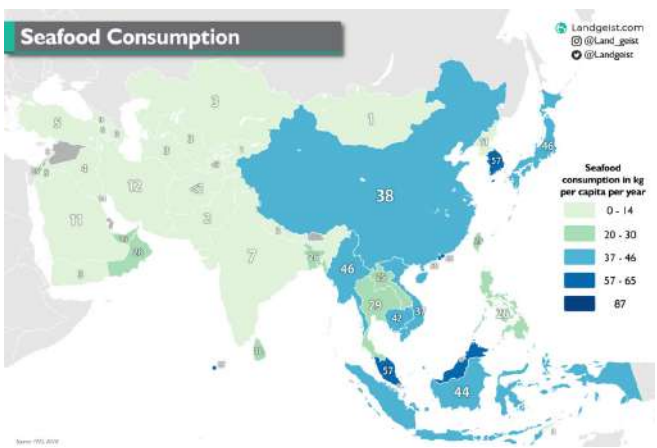
Asian consumers have a high preference for fresh/chilled seafood

According to the Food and Agriculture Organization of the United Nations' (FAO) report ***The State of World Fisheries and Aquaculture 2022 (SOFIA 2022[1])*****,** global consumption of aquatic foods (excluding algae) has increased at an average annual rate of 3.0 percent since 1961, compared with a population growth rate of 1.6 percent. On a per capita basis, consumption of aquatic food grew from an average of 9.9 kg in the 1960s to a record high of 20.5 kg in 2019, while it slightly declined to 20.2 kg in 2020. Preliminary estimates point to a lower consumption in 2020 due to a COVID-19-driven contraction of demand, followed by a slight increase in 2021. Upper-middle-income countries experienced the strongest annual growth. Rising incomes and urbanisation, improvements in post-harvest practices and changes in dietary trends are projected to drive a 15 percent increase in aquatic food consumption, to supply on average 21.4 kg per capita in 2030.

The Report continues to state that globally in 2019, aquatic foods provided about 17 percent of animal proteins and 7 percent of all proteins. For 3.3 billion people, aquatic foods provide at least 20 percent of the average per capita intake of animal protein. In Cambodia, Sierra Leone, Bangladesh, Indonesia, Ghana, Mozambique and some Small Island Developing States (SIDS), aquatic foods contribute half or more of total animal protein intake.

A map designed by the Landgeist project using FAO 2018 data illustrates the importance of aquatic foods in Asian consumption (Fig 1). In the western half of Asia, only consumers in Israel, Oman and the United Arab Emirates eat more than 10 kg/capita/year, but moving over to the rest of the continent, Hong Kong, Macao, Malaysia and South Korea are in the 57 – 65 kg/capita/year range, while the highest consumption is in the Maldives (87 kg/capita/year).

Figure 1: Seafood consumption in Asia per capita per year



Credit: Landgeist (https://landgeist.com/2021/01/27/seafood-consumption-in-asia/)

[1] FAO. 2022. *In Brief to The State of World Fisheries and Aquaculture 2022. Towards Blue Transformation*. Rome, FAO. *https://doi.org/10.4060/cc0463en*

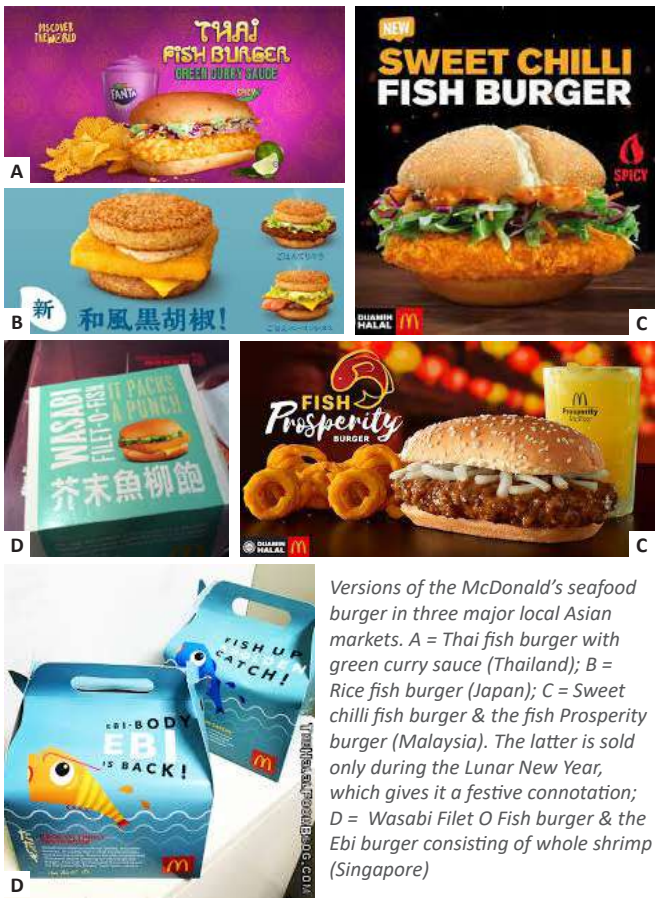
Flavour localisation is a key factor

More importantly for the purpose of this article, how do Asians prefer to consume their fish and fishery products? SOFIA 2022 reports that globally in 2020, about 20 percent of the aquatic food production of upper-middle-income countries was utilised in frozen form, 11 percent in canned form, and over 60 percent in live, fresh or chilled form. In contrast, for low-income countries, only 7 percent was in frozen form, more than 20 percent in cured form and about 70 percent in live, fresh or chilled form.

As most of Asia falls within the first income category[2], the expectation is that Asian consumers, like those in Europe and North America, want their food mainly fresh/chilled, followed by frozen and then canned. The main differences therefore lie in how the fishery product is presented, prepared, or incorporated into the evolving lifestyles, and yet forming a large part of traditional cuisines and cultural norms in Asia such as smoked, fermented, or salted and dried foods.

