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FAME
Fisheries, Aquaculture and Marine Ecosystems Division

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Cover picture: Lady walking home with a skipjack tuna in Tarawa, Kiribati. © Francisco Blaha

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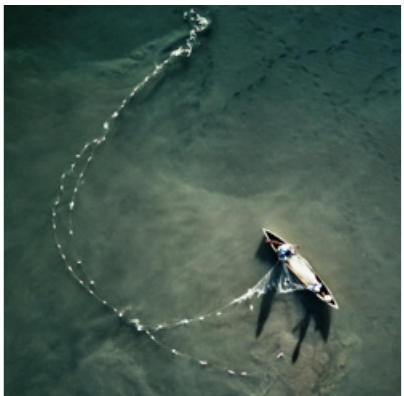

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Dr Timothy David Pickering

By Neville Smith, Chinthaka Hewavitharane, Andrew Smith and Ian Bertram

Pacific Community

Dr Timothy David Pickering—fondly referred to as "Dr Tim"—passed away in Auckland on Sunday 21 July 2024, after a valiant 10-month fight with illness. Dr Tim's legacy stretches far beyond his remarkable accomplishments and contributions to aquaculture, having a profound impact on the lives of those who knew him, and an enduring influence on many across the Pacific region and beyond.

Dr Tim's passion for aquaculture, the oceans and the life within them was evident in every endeavour he undertook. He worked alongside governments and communities, fostering a spirit of collaboration and innovation that resonated deeply with the Pacific Islands.

Dr Tim was born in New Zealand but spent over 28 of his 61 years in Fiji. As a child he also spent time living in Niue, Solomon Islands and of course Fiji, where his father worked as a teacher. Tim, being the person he was, continued to send remittances to his nanny from Solomon Islands and supported her son's education.

Tim completed his Bachelor of Science with Honours in Zoology in 1984 and then his Doctor of Philosophy in Botany in 1990, both at Victoria University of Wellington. Dr Tim's PhD thesis was on "Growth, phenology, agar quality and food quality for abalone of the red seaweed *Gracilaria sordida*". He also completed a Post-Graduate Certificate in Tertiary Teaching at the University of the South Pacific in 2005.

Dr Tim was a fellow of the Linnean Society of London, a reflection of his deep interest in natural history, particularly freshwater eels. He was also a member of the World Aquaculture Society, reflecting his global networks and interest in the potential of inland aquaculture, and aquaculture's role in sustainable development generally.

Tim had authored more than 60 publications, including over 30 journal articles and six books, noting that through his teaching and mentoring work he was responsible for influencing a great many more scientific papers and articles by ensuring they progressed from students' desks to publication. Dr Tim's professional career began in 1984 with the New Zealand Ministry of Agriculture and Fisheries (NZ MAF) Aquaculture Research Centre as an assistant hatchery manager. In 1989, became a research scientist. From 1991 to 1994 he moved to the NZ MAF head office, policy (fisheries) section, to work as a policy analyst on aquaculture and fisheries enhancement.

Moving to Suva, Fiji, in June 1995, Tim started a long tenure in various roles across 13 years at the University of the South Pacific (USP). He began as a lecturer in fish biology and aquaculture in the USP Marine Studies Programme, then from 1997 to mid-2000 he was a lecturer in Ocean Resources Management in the Marine Affairs Programme, followed by being the Lecturer in Aquaculture and Coordinator of Marine Science at USP's School of Marine Studies.

From early 2004 to mid-2005, Dr Tim was Acting Director of USP's Institute of Marine Resources (IMR), where he managed a team of six natural and social scientists and two support staff, raised external funding for marine resources-related consultancies and projects, and maintained the momentum of IMR activities, which focused on coral reef-monitoring databases, sustainable aquaculture, research on quarantine protocols for aquatic species introductions, aquatic species disease diagnosis, initiation of an atoll lagoon eutrophication study in Tarawa, and tropical marine environment/ecology education for fee-paying international students from Australia and USA.

Tim was then promoted to Senior Lecturer in Aquaculture, and Coordinator Marine Science, School of Marine Studies, USP, from late-2002 until mid-2008. This included the coordination and teaching of a 300-level course and a 400-level course in aquaculture, supervision of post-graduate students in aquaculture, marine science and marine affairs research topics, assisted in teaching of other marine science courses and conducted research in aquaculture. This also included the establishment of a team of aquaculture technical staff who operated a freshwater prawn hatchery and prawn farm as a business in conjunction with a private sector partner, Dairy Farms Fiji Ltd. This innovative public-private partnership resulted in the development of one of the most successful freshwater prawn farms in the Pacific region.

Dr Tim joined SPC in June 2008, commencing as the Aquaculture Officer based in Noumea. Ben Ponia, then head of the SPC Aquaculture Section, noted: "Tim's transition from university lecturer at USP to an SPC regional expert was seamless and impactful. I witnessed firsthand as the whole Pacific became his learning and teaching ground, indeed his networks quickly grew widely and extended deep in Asia and other continents." Late in 2009, his post was re-focused on inland aquaculture and as a result he relocated from SPC Noumea to SPC Suva in January 2010 to take up the role of Inland Aquaculture Adviser. With other aquaculture staff subsequently added to the SPC Suva office by 2022, he had day-to-day oversight of a team of three professional and one support staff, and two interns, who reported through Tim to the SPC Aquaculture Adviser in Noumea.

In these roles, Tim provided technical and policy advice, capacity-building, in-country project management, and provided a clearinghouse for information about inland aquaculture to all 22 SPC member Pacific Island country and territory governments, as well as the private sector and community groups across the Pacific islands region.

When the Principal Aquaculture Adviser role became vacant, Dr Tim competed for, and secured the position in August 2022. Heading up the Aquaculture Section of the Coastal Fisheries and Aquaculture Programme, within the Fisheries Aquaculture and Marine Ecosystems (FAME) Division, Dr Tim thrived under the responsibilities of leading and managing the work programme of the aquaculture section. He skilfully provided guidance, support and advice to governments, private sector, communities, and other aquaculture stakeholders in planning aquaculture and mariculture activities, including aquatic biosecurity, focusing on appropriate and viable aquaculture to provide for food security, sustainable and equitable livelihoods, nature positive, non-fed aquaculture, and economic growth. Dr Tim led a team of nine and could be meeting with a minister one morning on strategic investments at a national level, and in gumboots helping a recent graduate entrepreneur clean out a tilapia pond the same afternoon.

We like to think that in this role at SPC, Dr Tim had found his career home. He could chase eels, develop people, supervise interns and students, raise the profile of the Pacific globally, help people here, help people there, all while still wearing gumboots a few days a week, and being able to tell his fisheries-oriented bosses, so very politely and very delicately, that we needed to just accept he knew better, and aquaculture is the future!

Tim was globally respected. Iceland's Special Envoy on Ocean Affairs, Ambassador Stefán Jón Hafstein, relied on Dr Tim's advice in countless United Nations fora to raise the profile of blue foods in healthy diets as part of the global fight against non-communicable diseases, and for equitable access to healthy food for all.

Tim worked across languages, with his time in Noumea, and later work across French Polynesia and Wallis and Futuna, and some of his greatest professional champions were the francophone heads of aquaculture in the region.

Tim loved a good mystery, especially the one he was introduced to by his university professor, Peter Castle: Where do freshwater eels breed, and where are their larvae? This mystery remains one of the great unsolved natural history thrillers. As part of this, Tim spent time at sea on long research voyages searching for freshwater eel larvae and developed a strong network of Japanese research colleagues. This work is active and ongoing, with Dr Tim's own PhD student, Dr Chinthaka Hewavitharane, also now on the case, along with other SPC staff.

Dr Tim was respected across the Pacific, with fisheries ministers in Honiara, Solomon Islands at the 5th Regional Fisheries Ministers Meeting recently expressing their deepest condolences on the passing of Dr Tim, recognising his immense contribution to the region.

Beyond his professional accomplishments, Dr Tim was a man of varied interests. He found joy in the thrill of motorcycles ... many, many, motorcycles, in different stages of rebuilding, stashed in various locations, many to the surprise of his wife, Andie. This was also true for his love of guitars ... many, many, guitars. New guitars would sometimes be delivered to the office, worried about taking another one home! He was an accomplished musician playing bass guitar, which was his favourite, lead guitar and even drums at the Tanoa Plaza and Holiday Inn in Suva. He was a man of balance, nurturing his creative spirit while dedicating himself to scientific exploration and the well-being of his community.

Dr Tim is survived by his beloved wife, Andie, and daughter, Maraia. Tim was the proudest father, being able to recently see Maraia awarded her PhD at Cambridge, and as he proudly said to Chinthaka, Maraia is the first Fijian to graduate with a PhD from Cambridge – that's history!

We were blessed here in the Pacific to have Dr Tim, where he made significant strides in aquaculture, marine ecosystems and, unquestionably, nurtured a vast cohort of young scientists, high ranking officials and even diplomats. Many of his students are probably reading this and remembering the great encounters they had with him. Rest in peace, Dr Tim.

Pacific fisheries ministers chart a course for a sustainable future at the fifth regional meeting

The Fifth Regional Fisheries Ministers Meeting (RFMM5) held in Honiara, Solomon Islands, brought together Pacific leaders to advance strategies for sustainable fisheries management, climate change adaptation, marine pollution control, and the implementation of the 2050 Strategy for the Blue Pacific Continent. Ministers and senior officials from 18 Pacific Island countries and territories convened on 24 July 2024, to address the pressing challenges and opportunities facing the region's marine resources.

Coastal fisheries and aquaculture: Empowering communities

Recognising the critical role of coastal fisheries and aquaculture in providing food security and livelihoods for Pacific communities, ministers acknowledged the progress made in implementing sustainable management practices. The meeting emphasised the need for increased technical and financial resources to support science-based management and development initiatives in this sector. Ministers also endorsed a five-year extension of the *Pacific Framework for Action on Scaling-up Community-Based Fisheries Management*, underscoring the importance of empowering local communities to manage their marine resources sustainably. This extension will enable continued technical support, the completion of outstanding activities, and address emerging demands in community-based fisheries management.

Climate change: Navigating a changing ocean

Climate change poses a significant threat to the Pacific's fisheries and aquaculture, impacting ecosystems, livelihoods, and economies. Ministers noted the progress of a comprehensive regional climate change assessment, which will provide valuable insights into the vulnerability of the sector and guide adaptation efforts. The assessment, due to be completed in late 2024, will include technical chapters on Pacific fisheries (coastal, oceanic, freshwater), aquaculture, livelihoods and economies, and blue food systems. It will also provide summaries of results and recommended adaptations for each of the 22 Pacific Island countries and territories.

Ministers called for greater collaboration among regional agencies to champion fisheries issues within the global

Local fisherman and son. Olal village, Ambrym Island. Vanuatu © Laszlo Mates

Fisheries Ministers at the Fifth Annual Regional Fisheries Ministers Meeting in Honiara, Solomon Islands. ©FFA Media, FFA

climate negotiations process, ensuring that the Pacific's voice is heard on the international stage. They particularly highlighted the need to address the impacts of climate change on coastal fisheries, given their vital importance to coastal communities. The meeting highlighted the successful Pacific presence at COP28 and the ongoing efforts by the Secretariat of the Pacific Regional Environment Programme (SPREP) and the One CROP team to provide robust technical support and representation for Pacific Small Island Developing States (PSIDS) and emphasised the need for continued collaboration for COP29.

Marine pollution: Combating plastic waste

The devastating impact of marine pollution, particularly plastic waste, on the region's marine ecosystems was a key concern at RFMM5. Ministers stressed the importance of cross-sector collaboration to address this issue comprehensively. They reviewed the outcomes of recent sessions of the Intergovernmental Negotiating Committee (INC) tasked with developing an international legally binding instrument to address plastic pollution. The meeting underscored the importance of continued regional coordination and support, led by SPREP, to ensure Pacific voices are effectively represented in global negotiations. This effort is supported by significant financial contributions from donor partners such as Australia, New Zealand and the United Nations.

Regional initiatives: Unlocking the Blue Pacific's potential

A key highlight of RFMM5 was the discussion on the Unlocking Blue Pacific Prosperity (UBPP) initiative, an ambitious programme aimed at protecting 30% of the Blue Pacific Continent and promoting sustainable ocean management. Supported by substantial funding, including USD 100 million from the Bezos Earth Fund and USD 125 million from the Global Environment Facility, UBPP seeks to harmonise traditional knowledge, nature's wisdom, and innovative financial strategies to enhance community resilience and foster sustainable food systems.

This initiative aligns with the 2050 Strategy for the Blue Pacific Continent, aiming to mobilise high-impact investments and create a paradigm shift in sustainable ocean management. UBPP represents a significant opportunity for Pacific Island countries and territories (PICTs) to lead in global efforts to combat climate change and promote biodiversity, aligning regional priorities with international commitments.

Regional fisheries policies: Report card and review of Roadmap and New Song

- **Review of regional fisheries policies:** Ministers acknowledged the ongoing review of key regional fisheries policies, including the Regional fisheries roadmap and the New song for coastal fisheries. They endorsed the revised timeline for the review and stressed the importance of member input to ensure its quality and relevance to the region's evolving needs.
- **2024 Coastal Fisheries Report Card:** Ministers reviewed the draft 2024 Coastal Fisheries Report Card, which provides a snapshot of the progress made towards sustainable coastal fisheries management in the Pacific. While acknowledging the improvements in data quality and availability, they also noted the challenges in accurately capturing the contribution of fisheries and aquaculture to national GDPs.

2050 Strategy and regional architecture: Building a resilient future

The implementation of the 2050 Strategy for the Blue Pacific Continent was a major focus at RFMM5. Ministers reviewed progress on various regional collective actions (RCAs) and the development of monitoring, evaluation, and learning (MEL) systems to track and enhance the strategy's implementation. These efforts are designed to

ensure that regional initiatives are effectively coordinated and contribute to the overarching goals of sustainable development, resilience, and regionalism.

Ministers emphasised the need for coherent governance and strategic partnerships to support the 2050 Strategy's implementation, particularly in areas related to ocean management, climate resilience, and economic development. The meeting reaffirmed the commitment to align national and regional policies with the 2050 Strategy to achieve a sustainable and prosperous future for the Blue Pacific Continent.

Looking ahead

The Fifth Regional Fisheries Ministers Meeting concluded with a strong commitment to regional cooperation and sustainable development. Ministers reiterated the importance of collaborative efforts to address the pressing challenges facing fisheries and marine ecosystems. The meeting's outcomes demonstrate a strong commitment to sustainable management, climate change adaptation, marine pollution reduction, and regional cooperation, paving the way for a secure and prosperous future for the Blue Pacific.

The next meeting, RFMM6, will be hosted by Niue in July 2025, where ministers will reconvene to assess progress and explore new opportunities for advancing sustainable fisheries management and marine conservation in the region.

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Pacific Islands leaders commend progress on scaling up community-based fisheries management (CBFM) and extend the Pacific CBFM Framework for Action for a further five years

Coastal fisheries in the Blue Pacific

In October 2007, in *The Vava'u Declaration on Pacific Fisheries Resources: "Our Fish, Our Future"*[1] the Leaders of the Pacific Islands Forum committed themselves to managing coastal fisheries to support food security, sustainable livelihoods and economic growth for current and future generations of Pacific people. Nearly 17 years later, the Leaders met – also in Vava'u – and were able to appreciate the progress that has been made, commended the implementation of the Pacific Framework for Action on Scaling-Up Community-based Fisheries Management (CBFM): 2021–2025[2] and welcomed its extension for a further five years (2026–2030) as a fit-for-purpose tool in coastal fisheries.

Coastal fisheries are the lifeblood of Pacific Island communities, especially the more than 10,000 coastal communities[3] that are spread across in the Pacific region. The coastal food system is fundamental for supporting their livelihoods, nutrition and health, culture, and local economies. At the heart of this coastal food system is coastal fisheries along with locally grown Pacific fruits and vegetables. Despite coastal fisheries contributing less than 13% of the production volume of offshore fisheries, they are responsible for most of the region's contribution to gross domestic product (GDP), employment, and fish supply. The most recent study commissioned by the Pacific Community (SPC) in 2023, shows that in 2021, coastal fisheries supplied 13.8 kg per capita, down from 16.1 kg per capita in 2007. This represents a 14% decrease over the 14-year period—a concerning trend given the rising demand and the critical need for healthy local food in the Pacific.[4]

This significant decline should serve as a wake-up call for the Pacific to redouble efforts towards effective coastal fisheries management.

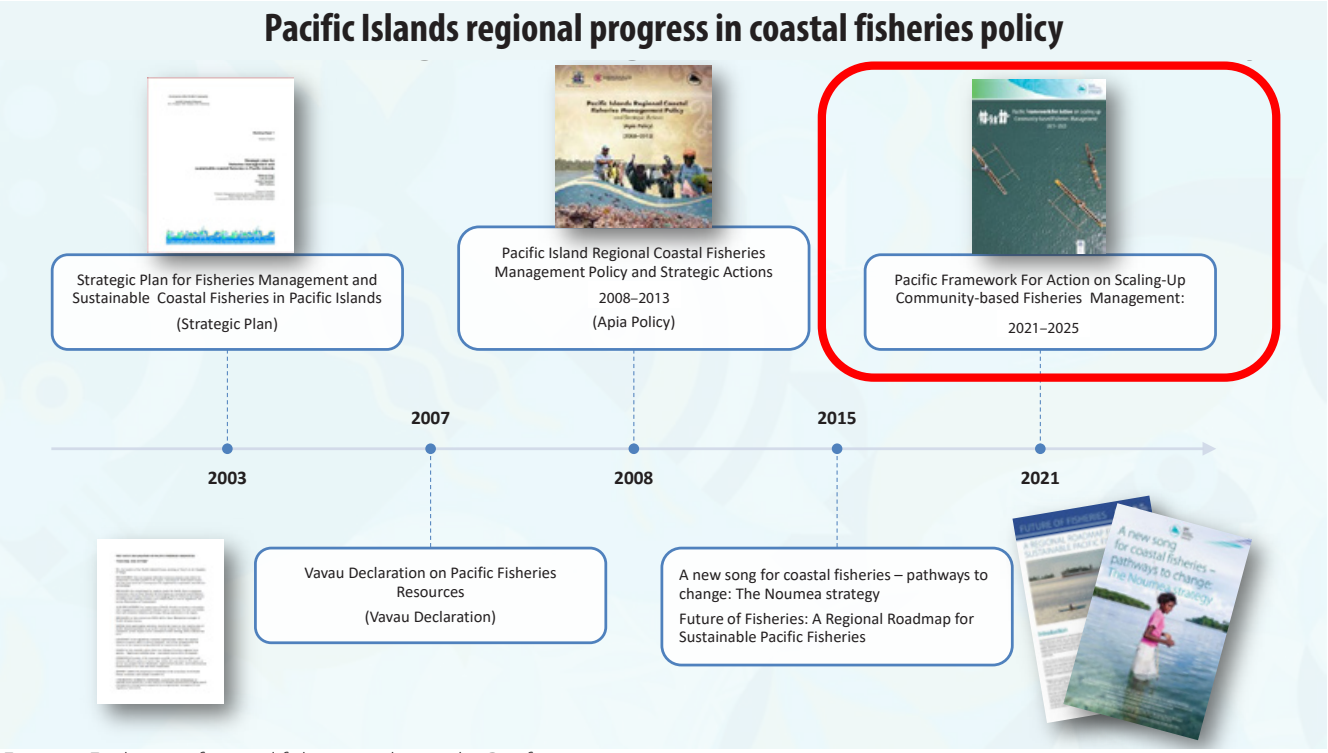

Figure 1. Evolution of coastal fisheries policy in the Pacific

[1] Vavau Declaration: https://forumsec.org/publications/vavau-declaration-pacific-fisheries-resources-our-fish-our-future
[2] Pacific Framework for Action on scaling-up CBFM: 2021-2025: https://purl.org/spc/digilib/doc/yr5yv
[3] The "Pacific Way" of Coastal Fisheries Management: Status and progress of community-based fisheries management https://purl.org/spc/digilib/doc/svtsz and https://purl.org/spc/digilib/doc/ocw6w
[4] Fisheries in the Economies of PICT (Benefish Study 4): https://purl.org/spc/digilib/doc/ppizh

Coastal fisheries management

Since the Leaders' meeting in 2007, the Pacific Islands region has come to explicitly recognise the significant contributions of coastal fisheries, and in the last decade this has focused efforts on a different approach to management, underpinned by community-based fisheries management (CBFM).[5]

In 2015, the Leaders committed to implementing[6] *The Future of Fisheries Roadmap,*[7] and *A New Song for Coastal Fisheries – pathways to change: The Noumea Strategy*[8] provided the regional context and pathway for managing coastal resources. As emphasised in the Noumea strategy, small pockets of effective coastal fisheries management will not be adequate to address the continuous decline of coastal fisheries resources. Therefore, it calls for coastal fisheries management in ways that are attuned to CBFM.

