A carefully protected treasure: the Pacific Marine Specimen Bank

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The treasure the Pacific Community (SPC) is accumulating at its headquarters is not precious stones and gold, but rather a wealth of science and knowledge that is constantly being expanded through the work of the Pacific Marine Specimen Bank (PMSB).

The PMSB is managed by SPC's Oceanic Fisheries Programme, which produces annual tuna stock assessments that enable the countries and territories of the western and central Pacific Ocean to determine sustainable management measures for their tuna resources. SPC's Fishery and Ecosystem Monitoring and Analysis (FEMA) Section contributes to this work by providing scientific knowledge on the biology of various tuna and tuna-associated species. The acquisition of this knowledge includes the collection and analysis of biological samples, which form PMSB. What was initially no more than a repository of specimens collected in an opportunistic manner (e.g. otoliths collected for growth studies, stomach and muscle samples collected for the purpose of studying dietary information) has, over time, grown into a much more structured specimen bank associated with a database and analysis results, and which has been expanded to include increasing numbers of species from the pelagic ecosystem in which tunas live (see box 2).

SPC and the Western and Central Pacific Fisheries Commission, as a partner in this project since 2015, are now able to provide scientists with 120,000 samples – from 38,000 specimens gathered from 120 different species – stored within the PMSB. Through the PMSB, research teams can access samples collected at extensive spatial and temporal scales, and Pacific Island countries and territories enjoy the benefit of more reliable stock assessments through a better understanding of species biology as permitted or facilitated by examination of these samples.

From collection to analysis, these specimens will go through many pairs of hands and often travel across the Pacific. These movements generate a succession of challenges from the point of view of maintaining quality in data, samples and results. Prior to analysis, the specimens may be stored for a number of years, and constant improvement is therefore needed, whether through the purchase of more modern and efficient equipment or through training for SPC staff by specialist agencies.

Sample storage

Storage is one of the many challenges in managing the specimen bank. This stage may not seem demanding in comparison with the human and financial efforts required by the annual collection of thousands of specimens, but it is an essential stage because the quality of storage and the accuracy of traceability are crucial to rapidly providing scientists with the high-quality samples they need.

At present, the vast majority of specimens are stored in freezers at -20°C. Each freezer is mapped in detail and the exact location of each sample in the freezers is known in order to be able to relocate each one as quickly as possible.

Depending on the kind of analysis to be carried out, researchers may express special sample storage requirements. With genetic analysis work, for example, the optimum storage temperature for muscle material is -80°C, whereas for histological purposes, gonads must be stored in a formalin solution and then transferred into ethanol. These requirements have led to the acquisition of new storage options, such as a deep freezer (a freezer at -80°C), solvent cabinets and desiccators.

In addition, storage capacity has increased over the years and the size of the laboratory at SPC in Noumea, which currently contains 14 freezers, totalling 9 m^3 in volume, has become insufficient. SPC is, therefore, reaching out to its partners in the region and some 22,000 PMSB samples are currently in storage in Australia, in the laboratories of the Commonwealth Scientific and Industrial Research Organisation (CSIRO), in Hobart and Brisbane. In Noumea, the New Zealand Incubator Fund has made it possible to renovate a below-zero cold storage facility in 2019–2020, thus expanding Noumea's storage capacity by 30% (to 12 m^3). In addition to the Noumea and CSIRO sites, SPC has funded the purchase of freezers in the main Pacific Island fishing ports in order to be able to store samples prior to their transfer. In some cases, collaborative arrangements with fishing companies has also made it possible to gain access to their storage areas.

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SPC's role is not restricted to the collection, storage and maintenance of the PMSB. FEMA teams also prepare certain samples (e.g. muscle lyophilisation, gonad fixation, otolith slicing) to make transporting them easier and safer (in an unfrozen state) to the analysis laboratories located outside New Caledonia. SPC is also deeply involved in the analysis process for certain samples.

Acquiring knowledge through sample analysis

The FEMA team is trying to gain a better understanding of the biology of top predators, including tunas, but also to understand how the pelagic ecosystem functions as a whole. More knowledge in these areas will help improve our understanding of tuna population dynamics and the influence of their environment on their behaviour, which are essential data for decision-making focusing on stock conservation.