Fermented foods and sauces are a staple in Asian dishes, either during cooking or as an appetiser with rice: for example, (left) anchovy stock and (right) fermented shrimp.

An important point for any party seeking to export seafoods to, and within, the region is to understand what appeals to consumers in Asia, with its complex heterogeneity in cultures and taste preferences. A simple example can be seen in the case of the global fast food chain, McDonald's, which varies its basic menu and spice range according to where in the world they are located and in line with local religious and cultural norms. Beef and pork/bacon/ham are not sold in some countries due to religious taboos, making fish and shrimp the alternative protein source for non-vegetarians while vegetarians have the choice of items such as potatoes, salads, and cheese.



Versions of the McDonald's seafood burger in three major local Asian markets. A = Thai fish burger with green curry sauce (Thailand); B = Rice fish burger (Japan); C = Sweet chilli fish burger & the fish Prosperity burger (Malaysia). The latter is sold only during the Lunar New Year, which gives it a festive connotation; D = Wasabi Filet O Fish burger & the Ebi burger consisting of whole shrimp (Singapore)

Green curry sauce, rice patties, the spicy black pepper sauce as used in the McDonald's Prosperity burgers, and wasabi would probably not accompany seafood burgers in the US or Europe, but it does illustrate how well the fast-food chain has understood the value of flavour localisation as well as innovative packaging and presentation formats.

Another example of localisation of flavour can be found in a product which is a staple in almost all Asian countries. Fish/cuttlefish/shrimp balls are basically surimi which can be found in a variety of flavours: curry, cheese, wasabi, seaweed, and there is even a range of fish balls in Malaysia with durian (a fruit with a pungent) flavour.

[2] *According to the United Nations Office of the High Representative for the Least Developed Countries, Landlocked Developing Countries and Small Island Developing States, the 12 Least Developed Countries in the Asia-Pacific region are: Afghanistan, Bangladesh, Bhutan, Cambodia, Kiribati, Lao People's Democratic Republic, Myanmar, Nepal, Solomon Islands, Timor-Leste, Tuvalu, and Yemen. Ten of these twelve Asia-Pacific LDCs are on the path to graduation out of the LDC category, but as senior officials in a virtual meeting held from August 30 – September 2, 2021 had discussed, the concern is how can they be supported after the shock of pandemic-related collapses in commodity prices, foreign direct investment and tourism.*

Fishballs with flavours you would not find easily in western supermarkets

Presentation on the plate (or in a bowl)

Fish and fishery products in Asia are generally eaten whole or in cuts, whether fried or in curries, stews, or soups together with rice or noodles, but there is also a huge market for foods which have been part of the traditional cuisines in the region for generations. Examples include hot pot soups and stews; as well as skewered and grilled meats.

The hot pot concept, which is popular in most of Asia where seafood is mixed with vegetables and other meats, and served as a soup. The amount and type of spices used are in accordance with local tastes.

Satay (also spelled sate) consists of any meat which is seasoned according to local tastes, then skewered on a stick and placed on a hot grill. Though traditionally satay has consisted of beef/chicken/pork which holds its texture as it cooks, fish satay is now available in many outlets. On the island of Bali, Indonesia, a popular item is the *sate lilit (lilit* meaning to wrap around) which is made from pounded mackerel or tuna, mixed with grated coconut and seasoned with local herbs, and then wrapped around sticks of lemongrass. In Malaysia, a similar concept is seen in its *otak otak*, which is usually pounded mackerel, seasoned and wrapped in coconut leaves, then placed on a hot grill.

A= fish satay; B = sate lilit; C=otak otak

Seafood snacks

Snacking has become a lifestyle for many consumers in the 11 countries that make up Southeast Asia (Indonesia, Malaysia, Brunei, Vietnam, Thailand, Singapore, Cambodia, Myanmar, Laos, East Timor, and the Philippines). Research reveals that eight in 10 (80%) of urban Thais and seven in 10 (69%) urban Indonesians snack at least once a day. These snacks (usually small fish and other species such as jellyfish and seaweed) tend to be bite-sized, in small packs, in easy to open cans or pouches, and flavourful according to local tastes.[3]

[3] *This topic was elaborated upon in an article entitled "Snacking on seafoods in Southeast Asia", written by the author and published in the INFOFISH International Issue 6/2019.*

Just a few of the fishery snacks that can be found in Asian supermarkets

Meals within minutes

Notwithstanding traditional preferences, sales of advanced value-added forms are on the rise in Asia, depending on the countries' infrastructure and cultural preferences. Like western markets, among the drivers of this process have been greater awareness of the health benefits of fish; rising incomes; busy lifestyles; as well as technological developments in processing, cold chain logistics, shipping and distribution.

In the case of canned/pouched foods, the Asia Pacific canned seafood market is expected to witness market growth of 5.8% CAGR during the 2022-2028, according to a report published by Research and Markets.[4]

The Report states that "The Asia Pacific is expected to witness an increase in canned seafood product adoption due to the enormous amount of raw material available and the big number of aquaculture canneries in the region. Additionally, the Asia Pacific market is expected to be driven by the ever-increasing demand for ready-to-cook seafood products in emerging economies. The presence of some of the most well-known canned seafood brands is expected to help the regional market grow even further. The rapidly surging demand for protein-based food items among health-conscious customers is one of the primary drivers for the regional canned seafood market."

For canned and pouched seafood, as well as ready-to-cook/ready-to-eat meals in Asia, price and localisation of flavour have been identified as being important factors in expanding sales; hence there is no shortage of flavour variants based on traditional Asian recipes and tastes. However, admittedly, there is some uncertainty regarding the evolving tastes of younger people who may have grown up on a diet containing a higher percentage of "western" flavours than older people, and who are likely to be more adventurous. A clear example of this can be seen in the rising demand for alternative "seafoods", and therefore, in 20 years from now, one would expect to see a different product range on Asian supermarket shelves.

