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Developing a Pacific Community Marine Specimen Bank

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Introduction

The Pacific Community (SPC) is attempting to establish a regional specimen bank for marine flora and fauna. Specimen bank samples can provide critical information to support natural resource management (e.g. the age and growth rate of fish as a key input to stock assessments, genetic analyses for stock structure). Maintained over the long term, historical samples can be compared with recent samples to understand important changes in key biological processes over time (e.g. increased methylmercury levels in fish due to climate change).

Establishing a regional specimen bank would be a significant and strategic science capacity and capability initiative. In principle, the concept of a specimen bank has received support within SPC and some key potential institutional partners in New Zealand and Australia. Meeting participants at the 10th SPC Heads of Fisheries Meeting also expressed strong support for the proposal. The next step is to use seed funding provided by New Zealand to fully explore the business case, and outline a plan for operationalising a Pacific Community Marine Specimen Bank.

This article briefly outlines the idea behind a regional Pacific Community Marine Specimen Bank, highlights the drivers for a regional bank and the benefits that could be derived from it, and outlines the next steps in developing the proposition into a full-scale proposal.

What is a specimen bank?

A specimen bank is a safe repository for biological samples (e.g. fish muscle tissue, otoliths). At its simplest, a specimen bank could be a chest freezer with some fish stomachs, or some otoliths in an envelope on a desk. A fully functioning and effective tissue bank, however, is much more (see Fig. 1). Specimens are collected in a strategic manner and cover a full range of tissue samples, including whole voucher specimens.[7] Collected specimens are identified as part of the

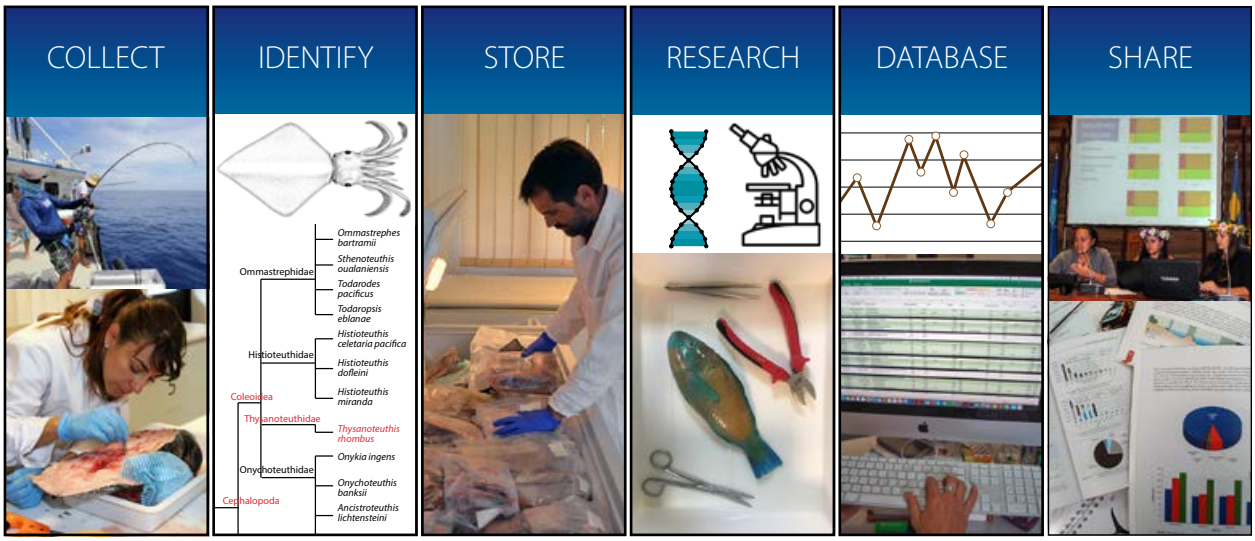

Figure 1: The role of a regional marine specimen bank (adapted from Nelson et al. 2015) (images: Jipé Le-Bars, Beth Vanden Heuvel, Elodie Vourey, Brad Moore, Stephen Brouwer and Laymik from the Noun Project).