Scaling-up community-based fisheries management (CBFM)

In 2021, the need to scale up CBFM led to the development,[9] approval,[10] and endorsement[11] of the Pacific Framework for Action on Scaling up Community-based Fisheries Management: 2021–2025 (the CBFM Framework for Action) by the Pacific Heads of Fisheries and regional Fisheries Ministers. Scaling up CBFM involves expanding from working with a few communities to developing systems that provide adequate support to all communities across the Blue Pacific continent to support the Pacific Island Forum Leaders' commitment on 100% effective ocean management.[12]

This year marks the fourth year of implementing the CBFM Framework for Action. At the Fifth Regional Fisheries Ministerial Meeting held in Honiara, Solomon Islands, in July 2024, the SPC provided an annual update on the implementation of the CBFM Framework for Action to the Fisheries Ministers. They acknowledged the considerable progress made over the past three years and endorsed a five-year extension of the CBFM Framework for Action (2026–2030).[13] The ministers also noted the risk to the success achieved to date if resourcing is not sustained, given that coastal communities across the Pacific are at varying stages of implementation. They emphasised the importance of CBFM to livelihoods, culture, and food security for the Pacific people and called on development partners to increase sustainable and nationally accessible funding for the scaling up of CBFM.

These were the sentiments reiterated by Leaders at the 53rd Pacific Islands Forum Leaders Meeting held in Vava'u, Tonga, in August 2024, which welcomed the five-year extension (2021–2030) of the CBFM Framework for Action and recognised it as a fit-for-purpose tool in coastal fisheries.

Conclusion

The Pacific region is defined by vast expanses of ocean, resource-rich coastal waters, and many dispersed islands that are home to thousands of coastal communities. These communities possess invaluable traditional knowledge and

[5] Coastal Fisheries Governance in the Pacific Islands: The Evolution of Policy and the Progress of Management-at-Scale: https://doi.org/10.1007/978-3-031-56716-2_11
[6] https://forumsec.org/publications/forty-sixth-pacific-islands-forum-port-moresby-papua-new-guinea-8-10-september-2015
[7] https://purl.org/spc/digilib/doc/xnc9f
[8] https://purl.org/spc/digilib/doc/q4ntz
[9] Outcomes of the Twelfth SPC Heads of Fisheries Meeting (para 24. D)
[10] Outcomes of the Thirteenth SPC Heads of Fisheries Meeting (para 12. a-e)
[11] Statement of Outcomes from the second Regional Fisheries Ministers Meeting (para 11-13)
[12] https://forumsec.org/sites/default/files/2024-03/2021%20Pacific%20Islands%20Forum%20Leaders%20Ocean%20Statement.pdf (para 17)
[13] https://www.spc.int/DigitalLibrary/Get/4x64x

Figure 2. Community fisher in Papua New Guinea. ©Elodie Van Lierde

Figure 3. The first and the second versions of CBFM Framework for Action

capacity. Their rightful stewardship over coastal zones and the inshore marine resources in them, position them as the true custodians of the Blue Pacific's Ocean resources. The late Epeli Hauo'fa, a respected Pacific scholar, emphasised this point eloquently in saying that:

"No people on earth are more suited to be guardians of the world's largest ocean than those for whom it has been home for generations."

The CBFM Framework for Action has performed well to coordinate appropriate and tailored support to individual countries' and territories' CBFM programmes as it provides a flexible guiding framework to address the very different situations of each and the disparity in progress between them. Progress overall has been notable, and numerous lessons learned, though significant gaps remain.

While some countries have been able to work directly with most communities on local management plans, this is not feasible for the larger countries as they are still challenged to facilitate and maintain meaningful numbers of village-based management plans. The creation of appropriate enabling environments—provision of information to all, effective enforcement, strengthening grassroot networks, and ensuring customary tenure rights are protected—remains critical.

Engaging provincial fisheries officers has been integral in scaling CBFM. Being more directly involved in collaborations with communities, provincial fisheries officers are important connection points between communities and national fisheries agencies, a critical mechanism for larger countries with hundreds or thousands of communities, rather than tens.

For most countries, CBFM constitutes most if not all those countries' contribution to the international conservation targets to achieve 30% of effectively conserved coastal areas by 2030. This should be seriously considered by donors and the conservation sector as a major pathway to ensuring Pacific Island country driven approaches appropriate to national contexts, the commitment to 100% effective ocean management[14] and aspiration to meeting the '30 by 30' target as stressed by the Fisheries Ministers at the Fifth Regional Fisheries Ministers Meeting.[15]

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Figure 4. Pacific Island Forum Leaders at the 53rd Pacific Islands Leaders Forum in Vava'u, Tonga. ©PIFS

[14] Coastal Fisheries Governance in the Pacific Islands: The Evolution of Policy and the Progress of Management-at-Scale: https://doi.org/10.1007/978-3-031-56716-2_11

[15] Fifth Regional Fisheries Ministers Meeting Statement of Outcomes: https://fame.spc.int/events/rfmm5 (para. 33)

Local communities on board: Citizen science is building the regional database on stranded drifting FADs in French Polynesia

SPC FAME's Stock Assessment and Modelling team's scientists have been working on a regional database recording stranded drifting fish aggregating devices (dFADs) in Pacific coastal areas. To date, 11 programmes have been set up in 11 Pacific countries and territories to record the stranding of these devices and their impact on the environment, particularly on coral reefs and fragile marine species, as well as the materials used, their design and the possibilities for reusing them.

French Polynesia launched a programme in 2019, led by the Département des Ressources Marines (DRM), with the same objectives, following the observation of large numbers of strandings events in the different archipelagos. The programmes are citizen-science based reports carried out by local communities. However, data can sometimes be incomplete, and this could affect data quality. To address this, data collection surveys have been used to quantify the number of strandings events and to gather information on both spatial and temporal aspects.

Jennyfer Mourot from the SPC team joined DRM to assist in a collection campaign for stranded dFADs in French Polynesia, and more specifically in the Marquesas Islands. It is part of the ongoing data collection effort and follows the first data collection survey on nine islands in the Tuamotus, carried out in 2022. This mission was also an opportunity to begin a feasibility study for the potential implementation of a FAD watch/FAD retrieval programme.

I was welcomed in Papeete by Thibaut Thellier, from DRM, who leads the deep-sea fishing projects as well as the drifting FAD survey programme. Our first stop was to visit the Plastic Odyssey ship, which had made a stopover in French Polynesia and during its three-year expedition to find and share solutions for plastic pollution. During their voyage, which started in October 2022, they confirmed that they had seen quite a few stranded or drifting FADs which could be relevant to our database. On board, they have a workshop for recycling plastic materials to create boards (or other shapes) from recycled plastic to make new objects. We were given a tour and an explanation of the various processes and machines used.

I left Papeete for Nuku Hiva to join the team in charge of the survey and the collection of drifting FADs. The team "Volume Ocean" are specialised in dive cruises in the Tuamotus, but they also take part in scientific projects. When I joined, they had already surveyed the islands of Hiva Oa and Tahuata, and Nuku Hiva was their last stop. They had registered about 150 stranding events, and even found some dFADs sunk on the ocean bed. The underwater removal process is shown in figure 2. They attached lift bags full of air to the structure, which is lifted towards the surface.

In Nuku Hiva, we began the survey by talking to fishers in the main village of Taiohae, giving them the background to

Figure 1. The Plastic Odyssey ship, which has an onboard workshop for recycling plastic materials.

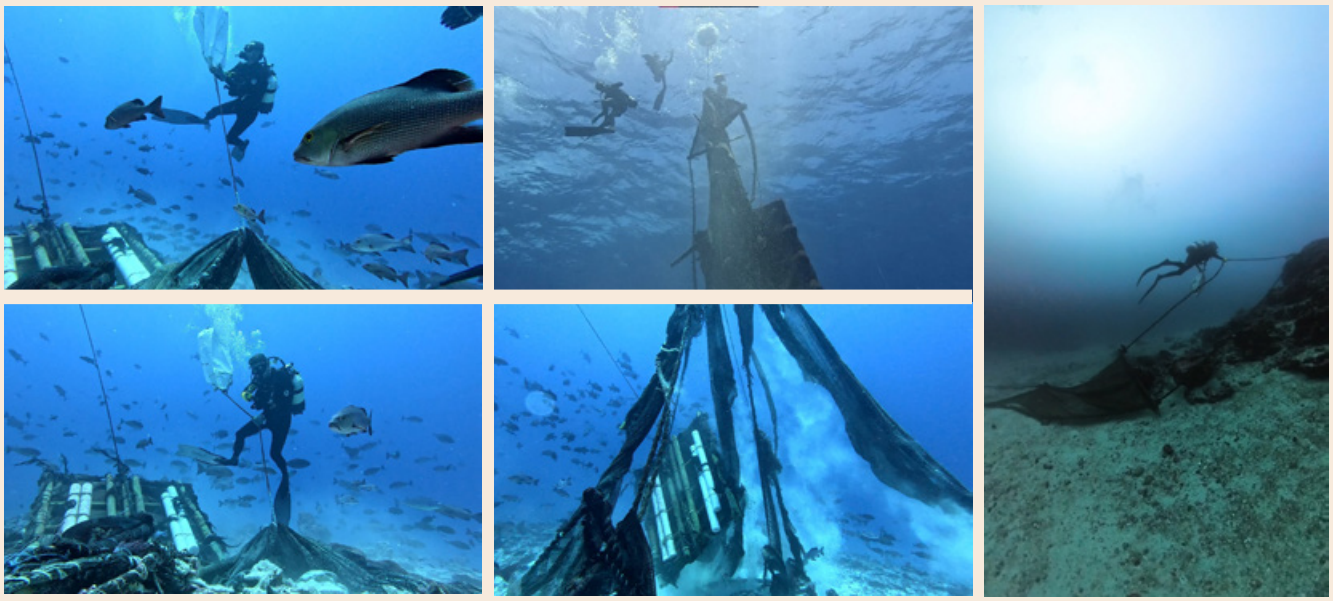

Figure 2. The sunken dFAD removal process: lift bags, full of air, are attached to the structure which is then lifted to the surface.

the survey programme in French Polynesia. We explained what dFADs are, in what context they are used, the benefits of dFADs as well as the negative aspects they present for the environment and navigation. During discussions with fishers and locals, we collected quite a few buoys and nets directly from their homes, some of which had been there for years.

We also organised a public meeting in the town hall, in addition to informal discussions, to explain the programme's objectives and answer any questions people may have. However, on Nuku Hiva, and from what I heard on the other islands, few people were present. On the whole, we found that some local residents were interested, keen to help and asked a lot of questions, while others had some reservations about the objectives and what benefits this programme would bring.

On the more isolated islands such as the Marquesas, journalists and scientists (and other professionals) come to work on projects that rely on the involvement of local communities, and they are very happy to help, but they also tell us that they have little, or no feedback on what they have contributed to. To increase awareness about this programme, DRM has produced communication tools that present the programme and summarise some results. At SPC, we are also working with the graphic design team to develop communication materials to meet this public demand, and recently produced a flyer summarising the programme's objectives, with some results either at a country or regional scale (Figure 3). Some Pacific islands do not have sufficient internet access, so the information relayed (or information they want to share from their side) does not always reach these remote locations. I realised how important it is to go there in person from time to time to share projects.

Prospecting for stranded dFADs on a windy day

Once the survey of the main village had been completed, we set off by boat to prospect along the east coast using a drone, or the manta-tow technique (this technique consists of dragging a person underwater behind a dinghy in search of sunken dFADs). However, it was a windy day and the presence of steep cliffs jutting directly into the ocean combined with the murky water meant that the manta-tow technique was not used. Even drone use was difficult under these weather conditions. But the 30 or so dolphins around the boat gave us some moral support.

We identified some small coves as potential stranding spots. In one small, hard-to-reach cove, we had spotted quite a few satellite buoys and pieces of dFADs using the drone (on a 50-metre long beach, there were about 10 buoys and three to four rafts). Part of the team disembarked with the dinghy to survey and bring the objects back on board. The operation was rather difficult given the size and frequency of the waves; it was perfect for surfing, but not for landing with a dinghy. Trying to keep the dinghy in the same place while reeling in bits of net, bamboo and satellite buoys full of water was also quite a challenge.

We kept on prospecting with the drone until we were sheltered from the wind and swell in Ha'atuatua Bay, which according to the locals is a veritable "open-air plastic dump site", so we were bound to find what we were looking for. Indeed, we did: there was plastic all over the beach, both whole and in pieces. We dropped anchor and swam ashore. We found several intact rafts buried in the sand and spent two hours digging them out and cutting them into pieces.

Figure 3. A flyer to raise awareness about the FAD data collection programme.

Part of the mission was to remove as much dFAD-related waste as possible from the environment and send them to Papeete for waste treatment. Once they had been dug up and cut into pieces, they had to be brought back on board the boat. However, this bay was not accessible by boat or car, only on foot ... or horseback! I had to reach back to my childhood to dig out my horse-riding skills as we brought the dFAD materials back on horseback. Unexpected methodology aside, we did manage to bring back around 300 kilograms of dFADs and satellite buoy materials from this bay alone.

Insights from the local communities

We then prospected the villages of Taipivai, Anaho and Hatiheu using the methods described above. The locals are very interested in recovering materials, and we found all kinds of possible reuse: from the classic net hammock, to using the satellite buoy as a source of energy to light a small house via solar panels, using the net as a cucumber stake, and even reusing the buoy screws for a wheelbarrow wheel. Indeed, many locals asked us to recover nettings, yellow floats, PVC tubes, etc. from these operations to reuse them at home or for fishing activities. This could explain why some bays that seem ideal for stranded FADs, in fact, do not present a lot of stranding events. While we found plenty of FAD items in the small, difficult to access cove mentioned previously, we did not find as many FAD materials as we might have expected at Ha'atuatua bay, which is accessible by horse or on foot. This is possibly because local communities

Figure 4. On the dinghy, going to try to retrieve the dFAD pieces. A tricky task in choppy waters.

Figure 5. Removing dFAD-related waste from beaches inaccessible by boat or car requires some extra skills.

often come to collect items to reuse them. So, a major part of our prospecting work was to go from door-to-door in villages to explain and collect information.

We have gathered a lot of useful information from talking to local communities. One interesting fact we heard is that sometimes in the tail of the dFAD they find a huge plastic barrel with many holes and inside some big animal bones, possibly from a carcass used to attract fish. However, I did not see any reports like this from other data collection programmes across the Pacific.

We also gained knowledge about the navigational hazards associated with dFADs, even though we didn't aim to collect this information through the programmes. Numerous discussions with fishers have told us that it represents a real danger for them. One fisher told us that he had to jump into the water in the middle of the night, without light, to free the net from his propeller.

What we learned

To conclude, on the Marquesas data collection programme, more than 370 data entries will be added to the existing database, which already contains more than 1000 stranding events. The use of a drone was very useful, as many of the islands and atolls are not easily accessible on foot, and this technique could be used to develop data collection on a regional scale in the various countries. It was really rewarding to show local communities some results we found thanks to their engagement and contributions. Talking with local communities, and listening to their own experiences of FADs, was an amazing and rich experience as well as being very beneficial to the data collection programme.

The interviews were carried out mainly on Papeete and Moorea, although the majority of strandings seems to involve the Tuamotus.

For more information:

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Establishing a sclerochronology lab at SPC – Bombs are never good, but their signature can be useful

Allen Andrews[1] and Jed Macdonald[2]

Proper fisheries management across the Pacific region requires that we understand how our fishes live and grow to plan for ecosystem and resource sustainability. Closely coupled with this information is how long a species can live because its potential reproductive output throughout its lifespan is an important factor in understanding population dynamics. In general, the age at which a fish matures and how many years it can reproduce are important factors in estimating how many fish can be taken sustainably over time. A lack of understanding and use of incorrect ages and growth traits may lead to harvest levels that exceed the capacity of the population to replenish itself, potentially leading to declines in fishery productivity and risks to food security. For teleost fishes (bony fishes), the most used method of age estimation is counting growth rings in the ear stones, also known as otoliths, but the structure of the rings can be complicated, and as a result the age estimate from counting the rings needs to be tested (Figure 1). A method that can be used to validate fish age, as well as the age estimation procedures, is the use of a chemical signature that is stored in otoliths known as bomb-produced radiocarbon.

The use of bomb radiocarbon (^{14}C) dating as a tool in the validation of fish age and lifespan has covered 30 years of progress in establishing a better understanding of fish ecology and stronger baselines for the sustainability of fisheries throughout the world. This approach uses a signal that was created in the 1950s and 1960s during cold-war efforts to increase the power of nuclear bombs. The sudden rise of bomb-produced ^{14}C from these nuclear tests can function as a time-specific marker in conserved structures, like the rings of trees and in the growth rings of otoliths. While the rings in trees are easy enough to prove as annual growth (one set of layers or rings per year), it is not as easy to know if the rings being counted in otoliths are in fact annual. Hence, if the bomb ^{14}C signal can be detected in the otoliths, then estimated age can be compared to the timing of this marker to determine if the age was correct.

The most common approach has been the use of the rise period as a reference to align ^{14}C measurements from otoliths to references in time, but for fish collected in recent years the hatch dates would need to be in the 1950s and 1960s (Figure 2), making them more than 50–60 years old. While this scenario is appropriate today for some long-lived species, it is necessary to use the declining ^{14}C signal that has occurred after peak levels were reached for recently collected fish that live no more than 20–30 years. A good example of success with this method is from recent findings for giant trevally (*Caranx ignobilis*) of Hawaii where ages up to 25 years were estimated from otoliths and then validated by a strong alignment of the otolith ^{14}C values with the coral ^{14}C chronology (Figure 3).

