The tuna pelagic ecosystem: The exciting inside story!
Setting up an ecosystem monitoring system

A great many things are hidden within the immensity of the Pacific Ocean and as scientists are, by their very nature, curious beings, we try to discover what lies under its surface. This is an enormous task, so one must choose their priorities well. Élodie Vourey and Valérie Allain from the Fisheries and Ecosystem Monitoring and Analysis Section of the Pacific Community (SPC) Oceanic Fisheries Programme have been focussing their energy on trying to understand one of the vital elements for explaining tuna abundance and movements; i.e. the micronekton that the fish eat.

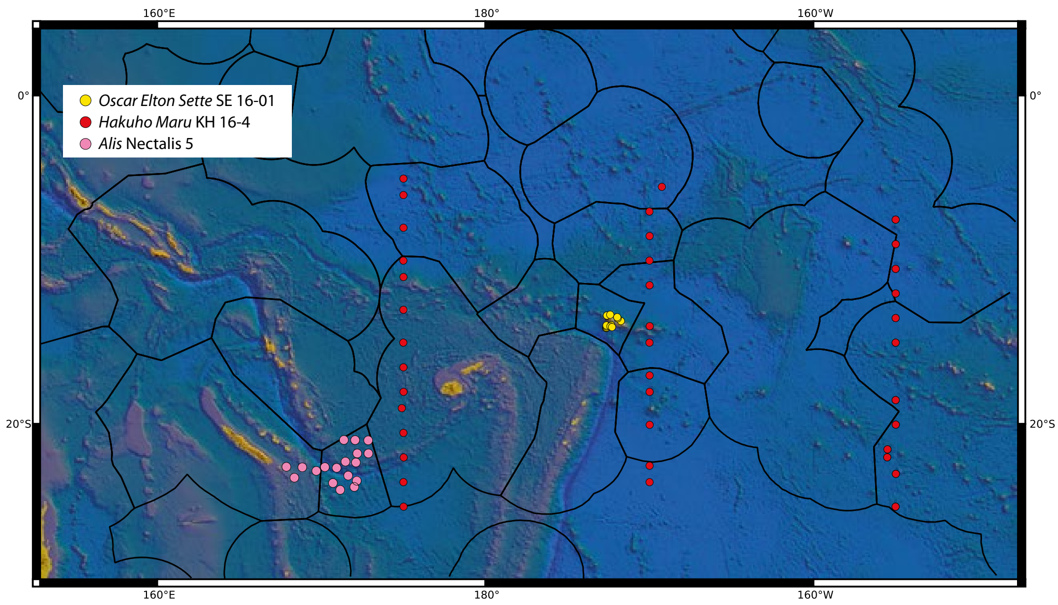

Figure 1.
Micronekton sampling zones in 2016 on board the research vessels *Oscar Elton Sette*, *Hakuho Maru* and *Alis*.

Part of Valérie and Élodie's work consists of examining the contents of tuna stomachs to find out what they eat. Another important part is determining where tuna food sources are concentrated, how abundant they are and which micronekton species are available. That involves nothing less than setting up a micronekton monitoring system in order to understand how the ecosystem operates, how it changes in response to climate conditions and what impact such changes may have on tuna stock abundance and movements: Find the food source and you'll find its predator!

A few scenarios may help better understand the important role that micronekton play in the pelagic ecosystem that tuna depend on.

- If the abundance of micronekton were to drop sharply due to climate change, this would mean less food for tuna. That could bring about a decrease in their growth and reproduction rates, or it could make them move to zones with more abundant food sources. In both cases, there would be a direct impact on yields or fishing strategies. So it is important to know the quantities of micronekton available, their spatial distribution and how they are changing.
- If the composition of micronekton species changes – for example, where certain small fish species are replaced with gelatinous organisms whose populations are exploding due to climate change – this will result in lower quality food for tuna, since gelatinous organisms are less nourishing. In this case, even if the quantity of micronekton remained the same, the change in its composition could have a negative impact on tuna growth and reproduction, and result in the tuna moving to more favourable zones. Therefore, it is not only important to monitor changes in micronekton quantities but also in its quality.

Monitoring micronekton species composition can be done in part by examining the contents of tuna stomachs. However, to determine micronekton's spatial distribution, the only current way is to go out into the field and check.

Phytoplankton can be partially monitored by satellite, but that is not yet the case with bigger organisms such as zooplankton and micronekton. For the latter two groups, models have been developed to estimate their abundance and distribution – such as the SEAPODYM model (Lehodey et al. 2015) – but field data to validate those models are very sparse.

Surveys at sea have to be carried out to observe the micronekton's vertical and spatial distribution, and to estimate its abundance and take samples to describe the micronekton species composition. A great deal of work was done in this area in 2016 since the Fisheries and Ecosystem Monitoring and Analysis Section team took part in three surveys at sea in New Caledonia, Samoa and in a large portion of the South Pacific (Fig. 1). This work was carried out in collaboration with other agencies that made their oceanographic research vessels available.