Canned/pouched fish packed in sauces formulated to appeal to consumers constitute another example of successful flavour localisation in Asia. As may be expected, most of the food contains a higher level of spices and traditional foodstuffs than would be found in western markets.

[4] *Asia Pacific canned seafood market size, share & industry trends analysis report by distribution channel, by product, by country and growth forecast, 2022 – 2028. https://www.researchandmarkets.com/reports/5615798/asia-pacific-canned-seafood-market-size-share*

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THE SEAFOOD SOFTWARE DIRECTORY HELPS COMPANIES TO FIND THE APPS THEY NEED

The rapidly increasing digitalisation of global fisheries and aquaculture industry has created a very wide range of technologies and smart apps, designed to, among others, collect and analyse data, maximise production and processing output, predict trends, manage risks, conduct e-commerce, connect with markets, and enhance traceability.

To make it easier for all stakeholders to keep track of these digitalisation tools, ThisFish Inc., a Vancouver-based company providing software and artificial intelligence to the seafood industry, has launched what it calls the "world's most extensive online directory of software, artificial intelligence and blockchain technologies for the seafood sector, from ocean to plate."

The directory, located at **https://this.fish/software-directory/**, contains almost 350 software companies which can be searched by more than 60 different filters.

"We've launched the Seafood Software Directory to help the global industry find the technologies they need for their digital transformation journey," says Eric Enno Tamm, Co-Founder and CEO of ThisFish Inc. "In the last five years, there has been an unprecedented explosion of new digital technologies for the seafood sector. The software market is getting crowded and confusing, and so a comprehensive directory will help the industry navigate this diverse market."

In the last five years, 135 new seafood software companies have been launched, representing 40 percent of the directory's total listings. Over the past decade, 307 new companies were founded, representing 91 percent of all listings. The directory contains 103 companies (30 percent) using artificial intelligence, either machine learning, neural networks or computer vision, and 28 companies (8 percent) powering their software with blockchain.

The directory is divided into sectors including aquaculture, fisheries, traceability, online marketplaces, quality/verification, and seafood processing. It also includes non-commercial software applications from government, academia and non-profits.

Users can easily search the directory by company name or use a menu of about 60 filters to find what they are looking for. Filters include types of sensors, sector functionalities, specialization, geographic market, country and technologies. Each company has a detailed profile with links to their corporate website and LinkedIn pages.

ThisFish plans to continue to update and expand the directory, including adding cold chain technologies, database APIs, and more in the future.

Software companies can provide feedback to ThisFish to update their profile or request to be added to the directory using this link: **https://this.fish/directory-feedback/**

CELEBRATING THE INTERNATIONAL YEAR OF ARTISANAL FISHERIES AND AQUACULTURE 2022 (IYAFA 2022) IN THE PACIFIC

INTERNATIONAL YEAR OF
ARTISANAL FISHERIES AND AQUACULTURE
2022

The United Nations General Assembly has declared 2022 the International Year of Artisanal Fisheries and Aquaculture (IYAFA 2022). The Food and Agricuture Organization of the United Nations (FAO) is the lead agency for celebrating the Year in collaboration with other relevant organizations and bodies of the United Nations system.

Celebrating IYAFA 2022 acknowledges the millions of small-scale fishers, fish farmers and fish workers who provide healthy and nutritious food to billions of people and contribute to achieving Zero Hunger. IYAFA 2022 aims to focus global attention on the role that small-scale fishers, fish farmers and fish workers play in food security and nutrition, poverty eradication and sustainable use of natural resources – thereby increasing worldwide understanding and action to collaboratively support them.

Some IYAFA 2022 celebration highlights from the Pacific nations of Kiribati and Samoa are showcased below.

KIRIBATI

The Kiribati Ministry of Fisheries and Marine Resources Development and the FAO, in collaboration with INFOFISH and Pacific Community (SPC) joined efforts to organize a side event to promote the International Year of Artisanal Fisheries and Aquaculture 2022 (IYAFA 2022). The celebration took place on 25 August 2022, on the sidelines of the 19th Regional Fisheries Forum Meeting held in Tarawa. The side event promoted IYAFA 2022 and its key messages to the high-level delegations which included regional Fisheries Ministers and distinguished delegates from 13 Pacific countries.

Mr Michael Savins, CTA for the FishFAD project at the FAO Subregional Office for the Pacific Islands (FAO SAP) provided opening remarks, and the Director of Coastal Fisheries Division in Kiribati, Ms Tooreka Temari gave a presentation outlining what IYAFA is all about. Mr Ekueta Ieremia, one of the country's leading artisanal fishers, spoke passionately about his life as an artisanal fisher and a boat builder in Kiribati.

The Fisheries Ministers and other delegates then visited the IYAFA booth where they were presented with an assortment of IYAFA branded communications and knowledge management products as well as packs of boutique packaged tuna jerky. They were all very impressed with the taste of the tuna sausages and tuna samosas that were also available at the booth. All tuna products were made by community fish processing activities and the tuna was caught by small-scale artisanal fishers. *Te Keang ni Marawa* (which translates as Grass of the Sea), a traditional dance troupe, performed several traditional dances for the occasion. Each delegate received a *"te itera,"* a unique floral garland made in the tradition of Kiribati, as part of the greeting dance.

The IYAFA booth was open during the whole five-day convention with the special day scheduled for Thursday, 25 August. The "artisanal fisheries and aquaculture" booth featured a fisherman mending a flying fish net and a two-man outrigger canoe among other items and displays. In the backdrop, educational videos were playing on two big screens. With such highlevel regional Fisheries Ministers and officials showing tremendous responsiveness and interest, the team believes the event was a true success.