Figure 1.Otolith of yellowfin tuna that was sectioned to reveal growth structure that can be aged to 14 years by counting the growth zones visible in this view (marked with yellow dots). It is easy to see just how difficult counting an otolith can be in some parts of the otolith and that even though the age determination is based on reader experience and interpretation, the estimate must ultimately be validated. © Jessica Farley, CSIRO

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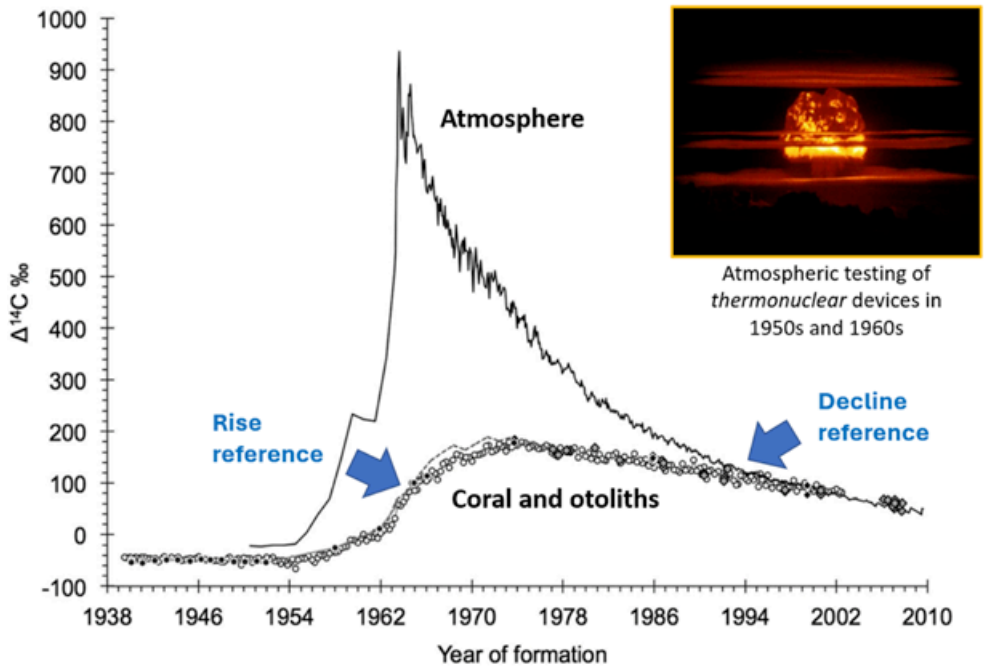

Figure 2. Bomb-produced radiocarbon (14C) in the atmosphere led to reference chronologies stored in known-age coral and otoliths of the marine environment that can be used to test estimates of age. The rise and the post-peak decline periods can be used to validate estimates of age for fishes of numerous aquatic environments of the world.

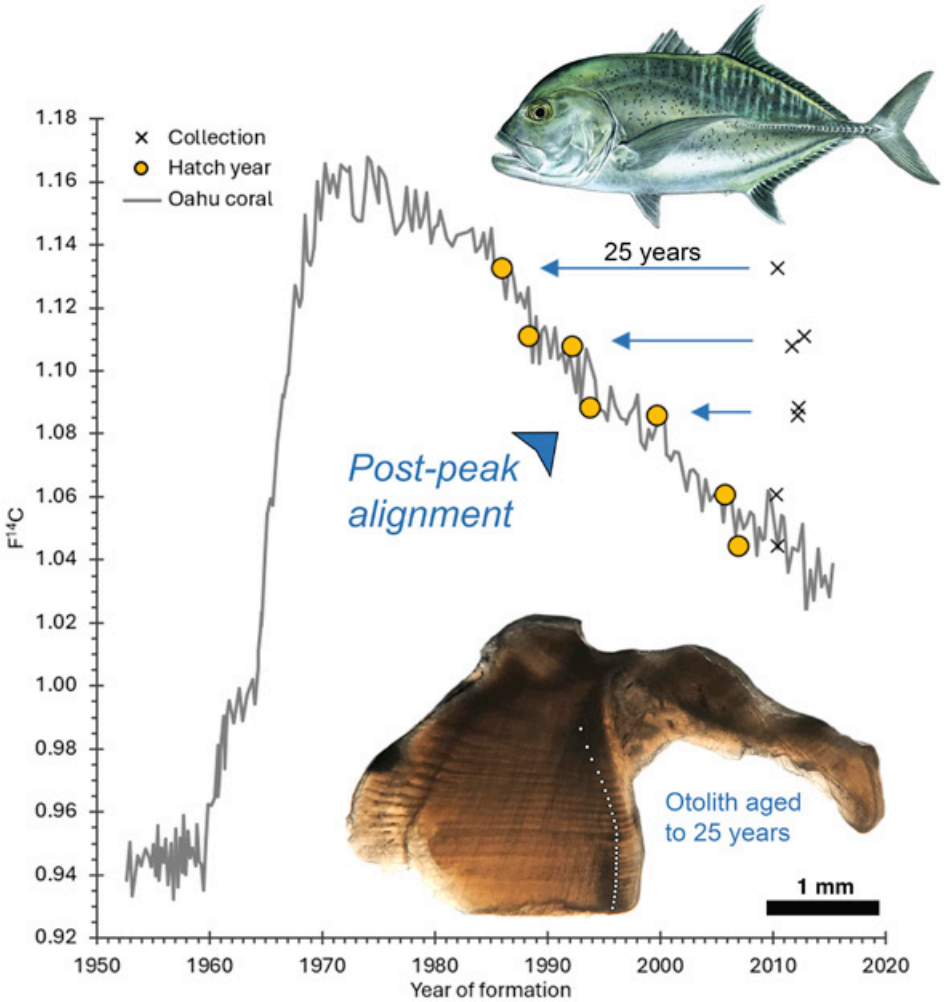

Figure 3. Giant trevally that were aged using otoliths — see inset image of an otolith cross-section that was aged to 25 years with each year marked by a white dot — had 14C measurements that aligned well with the post-peak decline of the Oahu coral 14C chronology. The X represents the capture or collection dates, from which the measured 14C value was projected back to its calculated hatch years (yellow dots). Alignment of the hatch years from seven fish (aged 3 to 25 years) with the chronology for Oahu is an indication the otolith ages were correct, and that this species can actually live 25 years.

One of the goals of the new SPC Sclerochronology Lab in Noumea is to continue to apply bomb ^{14}C dating to the fishes of the western and central Pacific Ocean (WCPO) by establishing new ^{14}C reference chronologies and then using them to test estimates of age for tunas, billfishes, and other pelagic fishes. In addition, this line of work will enhance SPC's Coastal Fisheries and Aquaculture Programme and project partners by addressing questions of age and growth for fishes of insular waters of the SPC member countries. To date, we have established a workspace that has state-of-the-art instruments, as well as the tried-and-true machines used in otolith processing (e.g. saw and grinding wheel) that will allow SPC to investigate the age and growth of regional fishes and provide a unique training hub for research in this field across the region. One of the first additions to the lab is the latest version of a micromilling machine by ESI, the MicroMill2 (MM2; https://www.icpmslasers.com/products/micromill2/), which was recently christened using a rare otolith sample (Figure 4) — a fortuitous capture of a giant grouper (*Epinephelus lanceolatus*) in Pohnpei (FSM) led to collection of the otoliths, of which one was the first sample analysed on the MM2. The measurement of ^{14}C from this otolith core (within the first year of growth) was at a level that could only be formed during the pre-bomb period, a hatch year earlier than 1958, indicating the fish was at least 61 years old.

This is the first validated age estimate for giant grouper throughout its Indo-Pacific range and while an age exceeding 60 years is not uncommonly encountered among large-bodied groupers, this fish was not even close to its maximum reported size of 2.7 m (~9 feet) with possible weight exceeding 400 kg (882 pounds). The fish from Pohnpei that we studied here was measured at 1.83 m (6 feet) with a weight of 126 kg (278.5 pounds) and was likely to have been an early adult considering maturity may be reached at lengths near 1.3 m. Further study on this species is currently being pursued across the Pacific, so please reach out to us if you happen to capture one of these leviathans of the fish world by accident as any assistance with gathering otoliths is most welcome.

Other notable progress from the lab includes a recently published paper[1] that has proven the age reading of thin-sectioned otoliths of Pacific yellowfin and bigeye tuna provide accurate estimates of age to 14–15 years. Following close on the heels of this work are age validation studies of skipjack tuna of the WCPO, broadbill swordfish in the southwest Pacific, and southern bluefin tuna of the Indian Ocean working in collaboration with member countries. Overall, an exciting new chapter in fish age and growth research has begun for SPC.

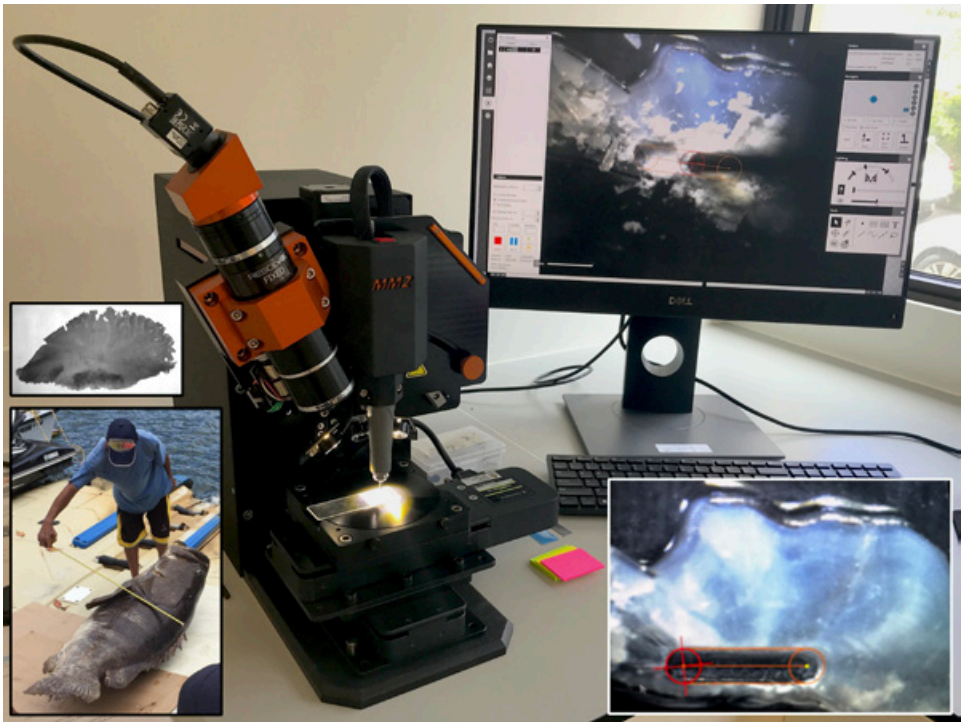

Figure 4. Photograph of the new ESI Micromill 2 in the SPC Sclerochronology Lab in Noumea with the monitor screen showing the live extraction of the earliest otolith growth using a computer-controlled dentist drill bit. The inset image on the bottom left is the captured giant grouper (*Epinephelus lanceolatus*) in Pohnpei (May 2019), with one of the collected otoliths from this individual shown above the fish picture. The inset image on the bottom right is the core extraction path as was cut from the otolith section (transverse) and measured for a 14C level. The otoliths were collected by James Wichman and made available for study by Ian Bertram.

[1] Andrews A.H., Eveson J.P., Welte C., Okamoto K., Satoh K., Krusic-Golub K., Lougheed B.C., Macdonald J.I., Roupsard F. and Farley J.H. 2024. Age validation of yellowfin and bigeye tuna using post-peak bomb radiocarbon dating confirms long lifespans in the western and central Pacific Ocean. ICES Journal of Marine Science 81(6): 1137–1149. https://doi.org/10.1093/icesjms/fsae074.

The 2024 Climate Awareness Workshop (CLAW)

Raising awareness of climate change by learning its language: perspectives from a participant and an organiser

Francisco Blaha[1] and Steven Hare[2]

Francisco writes as a participant and operational practitioner in the region; Steven writes from his organiser's perspective.

CLAW 2024 participants – wearing pink caps – outside the waterfront Wharewaka Function Centre in Wellington, New Zealand.
© Toky Rasoloarimanana, SPC

Introduction

The Pacific Community is deeply engaged in climate change work around the Pacific as it affects all aspects of life in the region. Climate change and its impact on fisheries was the focus of the inaugural Climate Awareness Workshop, dubbed the "CLAW", which was held in the heart of Wellington, New Zealand in February 2024, at the waterfront Wharewaka Function Centre.

More than 100 registrants attended some or all of the CLAW. The workshop was designed to present a comprehensive overview of the nature and impacts of climate variability and climate change on the industrial fisheries of the western and central Pacific Ocean (WCPO). The workshop was conducted in a seminar style, with many guest speakers from around the Pacific addressing a wide array of topics. The workshop content was tailored towards senior-level decision makers and policy advisors within the fisheries, environmental and national resources ministries of the Pacific Island countries and territories (PICTs) of the WCPO. The intent of the workshop was to "climate educate" fisheries managers and policy experts and enhance awareness of emerging issues related to climate change.

As part of FAME's Climate Science to Ensure Pacific Tuna Access (CSEPTA) project, we thought it important to conduct capacity building and familiarisation around

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climate change and its impacts to those whose job is to make decisions on how to manage their fisheries resources. The first step in overall capacity building is getting all those concerned to speak, and understand, a common language, the language of climate change.

To get from climate change to impacts on large-scale industrial fisheries, it is necessary to understand that the connection is not necessarily direct or easily grasped. Therefore, over the course of four days and 24 presentations, participants were briefed on the basics of climate change and how it differs from climate variability, and the broad ecosystem impacts of climate change, with a focus on the fisheries and oceanic ecosystems of the WCPO. Additionally, participants were briefed on how climate change scenarios are being incorporated into fisheries research and management. The CLAW concluded with a full day on loss and damage and advocacy for Pacific Island countries and territories. The following is a capsule summary of topics and interesting points raised for each of the four days.

Day 1: The terminology and basics of climate change

The field of climate change is awash in acronyms and compact abbreviations that present a real barrier to those outside the field and wishing to better understand the science. The first step to communicating the science is to organise, prioritise and decode the information being promulgated by the scientific community. The role of the Intergovernmental Panel on Climate Change (IPCC), particularly in the dissemination of its synthesis reports, was highlighted early during the CLAW. Besides quantifying what is known about the current impacts from the accumulation of greenhouse gases (GHGs) in the atmosphere, land and ocean of the planet, the IPCC produces standard sets of future impact scenarios. These scenarios are broadly used by the scientific community as the basis for predicting future impacts on the planet.

Day 2:The biological and physical impacts of climate change

Global warming is usually presented as the "poster child" of climate change. The earth's mean temperature has increased by more than 1.5°C since the 1950s. The warming of the planet has resulted in melting polar and high-altitude ice, sea-level rise and ocean warming. However, climate change has impacted the ocean in other ways such as reducing ocean pH and dissolved oxygen levels. Coastal regions, with shallower waters and locations proximate to land changes, have been most immediately impacted. Marine ecosystems, from mangroves to coral reefs to large oceanic gyres all show signs of disruption and change. Oceanic biodiversity and productivity are impacted in a variety of ways. Marine animal behaviour and survival change in response to changes in their environment, both physical and biological. The impacts are seen at all trophic levels, from the phytoplankton to the tunas to the top-level predators.

Day 3: Planning for and responding to WCPO changes

Human society is deeply impacted by climate change. Within the WCPO, the IPCC climate scenarios are integrated into models of coastal fish and tuna production. While there is high uncertainty in certain aspects of the modelling, the scenarios that project "business as usual" levels of GHG emission uniformly indicate negative impacts on coastal fisheries and an eastward shift in the WCPO target tuna distributions, potentially radically impacting food security and government revenues for Pacific Island countries and territories (PICTs). To prepare for these changes, urgent action is required to obtain better data for the models, regional and international collaborations need to be established to allow flexibility in management of shifting resources, and public awareness needs to be raised as the potential food security issues and economic impacts might be severe.

Palau. © Francisco Blaha

Day 4: Loss and damage for Pacific Island countries and territories

As shown throughout the CLAW, the WCPO is already experiencing the impacts of GHG forced climate change, and impacts are likely to accelerate. This is occurring through no fault of their own – PICT contributions to GHG emissions are negligible - and yet the PICTs are paying a heavy price. This has led to the idea of "climate justice", whereby compensation should be provided. However, in the political reality associated with climate change, the idea of justice, with legal declarations of responsible and harmed parties, is deemed untenable. In its place has arisen the notion of loss and damage. Under various bodies associated with the United Nations, a framework is being established wherein monies are contributed to a global fund, from which claims for loss and damage can be made. However, the process is fraught with complications and the PICTs require education and coordination in attempts to make loss and damage claims.

A participant's viewpoint: Feedback from Francisco

As a participant in many meetings, it would be an understatement to say it was one of the most sobering (and sometimes soul-crushing) workshops I have been to.

The workshop's premise is very sound: climate change impacts, sea level rise, and temperature are affecting Pacific islands in terms of their existence in the long-term, and economic viability in the medium-term, as climate change affects tuna distribution and abundance.

Much has been discussed over a long time so far. Yet, we are facing an increasing scope of research from climate science that needs to come into fisheries science. This sometimes uses similar terminology with different meanings, which is already confusing for Anglophones and even more so for those who have English as their second, third, or fourth language, as is the case for most people in the Pacific. Hence, this workshop responded to the need to standardise language and concepts while providing the latest information and research on climate change, fisheries, and their interactions, and it did a splendid job at that.

In 1949, the environmental philosopher Aldo Leopold wrote: "One of the penalties of an ecological education is that one lives alone in a world of wounds." He wasn't referring to climate change at the time but rather to the importance of preserving natural ecosystems and our ethical responsibility to care for them. If nature does not flourish, neither will we, seems to have been his message ... that obviously hasn't been heard.

Most of my work is operational, centred on increasing reporting accuracy, diminishing the impacts of illegal, unreported and unregulated (IUU) fishing, and expanding the understanding of fishing fleet logistics and dynamics. These efforts all contribute to the bigger picture of better fisheries management. However, many people scorn those who do this type of work for not being good enough or fast enough, for being political and industry puppets, and so on.

Most of the criticism comes from well-intentioned folks who are very fast at pointing fingers. Still, they may not know how technical the issues can get, mainly when adding other elements around subsidies, social responsibility, and the economic vulnerability of the nations that own the fish against the distant water fishing nations (DWFN) that catch most of the fish.

Yet, people keep pointing fingers at these issues while seemingly forgetting that climate change is a topic we all need to have a much more significant interest in and impact on.

The key learning from the four days is the scope of climate change in fisheries and how overwhelming it is in all aspects ... from the growth of individual fish to the macro-oceanic patterns, from variations in seawater chemistry to the literal survival of coastal nations, from adjusting the stock assessment models to pan-Pacific fisheries management.

Tuna is vital to food security, as can be seen in the centre of Tarawa, Kiribati. © Francisco Blaha

While we should continue focusing on the operational aspects, we urgently need to address these "new" and ongoing climate change-related variabilities and issues. We need to start thinking outside the box and develop new approaches that look at all the aspects, identify weak points, and try to respond to them. We also need to evaluate what happens within the intermediate periods, which has not been tested, as we tend to focus only on extreme scenarios.