FEMA staff have, for example, acquired high-level expertise in species identification and taxonomic assessment (see box 1). This kind of analysis is used by SPC's Oceanic Fisheries Programme to characterise the pelagic ecosystem and understand the feeding habits of tunas and other top predators.

Tunas' diet comprises a highly diverse group of prey known as micronekton, which consist of fish, crustaceans, molluscs and gelatinous organisms measuring between 1 and 20 cm. In order to understand tunas' feeding habits, it is necessary to be able to identify all forms of prey that are collected by either removing the stomachs of captured tuna in order to assess their content, or using fine-mesh pelagic trawl nets to directly catch micronekton in the ocean.

- **Stomach content analysis** makes it possible to perform qualitative and quantitative characterisations of top predator feeding habits by identifying, measuring and weighing prey, so as to enrich knowledge on trophic interactions (who eats who?) between species.
- **Trawl content analysis** from oceanographic cruises pursues the goal of acquiring new knowledge on ecosystem functioning in order to extend the study of the pelagic trophic web using stomach content analysis.

Adding value by creating and curating collections

Through the PMSB's work in taxonomic assessment and stomach and trawl content examination, SPC has been able to incorporate a range of collection types that are an integral part of the PMSB:

- reference collection of digested specimens from analysed stomach contents and whole collected specimens, preserved in alcohol-filled jars;
- collections of fish skeletons, otoliths and cephalopod beaks;
- collection of frozen specimens for the purpose of future analysis (e.g. genetic analysis);
- collection of fish radiography; and
- photographic collection of reference specimens.

Each of these collections forms a very important database for species identification purposes and research on pelagic marine biodiversity. SPC supplies them to scientists around the world in order to foster research on the pelagic ecosystem and top predator biology. It is, therefore, essential to keep these collections in good condition.

In order to learn the latest cutting-edge specimen storage and analysis techniques, the FEMA team is working with other taxonomists around the world, and team members will pursue training opportunities in museums that maintain collections. In November 2019, Élodie Vourey and Annie Portal visited the Te Papa Museum in Wellington, New Zealand. Funded by the New Zealand Ministry of Foreign Affairs and Trade, this exchange enabled them to discover the behind-the-scenes realities of New Zealand's biggest collection, which contains over 200,000 specimens and operates within a highly developed and secure infrastructure.

A museum's collections are of incalculable value. Centuries-old specimens and specimens of extinct species can be found there (e.g. the skeleton of the giant New Zealand bird known as the moa), and these are testimony to a period or a species. It is therefore absolutely essential to maintain the full range of these collections under high security. Researchers, technicians and illustrators work together in these spaces that are not open to the general public. Élodie and Annie met these people and worked for two weeks with Carl Struthers, Andrew Stewart, Jeremy Barker and Michelle Freeborn, specialists in the New Zealand National Fish Collection, whose work culminated in 2015 in the publication of an illustrated identification guide "The Fishes of New Zealand". Élodie and Annie followed and observed them through every phase of accession of the specimens to the collection (Fig. 1).

The visit to the Te Papa Museum was also an opportunity to discover their radiography system (Fig. 2). In taxonomy, radiographic images make it possible to more closely observe visible hard structures (e.g. fin spines) and invisible hard structures (e.g. vertebrae) in specimens. It is, therefore, an additional tool to assist in identification.

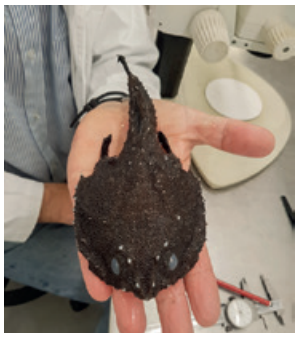
This experience also helped determine how to improve and develop the SPC fisheries laboratory and PMSB.

Conclusion

In order to supplement its available equipment, in 2020 the SPC Fisheries Laboratory acquired:

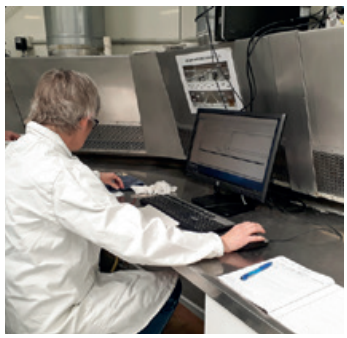
- a digital radiography system that can be used to conduct specimen radiographic examinations;

1 Identification
The specimens collected are examined through a stereo microscope for identification purposes.



2 Sampling and data
A muscle sample is removed from each specimen for genetic analysis. The data (species, weight, size, origin) are entered into a data base.