SMALL-SCALE FISHERIES PROCESSING IN KIRIBATI UNDER THE AUSPICES OF THE FAO TUNA VALUE CHAIN PROJECT

Fish processing by the Buariki community in North Tarawa: Training in the production of tuna jerky, smoked tuna, tuna samosas and tuna burgers using the offcuts

Fish processing by the Buariki community in North Tarawa: making samosas and tuna burgers from offcuts

FAO Tuna Value Chain Project in Kiribati, funded by the Republic of Korea: Training youth in Makin island how to make tuna sausages

SAMOA

Faamanatuina o faigafaiva & faa-faatoagaina o l'a ma figota ile sami ma le vaimagalo

On the 15th of September, the Fisheries Division of the Ministry of Agriculture and Fisheries celebrated the 2022 International Year of Artisanal Fisheries and Aquaculture at the Apia Fish Market in Upolu. A second celebration was held on the 23rd of September at the Salelologa Fish Market in Savaii, with over 100 artisanal fishers, village representatives and fish farmers in attendance. It was a collaborative effort between the Ministry and the United Nations Food and Agriculture Organization (FAO) to commemorate this important international event with its theme: **"Small in Scale, Big in Value" – *"E LAITITI i le mātau, ae TELĒ lona aogā".***

Scenes from the IYAFA 2022 celebration at Upolu on 15 September

At the opening ceremony, the Honourable Minister of Agriculture and Fisheries, Afioga Laaulialemalietoa Leuatea Polataivao Fosi Schmidt acknowledged with gratitude the contributions from the small-scale fishers and fish farmers in the development of fisheries in Samoa, and encouraged them to continue with their valuable work which has greatly contributed to the increase in the food security and livelihoods of local communities.

During the celebrations in Upolu, Apia, Ms Xiangjun Yao, FAO Subregional Coordinator for the Pacific Islands also acknowledged the work of the local artisanal fishers, fish workers and fish farmers in Samoa and the Pacific region. She quoted, "We celebrate together with you to help raise your profile and strengthen the necessary support that ensures healthy livelihoods and sustainable fisheries for present and future generations."

The Ministry organized competitions with prizes for tilapia fish farmers, as well as displays of giant clams and jewellery made from trochus shells and raised awareness on the numerous Fisheries Division activities for the benefit of village communities and fish farmers.

IYAFA 2022 celebrations at Savaii on 23 September, 2022

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https://www.fao.org/in-action/globefish/background/fishinfonetwork/en/

EUROFISH

Eurofish holds successful workshop in Gdansk, Poland

A workshop co-organised by Eurofish in Gdansk, Poland offered the audience a glimpse of developments in technology and their implications for the fish processing sector as well as insights into trends on markets and in consumer preferences

Eurofish International Organisation together with the Polish Ministry of Agriculture and Rural Development, the National Marine Fisheries Research Institute, the Polish Association of Fish Processors, and Polfish organised a one-day workshop on technology innovation and market opportunities on 13 September in Gdansk, Poland.

The event was attended by over 80 participants from Poland and from other countries in the region and beyond. Among the speakers, Magnus Fossheim from Marel, a leading manufacturer of food processing equipment including for the seafood industry, identified some of the broad trends that will shape the future including the shift in economic power from west to east, the increase in global population, and the growing complexity of technology. He mentioned the capabilities that seafood processing companies will need including higher yields, greater agility, increased throughput and less downtime, to succeed in their activities.

But how much fish should consumers be eating at all? In her presentation, Danuta Łukaszewicz from Lisner, a Polish processing company, introduced the Nutri-Score, a food labelling system developed by the French Public Health Agency that uses a combination of letters and colours to express the energy value and nutrient content of a food product. Several fish products that Ms Łukaszewicz showed, however, were rated D, the lowest but one rating. She provided an example of how to increase a product's score. Salted herring fillets when combined with rapeseed oil in the ration 80:20 were rated D but when onion and pickled cucumber were added so that the ratio changed to 40:40:20 (fish, vegetables, oil) the rating went up a notch to C. The European Fish Processors Association has suggested adding new categories such as protein and omega-3 content as that may offer greater clarity. The French system is not the only one in Europe—similar attempts are made in Italy, the UK, and Scandinavia, but whether it will lead to healthier lifestyles and less obesity remains a question.

The workshop featured several presentations which are available on the event website (https://eurofish.dk/events/2022-09-regional-workshop-gdansk/).

INFOPESCA

INFOPESCA co-organised Korea-Latin America fisheries forum with emphasis on small-scale fisheries

KOLAFF 2022 focused on small-scale fisheries with reference made to the International Year of Artisanal Fisheries and Aquaculture 2022 (IYAFA 2022)

The Korea-Latin America Fisheries Forum 2022 (KOLAFF) was held in September 2022, co-organised by INFOPESCA and the Korea Maritime Institute (KMI). The slogan this year was "Future International Cooperation Projects to Improve Small Scale Fisheries Management in Latin America".

The main objective of the Forum was to give the initial kick-off for the formulation of a project for the development of small-scale fisheries in the region. In addition to making a brief presentation on the role and current status of small-scale fisheries and aquaculture in Latin America and the Caribbean, INFOPESCA presented to the Korean authorities, with the contributions of the countries participating in the meeting, different ideas for the aforementioned international cooperation project, which will contribute to the sustainable development of the activity in each country.

Authorities, experts, academia, professionals and stakeholders from Barbados, Belize, Brazil, Chile, Colombia, Costa Rica, Dominican Republic, Ecuador, Grenada, Guatemala, Honduras, Nicaragua, Panama, Peru, Trinidad and Tobago, and Venezuela participated in the event.