Yet, in comparison, whatever we do right or wrong in fisheries has very little impact on its future if we don't reduce emissions as a starting point.

A question I often ask myself when thinking about this is how to stay productive in the face of climate change. Pessimism (throwing my hands in the air and saying, "we are doomed!") is paralysing, and so, for that matter, can optimism (why worry when it will all be okay in the end?). How, then, should I think and act around this?

I personally try to adhere to the philosophical perspective of "meliorism" which is defined as the "doctrine that the world, or society, may be improved and suffering alleviated through rightly directed human effort", and comes from the Latin "melior", meaning "better".

So, rather than wallowing in ""a world of wounds," the "meliorist" in me, likes to believe in the potential for gradual, incremental improvements through human effort. Even if reality and the actions (or, better said, inactions) of most governments today are discouraging, what other options do I have?

A phrase by the public intellectual Noam Chomsky has guided me over the years: "We have two choices: 'to abandon hope and ensure that the worst will happen' or 'to make use of the opportunities that exist and contribute to a better world'. It is not a very difficult choice."

The climate change studies, and the gloomy figures presented in CLAW can be discouraging. Yet, they need to be interpreted positively: Reducing warming by any amount will move us up the scale and produce a lesser impact on fisheries, so people like me can work better on fisheries monitoring, IUU, etc., and ultimately contribute to better fisheries management.

Final notes

Per participant polling, CLAW 2024 was judged to be a worthy workshop and there was almost unanimous call to hold another CLAW in 2025. When asked for potential improvements, one request was most noted. The original agenda had called for a five-day workshop, but several other SPC and FFA meetings were scheduled around the CLAW to take advantage of the concentration of PICT decision makers, resulting in a shorter workshop. The day that was dropped had been tentatively titled "the view from your island" and was intended as a forum for participants to present how they saw climate change impacting their land, resources and people. CLAW 2025, or whenever the next one is held, will include such a day in the agenda.

The CLAW has been preserved on the SPC FAME website. All 24 presentations were recorded and can be viewed and downloaded. Various other material associated with the CLAW – speeches from delegates, a final report, and several videos are also available. The website address is: https://fame.spc.int/event/claw/2024

The art of climate change: SPC regional Pacific photo competition

Johanna Johnson[1]

The Pacific Community's competition to find photos that capture the effects of climate change on tropical Pacific aquaculture and fisheries has found its winners. From among the 90 high-quality entries across three categories – professional, amateur and youth – the judging panel, after difficult deliberation, selected one winning photo and two honourable mentions per category.

The competition was launched in April 2024 to find visually striking and original images that convey the theme of climate change within Pacific Island fisheries and aquaculture. These images will be used to illustrate the soon-to-be-published book: *Climate change implications for fisheries and aquaculture in the Pacific Islands region.* The work is being led by editors Dr Johanna Johnson and Dr Colette Wabnitz, with an international team of over 50 experts in collaboration with the Pacific Community (SPC) and supported by funding from the Australian and New Zealand governments.

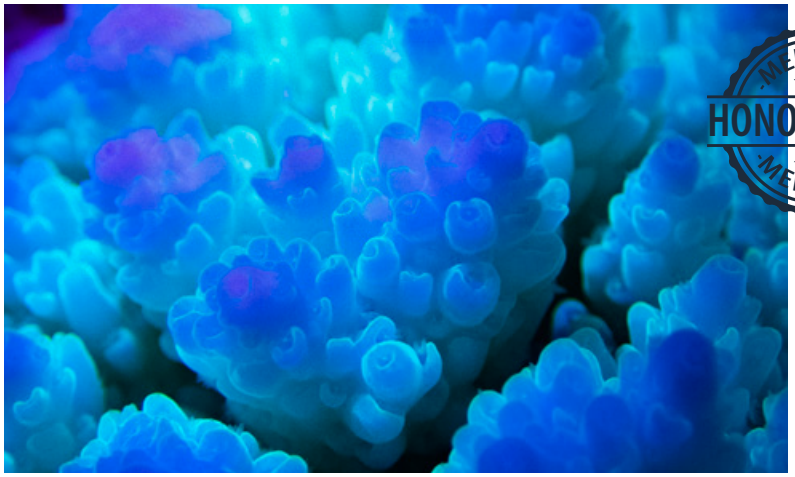
The book details recommended adaptations and management measures to minimise climate change impacts and maximise opportunities for Pacific Island fisheries and aquaculture. As well as providing a comprehensive assessment of the vulnerability of tropical Pacific fisheries and aquaculture to climate change, and a summary of results for each of the 22 Pacific Island countries and territories. It will be a valuable resource for anyone interested in the diverse oceanic, coastal and freshwater habitats, fisheries and aquaculture of the Pacific Islands region, and the managers and decision-makers working to maintain healthy ecosystems and sustainable fisheries that support Pacific communities and economies.

The first prize was USD 1000 worth of photo equipment, and winning photos will be featured on the cover or a prominent page of the SPC *Climate change implications for fisheries and aquaculture in the Pacific Islands region* book. Congratulations to our talented winners listed below.

[1] Senior Scientist and Director, C_2O Pacific

Category 1: Youth (16 to 24 years old)

Josh Kuilamu, Fiji. Amidst low tide, an iTaukei fisherwoman gathers cockles along the Nasese sea wall in Suva, a tradition weathered by time and tide. Her resilience mirrors the struggle of Pacific communities against rising seas and shifting ecosystems, illustrating the intimate connection between climate change and traditional fisheries.



Theo Guillaume, French Polynesia. Tetiaroa atoll lagoon. Due to the high temperatures of the lagoon, the polyps of this Acropora have expelled their symbiotic zooxanthellae, revealing the latter's limestone skeleton: this is coral bleaching. This photo was taken with a UV lamp.

MENTION
HONOURABLE
MENTION

Devavrat Bishwa, Fiji. "Balance" taken at sunset on the Coral Coast, Sigatoka.

Category 2: Amateur photographers (24 years old and above)

Zorik Olangi, Yuru Harbour, East Kwaio, Malaita Province, Solomon Islands. A fisherman casting his net over a muddy, silt-laden reef, highlighting the stark effects of climate change. Rising temperatures and altered precipitation patterns have led to increased siltation and disrupted aquaculture, threatening marine ecosystems and traditional livelihoods dependent on fishing.

Keziah Harry, Tuvalu. Water floods in, showing how nature and people are at risk. Trees can't grow because of salt, leaving no protection. This photo warns about climate change's effect on fishing and the sea. It's a clear sign we need to act to keep our world safe.

Francisco Blaha, Kiribati. Coastal fishing family in Kiritimati, 2022.

Category 3: Professional photographers (anyone who has made an income from selling one or more photo)

Zahiyd Namo, Solomon Islands. Living on 37 hectares of land, the people of Anuta in Solomon Islands depend entirely on their marine resources for survival. To adapt to climate change, they build sea walls that stop the incoming waves during cyclones or high swell, protecting their homes and outrigger fishing canoes, which are the most important thing on Anuta island.

Tiana Reimann, Papua New Guinea. Sinking Islands of Kove. For thousands of people, the islands of the Kove region have been a place to call home. As populations increase, more homes are built above the water. However, due to poor infrastructure and decreasing land mass, their homes are now threatened by rising sea levels and unpredictable weather patterns.

Chewy Lin, Marshall Islands. Marshallese fishermen from Kili Island fighting over strong waves to catch fish.

Photographer biographies

Youth

Winner - Joshua Kaitu'u Malo Kuilamu

Joshua Kaitu'u Malo Kuilamu is 24 years old and hails from Macuata, Fiji, with maternal links to Oinafa, Rotuma. He recently got into photography as a hobby, starting with taking pictures using his phone and then slowly saving up enough to purchase his first second-hand DSLR camera. Besides snapping photos, he enjoys learning new photography tips and tricks and spending time with his loved ones.

Honourable mention - Théo Guillaume

Théo Guillaume is 24 years old and lives in French Polynesia. He currently works for the Te Mana O Te Moana association on Tetiaroa atoll, where he coordinates the monitoring of green turtle hatchlings. He has been passionate about the sea since he was 10 years old, and it is only in the last two years that he has taken up underwater photography. For him, photography is a way of showcasing the beauty of this fascinating world and sharing knowledge about underwater biodiversity, with the aim of preserving the oceans.

Honourable mention – Devavrat Bishwa

Devavrat Bishwa is a Postgraduate diploma in marine science student at the University of the South Pacific. The picture was taken during a marine biology field trips where students were learning about coral reef surveys and how the marine environment is connected to the terrestrial environment, how the delicate balance between both habitats depends on us and how we utilise and conserve. If we do not act now, the beautiful pictures we take by the shore will no longer be possible. He is currently pursuing further studies in marine science and biology to better understand these habitats and how we can protect them.

Amateur

Winner – Zorik Olangi

Zorik Olangi is from Malaita Province in the Solomon Islands. He works as a medical officer (doctor) at the Atoifi Adventist Hospital on the Eastern Side of Malaita Province. He is also a drone enthusiast who loves taking aerial photos and videos in his free time.

Honourable mention – Francisco Blaha

Francisco has called the Pacific home since he arrived as a migrant fisherman in 1991 after taking a boat for repairs to New Zealand in 1995. He settled there but kept working in the region as a fisher, and later a consultant for the major organisations and donor governments. He gained along the way various degrees and qualifications. He is passionate about fishers because he emphasises that there would not be a fisheries industry or regulators without them. His work experience, reports, blogs and photographs are in his website www.franciscoblaha.info

Honourable mention – Gitty Keziah Yee

Gitty Keziah Yee comes from Tuvalu. A self-taught photographer, her passion for photography was awakened at the age of 5, when she was handed a camera for the first time. Photography is her way of capturing the beauty and reality of her country. Each photograph she takes is with love and passion, and she aims for each one to convey a powerful message that will resonate with future generations. Today is unique, and through her lens, she strives to preserve its essence for tomorrow. A photograph is a moment that is frozen in time forever.

Professional

Winner – Zahiyd Namo

Zahiyd Namo is from the village of Waisurione, West Are'are, in the Province of Malaita, Solomon Islands. He is an indigenous photographer/filmmaker who enjoys capturing images of Solomon Islands' indigenous cultures, beautiful places, music and people, "because that's who we are", as he puts it. Stories of challenge and success that he is convinced are similar to those of other Pacific families.

Honourable mention – Chewy Lin

Growing up in the Marshall Islands and residing there for 25 years, Chewy developed a deep connection to the region's unique culture and environment. Chewy's passion for photography began during studies in the United States, leading to a multifaceted career as a photographer, documentary filmmaker, and photojournalist, including serving as the official photographer for the Republic of the Marshall Islands government. Involved in various United Nations projects and collaborating with international media, Chewy captures authentic stories from around the world. Chewy's work focuses on the Pacific's rich cultural history and pressing issues like nuclear legacy and climate change, striving to bridge cultural gaps, foster global understanding, and amplify the voices of the Pacific.

Honourable mention – Tiana Reimann

Tiana Reimann, a conservationist and photographer, was born in Brisbane and raised in Kimbe, Papua New Guinea. Her upbringing instilled a deep love for nature, driving her work with the Sea Women of Melanesia to empower indigenous women in coral conservation. Through her efforts, Tiana aims to protect the coral and promote sustainability. She believes education is the key to a sustainable future for our planet.

Towards inclusion of persons with disabilities in coastal fisheries in the Pacific: A review of current practice and approaches

Jenny House,[1] Aurélie Delisle,[2] Vasemaca Malverus,[3] Tarateiti Uriam,[4] Lyn Vaike[5] and Dirk Steenbergen[2]

Introduction

Coastal fisheries are an important source of food, nutrition and livelihoods for Pacific Islanders. Community-based fisheries management (CBFM) has been recognised in the Pacific as the most viable strategy to achieve widespread self-decisive management by communities as opposed to localised, site-based interventions driven at national level. In the context of the Pacific, CBFM means that fisheries management approaches are community-driven and encompass an ecosystem approach that will sustain livelihoods and ensure resilient island communities (SPC 2021). An enduring challenge for governments of Pacific Island countries and territories (PICTs) is to support widespread management action across hundreds if not thousands of communities. In 2021, Pacific Fisheries Ministers endorsed a regional directive for scaling up CBFM. A people-centred approach is at the core of the Pacific Framework for Action on Scaling CBFM (SPC 2021). A people-centred approach applied to CBFM aims to assist CBFM practitioners achieve the most desirable outcomes for all in community fisheries management. The approach promotes equity through social inclusion to understand the different needs of various community groups, especially marginalised groups including women, youths, and persons with disabilities. In November 2023, representatives of the Third Community-Based Fisheries Dialogue (CBFD-3) noted that although progress for women and other marginalised groups to fully participate in CBFM had been made, it was still limited in the region (SPC 2023). Although progress has been acknowledged, much of the work around the people-centred approach in CBFM has mainly focused on women as opposed to other marginalised groups such as persons with disabilities.

The UN 2030 Agenda for Sustainable Development emphasised the need for strengthening inclusive development, "leaving no one behind", and the importance of inclusion and equity for persons with disabilities across all aspects of society (United Nations 2016). Despite progress, there is increasing inequality between persons with disabilities and those without globally (Niewohner et al. 2020). Though the Small-Scale Fisheries voluntary guidelines (FAO 2015), and other instruments, advocate for inclusive fisheries management, there has been little focus on inclusion of persons with disabilities in coastal fisheries. In the Pacific, focus on this issue is more apparent in sectors such as disaster risk reduction, water, sanitation and hygiene (WASH) programmes, climate change, education, and health (PDF 2024).

This literature review examines participation of persons with disabilities in fisheries and other production sectors as a contribution towards ensuring inclusive coastal fisheries management in the Pacific. This review forms a precursor to understanding how to apply disability-inclusive development in CBFM work. The review comes in response to an emerging demand from discussions between teams working on a CBFM project in Kiribati, Solomon Islands and Vanuatu where members reflected on the need to consider how they could extend the progress made in including women into CBFM to other marginalised groups. Ongoing discussion with national organisations of persons with disabilities have begun to apply the principle of "nothing about us without us". This review acknowledges a growing recognition that the integration of equity and disability inclusive lenses has become an important cross-cutting consideration across all sectors, and that Pacific small scale fisheries are at an early stage of integrating such considerations. This review may, therefore, serve as a useful departure point for stakeholders seeking to engage in this space. To do so, we provide an overview of disability and inclusive development in the Pacific, explore how lessons and issues from other sectors may apply to coastal fisheries, and suggest some considerations on how coastal fisheries practitioners can improve accessibility, inclusion and participation to promote community cohesiveness and derive equitable benefits from coastal fisheries.

Resources and work of the Pacific Disability Forum (PDF), the region's foremost platform on disability inclusion work, forms the foundation of this review. The PDF is a "partnership of Pacific Organisations of and for Persons with Disabilities", with members across 22 countries and territories, working "towards an inclusive and resilient Pacific for all persons with disabilities" through achieving the preconditions for inclusion and promoting leadership, partnerships, regional cooperation, and resource mobilisation (PDF n.d.).

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Disability and inclusive rural development

Globally, 16% of people have a disability (WHO 2024). The United Nations Convention on the Rights of Persons with Disabilities (UN-CRPD) states that:

> *"Persons with disabilities include those who have long-term physical, mental, intellectual or sensory impairments which in interaction with various barriers may hinder their full and effective participation in society on an equal basis with others."* UNCRPD Article 1, 2006

There is an ongoing and necessary shift to the social and rights-based models of disability in the Pacific (Puamau 2007), which emphasises the barriers that exclude persons with disabilities from mainstream society and the "inherent dignity" of a person (Lawson and Beckett 2021). These perspectives suggest that society must work to reduce barriers, critiquing a narrow conception that disability is primarily a medical problem to be solved. The disability community is diverse, and it is important to consider underrepresented groups within this community and also how disability intersects with other social characteristics and identities, such as age, sexual orientation, ethnicity, or gender (Blyth et al. 2020; PDF 2024).

In disability-inclusive development, persons with disabilities are active agents of development while barriers which may exclude them from participating in and benefitting from development are addressed concurrently (AusAID 2008). The PDF (2024) advocates for a dual approach that incorporates mainstreaming (i.e., including persons with disabilities as participants and beneficiaries), as well as disability-targeted initiatives. This twin track approach draws parallel with the gender mainstreaming strategy advocated for the consideration of gender in fisheries. Rather than a sectoral approach, the PDF seeks the preconditions for inclusion across programs, institutions, and society. These are "accessibility, assistive devices, support services, non-discrimination, protection payments, and community-based inclusive development" (PDF 2023). This approach aims to provide an enabling environment for disability equity and inclusion across all institutions and contexts. Niewohner et al (2020, p1171) identified four main barriers associated with NGOs that limit disability inclusive development: "lack of awareness, beliefs that persons with disabilities constitute a separate focus area, assumption that the costs of inclusion are too high, and responsibility shifting onto others". The same conclusions could be applied to governments. Governments, NGOs and individuals working on the frontline of development shape how individuals and communities experience or participate in community development, including in coastal fisheries.

The Pacific context

More than 1.7 million Pacific Islanders are living with at least one disability (PDF and Pacific Islands Forum Secretariat 2023). Though there are data gaps on the numbers and experiences of persons with disabilities in the Pacific, there have been efforts to rectify this situation through censuses and surveys (Washington Group 2022). The UNCRPD has been ratified by 14 Pacific countries,[6] making disability inclusion a state obligation. Although the CRPD states that the rights of persons with and without disabilities are the same, persons with disabilities often have less access to healthcare, education, employment, and other aspects of public life (WHO and The World Bank 2011). Persons with disabilities

[6] https://tbinternet.ohchr.org/_layouts/15/TreatyBodyExternal/Treaty.aspx?Treaty=CRPD

face stigma and discrimination, and women with disabilities face intersecting and compounding forms of discrimination and risk (Spratt 2013; UNPF, WEI and PDF 2021, 2022a, 2022b). Persons with disabilities are often more likely to be living in poverty, as disability is both a cause and consequence of poverty (WHO and The World Bank 2011).

The Pacific Regional Strategy on Disability (2010–2015) and the subsequent Pacific Framework for the Rights of Persons with Disabilities: 2016–2025 have supported "Pacific governments to promote, protect and fulfil the rights of persons with disabilities" and have the vision of "an inclusive, barrier-free, and human rights-based society for men, women and children with disabilities, which embraces the diversity of all Pacific people." This framework has five goals, covering the topics of livelihoods, mainstreaming, leadership and enabling environment, disaster risk management, and evidence, all of which have relevance for coastal fisheries. Across the Pacific, great progress has been made in developing disability research and statistics (e.g., UNICEF et al. 2017; TSD et al. 2019), and there are active organisations of persons with disabilities (OPDs) on the national and regional levels (PDF 2023; CBM et al. 2022). Sector-specific efforts have been made, e.g., the Pacific Education Development Framework, and research on certain groups, such as women or children with disabilities, has been conducted to identify specific issues or to understand different contexts (CBM 2022; Spratt 2013; UNPF, WEI and PDF, 2021, 2022a, 2022b).