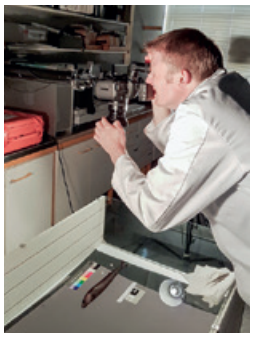


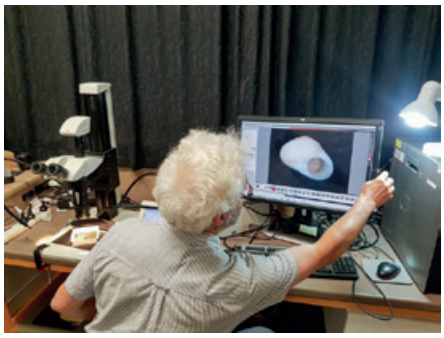


3 Fin fixation
In order to facilitate future observations, fish fins are kept open by needles on a backing and fixed with formalin.

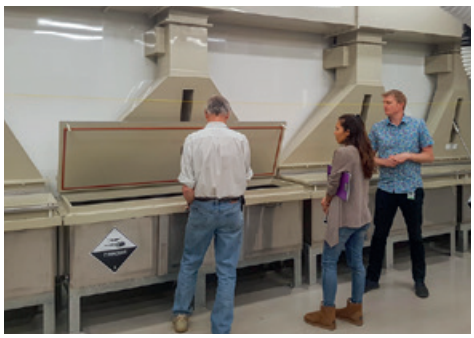
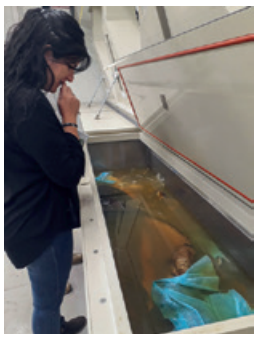


4 Photography
In a studio with dimmable lighting, the specimens are photographed in order to compose a reference catalogue.





5 Final fixation
The specimens are first fixed in formalin, then immersed in alcohol baths in gradually increasing concentrations.


6 Accession to collection
The specimens are placed in labelled hermetic containers. Te Papa has three large rooms set aside for the collection.



Figure 1. The stages in adding a specimen to a collection.

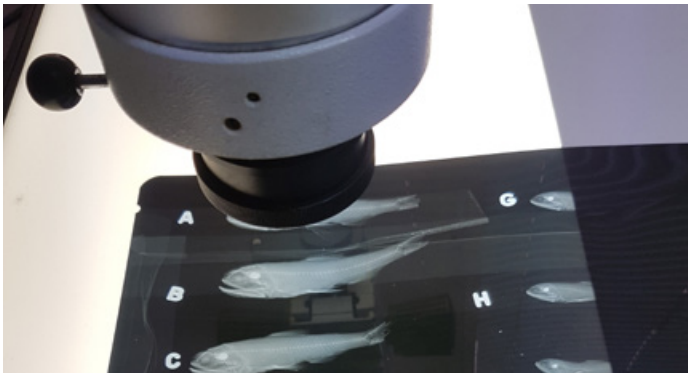


Figure 2. Reading a specimen radiography on a light table.

- ultra-low-temperature freezers (-80°C) that will make it possible to store tissue samples under optimum conditions; and
- a below-zero cold room (-20°C) to expand the PMSB's sample storage capacity.

Our aim now is to continue to develop the PMSB to make it the most comprehensive specimen and data bank possible. As part of the activities designed to achieve this goal, the FEMA team would like to create a kind of "identity card" for every specimen added to the collection. This card would include:

- a good-quality photograph displaying the features having enabled identification;
- pieces of tissue so as to be able to carry out genetic analysis;
- a radiography; and
- a summary of the bibliographical references used for identification purposes.

The contents of the sample and specimen collection managed by the PMSB help us to improve the available knowledge on the pelagic ecosystem and to contribute to better Pacific marine resource management. It is essential that this scientific treasure be very carefully curated by improving the relevant infrastructure and constantly developing our conservation and management techniques.