The event was part of a joint research project between KMI and INFOPESCA. The first stage consisted of a report prepared by INFOPESCA for the Korean authorities on: (i) Current Status on Small-scale Fisheries and Its Management in Latin America, including the volume and value of the catches, the number of vessels and fishermen, etc. of small-scale fisheries; (ii) Key issues on small-scale fisheries in Latin America, including illegal, unreported and unregulated (IUU) fishing, decline of fishery resources, fisheries management, post-harvest, etc.

The second stage of the project was the organisation of this forum and the compilation of the proposals of all the countries, which were delivered to the KMI.

More details on the way forward will be announced soon.

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INFOFISH

TUNA 2022, the 17th INFOFISH World Tuna Trade Conference and Exhibition was held in October in the "tuna capital" of Bangkok, Thailand, witnessed by more than 500 participants, 43 speakers, exhibits by 41 international companies, and the Hon Ministers from Ecuador (HE Andres Arens Hidalgo), Fiji (HE Semi Koroilavesau), the Republic of Kiribati ((HE Ribanataake Tiwau), the Republic of the Maldives (HE Dr Hussain Rasheed), and Papua New Guinea (HE Jelta Wong). The theme was "Strengthening Resilience, Adaptability and Sustainable Growth in the Global Tuna Industry".

Mr Neil Bohannon (Group Director Seafood at Princes UK), the co-Conference Chair, acknowledged that the past year has been especially difficult for the tuna sector due to the COVID-19, alongside market disruptions and inflationary pressures. However, the response to these challenges from tuna producers and suppliers alike has also defined 2021/22 as a period of resilience, innovation and progress which is taking the industry from strength to strength. He commended the industry for successfully adopting new technologies, forging effective collaborations, and launching creative initiatives to support the long-term sustainable growth of the industry.

The Hon Ministers were then invited to address the Conference.

In the Welcome Address given by the Guest of Honour, Mr Somchuan Ratanamungklanon, Deputy Permanent Secretary of Thailand's Ministry of Agriculture and Cooperatives, he stated that Thailand, as the world's leading importer of tuna raw materials for processing and one of the largest exporters of tuna products, prioritises the global sustainability of tuna resources. As part of this focus, the government collaborates with the Indian Ocean Tuna Commission (IOTC) and the Western and Central Pacific Fisheries Commission (WCPFC). Thailand has also ratified the Port State Measures Agreement (PSMA) to demonstrate its commitment to the fight against IUU fishing and catalyse reforms in the sector.

In her closing remarks at the end of the event, Shirlene Anthonysamy, Director of INFOFISH, said that a clear message that had surfaced over the three days of the Conference and which also resounded in a closed-door Ministerial Roundtable that was held two days ago, was that the global fisheries industry really needs to step up on communicating better to avoid becoming the target of misinformation and negative publicity. This also affects the small-scale and artisanal fishers whose role in providing the fish is often under-recognised, but whose voices must be heard.

She also thanked the Conference Chairs Mr Neil Bohannon and Mr Chanintr Chalisarapong (President, Thai Tuna Industry Association), co-organisers Thai Tuna Industry Association and the Department of Fisheries, Thailand; Conference collaborators FAO, WCPFC, IATTC, IOTC, ICCAT, WTPO, ANFACO CECOPESCA, Atuna.com; the media partner Undercurrent News; as well as the sponsors Marine Instruments, MIFCO, Baader, Biolan, Ensis, Olen and FDO.

Developments in the research and production of alternative seafoods continue to gather speed, with more and more companies worldwide choosing to invest and form collaborations to supply this (as-yet) niche market. With regard to plant-based foods in general, Bloomberg Intelligence says that the market could make up to 7.7 percent of the global protein market by 2030, with a value of over USD 162 billion (EUR 143 billion), up from USD 29.4 billion (EUR 26 billion) in 2020. The increasing demand has been attributed by industry sources to the rise of flexitarian consumers who are actively restricting animal-based products but have not fully eliminated these from their diet.

Alternative seafoods are broadly classified as plant-based or cellular foods. Below are a few of the recent offerings as announced by the companies involved; most are based in the USA or Europe but Asia is also beginning to see a rise in the presence of alternative seafood start-ups.

Plant-based analogues

A whole-cut cod fillet analogue is being developed after Loki Foods (Iceland) raised USD 650 million in a funding round. The company says that it will produce "plant-based cod that cooks like cod" which is high in protein, vitamins, and omega 3 and 6 fatty acids, as well as free of microplastics and other pollutants.

Meanwhile, the world's first whole-cut salmon alternative is being marketed by Plantish (Israel) which has combined 3D printing with legume proteins and algae, following a USD 2 million funding round in 2021. The product looks like a boneless fillet. Legume proteins and algae extract are used in the 3D printing process to give the product an authentic look. It is expected to be launched commercially in 2024.

Whole-cut plant-based alternatives: cod (left); salmon (right)

A tomato-based raw tuna alternative called Tunato was launched in 2019 by Mimic Seafood (Spain), made from tomatoes, olive oil, algae, soy sauce, and a spice blend. More recently, it developed an aubergine-based eel alternative. Called Aubergeel, the product is seasoned with Asian-style ingredients such as soy sauce, rice vinegar, mirin, sake, and sesame oil.

Apart from fish alternatives, crabs, scallops, and oysters are among the recent offerings which have been well-received by consumers in the US and Europe. For example, The Plant Based Seafood Company (USA), under its Mind Blown brand, is marketing crab cakes made of konjac powder, vegetable gum, and vegetable root starch, and seasoned with celery, onion, and panko breadcrumbs. Meanwhile, Handy Seafood (USA)'s crab cake analogues are made of a pea and wheat protein blend and seasoned with a savoury flavour.