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[7] A voucher specimen is a representative specimen of a plant of animal stored for long-term reference. A common example is a whole specimen collected during a research voyage. Voucher specimens are used to confirm species identity in future studies, and as such, provide for quality assurance of species identification over time.

curation process. Once identified, tissue samples are stored in a manner appropriate for the tissue type, and in a way that keeps them useful for as long as possible. Figure 1 shows that research occurs at this point, although the reality is that in many cases, there is research at each step of the process. For instance, data analysis to determine where to sample and when, taxonomic research to identify new species or previously undescribed life stages, and exploring techniques to store specimens and techniques to extend the storage life of specimens. The advantage of properly curated specimens in a tissue bank at this research stage is that they can then be withdrawn from the bank now or at some point in future – in part or in whole – for additional high-value science. Just like research, data are a dynamic part of a specimen bank, with details of a sample collection entered into relational databases, and those samples tracked through identification, storage and research, so that for any sample at any given time, the origin, place of storage, and what has been learned from it are known. Sharing the results of the research is critical, as is making transparent what specimens are held so that other researchers can borrow specimens to conduct relevant science. One way to synthesise all of this is through a specimen bank, which can be thought of as a living learning science system built on the collection and study of biological samples.

The concept

A Pacific Community Marine Specimen Bank would be unique because it would be Pacific Islands owned and operated. While other specimen banks exist, including those containing specimens from the Pacific, what is different about this bank is that it will be located in the Pacific and will form a regional asset where the bank's "biological capital" will be used to invest in the people of the region for a sustainable return on investment. It also has the advantage of providing biological capital insurance for regional partners.

In this context, a tissue bank would include the ability to curate and store a broad range of samples over long periods of time (decades rather than years). Importantly, it would include the associated science resources to analyse and interpret specimens and would act as a teaching facility in building regional capacity. Such a bank would need to take full account of the cultural heritage aspects of collecting, storing, accessing and using specimens.

A Pacific Community Marine Specimen Bank fits with SPC's strategic priorities in that it would provide biological information and knowledge to contribute to increasing economic and food security benefits from sustainable fisheries in the region. There is also potential for such a specimen bank to contribute to and facilitate benefit-sharing among Pacific Island countries and territories arising from the use of marine genetic resources as part of negotiations on biological diversity beyond national jurisdiction / United Nations Convention on the Law of the Sea. It will also improve regional capability and the availability of information to monitor, mitigate and adapt to the environmental impacts of climate change. Further, through careful design and the use of modular "green" freezer technology,[8] the bank will advance the use of renewable energy technologies in the Pacific, a key regional need.

It is, therefore, anticipated that a Pacific Community Marine Specimen Bank will have the capacity to make significant impacts in the region, both in the short term, and in the coming decades by building preparedness for the scientific challenges to come, such as food security and resilience to climate change. Specifically, this will occur through preserving and conserving biodiversity, developing regional solutions to ecosystem-scale challenges, building the capacity of Pacific Island scientists, increasing the scientific basis for climate change adaptation and resilience, supporting enhanced food security and nutrition, providing leadership at the interface between science and cultural heritage, and thinking about the finances of climate and biodiversity.

Drivers for a Pacific Community Marine Specimen Bank

Lessons learned, often the hard way, from other specimen banks at the fringes of the region will need to be carefully considered. Developing expertise in cultural heritage in the region will be drawn on to support the bank's design.

SPC currently operates the Western and Central Pacific Fisheries Commission (WCPFC) Tuna Tissue Bank (TTB), which has been funded by WCPFC since 2015. Since 2001, SPC's Oceanic Fisheries Programme has been coordinating the collection of biological samples of pelagic species from across the Pacific. The current TTB is the result of collaboration between SPC and its member countries, the Commonwealth Scientific and Industrial Research Organisation, WCPFC, University of Hawai'i, National Research Institute of Far Seas Fisheries, and the French Institute for Research and Development.

The notion of a Pacific Community Marine Specimen Bank evolved from the successful WCPFC TTB that now has ongoing operational funding from WCPFC. The funding is used to maintain the WCPFC TTB, which has a particular emphasis on tissue samples of bigeye, yellowfin, albacore and skipjack tunas, and swordfish, and which facilitates the transmission of samples to specified researchers using the access protocols of WCPFC TTB. SPC, as the Scientific Services Provider for WCPFC, is tasked with enhancing and maintaining the WCPFC TTB and, through the biological sampling programme, expanding the inventory of samples held.