The PMSB has not been spared by the COVID-19 crisis. The suspension of observer embarkation on fishing vessels for health reasons, and the ban on international flights to and from many countries has made it impossible to collect new specimens at sea. But SPC and the observer programmes have adapted to this by consolidating port-sampling operations where those have remained possible. This very unusual situation highlights the importance of tools such as the PMSB, which enable us to monitor ecosystem health and, thus, to contribute to the resilience shown by Pacific Island countries in facing major emergencies such as COVID-19. Countries' economies and social organisations are suffering throughout the region and it remains of primary importance to be able to sustainably manage primary resources, such as fisheries, which contribute to food security and economic well-being in Pacific Island countries.

Acknowledgements

The development of the PMSB is the result of commitment and support from many SPC staff in terms of securing funding, collecting samples, and maintaining and improving the facility. The FEMA team, which manages the repository, wishes to warmly thank the at-sea observers and regional observation programmes who collect specimens, partners who store such specimens in their facilities, and the organisations that contribute to funding for the specimen bank. Our thanks go also to the Te Papa Museum for their hospitality and precious advice.

Other articles on the same theme

Sanchez C., Roupsard F., Allain V. and Nicol S. 2014. Tuna tissue bank for ecosystem management in the Pacific. SPC Fisheries Newsletter 144:6–8. Available at: http://purl.org/spc/digilib/doc/ye7y3

Smith N., Donato-Hunt C., Allain V., McKechnie S., Moore B. and Bertram I. 2017. Developing a Pacific Community Marine Specimen Bank. SPC Fisheries Newsletter 152:43–47. Available at:http://purl.org/spc/digilib/doc/4kxdc

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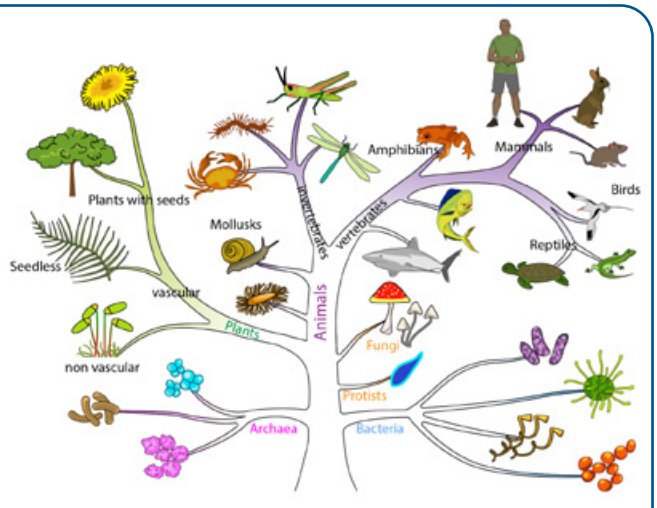
Box 1: What is taxonomy?

Taxonomy is the branch of science that describes living organisms and classifies them into groups called taxa in order to be able to identify and name them. A taxon, or taxonomic group, encompasses species sharing the same morphological characteristics (e.g. the number of spines in a fin, the number of bioluminescent organs, the shape of the teeth).

Taxonomic classification is structured as a tree, going from the most general (the trunk) into successive divisions (branches) that eventually lead to the most specific (the leaves). The most general level is called "kingdom"; for example the animal kingdom and the plant kingdom, and contains all animals and all plants, respectively. An intermediate taxon level is "family", such as Scombridae, which include the tunas. The species, associated with the genus, forms the most specific level; these are the leaves of the tree and, in the case of yellowfin tuna, includes the genus *Thunnus* and the species *albacares*.



The tree of life. Designed by Boris Colas, based on an illustration from the Mammoth Memory website.