Tomato-based tuna alternative (left); Aubergeel (right)

Credit: Handy Seafood

Plant-based crab cakes

Ocean-farmed kelp is the main ingredient in "Krab Cakes", created by AKUA (USA), comprising a blend of kelp, cannellini beans, Dijon mustard, artichokes, garlic, onion and celery. The previous year, the company had launched what it says is the world's first kelp burger. Apart from the kelp, the burger contains crimini mushrooms, pea protein, black beans, quinoa, and crushed tomatoes.

Another seaweed-inspired choice comes from the Swedish startup Hooked, with its plant-based shredded salmon and tuna made with soya protein isolate, seaweed, sea algae, algal oil for omega-3 fatty acids, etc. These alternative fish products are meant for use in salads, pastas, wraps and bowls.

Cell-based alternative seafoods

Salmon alternatives using cellular technology are being produced in prototype forms or are about to be commercialized. Examples include the salmon alternative that Wildtype (USA) says has chefs struggling to tell the difference between conventional salmon and the alternative.

Sushi-grade "salmon"

Another USA-based start-up called Pearlita Foods has developed a cell-cultured oyster prototype comprising mushroom and seaweed. The company says that the dissected tissues from one live oyster sample can produce thousands of cultivated oysters. For now, recycled oyster shells are being used but there are plans to develop biodegradable shells that remove the need for shucking.

"Oysters" made from mushroom and seaweed

Credit: Pearlita Foods

E-FISHient Protein (Israel) is one of the few start-ups that is utilizing Nile tilapia. The company says that the first step involves collecting cell samples from animal tissue (typically by biopsy) without harming the fish. After the cells have multiplied into billions of cells and formed additional elements such as tissue, muscle and fat, it is used to make fish meat products such as fish balls, fillets, cutlets and fingers.

Shiok Meats (Singapore), marketing itself as "Seafood, Reinvented" is the first of its kind in SE Asia. The company is producing cell-based crustacean meats (shrimp, crab, lobster), with an eye on the Asia Pacific (Australia, mainland China, Hong Kong, India) and the US.

Alternative shrimp dumplings

Seafood analogues made from algae and fungi

Algae and/or fungi (usually mushroom) can also form the basis of some seafood analogues. Aqua Cultured Foods (USA) says it is the first company ever to produce whole muscle seafood using fermentation of fungi. Its products include alternatives to tuna, whitefish, popcorn shrimp, calamari, and scallops.

Sushi-grade analogues produced through fermentation of mushrooms

Fermented Japanese fungus koji is the basis of alternative meats (including seafood) produced by Prime Roots (USA). Koji, which has been incorporated into Asian cuisines for centuries to give dishes a fermented umami flavour, has a fibre-like texture. To date, this seems to be the only start-up which is offering koji-based vegan meat alternatives.

Example of a seafood analogue made from fermentation of koji

Credit: Prime Roots

The 17th INFOFISH World Tuna Trade Conference and Exhibition (TUNA 2022) took place from the 11th – 13th of October in Bangkok, Thailand. There were 38 exhibition booths showcasing equipment and items which are relevant to tuna fishing, monitoring, processing, packaging as well as AI/digitalisation tools. A brief review of some of the equipment on display, and services offered, can be seen below.

DIGITAL INNOVATION

BIOLAN, Gold Sponsor of TUNA 2022, displayed digital biosensors for advanced monitoring of food quality and safety systems. This range included an enzyme-specific biosensor for the quantification of histamine in less than a minute. Its BIOLANglobal Digital Services Platform stores and manages real-time data so that faster and better decisions can be made.

The BIOLAN7000 for monitoring food industry parameters

Reagents and instruments for the rapid, low-cost, high-sensitivity analysis of substances in fish and seafood products were at the ***BioSystems*** (Spain) booth. These included reagents for histamine and sulphite analysis, paired with the Y15 and Y350 Analyzer.

High resolution fishing software has been developed by ***CatSat*** (France). Among its features are habitat maps (targeting the adults of the desired species); buoy tracking and drift prediction; identifying high dynamic current zones (understanding movement of buoys, phyto and zooplankton, etc); and an integrated catch history database.

Digital Observer Services (Spain) is a fisheries consultancy and Electronic Monitoring (EM) service provider which uses Satlink equipment (Satlink SeaTube), high definition cameras, GPS systems and other information to produce detailed reports on vessel fishing activity.

Marine Instruments (Spain), Platinum Sponsor of TUNA 2022, lead in the development and manufacture of smart electronic equipment adapted to the marine environment and sustainable fishing. An innovative exhibit at the booth was the M3iGO, the first tuna satellite buoy to incorporate artificial intelligence.

Software designed for the seafood industry was exhibited by Vancouver-based ***ThisFish***, with special focus on Tally which helps companies to digitise all data, monitor dashboards to improve compliance, and analyse data to improve productivity.

SUSTAINABLE FISHING

Ensis Fisheries Pvt Ltd (the Maldives), Silver Sponsor of TUNA 2022, informed booth visitors that the tuna processed and marketed by the company are certified by Marine Stewardship Council (MSC) and Friend of the Sea (FOS) as sustainable. Each fish is caught individually by hook and line.

Fisheries Development Oman (FDO), Bronze Sponsor of TUNA 2022, was established through a joint commitment between the Ministry of Agriculture and Fisheries Wealth and Oman Investment Authority (OIA). Al Wusta Fisheries Industries (a subsidiary of FDO) aims to increase the production of pelagic fish stocks in Oman's coastal waters and the Indian Ocean.

Marco (Spain) exhibited its expertise in fishing equipment and deck machinery. It designs and manufactures innovative and quality marine machinery according to the specifications of owners and shipyards, in line with the ISO 9001-2000 standard. The company also supplies and repairs all types of vessels and deck machinery.