[8] Green in this context means using renewable energy sources, to the greatest extent practical, by utilising recycled goods in manufacturing, and using freezing technology that will minimise and/or eliminate future damage to the environment.

The operation of the WCPFC TTB has included the development of standards for training observers in biological sampling (Pacific Islands Regional Fisheries Observer), and the ongoing training of observers across the region in biological sampling data recording, sample handling, and transportation. A web-based tool has been implemented to allow WCPFC members to track the collection of samples. It includes interactive maps where the user can obtain information on the number, type, species and length classes of samples collected from particular exclusive economic zones and high seas areas (Smith et al. 2016).[9]

The current WCPFC tissue bank, however, is tuna-focused, as well as curation- and storage-focused, and the current method of storage for many tissue types does not ensure their longevity. In 2016, WCPFC was informed of the need to design and seek funding for a strategic investment in a super-cold storage facility that would ensure the longevity and relevance of the WCPFC TTB (Smith et al. 2016).

Subsequent relevant developments in 2016 included the rapid and substantive expansion of the collection of a range of non-tuna specimens from across the Pacific for ecosystem monitoring purposes (Allain and Vourey 2017), and the recognition of the need for a similar facility for coastal fisheries science. Participants at the 10th SPC Heads of Fisheries Meeting identified many current and pressing science questions that a Pacific Community Marine Specimen Bank could and should address. The bank seeks to avoid short-term-only considerations by looking well beyond the coming decade in terms of preparedness for the scientific challenges to come. This proposal seeks to bring together several critical threads for preparedness in a centre of scientific excellence: preserving and conserving biodiversity; providing regional solutions to ecosystem-scale challenges; building capacity of Pacific scientists; recognising, respecting, preserving, managing, curating, storing and disseminating information on cultural heritage; developing climate change adaptation and resilience approaches, especially those pertaining to food security; and, public health outcomes.

Case study I: Success with the current Tuna Tissue Bank

As a case study, we briefly consider bigeye tuna age and growth. This research used specimens from the WCPFC TTB and was in collaboration with the Commonwealth Scientific and Industrial Research Organisation in Australia. The team set out to determine at what length and age bigeye tuna reach sexual maturity, the age of bigeye tuna at a particular length, whether there were any sex-specific differences in growth rates, and whether patterns in these data were similar across the Pacific. The study found that approximately 50% of the bigeye population (males and females) reach sexual maturity at a fork length of about 105 cm (Fig. 2), when the fish are approximately three years old. The maximum recorded ages in this study were around 14 years, and there did not appear to be sex-specific differences in growth rates (Fig. 3). Apart from a cluster of larger fish in the east, there did not appear to be clear differences in growth at the regional scale. The value of the WCPFC TTB bank in this case was that a large number of samples were available from a scale comparable to the fishery so as to make the results immediately applicable to stock assessments; in fact, these data are currently being used for the 2017 bigeye tuna stock assessment.

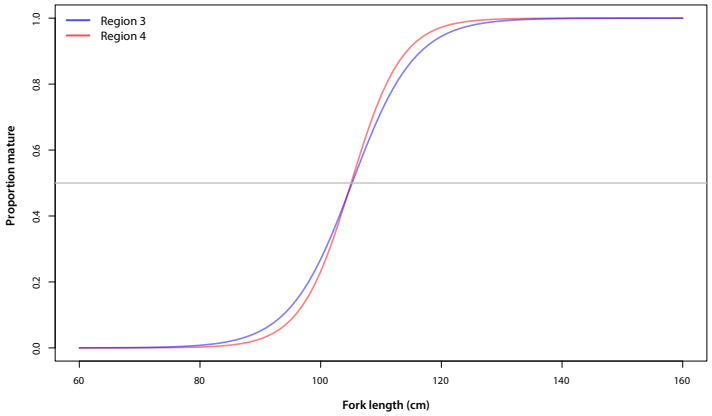

Figure 2. Maturity ogive for bigeye tuna at length in the western and central Pacific Ocean (prepared from data reported by Farley et al. 2017).