Why is this important for Pacific coastal fisheries?

For many Pacific people, coastal fisheries provide food, a livelihood, a workplace, a recreational space and more. As fisheries practitioners, ensuring that we understand the intersection of food security, the ability for different people to participate in and influence decisions on the access to and control over marine resources, the poverty considerations in fisheries livelihood programs and other aspects of coastal fisheries that benefit and/or impact people's lives requires us to integrate disability inclusive lenses. Such an understanding would ensure that persons with disabilities are not left behind and that interventions are inclusive with a real opportunity to benefit everyone fairly. Thus, coastal fisheries practitioners and organisations have a critical role to play in including persons with disabilities, investigate the barriers that manifest in this field and work to improve disability equity. To apply the people-centred approach central to the Pacific Framework for Action on Scaling up CBFM, we need meaningful participation of everyone in society for any development interventions including coastal fisheries. Several Pacific countries have emphasised inclusive development in their national strategic plans and their fisheries policy. For example, a guiding principle of the Vanuatu National Fisheries Sector Policy 2016–2032 is to "safeguard the welfare of the future generations, recognising gender equity and vulnerable groups". Similarly, the Solomon Islands National Fisheries Policy 2019–2029 states that "sustainable use will be facilitated through improved preservation, market access and enhanced livelihood opportunities for rural men and women, including vulnerable and marginalised groups".

For many Pacific people, coastal fisheries provide food, a livelihood, a workplace, a recreational space and more. ©SPC

Much of the literature on disability and fisheries has focused on fishing injuries (e.g., Syddall et al. 2002; Rodríguez-Romero et al. 2013; Murray 2007) or on recreational fishing as a source of wellbeing for persons with disabilities (e.g., Freudenberg and Arlinghaus 2009; Lindsay et al. 2022), rather than on disability inclusion in coastal fisheries generally. However, much can be learned from other sectors regarding barriers, risks, participation, and inclusion of persons with disabilities. The responsibility for addressing these barriers (Table 1) must be borne by all organisations and agencies working in coastal fisheries, with engagement and collaboration with OPDs.

Persons with disabilities are often not in formal employment[7] and rely heavily on subsistence activities, such as farming, fishing, and rearing livestock, making them more vulnerable to the impacts of climate change (PDF and AusAID 2022). We understand fishing to encompass the wide field of fishing activities along a supply chain including post-harvest, value-adding, marketing and selling including gleaning for food or shells for handicrafts where persons with disabilities may be involved. In terms of fisheries, participants from several countries reported concerns about decreasing fish stocks and the use of inaccessible technologies to access further fishing grounds, e.g.:

> *"Persons with disabilities in Kiribati do not have the opportunity to get loans to buy this improved fishing equipment. In addition, people who are deaf are not comfortable with using outboard engines since they are not able to hear them and there is a risk of drifting when a mechanical problem happens in open waters."* – "Based on information from male participant with disabilities, Kiribati" (PDF and AusAID 2022).

[7] https://pacificdata.org/disability-dashboard

Table 1. Types of barriers faced by persons with disabilities and some examples of how these could manifest in the coastal fisheries context

Barriers	Description (CBM et al. 2022)	Possible fisheries examples
Policy and institutional	"discriminatory laws, regulations, policies and strategies that systematically discriminate or disadvantage certain groups of people."	Are persons with disabilities represented in CBFM institutions? Are the situation and needs of persons with disabilities considered in needs assessments and surveys?
Physical and environmental	"barriers in the environment due to the design of infrastructure or features of the natural environment."	Are the places where decision-making takes place physically accessible? When restricting fishing grounds through CBFM, are the areas used by persons with disabilities considered?
Attitudinal	"stigma and discrimination based upon misconceived understandings of disability."	Do fisheries officers have enough understanding of disability and inclusive development to ensure inclusion during their work?
Information and communication	"experienced by people who have disabilities that affect hearing, speaking, information processing, reading, writing, and/or cognitive functioning, and require specific methods to communicate and access information equally."	Are CBFM plans presented in accessible ways? Do persons with disabilities have access to information on fishing practices?

However, programmes can benefit persons with disabilities and support poverty reduction if directed to be disability inclusive. In Fiji, the "trash to cash" initiative is an example of an alternative livelihood project for coastal fishing communities which included persons with disabilities.

Changes in the demographics of coastal communities can have an impact on persons with disabilities in relation to fisheries. It is often the case that the younger population without disability tend to migrate leaving behind persons with disabilities that may depend on others to fish for food. At the same time, most PICs have social protection schemes to support persons with disabilities which can often help broader fishing communities who lack access to social protection because of the informal nature of their work. An understanding of these changes and the intersection with social protections systems in the fisheries sector is understudied and could benefit from further investigation.

Climate change, while often framed along impacts of environmental changes, has been found to reinforce existing participatory exclusions, and create new risks and impacts faced by persons with disabilities (PDF and AusAID 2022), including discrimination within the household, in program design and in policy development. Existing barriers may increase as fishing practices change, such as more offshore fishing, inability to access loans or technologies, and certain technologies not being accessible (PDF and AusAID 2022). Disruptions to subsistence activities may have consequences for food security for persons with disabilities and it has been reported that, when households face food shortages, household members without disabilities may be prioritised over those with disabilities in terms of food allocation (PDF and AusAID 2022). Therefore, economic and food security impacts of climate change are likely to have a disproportionate effect on persons with disabilities, who may experience barriers to alternative livelihoods or modifying their fishing practices.

As resources become scarcer, persons with disabilities may face greater risks and exclusions from fishing and other livelihoods, as well as greater competition for resources (PDF and AusAID 2022). This emphasises the need to mainstream and target disability inclusion in coastal fisheries and CBFM, to identify and mitigate these changing risks, and to ensure that management interventions do not cause harm or further exclusion for persons with disabilities. First, we must understand how persons with disabilities are engaging with fishing, what their needs are, and how they can engage with more sustainable or effective livelihoods opportunities. It is important to consider that this includes persons with disabilities unrelated to fishing and which are the result of fishing injuries, and that a person may experience a disability at any age. Just as the disability community is diverse, the way that persons with disabilities have engaged with fisheries in their life will also be diverse, so research into the lived experiences of persons with disabilities in fisheries is needed to understand this diversity.

Preconditions for inclusion

Several preconditions for inclusion have been identified by the PDF (2020d), including accessibility, which involves ensuring equal access to "the physical environment, to transportation, to information and communications, including information and communications technologies and systems, and to other facilities and services open or provided to the public, both in urban and in rural areas" (PDF 2020b p4). Examples of ensuring access could include making sure that meeting venues have a ramp and/or sufficiently wide doorways, having appropriate lighting, and having clear signage and sufficient facilities, such as bathrooms. Accessibility also includes ensuring that everyone has the transport or support needed to attend and actively participate in meetings or other activities, such as a sign language interpreter or

a support person. A comprehensive list of accessibility recommendations is not provided here, so these are just some examples. In terms of coastal fisheries, many of the accessibility issues are similar to other sectors, but there may be additional considerations related to accessing the marine environment and specific livelihoods opportunities.

In the context of regional ambition to scale up CBFM (SPC 2021), information delivery forms a key strategic component in supporting widespread management in communities. This extends to considering how to ensure the inclusive and sustainable participation of persons with disabilities in fisheries. In general, persons with disabilities may have less access to information about policies that impact them, as well as facing other barriers to participating in decision-making. For example, a climate change study found that participants with disabilities were not aware of, and did not participate in the development of, relevant policies, apart from staff of OPDs who had participated in development of national policy in Tuvalu (PDF and AusAID 2022). In inclusive development, information must be delivered in accessible and inclusive ways that reflect the diversity of disabilities, consultations must seek out the participation of persons with disabilities (including OPDs), and community-based development processes such as CBFM must mainstream disability as part of their programming (PDF 2020b, 2020d; AusAid 2008). The PDF provided practical guidance on inclusive communication during COVID-19 that can be applied by those working in fisheries management (PDF 2020a and 2020c). In addition to the messaging itself, there are a range of ICTs and assistive technologies that may assist with information delivery (PDF 2020d).

Assistive devices support the participation of persons with disabilities, with different devices supporting different needs (PDF 2020d). In addition, persons with disabilities may use various support services to facilitate active participation, especially in areas such as decision-making, communication, and daily activities (PDF 2020d). Knowledge of assistive devices and support services is important to ensure that fisheries staff can work with persons with disabilities in a way that promotes communication and preserves dignity (IASC 2019). The PDF also recommends that development should "promote and protect wellbeing of persons with disabilities, their families, carers and community" and "ensure representative organisation of persons with disabilities play a key role in awareness raising" (PDF 2020d, p7).

Relation to other forms of marginalisation

There are a range of intersections that may compound the barriers or marginalisation faced by persons with disabilities, for example those related to age, gender, sexuality, ethnicity, or other layers of identity. Women with disabilities face a variety of specific risks, including being excluded

Finding ways to overcome barriers for people with disabilities is essential to improving equal and inclusive access to coastal fisheries. Top image: Lindsay Chapman, ©SPC; bottom image: Sebastien Gislard, ©SPC

from sexual and reproductive health services, being deprived of legal capacity (instead of legitimate supported decision-making), and increased risk of gender-based violence (Spratt 2013; UNPF, WEI and PDF 2021, 2022a, 2022b), as well as having less access to certain information and services (Baker et al. 2017). Age is also a factor, as older people have a higher rate of disability (Hayes 2009). Children with disabilities are less likely to attend school compared to children overall, often due to a physical barriers and transport issues, or discrimination and lack of information (Hassan and Macanawai 2021). However, a commitment to disability inclusive education has been made, as per the Pacific Education Development Framework 2009 – 2015 and similar national policies.

The intersection between disability and people of diverse SOGIESC[8] has also been highlighted as an understudied but important consideration, given the greater barriers and discrimination persons with disabilities and diverse SOGIESC face (Blyth et al. 2020). More work is needed to understand the

[8] Sexual orientation, gender identity, gender expression and sex characteristics

specific barriers and challenges for persons with diverse impairments or who have disabilities that are less represented in the disability community. Currently there is a growing body of work on gender or women in fisheries (Kleiber et al. 2015; Mangubhai and Lawless, 2021), very few studies on people of diverse SOGIESC in fisheries (Kenny and Tapu-Qiliho 2022; Fisk et al. 2023), and limited understanding of issues relating to disability in fisheries. People do not fall into single categories, so GEDSI/GESI approaches in fisheries must acknowledge and address the diversity and complexity of people in coastal communities (Barclay et al. 2021). Intersectional sector specific research is needed develop inclusive fisheries management.

Key considerations

This review has outlined key issues and knowledge gaps, and implementation considerations in relation to inclusion and equity for persons with disabilities in the coastal fisheries sector. As this review draws from existing literature and lessons from other sectors, a thorough investigation of specific sector-related issues and experiences of persons with disabilities is beyond its scope. As such, this review supports calls for greater disability inclusion in coastal fisheries and in that we suggest the key considerations:

Promote participation and seek the voices of persons with disabilities in fisheries

1. Consult persons with disabilities, and their families, and ensure their views are addressed in fisheries management and policy. Actively seek their participation and ensure their needs and priorities are addressed in CBFM and other activities. When developing fisheries management interventions, ensure that no harm is being done as a result of not including persons with disabilities, for example closing the more accessible fishing grounds or reinforcing stigma.
2. Consult and collaborate with OPDs and persons with disabilities to improve disability inclusion in coastal fisheries, but take responsibility for doing the work, and ensure inclusive workplace practices whilst doing so.
3. Embed the preconditions for inclusion into coastal fisheries programs and policies.
4. Recognise intersectionality and how various identities may compound marginalisation or barriers, in general or in fisheries. Make sure to include persons with underrepresented disabilities.

Make sure information sharing is inclusive and accessible

5. Use accessible and inclusive modes of information delivery and develop messaging and content (words and imagery) that avoids stigma and discrimination of any kind. E.g., through the use of sign language interpretation, braille, local languages, or easy read documents (IASC 2019).

Logo from the Nei Tengarengare CBFM programme in Kiribati highlighting the inclusive nature of the programme ©MFMRD

6. Provide reasonable accommodations and support to ensure that persons with disabilities have access and participation that is equal to other people. E.g., accessible meeting venues, transport, and other reasonable accommodations (IASC 2019).

Value and support persons with disabilities

7. Recognise and develop the capacities of persons with disabilities to participate in fisheries and equip them with accurate knowledge and skills to engage and benefit from the sector.
8. Train fisheries staff to design and implement disability-inclusive programmes. Increase their understanding of the rights of persons with disabilities to reduce barriers and discrimination.
9. Fund disability-targeted and mainstreaming approaches in programming and allocate funds for reasonable accommodations.

Data and disability research

10. Research the participation of persons with disabilities in fisheries, as well as barriers, risks, and enablers to participation. There is a severe knowledge gap about the experiences of persons with disabilities in fisheries, and how they would like the sector to develop.
11. Incorporate disaggregated data and disability statistics into programme monitoring and evaluation and adopt disability specific targets and indicators.

You can learn more about disability-inclusive initiatives in the Pacific through:

- Pacific Disability Forum https://pacificdisability.org
- Human Rights and Social Development, Pacific Community https://hrsd.spc.int
- National Organisations for Persons with Disabilities in each country

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References

Australian Agency for International Development (AusAID). 2008. Development for All: Towards a disability-inclusive Australian aid program 2009–2014. www.dfat.gov.au/sites/default/files/dev-for-all.pdf

Baker S., Brown T., Caleb N., Iakavai J., Marella M., Morris K., Nasak M., Reeve M., Roubin D. and Pryor W. 2017. Disability Inclusion in Disaster Risk Reduction: Experiences of People with Disabilities in Vanuatu during and after Tropical Cyclone Pam and Recommendations for Humanitarian Agencies. Nossal Institute for Global Health, CBM Australia, Oxfam in Vanuatu, Vanuatu Society of People with Disabilities, Vanuatu Disability Promotion and Advocacy Association, Ministry of Justice and Community Services, Vanuatu National Disaster Risk Management Office: Melbourne, Australia.

Barclay K., Mangubhai S., Leduc B., Donato-Hunt C., Makhoul N., Kinch J. and Kalsuak J. (eds). 2021. Pacific handbook for gender equity and social inclusion in coastal fisheries and aquaculture. Second edition. Noumea, New Caledonia: Pacific Community. 202 p. https://purl.org/spc/digilib/doc/mav7c

Blyth J., Alexander K., Woolf L., Devine A. and Bush A. 2020. Out of the margins: An intersectional analysis of disability and diverse sexual orientation, gender identity, expression and sex characteristics in humanitarian and development contexts. CBM–Nossal Institute Partnership for Disability Inclusive Development.

CBM. 2022. Towards Brighter Futures: Children with Disabilities in the Asia-Pacific Region. https://www.cbm.org.au/wp-content/uploads/2022/11/Towards-Brighter-Futures-paper-28-NOV-2022.pdf

CBM Global Inclusion Advisory Group, Humanitarian Advisory Group, People with Disabilities Solomon Islands, Vanuatu Disability Promotion & Advocacy Association, and The Pacific Disability Forum. 2022. Organisations of Persons with Disabilities: Making a Difference in Vanuatu and Solomon Islands. https://cbm-global.org/wp-content/uploads/2022/06/OPD-making-difference-vanuatu-solomon-islands.pdf

FAO. 2015. Voluntary Guidelines for Securing Sustainable Small-Scale Fisheries. In Voluntary Guidelines for Securing Sustainable Small-Scale Fisheries in the Context of Food Security and Poverty Eradication. http://www.fao.org/docrep/field/003/ab825f/AB825F00.htm#TOC

Fisk J., Matagi N. and Kleiber D. 2023. Gleaning the expanse: Gender and invisibilised dimensions of fisheries in American Samoa. SPC Women in Fisheries Information Bulletin 37: 7–10. https://purl.org/spc/digilib/doc/vwxrz

Freudenberg P. and Arlinghaus R. 2009. Benefits and constraints of outdoor recreation for people with physical disabilities: Inferences from recreational fishing. Leisure Sciences 32(1):55-71.

Hassan F. and Macanawai S. 2021. Disability Inclusion in the Solomon Islands, Disability Inclusion Helpdesk Research Report No. 72. London, UK: Disability Inclusion Helpdesk.

Hayes G. 2009. Population ageing in the Pacific Islands: a situation analysis. Suva, Fiji: UNFPA Sub-Regional Office.

IASC Task Team on inclusion of Persons with Disabilities in Humanitarian Action 2019. Guidelines: Inclusion of persons with disabilities in humanitarian action. Available at: https://interagencystandingcommittee.org/iasc-guidelines-on-inclusion-of-persons-with-disabilities-in-humanitarian-action-2019

Kenny C. and Tapu-Qiliho F. 2022. Exploring the access to, and experiences of people of diverse sexual orientation and/or gender identity engaged in fisheries: A scoping study. Australian Centre for International Agriculture Research. https://hdl.handle.net/1959.11/56368

Kleiber D., Harris L. M. and Vincent A. C. 2015. Gender and small-scale fisheries: a case for counting women and beyond. Fish and Fisheries 16(4):547-562.

Lawson A. and Beckett A. E. 2021. The social and human rights models of disability: towards a complementarity thesis. The International Journal of Human Rights 25(2):348–379. https://doi.org/10.1080/13642987.2020.1783533

Lindsay R. K., Carmichael C., Allen P. M., Fossey M., Godier-McBard L., Butler L., Trott M., Pardhan S., Tully M.A., Wilson J.J., Torrance A. and Smith L. 2022. Fishing participation, motivators and barriers among UK anglers with disabilities: Opportunities and implications for green social prescribing. International Journal of Environmental Research and Public Health., 19(8):4730.

Mangubhai S. and Lawless S. 2021. Exploring gender inclusion in small-scale fisheries management and development in Melanesia. Marine Policy 123:104287.

Murray M. 2007. 'It's in the blood and you're not going to change it': Fish harvesters' narrative accounts of injuries and disability. Work 28(2):165-174.