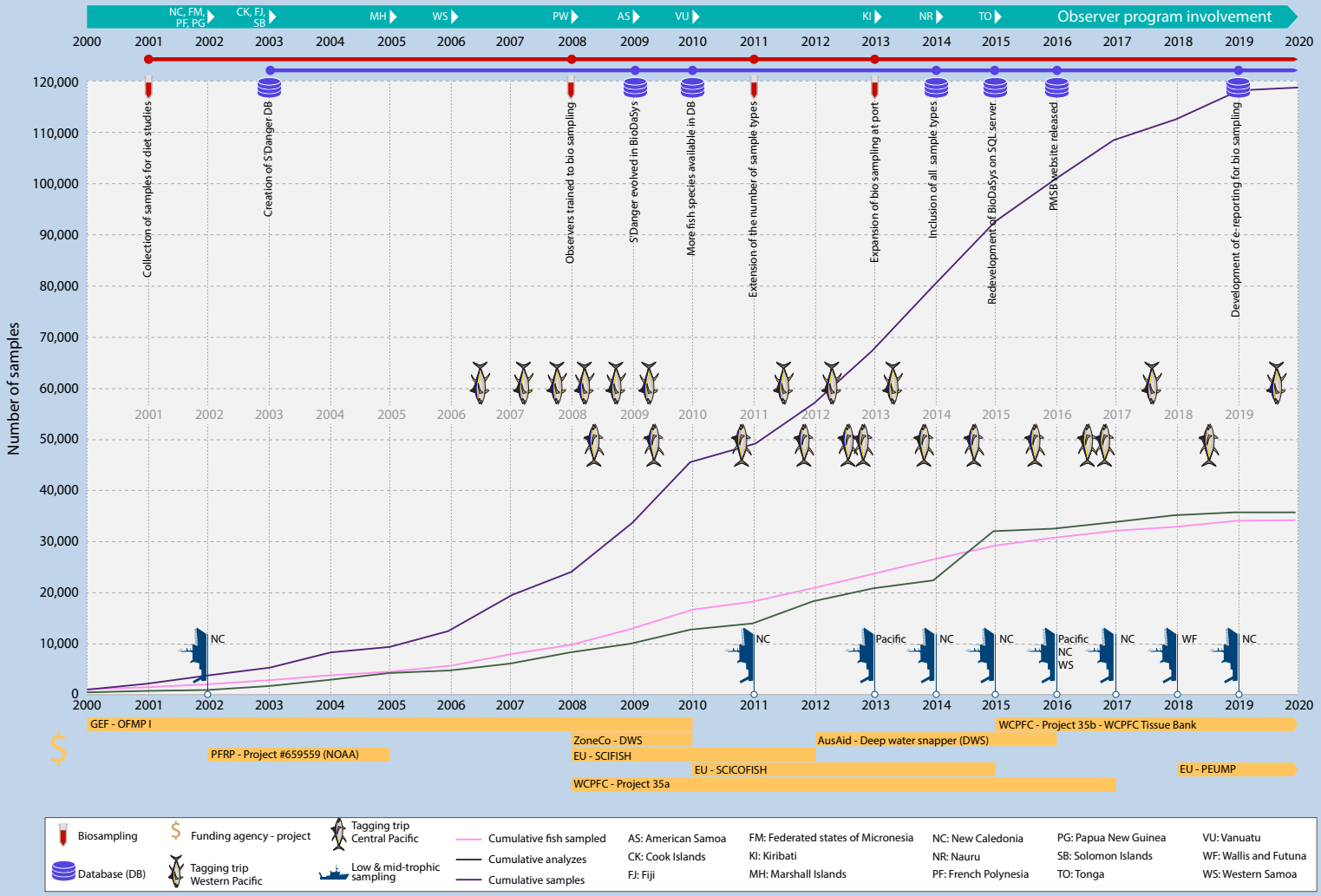
Box 2: Chronology of the Pacific Marine Specimen Bank (PMSB)

The collection of samples from the Pacific, which began in 2000, has continuously progressed. As of April 2020, PMSB had nearly 120,000 samples collected from 34,000 specimens, on which 36,000 analyses had been carried out. Some national observer programmes have participated in the PMSB since 2002, such as New Caledonia and Papua New Guinea, and other programmes have recently begun contributing.

Several events have accelerated the collection of samples:

- the launch of the tagging programme (2006) during which many samples are taken each year;
- the integration of biological sampling in the training of observers (2008);
- the addition of the collection of otoliths, spines and gonads to the collection of stomach, muscle and liver samples that was already taking place (2011); and
- the introduction of training for port samplers (2013).

Whole specimens of tuna prey (micronekton) began to be collected on a regular basis starting in 2011 during scientific campaigns on low and intermediate trophic levels (zooplankton, micronekton); these samples are available for analysis and enter in the reference collections. In parallel with the collection of samples, a database has been created, requiring regular improvements, including the creation of a website to enable everyone to query the database. This important work benefits from the financial support of many organisations.



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