The SeaStar Information Service from ***MAXAR*** (USA) combines oceanographic and meteorological datasets, asset tracking data, and information that is required to monitor and analyse ocean conditions, vessels and fishing gear. Search time and fleet operation costs are minimised.

The manufacture of steel wire ropes for fishing, lifting, cranes and elevation systems is the specialty of ***Oliveira*** (Portugal), established in 1825. Its quality assurance system is according to ISO 9001/2008 and upon request, certificates can be issued in accordance with Det Norske Veritas.

Platinum Sponsor of TUNA 2022, the ***Maldives Industrial Fisheries Company (MIFCO),*** showcased its focus on sustainability in fishing method (pole and line), that all the fish are fully traceable, and how the industry benefits local fishing communities through food security and livelihoods.

Thalos (France) offers satellite communications controlled and managed with OceanBox integrated solutions. Navigation and oceanographic analysis tools make it possible to make the right decision at the right time, and smart monitoring systems aid in real time fleet and operations management.

PROCESSING

TUNA 2022 Platinum Sponsor ***BAADER*** is a global partner for innovative end-to-end food processing solutions. It has a majority share in Skaginn3X which offers a range of patented chilling, freezing and thawing solutions as well as efficient food processing systems designed to maximize product quality, increase yield, throughput and overall efficiency.

MENT AUTOMATION (Vietnam) offers tuna processing equipment including a smoke injection machine, liquid injection machine, tuna grader and checkweigher. The grader has a speed of up to 120 pcs per minute and the checkweigher is able to process cans of about 300 pcs per minute.

Bronze Sponsor of TUNA 2022, ***Olen System*** (France) has developed the Smart Brine Viewer, a complete system to supervise the freezing process by brine used on board for tuna purse seiners. This new technology measures in real time, the salt concentration and temperature of the brine.

Sripipat Engineeing Company Ltd (Thailand) is a manufacturer and importing agent of food processing machines for inspection, sorting, filling and vacuum packing purposes. Specific to tuna, on display at the booth was information on the "PP" flaker which processes defrosted or chilled loins; the chunk cutter; and pouch filler.

Thai Tuna Industry Association (TTIA), co-organiser of TUNA 2022, was set up to enhance growth in the Thai tuna fishing and processing sector, and to ensure that all 26 members of the Association comply with international regulations on sustainability, traceability, social responsibility, and quality assurance. TTIA has been successful in raising awareness on food safety according to GMP and HACCP rules as well as good labour practices and human trafficking.

PACKAGING

Cellonpack Ekart Co Ltd (Thailand) produces retort packaging material such as pouches, easy peel packs, and sachets, for the domestic and international markets.

Retortable/microwaveable pouches suitable for sterilisation at high temperatures are available from ***Dongwon Systems Corp*** (Republic of Korea), as well as 100% biodegradable pouches in various shapes and sizes. The company also produces bottles, steel/aluminum cans, laminated film, and aluminum foil.

Hermann Ultraschalltechnik GmbH (Germany) offers ultrasonic welding technology in the making of packaging material with thermoplastic sealing layers. The company says that this technology is a reliable and economic alternative to typical thermal processes and is particularly suited for high production rate requirements.

TRANSPORT & FREIGHT SERVICES

Singapore's ***SK B&T*** (sales agent: Hispafrio) offers bunkering value chain services backed by ISO 9000 and ISO 14001 certification and is also fully compliant with MARPOL regulations to prevent environmental pollution. Key activities: cargo sourcing, marketing, delivery at sea, port bunkering, cargo trading.

Yuki Chidui, owner of Nadeshico Sushi, Japan, demonstrating tuna sushi preparation and tasting.

A NEW BLUE CURRICULUM – A TOOLKIT FOR POLICY-MAKERS

Published by UNESCO and Intergovernmental Oceanographic Commission (IOC)

The IOC-UNESCO 'A new blue curriculum' Toolkit for Policy-makers is the result of a collaborative effort between IOC-UNESCO, AXA, and many other partners. It aims to achieve the targets proposed by the strategic vision of 'Ocean Literacy within the Decade: A Framework for Action', which establishes 'mainstreaming Ocean Literacy in education policy formulation' and 'enhancing Ocean Literacy in formal education' as a priority for the Ocean Decade. This Toolkit, and Ocean Literacy more broadly, also supports Education for Sustainable Development, which is an integral element of the UN's Agenda 2030 Sustainable Development Goals. The Agenda highlights the purposes and values that underpin education and aims to reorient all levels of education and learning to contribute to sustainable development.

This publication invites education authorities and Ministries to engage with emerging trends in school curricula, and advance Education for Sustainable Development and Ocean Literacy within their formal education systems. To meet the challenges of today, numerous international trends in formal education are guiding the design and update of curricula – through which the ocean must be included as a fundamental part of our world.

This document can be downloaded at: https://unesdoc.unesco.org/

IMPLEMENTING THE WTO AGREEMENT ON FISHERIES SUBSIDIES — CHALLENGES AND OPPORTUNITIES FOR DEVELOPING MEMBERS

Published by the World Trade Organization, 2022

The WTO Agreement on Fisheries Subsidies (the Agreement), adopted at the 12th Ministerial Conference on 17 June 2022, marks a major step forward for ocean sustainability by prohibiting harmful fisheries subsidies, which are a key factor in the widespread depredation of the world's fish stocks. The new disciplines will have important, positive effects on the sustainability of marine fish stocks and fisheries:

- By curbing subsidies to illegal, unreported and unregulated fishing, the Agreement creates a powerful new weapon in the global fight against such fishing;
- By prohibiting subsidies to fishing on overfished stocks, the Agreement puts important protections in place where management measures are ineffective;
- By prohibiting subsidies to fishing on the unregulated high seas, the Agreement also puts important protections in place where management measures do not exist. Improving the sustainability of fisheries is critical to the development of the sustainable blue economy, and especially to the millions of mostly poor people who make their living by fishing.