Niewohner J., Pierson S., and Meyers S. J. 2020. 'Leave no one behind'? The exclusion of persons with disabilities by development NGOs. Disability & Society 35(7):1171–1176. https://doi.org/10.1080/09687599.2019.1664053

Pacific Framework for Action on Scaling up Community-based Fisheries Management: 2021-2025. Noumea, New Caledonia: Pacific Community. 22 p. https://purl.org/spc/digilib/doc/yr5yv

Pacific Islands Forum Secretariat. 2009. Pacific Regional Strategy on Disability (2010 – 2015). PIFS(09)FDMM.07. https://www.un.org/development/desa/disabilities/wp-content/uploads/sites/15/2019/10/Pacific-Islands-Forum_Pacific-Regional-Strategy-on-Disablility.pdf

Pacific Islands Forum Secretariat. 2009. Pacific Education Development Framework (PEDF) 2009-2015. Fiji: Pacific Islands Forum Secretariat. http://www.paddle.usp.ac.fj/collect/paddle/index/assoc/pifs046.dir/doc.pdf

Pacific Islands Forum Secretariat. 2010. Pacific Framework for the Rights of Persons with Disabilities: 2016 -2025. https://en.unesco.org/inclusivepolicylab/system/files/teams/document/2018/7/Pacific%20Framework%20Rights%20of%20PWD_0_0_0_0_0.pdf

Pacific Islands Forum Secretariat. 2009. Pacific Education Development Framework 2009 – 2015. http://www.paddle.usp.ac.fj/collect/paddle/index/assoc/pifs046.dir/doc.pdf

Pacific Disability Forum (PDF). 2020a. Pacific Disability Forum Covid19 Update: Disability Inclusive Messaging Guidelines. Ref No. COVID-19_PDF_04. https://pacificdisability.org/wp-content/uploads/2021/03/Disability-Inclusive-Messaging-Guideline.pdf

Pacific Disability Forum. 2020b. Pacific Disability Forum Covid19 Update: Human Rights Based Approach Guideline. Ref No. COVID-19_PDF_05. https://pacificdisability.org/wp-content/uploads/2021/03/Human-Rights-Based-Approach-Guideline-to-Disability-Inclusion-in-COVID-19-Response.pdf

Pacific Disability Forum. 2020c. Pacific Disability Forum Covid19 Update: Disability Inclusive Communication Guidelines. Ref No. COVID-19_PDF_07. https://pacificdisability.org/wp-content/uploads/2021/03/Disability-Inclusive-Communication-Guideline.pdf

Pacific Disability Forum. 2020d. Pacific Disability Forum Covid19 Update: guideline on pre-condition to inclusion. Ref No. COVID-19_PDF_08 https://pacificdisability.org/wp-content/uploads/2021/03/Guideline-on-pre-condition-to-inclusion-for-persons-with-disabilities-1.0.pdf

Pacific Disability Forum. 2023. PDF 2023 Conference Discussion Paper. https://pacificdisability.org/wp-content/uploads/2023/04/PDF-2023-Conference-Discussion-Pr_compressed.pdf

Pacific Disability Forum. 2024. Pacific Disability Forum Submission to Australia's International Disability Equity & Rights Strategy. https://pacificdisability.org/wp-content/uploads/2024/01/Pacific-Disability-Forum_IDEARS-Submission_FINAL_Jan-10_2024.pdf

Pacific Disability Forum. "Our work". https://pacificdisability.org/what-we-do/

Pacific Disability Forum (PDF) and Australian Aid (AusAid). 2022. Disability and Climate Change in the Pacific: Findings from Kiribati, Solomon Islands, and Tuvalu. https://pacificdisability.org/wp-content/uploads/2022/08/PDF-Final-Report-on-Climate-Change-and-Persons-with-Disabilities.pdf

The Pacific Disability Forum and the Pacific Islands Forum Secretariat. 2023. 7th Pacific Regional Conference on Disability – Outcome Document. https://pacificdisability.org/wp-content/uploads/2023/04/Final_Outcome-Document_PDF-2023-7PRCD-Conference-Outcome-Statement.pdf

Puamau P. 2007. Inclusive education in the Pacific Chapter 2: Advancing inclusive education in the Pacific. Directions, Journal of Educational Studies, 29(1-2), 17-31.

Rodríguez-Romero B., Pita-Fernández S. and Carballo-Costa L. 2013. Impact of physical and psychosocial factors on disability caused by lumbar pain amongst fishing sector workers. Rheumatology international 33:1769-1778.

Solomon Islands Ministry of Fisheries and Marine Resources. 2019. Solomon Islands National Fisheries Policy 2019–2029: A policy for the conservation, management, development and sustainable use of the fisheries and aquatic resources of Solomon Islands. MFMR, Solomon Islands. https://faolex.fao.org/docs/pdf/sol188935.pdf

Spratt J.M. 2013. A Deeper Silence: The Unheard Experiences of Women with Disabilities and Their Sexual and Reproductive Health Experiences : Kiribati, the Solomon Islands and Tonga. Suva, Fiji : United Nations Population Fund Pacific Sub-Regional Office. https://pacific.unfpa.org/sites/default/files/pub-pdf/UNFPAReport-ADeeperSilenceA4PublicationLR3%283%29.pdf

Syddall V. M., Fisher K. and Thrush S. 2022. What does gender have to do with the price of tuna? Social-ecological systems view of women, gender, and governance in Fiji's tuna fishery. Maritime Studies 21(4):447-463.

Tonga Statistics Department (TSD). 2019. Tonga Disability Survey Report. https://www.unicef.org/pacificislands/reports/tonga-disability-survey-report-2018

UN General Assembly, Convention on the Rights of Persons with Disabilities (UNCRPD): resolution / adopted by the General Assembly, A/RES/61/106, 24 January 2007. https://www.refworld.org/legal/resolution/unga/2007/en/49751

United Nations Children's Fund (UNICEF) Pacific, Kiribati National Statistics Office and Pacific Community. 2017. Disability Monograph: From the 2015 Population and Housing Census. UNICEF, Suva

United Nations. 2016. Leaving No One Behind – The Imperative of Inclusive Development, ST/ESA/362. https://www.refworld.org/reference/annualreport/un/2016/en/114065

United Nations Population Fund, Women Enabled International and Pacific Disability Forum. 2021. Women and young people with disabilities in Samoa: Needs assessment of sexual and reproductive health and rights, gender-based violence, and access to essential services. https://pacificdisability.org/wp-content/uploads/2022/09/pwd_srh-gbv_needs_assessment_samoa.pdf

United Nations Population Fund, Women Enabled International and Pacific Disability Forum. 2022a. Women and young people with disabilities in Vanuatu: Needs assessment of sexual and reproductive health and rights, gender-based violence, and access to essential services. https://pacificdisability.org/wp-content/uploads/2022/09/pwd_srh-gbv_needs_assessment_vanuatu-1.pdf

United Nations Population Fund, Women Enabled International and Pacific Disability Forum. 2022b. Women and young people with disabilities in Fiji: Needs assessment of sexual and reproductive health and rights, gender-based violence, and access to essential services. https://pacificdisability.org/wp-content/uploads/2022/09/pwd_srh-gbv_needs_assessment_fiji.pdf

Vanuatu Department of Fisheries. 2017. Vanuatu National Fisheries Sector Policy 2016—2031 Noumea, New Caledonia: Pacific Community. 52 p. https://purl.org/spc/digilib/doc/8zgjg

Washington Group on Disability Statistics. 2022. The Washington Group Short Set on Functioning (WG-SS). https://www.washingtongroup-disability.com/question-sets/wg-short-set-on-functioning-wg-ss/

World Health Organization (WHO). 2022. Global report on health equity for persons with disabilities. Geneva: World Health Organization. https://www.who.int/publications/i/item/9789240063600

Starter pack for octopus monitoring: An overview of octopus biology, ecology and measurement protocols for fisheries management

Hannah Gilchrist,[1] Indah Rufiati[2] and Epeli Loganimoce[3]

Importance of octopus fisheries in the Pacific

Globally, small-scale octopus fisheries have an estimated landed value of USD 2.3 billion, with a total annual catch of 88,000 tonnes (t) (Willer et al. 2023). In the Pacific, estimates for the production and value of these under-studied fisheries are hard to find, but national studies provide examples emphasising their contribution. For example, an estimated 1,458 t of octopus was landed per year in Samoa between 1950 and 2010, 1,355 t of which was for subsistence (Lingard et al. 2012). In Fiji, 90 t of octopus are reported to be produced every year (FAO 2024) – a quantity that may be below actual catch figures due to the subsistence and unreported nature of many octopus fisheries. And, in American Samoa, *Octopus cyanea* makes up 5% by weight of all species caught for subsistence (Craig et al. 2008; Sauer et al. 2021).

Women play a crucial role in octopus fisheries (Bataille-Benguigui 1988; Pinca et al. 2009; Williams 2015). In Fiji, 78% of women across 11 provinces were found to glean for invertebrates (Thomas et al. 2021) Additionally, in the region, women take part in gleaning more than other fishing activities (Williams 2015). Since women are more active in gleaning for invertebrates than men, any declines in health of invertebrate stocks, including octopus, are likely to disproportionately impact women's livelihoods and their contributions to household income.

Despite the socio-economic contribution of octopus fisheries in the Pacific, knowledge of their stock statuses is limited (Gillett and Tauati 2018; Sauer et al. 2021). In this article, we intend to build understanding of octopus ecology, biology and identification. Furthermore, we outline protocols to measure octopus length, weight, sex, maturity status and age – all of which are variables required to create parameters needed in length-based stock assessments, working towards improved octopus fisheries management in the Pacific.

Octopus classification and distribution

Octopuses belong to the order Octopoda, globally comprising around 300 species. It shares the class Cephalopoda with squids, cuttlefishes, and nautiloids. A review by Loganimoce et al. (2023) reported that 23 species of octopus across 11 genera were documented from the

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Figure 1. Women gleaning for octopus. © Stuart Campbell

Figure 2. *O. cyanea* on sale in Suva, Fiji. Image: © Pauline Bosserelle, SPC.

tropical Pacific (Loganimoce et al. 2023). While not all species are important to fisheries, it is worth noting that some of these species are endemic to the region (Norman et al. 2005).

Octopuses are known to be fished in 19 Pacific Island countries and territories (Smith 1992; Dalzell et al. 1996; Haws 2006; Pasilio et al. 2013; Gillett and Tauati 2018; Gillett and Fong 2023; Loganimoce et al. 2023; FAO 2024), but only nine of these have octopus capture production reported in the FAO Fisheries and Aquaculture Yearbook between 2017 and 2021 (FAO 2024). No information could be found about modern octopus fisheries for Niue and Pitcairn, but there is historical evidence of octopus fishing activities in Niue (Ryan 1981).

Two species are known to be fished for food in the Pacific. The most widely fished species is the big blue or day octopus, *Octopus cyanea*, and to a lesser extent the white-striped or night octopus, *Callistoctopus ornatus* (Table 1; Loganimoce et al. 2023).

Although *Octopus vulgaris* is a commonly fished species in tropical to temperate waters globally (Sauer et al. 2021), it has only one recorded sighting in the Pacific islands (Koshida et al. 1986). Today, *O. vulgaris* is thought to be a species complex made up of at least six different cryptic species (Söller et al. 2000; Leite et al. 2008; Amor et al. 2015; G. Gleadall 2016). Of these six, *Octopus sinensis* and *Octopus tetricus* are found in the wider Pacific; they are also found in the Eastern China Sea (G. Gleadall 2016), and south-eastern Australia/northern New Zealand (Amor et al. 2017) respectively. The presence of species from the *O. vulgaris* complex in the Pacific cannot be ruled out completely as the cryptic nature of these animals leads to misidentification (Taylor et al. 2012).

Identification

Misidentification of octopus species is common (Taylor et al. 2012; Van Nieuwenhove et al. 2019). In the Pacific, octopuses are mostly recorded as *Octopus* sp. in catch records instead of being identified by their species name (Gillett 2010). This is due to challenges/difficulties determining individuals based on soft bodied morphological characteristics. Key differences between *O. cyanea* and *C. ornatus* are summarised in Table 1.

Table 1. Summary of key differences between *O. cyanea* and *C. ornatus* to facilitate their identification (Jereb et al. 2016)

Features	*Octopus cyanea*	*Callistoctopus ornatus*
Lengths of arms relative to mantle	Arms are 4–6 times the length of the mantle	Arms are 6–8 times the length of the mantle
Arms	The lateral arms are the longest	The dorsal arms are the longest (those closest to the eyes)
Patterns/colouration	Varies from uniform white to mottled patterns to uniform dark brown	Red-brown in colour with distinctive white stripes on mantle and paired white spots along arms

Figure 3. Left: *O. cyanea* caught by a fisher in Flores, Indonesia. © Megan Francis, Blue Ventures, 2023; Right: *C. ornatus* at night in Rodrigues. © Philippe Bourjon, 2011

Ecology

Both *O. cyanea* and *C. ornatus* live on shallow, tropical coral reefs, with *O. cyanea* found up to depths of at least 22 m and *C. ornatus* down to around 10 m. Both species are known to be associated with coral rubble and bedrock (Jereb et al. 2016).

O. cyanea is active during the day, with peaks in activity at dawn and dusk (Yarnall 1969), whereas *C. ornatus* is a nocturnal species, mostly encountered hunting on reef flats at night (Jereb et al. 2016). Adult octopuses live and feed on the seabed (Sauer et al. 2021). Their diets are diverse, including crabs, shrimps, fish and other molluscs (Jereb et al. 2016; Scheel et al. 2017).

Life cycle and reproduction

C. ornatus and *O. cyanea* are known to produce planktonic larval hatchlings that are free swimming for one to two months. This reproductive strategy allows ocean currents to carry free swimming larval hatchlings away from where the eggs were initially attached, leading to propagation of a population across vast reef areas (Casu et al. 2002; Murphy et al. 2002; Villanueva and Norman 2008). After this larval stage, both *O. cyanea* and *C. ornatus* settle on the reef flat where they mature. Mature *O. cyanea* females are known to migrate to deeper waters to spawn, where they lay between 150,000 to 700,000 eggs in one clutch (Heukelem 1973; Caverivière 2006). Both *C. ornatus* and *O. cyanea* can lay eggs throughout the year, females die shortly after the eggs hatch (Heukelem 1973; Raberinary and Benbow 2012). Males may mate several times with many females, but their smaller body size puts them at risk of being eaten by the larger females (Hanlon and Forsythe 2008).

Growth and size-at-maturity

Growth rates of octopuses differ between species. *O. cyanea* is reported to grow to a maximum size of between 2 kg and 6.5 kg, and maximum mantle length of up to 160 mm (Heukelem 1973; Herwig et al. 2012; Jereb et al. 2016) - though larger individuals are noted in the literature (Guard and Mgaya 2003; Raberinary and Benbow 2012; Noegroho et al. 2023). *C. ornatus* on the other hand, reaches a maximum size of at least 1 kg and mantle length of 130 mm (Jereb et al. 2016). This range of maximum weights and lengths between just two species highlights the need for species-level identification of octopuses in fisheries monitoring programmes.

Maximum sizes of octopuses differ between places because growth is driven by factors such as temperature (Herwig et al. 2012), food availability (Heukelem 1973) and diet composition (Iraba et al. 2023). For example, in Western Australia, the maximum weight of *O. cyanea* came to ~2 kg (Herwig et al. 2012) whereas in the warmer waters of Tanzania, a male *O. cyanea* specimen was found weighing over 11 kg (Guard and Mgaya 2003). Changes in growth rates also affect the size at which octopuses mature and can start producing offspring to replace the population that die due to fishing or natural causes.

The size at which 50% of animals are mature is denoted as L_{50} when using length, or W_{50} when using weight. This information is important in running stock assessments and can be used to set size limits for fishing. Because of the variability of growth rates and sizes of *O. cyanea,* country specific-parameters are essential for accurate assessments of stock health.

Octopuses can also grow at different rates depending on their sex. For *O. cyanea*, female octopuses tend to grow larger than males and have a greater size at maturity (Herwig et al. 2012; Raberinary and Benbow 2012); in southwest Madagascar, the difference in these sizes between males and females is ~1.5kg (Raberinary and Benbow 2012). Recording the sex of each octopus caught is important because differences in sizes between sexes need to be taken into account when conducting stock assessments, and also in designing fisheries management.

Lifespan

O. cyanea reaches a maximum age of between 12 and 15 months (Heukelem 1973), whereas the lifespan for *C. ornatus* is unknown. Understanding the age of an organism is essential information in age-based stock assessments. This is because it gives us information about how quickly organisms grow, how quickly they mature, and how often they reproduce.

Recent research shows that examining the growth bands in the stylets or the beak of the octopus are the most effective in determining age across different species and life stages (Durante et al. 2024). The stylet is a rudimentary shell found in some species of octopus that is used to support the muscles of the mantle, whereas the beak is the hard mouthpart used to hold and break up prey (Figure 4).

Only one study on the age of *O. cyanea* using stylet increment analysis could be found through literature review (Herwig et al. 2012). These octopuses reached a maximum age of 300 days; with males maturing after 155 days (350 g), and females after 225 days (1350 g). However, this study assumed that growth increments were laid down daily, similar to *Octopus pallidus* (Barratt and Allcock 2010). However, this assumption needs testing, as stylet increment periodicity is 18 hours (0.75 days) for *Octopus berrima* (Durante et al. 2023). Stylet increment and/or beak increment analyses have been conducted on only a few other species i.e. *O. vulgaris, O. huttoni and O. australis* (Durante et al. 2024), but not for *C. ornatus*.

Measurement protocols

Length and weight

Measuring the length and weight of an octopus should be an important part of any fisheries-dependent survey. The mantle length is measured in millimetres from the tip of the mantle to between the eyes (Figure 5). The length of arms is not included in these measurements as they are more variable in length than the mantle.

When using the fisheries monitoring application Ikasavea, artificial intelligence built into the accompanying web platform can automatically take the length of the mantle from a photo if the appropriate measuring tools are used (Figure 6). Alternatively, vernier callipers or a ruler with millimetres work for manual data entry (Figure 7).

When measuring weight, it is best to use a waterproof digital scale set to grams to ensure high precision and accuracy (e.g. Figure 7). Mechanical scales do work (Figure 8) but tend to be prone to human error when reading the values and are less precise than their digital counterparts. When weighing an octopus, it is also important to check if the specimen is damaged (e.g., if it has lost any tentacles or has been gutted). If so, this also needs to be recorded, otherwise an accurate length-weight relationship cannot be established.

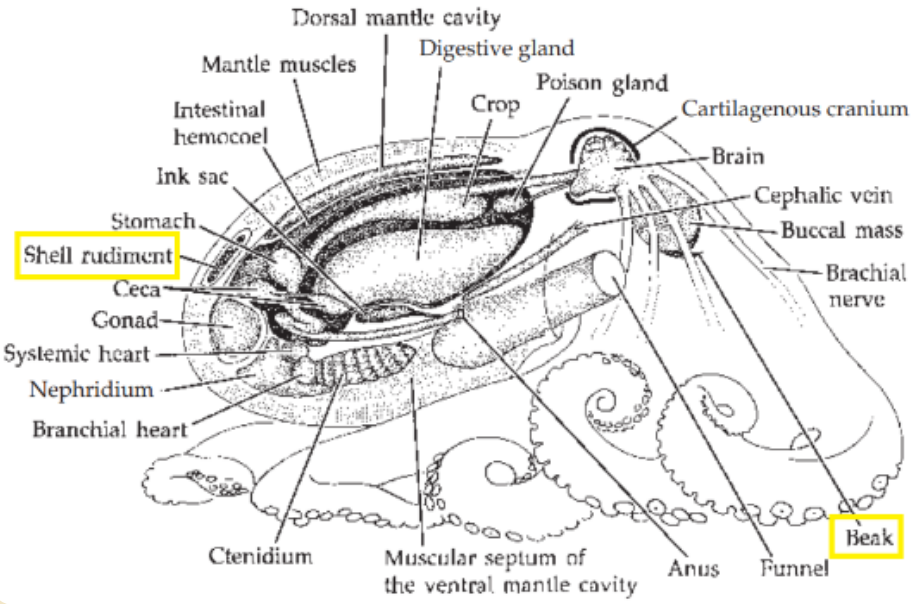

Figure 4. Octopus anatomy, with calcified structures that can be used for ageing highlighted in yellow. The stylet is here referred to as the 'shell rudiment'. Diagram from Brusca et al. (2023).