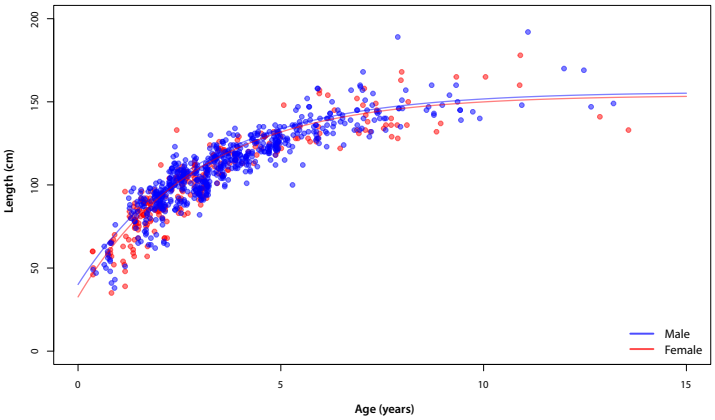

Figure 3. Age of bigeye tuna at length for males (blue diamonds) and females (pink circles) in the western and central Pacific Ocean (prepared from data reported by Farley et al. 2017).

Case study II: Why spatial and temporal coverage are critical

This case study highlights the potential public health benefits of having an active specimen bank. The study is ongoing, and the associated PhD student looking at one component of the methylmercury problem has just finished in April 2017 (Houssard 2017). The first results demonstrate the

[9] See: www.spc.int/tagging/webtagging/BioDaSys

complexity of the problem of methylmercury bioaccumulation in tuna.

Some studies from other oceans suggest that the average methylmercury content in yellowfin tuna has increased over time. This creates a public health perspective that yellowfin tuna is now a riskier food source than it used to be, or maybe even too risky. This in turn poses several questions that science – if we have the samples – may be able to answer. For example, is the increase in methylmercury content in yellowfin really occurring? And if so, why? Is this a new issue? Is it common across all tuna species? Does this also occur in the Pacific? If so, does it impact all of the Pacific islands in the same way?

By using samples from the existing tissue bank and integrating data from other studies these questions have been investigated at the regional scale. Yes, bioaccumulation of mercury in yellowfin tuna does occur in the Pacific, and increasingly so in larger fish. Yes, there are subregional variations in where this occurs, with increasing levels of methylmercury generally detected in fish with increasing southerly latitude (e.g. there is a latitudinal gradient in the rate of bioaccumulation). However, if fish size and sampling location biases are accounted for, and we compare trends over 15 years, there is no change in the rate of bioaccumulation of methylmercury in yellowfin tuna in the western Pacific (Fig. 4).

The spatial and temporal extent of the existing modest tuna specimen bank provided a unique tool to examine methylmercury levels in yellowfin tuna at the regional level and over a decade. The annual sampling allowed inter-annual effects to be separated from decadal shifts in the ecosystem. Moreover, the regional scale of samples analysed allowed the identification of factors (such as a fish length effect, and a location effect) that would not have been detected from more limited-scale, national-level studies, and which could have led to false conclusions. A more comprehensive set of samples collected over time will allow not only further research on methylmercury bioaccumulation in tuna, but also analysis on potential harmful and helpful chemical properties of fish on an ecosystem-wide scale.

Benefits of a Pacific Community Marine Specimen Bank

The assumed benefits of this regional strategic science asset are many, and include: 1) enhanced science capacity and capability; 2) new economic opportunities; 3) heightened biosecurity; 4) enriched human health; 5) improved biodiversity conservation; 6) better sustainable use; 7) increased global relevance and international leverage; 8) deepened awareness of and support for Pacific Island culture and identity; and 9) greater scientific credibility and quality assurance. A critical benefit of any specimen bank is that once it is established, key scientific studies can begin immediately without having to await additional fieldwork – potentially over many years – before adequate specimens are available.

A practical and hypothetical, oceanic example of the value of a Pacific Community Marine Specimen Bank may include the following:

- Tuna tissue samples collected, curated and analysed through the Pacific Community Marine Specimen Bank in 2018 will allow a Pacific Island student to complete their PhD in 2021, and subsequently obtain a job lecturing at the University of the Pacific, with their students using samples from the bank to study for their Master of Science degrees in 2022;
- The student's PhD results show that magnesium levels in tuna drop below those required for good human health with sea surface temperatures 1°C above current, and, as a result, magnesium substitution public health guidelines are implemented in the affected member countries and territories; and