This report summarizes the main elements of the Agreement on Fisheries Subsidies and its implementation from the perspective of developing country and LDC members. The final section of the report maps out development finance to the fisheries sector based on the OECD Development Assistance data. The overall objective of the report is to provide an overview of the existing development finance to the fisheries sector that could be relevant to the implementation of the Agreement.

This document can be accessed at: World Trade Organization (www.wto.org)

INFOFISH

Vacant Position

TRADE PROMOTION OFFICER

Working under the overall supervision of the Acting Director/Director, INFOFISH, the Trade Promotion Officer shall be responsible for the following:

- Monitor and review fishery trade in the Asia Pacific region and beyond;
- Collect and analyse price and market information on specific fishery products for the 'INFOFISH Trade News', a fortnightly bulletin;
- Attend to queries on supply, marketing and trade of fishery products worldwide;
- Work on identification and export promotion of fishery products from the region;
- Maintain regular contact with institutions, market news correspondents and organisations relevant to the fish marketing information network;
- Write and review articles pertaining to marketing and international trade of fishery products for the INFOFISH International magazine and other publications;
- Undertake other activities as assigned by the Supervisor or the Acting Director/Director

Qualifications:

- Post graduate degree from a reputable university in Fisheries / Fisheries Economics / Economics / Marketing / Trade/Business Management or related fields;
- Experience in international trade and marketing;
- Excellent writing and communication skills in English;
- National of a Member Country* of INFOFISH

Duty station

These positions are based in Kuala Lumpur, Malaysia. Applicants must be prepared to travel if required to do so.

Age limit

40 years; might be extended in the case of highly qualified and experienced candidates or government employees/nominees from Member Countries.

Emoluments

Salary will commensurate with qualifications/experience.

Applications stating the position applied for and containing full curriculum vitae and recent passport size photograph should be sent to the following, preferably through the INFOFISH National Liaison Office in each Member Country* of INFOFISH.

The Director
INFOFISH, 1st Floor, Wisma LKIM,
Jalan Desaria, Pulau Meranti,
47120 Puchong, Selangor Darul Ehsan, Malaysia
Email: info@infofish.org

Closing date: 15 November 2022
for the receipt of application at INFOFISH.
Only short-listed candidates will be notified.

***Bangladesh, Cambodia, Fiji, Iran, Malaysia, Maldives, Pakistan, Papua New Guinea, Philippines, Solomon Islands, Sri Lanka and Thailand.**

Please visit our website www.infofish.org for contact details of INFOFISH National Liaison Officers in the respective Member countries.

2022

NOVEMBER

9-12
SEAFOOD SHOW OF ASIA EXPO 2022
Jakarta, Indonesia
https://kristamedia.com/events-2?page=3

20-23
6th Int'l Fisheries Industry Exhibition of Iran (IFEX 2022)
Tehran, Iran
https://www.ifex.ir/en/index.php

29-Dec 2
World Aquaculture Singapore 2022
Singapore
https://www.was.org/Events/Calendar#.YhwO9t8RWIE

2023

FEBRUARY

15-17
23rd India International Seafood Show
Kolkata, India
https://www.indianseafoodexpo.com/

20-24
SEAFEX Middle East
Dubai, UAE
seafexme.com

MARCH

12-14
Seafood Expo North America (SENA)
Boston, USA
https://www.seafoodexpo.com/north-america/

APRIL

25-27
Seafood Expo Global (SEG)
Barcelona, Spain
https://www.seafoodexpo.com/global/

MAY

11-14
International Indonesia Seafood & Meat Expo (IISM)
Jakarta, Indonesia
https://iism-expo.com//

AUGUST

23-25
Vietfish
Ho Chi Minh City, Vietnam
https://vietfish.com.vn/en

SEPTEMBER

6-7
Pacific Tuna Forum (PTF)
Port Moresby, Papua New Guinea
http://infofish.org

11-13
Seafood Expo Asia (SEA)
Singapore
https://www.seafoodexpo.com/asia/

OCTOBER

18-20
GLOBAL FISHERY FORUM & SEAFOOD EXPO RUSSIA
Saint Petersburg, Russia
https://seafoodexporussia.com/en/

www.hermasa.com

The functionality of a Swiss army knife

A lot of ingenuity is needed to solve the technical problems of our technological society. In the early 20th century, the Swiss army presented Karl Elsener with a challenge that seemed impossible at that time: To create a multi-purpose, small, versatile, tough and functional tool. The inventor shut himself in his workshop at the foot of the Alps and invented one of the most highly valued utensils in history. Today it is a brand that represents values such as quality, functionality and adaptation to the market. In Hermasa we see the story of the Swiss army knife as an example to follow: behind its simple handling, you can find continuous innovation and functionality. Over the years, Hermasa has also become an example to follow. Because it solves the problems of companies and its “turnkey” service enables us to deliver complete customised production lines and factories anywhere in the world. This is why we say "You supply the fish and we will supply you with the factory ".

Behind easy and efficient handling, you can find continuous innovation work in machinery and complete fish processing lines

The tuna packing machine Tunipack® incorporates in all versions the new Density Control (DC) System that adjusts the weight of the product in each can, maintaining the speed, presentation quality and versatility features.

Hermasa is present in more than 65 countries on all five continents. A leader in technology and machinery for fish canning. Hermasa designs and installs complete production lines for the canning industry.

Hermasa
Canning technology


PTF
2023
8th PACIFIC
TUNA FORUM
6-7 SEPTEMBER 2023
Port Moresby, PAPUA NEW GUINEA
Co - Organized by:
PAPUA NEW GUINEA
INFOFISH
National Fisheries Authority
Papua New Guinea