Sex

There are several features that can be examined to determine the sex of an octopus, looking at external features or the anatomy inside the mantle (Figures 9–11).

External features

With the octopus laid out face up with the tentacles pointing downwards, divide up the tentacles so that from the mid-point between the eyes, there are four on the left and four on the right. The third arm to the left (Figure 9) in males has a white duct (the spermatophoric groove) running laterally along its length, and a rounded end with no suckers (the ligula). This specialised arm is called the hectocotylus and is used to deliver sperm to the female. Female octopuses do not have a hectocotylus tentacle, instead all the tentacles possess the same features, with no duct and pointed tips (Figure 10).

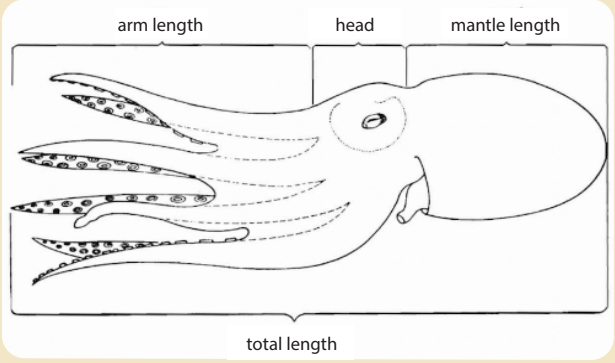

Figure 5. Different measurements of *Octopus cyanea*. Mantle length is the most commonly used length measure for octopus species. Image source: Vecchione et al. 1989.

Internal features

If there is a tentacle missing, or if the sex is unclear based on observation of external morphology, it might be necessary to examine internal features. With the mantle turned inside out, in males one white duct (the vas deferens) can be observed behind the digestive system running down the back of the head, and in females two white to yellow oviducts (Figure 11).

Maturity

The maturity status of the octopus can be understood by observing the gonads. The gonads can be removed carefully from the genital bag (Figure 4) before taking their weight and observing them under a microscope at 100x magnification. In males, maturity tends to correlate with the mass of the gonad, but direct observation of spermatophores is required under a microscope for confirmation (as per Table 2). In females, the weight and external appearance of the gonad can be used to stage the individual. For full methods see Raberinary and Benbow (2012).

Age

The procedure for extracting the stylet includes cutting the ventral side of the mantle below the gills along the long axis of the stylet (Figure 14; stylet is usually visible in the tissue). Remove the right stylet completely, intact, then repeat for the left stylet. The stylets are stored in pairs in 70% ethanol for long-term storage (Figure 14), but based on experience, the stylets will fade after one week, so it is best to examine them as soon as possible after extraction. Each pair of stylets is given a label (sample number) to link the stylet data with the octopus' biological parameter data (i.e. length, weight and maturity status). Make sure there are no repeated

Figure 6.

Top: Octopus on digital scale and measuring board. Mantle length and weight are displayed on scales to be taken from the image using AI integration on SPC's CFAP web platform.
© Sebastien Gislard, SPC

Bottom: Octopus on mat. Length to be taken from the image using AI integration on SPC's CFAP web platform.
© Pauline Bosserelle, SPC

Figure 7. Community monitors conducting data collection in Indonesia. © Meghan Francis, Blue Ventures

Figure 8. Community monitor conducting data collection in Indonesia. © Meghan Francis, Blue Ventures

numbers while labelling the stylets; for example, if there are 295 samples, the labels prepared are numbers 1 to 295 so that each is unique.

Stylet preparation in the laboratory includes taking a pair of stylets from a sample tube and cutting the stylets crosswise, focusing on the area of the stylet shown in Figure 15 (Doubleday et al. 2006; Herwig et al. 2012; Durante et al. 2024). Cutting stylets to a thickness of 1 mm is easier with a cutter than with a razor blade.

The cross-section of the stylet is then placed on a slide and a drop of mineral water is applied over the top. The stylet should be examined under a microscope connected to a camera and laptop screen at 40x magnification (Figure 16). The next step is to take a photo of the stylet and save it on a laptop by naming the file according to the tube label number. Count the number of rings (Figure 17) in each stylet photo using a hand counter and record these in a datasheet. Count the number of rings in the first stylet from the outermost ring to the innermost ring before the nucleus; the second stylet from the same octopus should be observed in the other direction, from the innermost ring after the nucleus, to the outermost ring. The resulting number of rings can then be used to calculate the age of the octopus, with one ring equating to roughly one day (Barratt and Allcock 2010; Herwig et al. 2012)[4].

Counting the two stylets in different ways allows us to validate the count and therefore age estimate; if the percentage difference between the two estimated ages is greater than 10%, these stylets are not used (Leporati et al. 2008). For further analysis, the age estimate from only one stylet from each octopus is used.

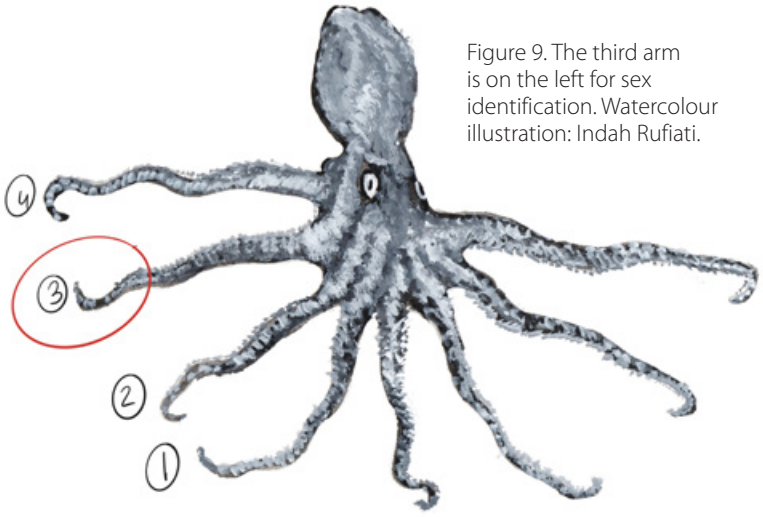

Figure 9. The third arm is on the left for sex identification. Watercolour illustration: Indah Rufiati.

[4] This is based on ageing studies of *O. pallidus*, however studies on the ageing of *O. berrima* indicate that rings on stylets are laid down every 0.75 days (Durante et al. 2023). Research investigating stylet ring periodicity is needed for *O. cyanea*.

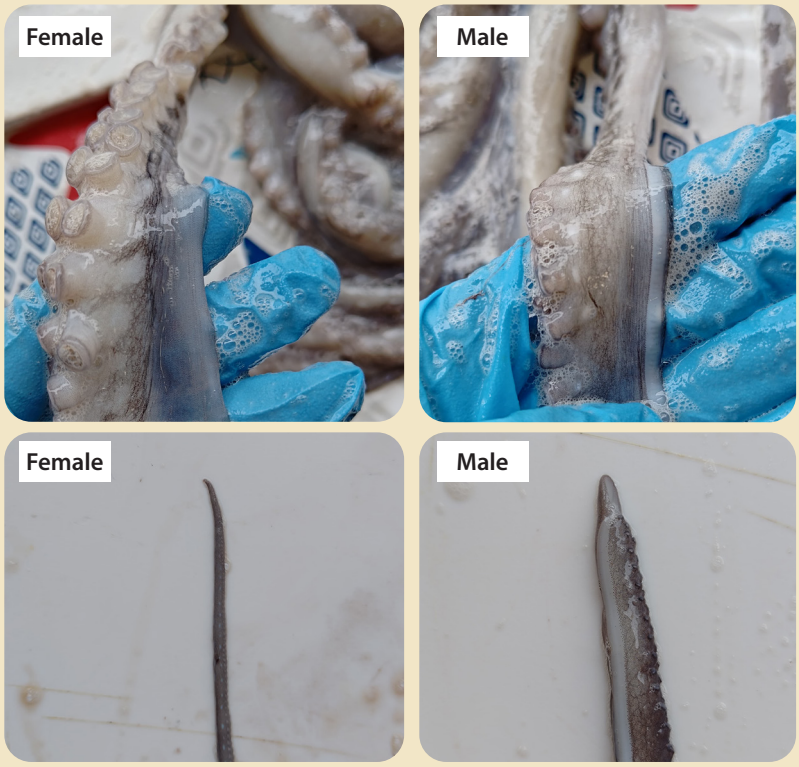

Figure 10. External features used to identify the sex of an octopus. Female features are on the left and male features on the right.
© Hannah Gilchrist, SPC

The male octopus has a white duct running laterally along the third tentacle to the left, whereas the female does not.

The third arm to the left looks like all other arms in females, but in males there is a rounded tip called a ligula.

Figure 11. Inside the mantle the male has one duct running underneath the digestive system (1; left). The female has two ducts instead running from the ovary (2; right). © Blue Ventures

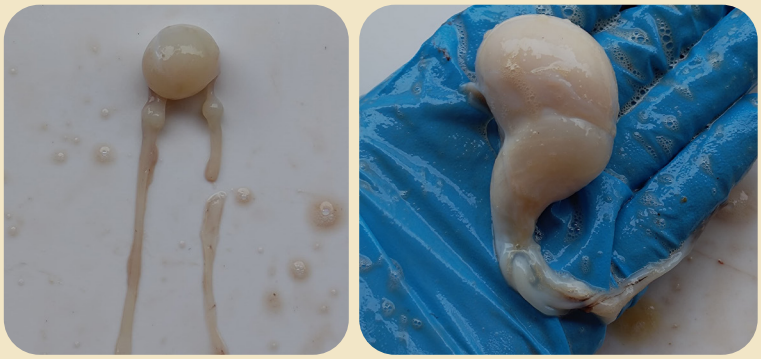

Figure 12. Examples of an ovary (left) and testes (right) of octopus. Based on the gonad size, the ovary is likely to be immature (stage I), and the testes is likely mature (stage III). © Hannah Gilchrist, SPC

Figure 13. Gonads of mature male octopus (left, white) and fully mature female (right, yellowish). © Indah Rufiati, Blue Ventures

Table 2. Gonad mass and appearance to identify the maturity stage of Octopus cyanea (Raberinary and Benbow 2012).

Sex	Maturity stage		Identification	
			Gonad mass	Gonad appearance
Males	I	Immature	<2 g	<8 spermatophores in Needham's complex
	II	Pre-maturation	2–5 g	Spermatophores are disordered and number 8–208
	III	Mature	>5–47 g	Spermatophores arranged in parallel and number 18–687
Females	I	Immature	<3 g	Ovary white
	II	Incipient maturity	3–7 g	Ovary white/pale yellow
	III	Mature	8–80 g	Ovary pale yellow/yellow
	IV	Fully mature	>80 g	Ovary yellow/dark yellow
	V	Post laying	4–16 g	Distended empty ovary

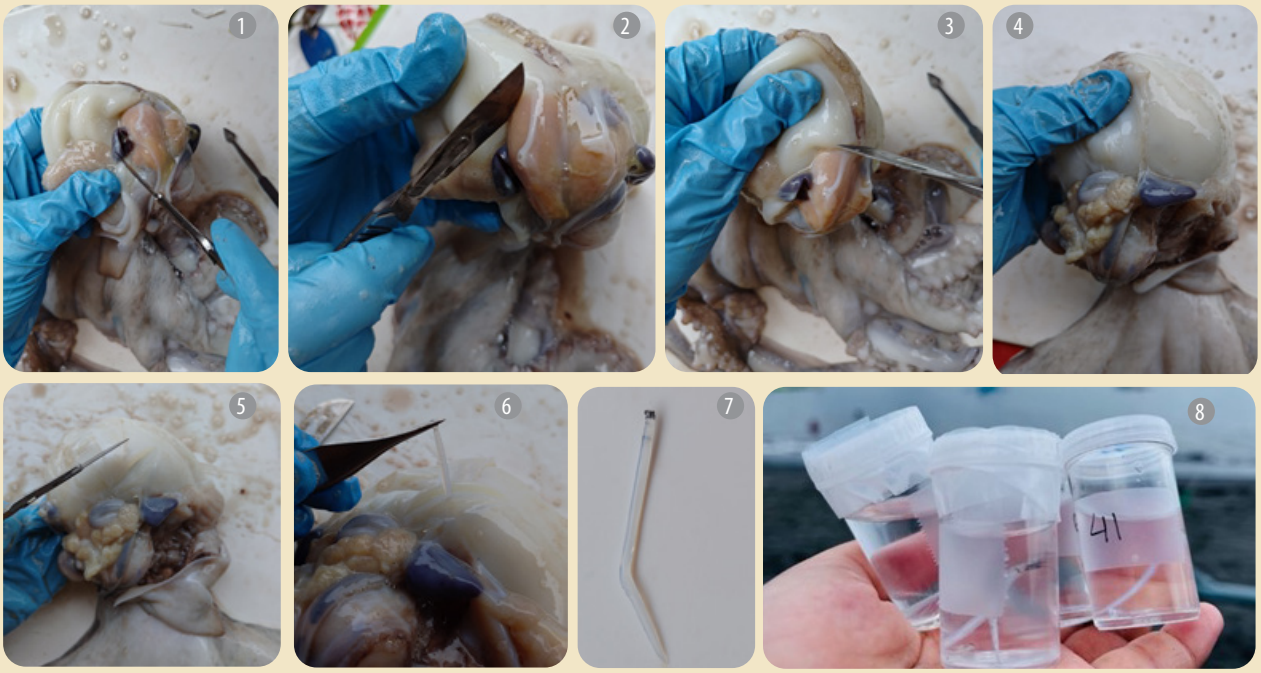

Figure 14. The process of dissecting an octopus to extract the stylet. Images 1–7: © Hannah Gilchrist, SPC, 2024; image 8: © Indah Rufiati, Blue Ventures, 2022

1 The stylets are found behind the brachial hearts, running laterally alongside the ctenidia (gill-like structures) when the mantle is turned inside out. The dark masses in the image here are the brachial hearts.

2 3 Removing some of the organs, including the gonads and digestive system, makes it easier to access the stylet, cut the membrane enclosing these organs and remove them. At this point you could also put the gonads aside for staging.

4 To the side of the brachial heart you will be able to feel a rigid structure running laterally towards the ctenidium. You can push up on this structure from the outside of the mantle to see its outline – this is the stylet.

5 Make a careful incision in the tissue either laterally alongside the stylet, or just above the end of the stylet.

6 Gently remove the stylet with tweezers, being careful not to damage the area around the 'elbow' as this is where the increment analysis will be done (see figure 15)

7 The resulting stylet. There are two in every animal; extract both.

8 Store both stylets from the same animal in 70% ethanol in a labelled sample tube.

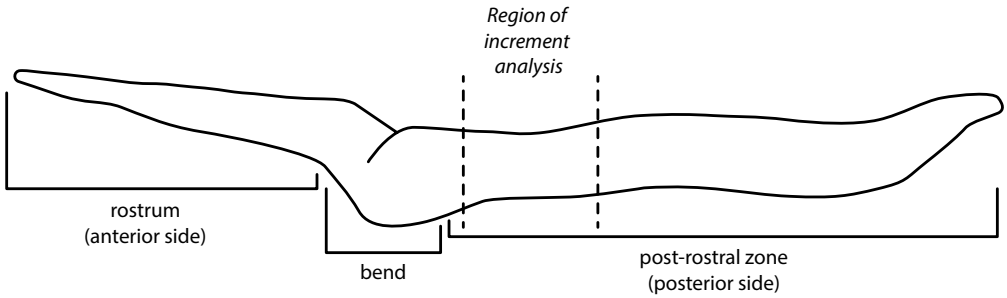

Figure 15. Morphology of stylet. Source: Doubleday et al. 2006

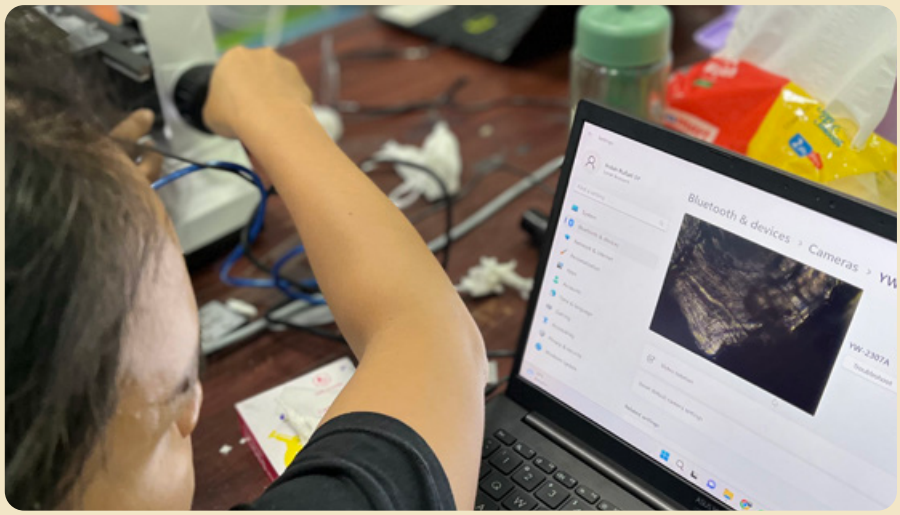

Figure 16. Examining a stylet under a microscope. © Indah Rufiati, Blue Ventures, 2022

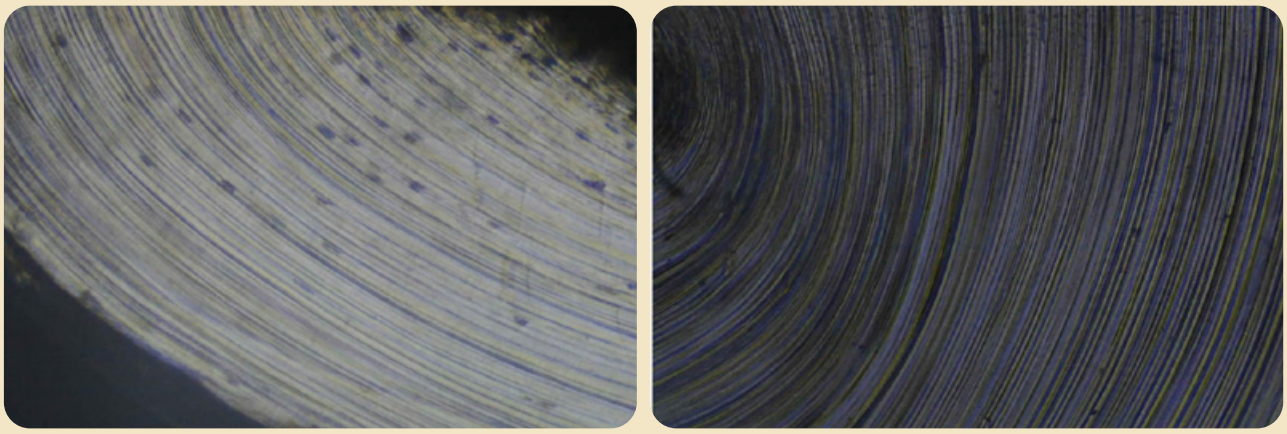

Figure 17. Example of stylet daily rings under a microscope at 40x magnification.
© Blue Ventures in collaboration with the JARI Foundation[5].