In March and April 2016, Valérie Allain took part in the first micronekton monitoring campaign of the year; i.e. 10 days in the waters of Samoa aboard the research vessel *Oscar Elton Sette*, an American ship that is approximately 70 m and belongs to the NOAA (National Oceanic and Atmospheric Administration). This was a multi-faceted mission and some teams worked during the day catching deep-water snapper and parrotfish, while a small team worked at night collecting micronekton using two different kinds of pelagic trawl; i.e. the Cobb and IKMT (Isaacs-Kidd Mid-water Trawl). A total of 12 hauls were carried out, collecting a large variety of fish, shrimp, squid and gelatinous organisms from the deep-sea (maximum depth: 587 m) to the surface. The Cobb trawl, with a cod-end mesh size of 1 mm and an opening of about 140 m^2, made it possible to catch bigger organisms than the IKMT, which has a cod-end mesh size of 0.5 mm and an opening of about 2.8 m^2. The catches were sorted into major taxonomic groups on board with the help of colleagues from the Samoa Fisheries Division.

Then in August and September 2016, there was a survey in the South Pacific on board the research vessel *Hakuho Maru*, a 100 m Japanese ship that belongs to JAMSTEC (Japan Agency for Marine-Earth Science and Technology). This mission was carried out in collaboration with the University of Tokyo, focussed on identifying the larvae of eel-like fish (e.g. common eel, conger eel, moray eel), leptocephalus, and their spatial distribution in the zone (Pickering 2016). In order to catch such larvae, which are part of the micronekton, an IKMT pelagic trawl (cod-end mesh size of 0.5 mm and an opening of about 8.7 m^2) was used, and while our French and Japanese colleagues were only interested in the leptocephalus, the SPC-IRD (French National Research Institute for Sustainable Development) team had access to all the other micronekton organisms. This was a very intense mission for the team, which included Patrick Houssard, an IRD PhD student, during the second part of the voyage; i.e. from Noumea to Pago Pago (4–17 August 2016), and Élodie Vourey from SPC for the third part of the campaign between Pago Pago and Tahiti (20 August–12 September 2016). In all, specimens were recovered from 48 IKMT hauls from a depth of 200 m to the surface.

In the R.V. *Oscar Elton Sette* lab, Valérie Allain (SPC) and Louise Giuseffi (NOAA) sort the micronekton organisms from a night haul off Samoa (image: NOAA).

Some specimens require careful handling, such as this 20-cm long *Chauliodus* sp., which can tilt its head to allow the ingestion of large prey (image: Valérie Allain).

Aboard R.V. *Alis*, Élodie Vourey (SPC) takes a sample from the liquid in which the micronekton bathes, in order to carry out DNA analyses (image: Valérie Allain).

In November and December 2016, Valérie and Élodie worked on board the oceanographic research vessel *Alis*, a 28 m French ship that belongs to IRD, for two weeks in the waters south-east of New Caledonia. This research trip, known as the Nectalis 5,[1] was the fifth in New

[1] http://www.spc.int/oceanfish/ofpsection/ema/biological-research/nectalis/447-nectalis-5-journal-a-logbook

Trawl nets used to collect micronekton (image: Élodie Vourey).

Gear used to collect and analyse seawater's physical and chemical characteristics, from 0–1000 m depths (image: Élodie Vourey).

Caledonia's series of voyages that began in 2011, designed to explore the open ocean. This very comprehensive campaign made it possible to collect data on the ocean's physical characteristics (currents, temperature), chemistry (nitrates, phosphates), and the phytoplankton, zooplankton and micronekton. Some 18 stations were sampled and a total of 32 hauls for micronekton (cod-end mesh size of 10 mm and an opening of about 100 m^2) were carried out between 564 m and the surface. The *Alis* is equipped with an echo sounder (SIMRAD EK60) that allowed the team to collect acoustic profiles of micronekton between the surface and a depth of 600 m throughout the voyage. This instrument provided a good overview of micronekton spatial distribution.

Therefore, a large number of samples were collected in 2016 and many months will now be needed to identify all the specimens currently stored in SPC's freezers. New campaigns are planned over the coming years, particularly in March 2017 in New Caledonia on board the *Alis*, once again in collaboration with IRD and possibly in March 2018 in Wallis and Futuna. SPC has also begun discussions with the KIOST (Korea Institute of Ocean Science and Technology) on carrying out a North Pacific campaign in the Palau and the Federated States of Micronesia area in late 2017 on board their new oceanographic research vessel, the *Isabu*.

After laboratory analysis to identify the specimens collected and acoustic data processing, the goal of this work is to be able to provide countries with maps showing micronekton biomass distribution and micronekton biodiversity. Those data would then allow countries to identify areas that should be protected because, for example, they harbour a wide diversity of organisms or a high density of tuna prey and thereby are likely to be preferred feeding zones. By using this type of information, decision-makers can take fully informed management and conservation measures. That is the ultimate goal of the BIOPELAGOS[2] project (funded by the European Union's BEST 2.0 programme), which is designed to provide support to New Caledonia and Wallis and Futuna in managing the biodiversity of their oceanic pelagic ecosystems. Collecting such information in various zones of the Pacific, but also in the same zone repeatedly, will also make it possible to conduct in-depth analyses and gain a better understanding of the impact that environmental factors and climate change have on ecosystem organisation.

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[2] http://www.spc.int/oceanfish/ofpsection/ema/biopelagos