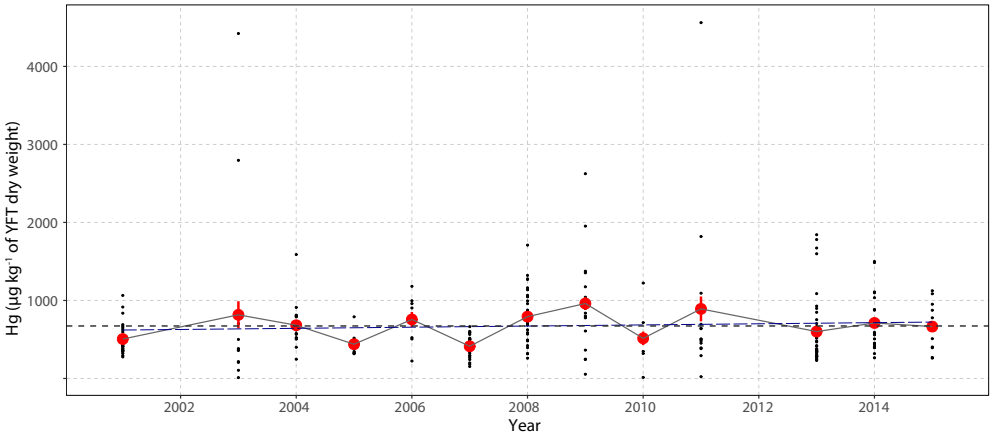

Figure 4. Temporal variation of the methylmercury concentration (µg kg^{-1} of dry weight) of yellowfin tuna (YFT) collected around New Caledonia and Fiji. Red circles represent average annual values, small black dots indicate individual values, and the horizontal dashed line indicates the trend of the time series, which is flat, demonstrating that there has been no change in methylmercury accumulation over time. Source: Receveur et al. in prep.

- The magnesium health supplements that are sensitive to temperatures above 20°C are able to be stored long term in a carbon-neutral modular cold store designed from the technology developed in step one of the project.

Similarly, a practical and hypothetical, coastal example of a Pacific Community Marine Specimen Bank may include the following:

- Sea cucumber tissue samples collected, curated and analysed through the Pacific Community Marine Specimen Bank see a regional agreed on taxonomy and associated identification guides;
- With codified names, market labelling requirements are able to be met and trade barriers reduced; and
- With advanced genetic techniques, traceability to a specific exclusive economic zone (EEZ) (or smaller scale) can be established, and as a result, illegal fishers from outside the region are able to be prosecuted for harvesting inside members' EEZs.

Next steps

Despite these anticipated benefits, the nature and scale of investment required to establish a Pacific Community Marine Specimen Bank requires a comprehensive analysis of the business case and implementation arrangements to operationalise the concept in order for it to maximise benefits for the region, both now and into the future.

Seed funding has been sought and successfully obtained to fund a project to undertake the necessary research and analysis to develop a business case for a Pacific Community Marine Specimen Bank, including a proposed model for how the bank could be operationalised in partnership with regional institutions. The business case will also explore and further define the scope of biological samples to be deposited in the bank, including species selection, sample types and storage procedures.

The business case will be designed for a Pacific Community Marine Specimen Bank that would serve the region to achieve the following:

- Provide a regional strategic science asset, a storage facility to house biological specimens over the long term and the supporting infrastructure to conduct associated scientific research;
- Significantly enhance the collection of a full range of relevant biological specimens of marine flora and fauna from across the region to ensure the bank has an ecosystem baseline, and the potential to monitor the impacts of future ecosystem changes;
- Curate, identify and analyse biological specimens in the bank across the full range of biological, physical, genetic and public health traits, and to store that information securely for future generations, taking into account cultural heritage;
- Integrate data from the bank with data from other information sources – fisheries, remote sensing, and climate science – to investigate relationships and potential impacts of climate change on the ecosystem, including with and without harvesting, to provide scientific knowledge products for biodiversity conservation;
- Use the Pacific Community Marine Specimen Bank platform to educate a new generation of Pacific Island scientists to serve the region into the future; and
- Identify and develop reciprocal capacity sharing and biological insurance for institutional partners across the region.

This business case development project will get underway in June 2017, and a report to the New Zealand government is due in mid-2018. At that time, an assessment about whether to find a suitable donor, or rethink the proposal, will be made. Through the *Fisheries Newsletter*, meetings and media, SPC will keep interested parties updated on the establishment of a Pacific Community Marine Specimen Bank.

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