[5] https://www.jari-indonesia.org/

Community-based octopus fisheries management; a case study from Indonesia

In Indonesia, octopus fisheries are dominated by small-scale fishers. Many fishing communities rely on octopus fishing as their main livelihood due to its high economic value and accessibility to fishing, which often involves women. Indonesia's small-scale octopus fishers use low-impact fishing gear, such as spears or artificial bait.

Blue Ventures supported local organisations to assist communities in community-based fisheries monitoring and management. Community members are trained to collect catch data, including fishing effort, lengths and weights, and discuss results regularly to understand the state of their fisheries and potential management strategies.

One such management strategy is a temporary closure. When implemented for octopus, this bans fishing for octopus in a specific area or fishing site for a set period. Octopus grow fast so can demonstrate quick returns as a result of fisheries management when at least 20% of fishing grounds are closed to fishing between two and seven months (Oliver et al. 2015). In Indonesia, these quick returns have led to increasing numbers of communities using this approach; from two closures implemented in 2018 to 36 closures implemented in 2023. In total, 133 closures have been implemented to date with Blue Ventures' support (Blue Ventures, unpublished data). Temporary closures also provide a simple learning opportunity for local management bodies and village councils to implement management measures and fisheries governance (Goetze et al. 2018).

[6] https://japesda.or.id/

For example, Blue Ventures works with the organisation Japesda[6] to support a community in Torosiaje, Gorontalo Province in effective fisheries management. Through ongoing octopus fisheries monitoring and regular data feedback sessions, Japesda facilitated the establishment of the Sipakullong fisher group in Torosiaje (March 2022). They conducted a mapping exercise of their fishing grounds and collaborated with a neighbouring village, Torosiaje Jaya, to plan a temporary octopus fishery closure.

The two villages collectively closed 281 hectares of fishing grounds between 8 October 2022, to 9 January 2023 (Figure 18). This was enabled by formal, village-level regulation put in place in September 2022 by Torosiaje Village. A second closure was implemented from 4 November 2023, to 4 May 2024, targeting O. cyanea across 292 hectares of fishing ground in Perairan Lana Bonda, Lana Darat, and Lana Mbok Meo. Although evaluation of the impacts of closures on these octopus fisheries is underway, fishers reported a perceived increase in catch volume.

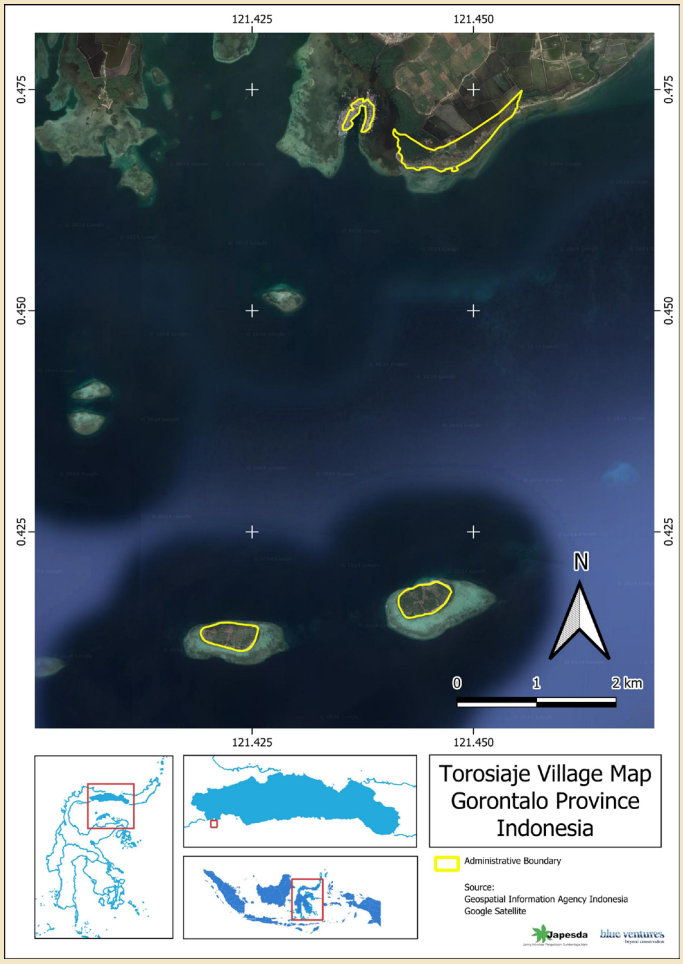

Figure 18. Map of the temporary closure areas put in place by Torosiaje and Torosiaje Jaya villages. © Blue Ventures

Next steps and further research at SPC

Because of the large differences in growth of octopuses across latitudes, building a picture of country-specific octopus' life histories is important. With the support of SPC's data collection tools – Ikasavea and associated Coastal Fisheries web platform – SPC hopes to begin working with Pacific Island countries and territories to build capacity in fisheries-dependent monitoring of octopus catches, learning from organisations such as Blue Ventures, which has experience supporting communities in the monitoring and management of octopus fisheries globally.

In particular, the SPC team hopes to:

- continue to train the AI integration behind Ikasavea to be able to better measure octopus, and ID to species level, if possible;
- build capacity within Pacific Island countries and territories to identify octopus species, and record information to inform understanding of life history parameters;
- partner with Pacific Island countries and territories to undertake in-depth work on octopus maturity and growth rates in the region.

If you are interested in being involved, please reach out to the SPC Coastal Fisheries Science team by contacting : **hannahg@spc.int**

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Bibliography

Amor M.D., Laptikhovsky V., Norman M.D. and Strugnell J.M. 2015. Genetic evidence extends the known distribution of *Octopus insularis* to the mid-Atlantic islands Ascension and St Helena. Journal of the Marine Biological Association of the United Kingdom. 97(4):753–758. https://doi.org/10.1017/S0025315415000958

Amor M.D., Norman M.D., Roura A., Leite T.S., Gleadall I.G., Reid A., Perales-Raya C., Lu C., Silvey C.J., Vidal E.A.G., Hochberg F.G., Zheng X. and Strugnell J.M. 2017. Morphological assessment of the *Octopus vulgaris* species complex evaluated in light of molecular-based phylogenetic inferences. Zoologica Scripta. 46(3). https://doi.org/10.1111/zsc.12207

Barratt I.M. and Allcock A.L. 2010. Ageing octopods from stylets: development of a technique for permanent preparations. ICES Journal of Marine Science. 67(7):1452–1457. https://doi.org/10.1093/icesjms/fsq047

Bataille-Benguigui M. 1988. The fish of Tonga: prey or social partners. Journal of the Polynesian Society. 97(2):185–198.

Brusca R.C., Giribet G. and Moore W. 2023. Invertebrates. Fourth edition. New York: Oxford University Press.

Casu M., Maltagliati F., Meloni M., Casu D., Cossu P., Binelli G., Curini-Galletti M. and Castelli A. 2002. Genetic structure of *Octopus vulgaris* (Mollusca, Cephalopoda) from the Mediterranean Sea as revealed by a microsatellite locus. Italian Journal of Zoology. 69(4):295–300. https://doi.org/10.1080/11250000209356472

Caverivière A. 2006. Principaux traits de vie du poulpe *Octopus cyanea* en zone tropicale. Antananarivo, Madagascar: CNRE, Ministère de l'agriculture, de l'élevage et de la pêche.

Craig P., Green A. and Tuilagi F. 2008. Subsistence harvest of coral reef resources in the outer islands of American Samoa: Modern, historic and prehistoric catches. Fisheries Research. 89(3):230–240. https://doi.org/10.1016/j.fishres.2007.08.018

Dalzell P., Adams T. and Polunin N.V.C. 1996. Coastal Fisheries in the Pacific Islands. Oceanography and Marine Biology. 34:295–531.

Doubleday Z., Semmens J.M., Pecl G. and Jackson G. 2006. Assessing the validity of stylets as ageing tools in *Octopus pallidus*. Journal of Experimental Marine Biology and Ecology. 338(1):35–42. https://doi.org/10.1016/j.jembe.2006.06.027

Durante E.D., Grammer G.L., Martino J.C., Payne J.L. and Doubleday Z.A. 2023 Dec 1. Nondaily growth increments in the commercial species, *Octopus berrima*, and the importance of age validation. Arkhipkin A., editor. ICES Journal of Marine Science. https://doi.org/10.1093/icesjms/fsad188

Durante E.D., Hosking L., Hall K. and Doubleday Z.A. 2024. A step-by-step guide to ageing octopus. Finlayson M., editor. Marine and Freshwater Research. 75(6). https://doi.org/10.1071/MF23159

Food and Agriculture Organization of the United Nations (FAO). 2024. Fishery and Aquaculture Statistics – Yearbook 2021. FAO.

Gleadall I. G. 2016. *Octopus sinensis* d'Orbigny, 1841 (Cephalopoda: Octopodidae): Valid Species Name for the Commercially Valuable East Asian Common Octopus. Species Diversity. 21(1):31–42. https://doi.org/10.12782/sd.21.1.031

Gillett R. 2010. Marine fishery resources of the Pacific Islands. Rome: Food and Agriculture Organization of the United Nations (FAO fisheries and aquaculture technical paper).

Gillett R. and Fong M. 2023. Fisheries in the economies of Pacific Island countries and territories (Benefish Study 4). 4th ed. Noumea, New Caledonia: Pacific Community. https://purl.org/spc/digilib/doc/ppizh

Gillett R.D. and Tauati M.I. 2018. Fisheries of the Pacific islands: regional and national information. Apia: Food and Agriculture Organization of the United Nations.

Goetze J.S., Claudet J., Januchowski-Hartley F., Langlois T.J., Wilson S.K., White C., Weeks R. and Jupiter S.D. 2018. Demonstrating multiple benefits from periodically harvested fisheries closures. Trenkel V, editor. Journal of Applied Ecology. 55(3):1102–1113. https://doi.org/10.1111/1365-2664.13047

Guard M. and Mgaya Y.D. 2003. The Artisanal Fishery for *Octopus cyanea* Gray in Tanzania. AMBIO: A Journal of the Human Environment. 31(7):528–536. https://doi.org/10.1579/0044-7447-31.7.528

Hanlon R.T. and Forsythe J.W. 2008. Sexual cannibalism by *Octopus cyanea* on a Pacific coral reef. Marine and Freshwater Behaviour and Physiology. 41(1):19–28. https://doi.org/10.1080/10236240701661123

Haws M. 2006. Natural resources management needs for coastal and littoral marine ecosystems of the U.S. afficiliated Pacific Islands: American Samoa, Guam, Commonwealth of the Northern Marianas Islands, Republic of the Marshall Islands, Federated States of Micronesia and the Republic of Palau. Hawaii: University of Hawaii.

Herwig J.N., Depczynski M., Roberts J.D., Semmens J.M., Gagliano M. and Heyward A.J. 2012. Using Age-Based Life History Data to Investigate the Life Cycle and Vulnerability of *Octopus cyanea*. Ferse SCA, editor. PLoS ONE. 7(8):e43679. https://doi.org/10.1371/journal.pone.0043679

Heukelem W.V. 1973. Growth and life- span of *Octopus cyanea* (Mollusca: Cephalopoda)*. Journal of Zoology. 169(3):299–315. https://doi.org/10.1111/j.1469-7998.1973.tb04559.x

Iraba N., Yahya S., Mang'ena J. and Malesa F. 2023. Comparison of growth and survival rates of big blue octopus (*Octopus cyanea*, 1849) fed on natural and formulated diets in captivity. Western Indian Ocean Journal of Marine Science. 22(1):47–55. https://doi.org/10.4314/wiojms.v22i1.5

Jereb P., Roper C.F.E., Norman M.D., Finn J.K., and FAO, editors. 2016. Octopods and vampire squids. Entirely rewritten, revised and updated version. Rome: Food and Agriculture Organization of the United Nations (Cephalopods of the world / edited by Jereb P. and Roper C.F.E.).

Koshida Y., Horiuchi S., Tajika K. and Raj U. 1986. Detection of dicyemid mesozoans in Nautilus pompilius and in *Octopus vulgaris* from Fiji: taxonomy and systematics. Zoological Society of Japan. 3(6):1108.

Leite T.S., Haimovici M., Molina W. and Warnke K. 2008. Morphological and genetic description of *Octopus insularis*, a new cryptic species in the *Octopus vulgaris* complex (Cephalopoda: Octopodidae) from the tropical southwestern Atlantic. Journal of Molluscan Studies. 74(1):63–74. https://doi.org/10.1093/mollus/eym050

Leporati S., Semmens J. and Pecl G. 2008. Determining the age and growth of wild octopus using stylet increment analysis. Marine Ecology Progress Series. 367:213–222. https://doi.org/10.3354/meps07558

Lingard S., Harper S. and Zeller D. 2012. Reconstructed catches of Samoa 1950-2010. In: Fisheries catch reconstructions: Islands, Part III. Vancouver: Fisheries Centre, University of British Columbia. (Fisheries Centre Research Reports). p. 103–118.

Loganimoce E.M., Brown K.T., Savou R., Kitolelei J.V., Tukana M., Southgate P.C. and Lal M.M. 2023. Octopuses in the south-west Pacific region: a review of fisheries, ecology, cultural importance and management. Reviews in Fish Biology and Fisheries. 33(4):977–1003. https://doi.org/10.1007/s11160-023-09772-9

Murphy J.M., Balguerias E., Key L.N. and Boyle P.R. 2002. Microsatellite DNA markers discriminate between two *Octopus vulgaris* (Cephalopoda: Octopoda) fisheries along the northwest African coast. Bulletin of Marine Science. 71(1):545–553.

Noegroho T., Kembaren D.D., Nurdin E., Panggabean A.S., Taufik M., Fauzi M. and Wibowo S. 2023. Characteristics of octopus fishery in Ampana Tojo Una-Una Sea waters. IOP Conference Series: Earth and Environmental Science. 1224(1):012010. https://doi.org/10.1088/1755-1315/1224/1/012010

Norman M.D., Hochberg F.G. and Boucher-Rodoni R. 2005. A revision of the deep-water octopus genus *Scaeurgus* (Cephalopoda: Octopodidae) with description of three new species from the southwest Pacific Ocean. Journal of Molluscan Studies. 71(4):319–337. https://doi.org/10.1093/mollus/eyi033

Oliver T.A., Oleson K.L.L., Ratsimbazafy H., Raberinary D., Benbow S. and Harris A. 2015. Positive Catch and Economic Benefits of Periodic Octopus Fishery Closures: Do Effective, Narrowly Targeted Actions 'Catalyze' Broader Management? Higgs DM, editor. PLOS ONE. 10(6):e0129075. https://doi.org/10.1371/journal.pone.0129075

Pasilio T., Pereira F., Rikim K., Pakoa K. and Bertram I. 2013. The status of reef invertebrate resources and recommendations for management at Tokelau. Noumea, New Caledonia: Pacific Community. https://purl.org/spc/digilib/doc/enatm

Pinca S., Tardy E., Pakoa K., Boblin P., Friedman K.J., Vunisea A., Lasi F., Magron F., Chapman L.B. and Kronen M. 2009. Marshall Islands country report: Profiles and results from survey work at Likiep, Ailuk, Arno and Laura (August and September 2007). Noumea, New Caledonia: Pacific Community. https://purl.org/spc/digilib/doc/nxmcu

Raberinary D. and Benbow S. 2012. The reproductive cycle of *Octopus cyanea* in southwest Madagascar and implications for fisheries management. Fisheries Research. 125–126:190–197. https://doi.org/10.1016/j.fishres.2012.02.025

Ryan T. 1981. Fishing in transition on Niue. Journal de la Société des Océanistes. 72–73:193–203.

Sauer W.H.H., Gleadall I.G., Downey-Breedt N., Doubleday Z., Gillespie G., Haimovici M., Ibáñez C.M., Katugin O.N., Leporati S., Lipinski M.R., Markaida U., Ramos J.E., Rosa R., Villanueva R., Arguelles J., Briceño F.A., Carrasco S.A., Che L.J., Chen C.-S., Cisneros R., Conners E., Crespi-Abril A.C., Kulik V.V., Drobyazin E.N., Emery T., Fernández-Álvarez F.A., Furuya H., González L.W., Gough C., Krishnan P., Kumar B., Leite T., Lu C.-C., Mohamed K.S., Nabhitabhata J., Noro K., Petchkamnerd J., Putra D., Rocliffe S., Sajikumar K.K., Sakaguchi H., Samuel D., Sasikumar G., Wada T., Zheng X., Tian Y., Pang Y., Yamrungrueng A. and Pecl G. 2021. World Octopus Fisheries. Reviews in Fisheries Science and Aquaculture. 29(3):279–429. https://doi.org/10.1080/23308249.2019.1680603

Scheel D., Leite T., Mather J. and Langford K. 2017. Diversity in the diet of the predator *Octopus cyanea* in the coral reef system of Moorea, French Polynesia. Journal of Natural History. 51(43–44):2615–2633. https://doi.org/10.1080/00222933.2016.1244298

Smith A.J. 1992. Federated States of Micronesia Marine Resources Profiles. Australia: FFA Report No.: FFA report 92/17.

Söller R., Warnke K., Saint-Paul U. and Blohm D. 2000. Sequence divergence of mitochondrial DNA indicates cryptic biodiversity in *Octopus vulgaris* and supports the taxonomic distinctiveness of *Octopus mimus* (Cephalopoda: Octopodidae). Marine Biology. 136(1):29–35. https://doi.org/10.1007/s002270050004

Taylor A.L., McKeown N.J. and Shaw P.W. 2012. Molecular identification of three co-occurring and easily misidentified octopus species using PCR–RFLP techniques. Conservation Genetics Resources. 4(4):885–887. https://doi.org/10.1007/s12686-012-9665-y

Thomas A., Mangubhai S., Fox M., Meo S., Miller K., Naisilisili W., Veitayaki J. and Waqairatu S. 2021. Why they must be counted: Significant contributions of Fijian women fishers to food security and livelihoods. Ocean and Coastal Management. 205:105571. https://doi.org/10.1016/j.ocecoaman.2021.105571

Van Nieuwenhove A.H.M., Ratsimbazafy H.A. and Kochzius M. 2019. Cryptic diversity and limited connectivity in octopuses: Recommendations for fisheries management. Bernardi G., editor. PLOS ONE. 14(5):e0214748. https://doi.org/10.1371/journal.pone.0214748

Vecchione M., Roper C.F.E. and Sweeney M.J. 1989. Marine Flora and Fauna of the Eastern United States Mollusca: Cephalopoda. US Department of Commerce Report No.: NOAA Technical Report NMFS 73.

Villanueva R. and Norman M.D. 2008. Biology of the planktonic stages of benthic octopuses. In: Oceanography and Marine Biology. 1st ed. CRC Press. p. 98.

Willer D.F., Aldridge D.C., Gough C. and Kincaid K. 2023. Small-scale octopus fishery operations enable environmentally and socioeconomically sustainable sourcing of nutrients under climate change. Nature Food. 4(2):179–189. https://doi.org/10.1038/s43016-022-00687-5

Williams M.J. 2015. Pacific invertebrate fisheries and gender - Key results from PROCFish. SPC Women in Fisheries Information Bulletin. 26. https://purl.org/spc/digilib/doc/hz4bo

Yarnall J.L. 1969. Aspects of the behaviour of *Octopus cyanea* Gray. Animal Behaviour. 17(4):747–754. https://doi.org/10.1016/S0003-3472(69)80022-9

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