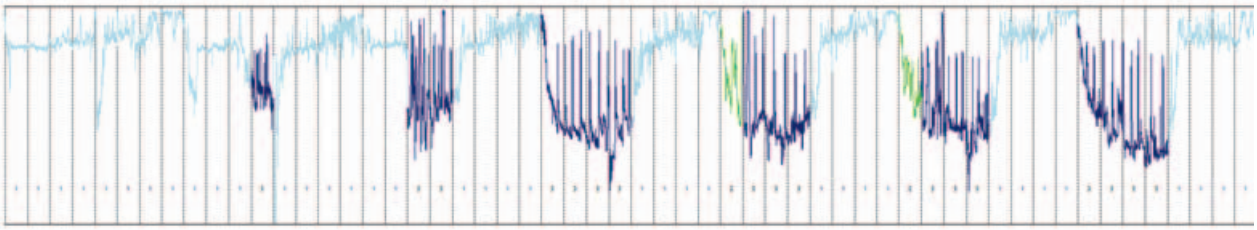
Understanding the vertical movement of tropical tunas

Although the majority of new research on tuna fisheries tends to focus on populations and fishing fleets, there is still much to learn about the individual behaviour of these remarkable animals. In particular, individual movement through the water column is of interest to fisheries scientists because this movement determines how tunas are affected by different types of fishing gear.

Since 2006, as part of the Pacific Tuna Tagging Programme, SPC has been inserting electronic archival tags into the bellies of tunas in order to obtain information on their vertical movements within the tropical western and central Pacific Ocean. These tags, which are surgically implanted, are electronic devices that record data on the light intensity, depth and temperature that an individual fish experiences, as frequently as every 10 seconds. When tunas are caught by fisherman, the implanted tags are returned to SPC for analysis. To date, the PTTP database (held at SPC) contains data on over 130 returned tags for three different tuna species, spanning a wide range of fish sizes, regions and time periods, and equating to over 130,000 days of data, each with up to 14,000 observations of depth, temperature and light!

The individual behaviour patterns observed from these tagging data are sometimes very consistent, and sometimes extremely irregular. Some fish exhibit very clear patterns day-in and day-out for many months at a time. For example, bigeye (*Thunnus obesus*) and yellowfin (*Thunnus albacares*) tunas often remain in shallow water at night and move deeper within the water column during the day. This is believed to be due to tunas feeding on smaller fish and invertebrates that occupy these different depths throughout the course of a day. However, striking deviations from these patterns are sometimes observed. An individual tuna may abandon its deep-diving behaviour for weeks at a time, and then undertake sudden deep dives down to many hundreds of meters, or spend time moving constantly through the water column, rarely staying within one layer of water for more than a few minutes. The challenge in analysing these data has always been in objectively characterising these patterns and understanding how they change, and how those changes may be influenced by other factors such as the biological development of the individual, the availability of local food, or the effects of floating objects.

As a PhD attachment to SPC, I have been developing new analytical approaches to address these problems alongside SPC's Oceanic Fisheries Programme staff. We have been developing computer models that discern patterns of vertical behaviour from archival data tags and attribute these identified behaviours (and the switching between them) to factors such as location, time or size of a fish. We can then quantitatively compare the differences in the behaviour of individual tunas or the same tuna over time. In particular, this approach will



Dive data from a large bigeye tuna, classified using the Hidden-Markov model. This individual tuna alternates between shallow behaviour (light blue) and very deep behaviour (dark blue), occasionally exhibiting short periods of high amplitude diving (green), particularly during the hours before and after sunrise.

be used to examine some of the specific effects of how tunas may become more vulnerable to fishing gear when they gather near floating objects such as fish aggregation devices, or FADs. This is of particular interest given the increasing use of FADs in the Pacific Islands region, and given their perceived negative impact on certain tuna stocks and smaller tunas. Identifying when associations occur and characterising their effects across size classes of tunas is a goal of this project.

These independent descriptions of vertical behaviour are useful not only for unravelling the life history of tunas, which is very difficult to observe in the wild, but can also inform scientists of important behavioural changes that affect the advice provided to fisheries managers. For example, it has been observed for some time that larger tunas spend more time diving to greater depths than smaller individuals, due to physiological developments as they grow older that allow the fish to feed and hunt in colder, less oxygen-rich water. Such vertical behaviour is referred to as habitat use, and is a critical component to understanding how susceptible tunas are to fishing gear. However, when these biological changes occur, the speed at which they happen, and the degree to which these developments differ by species and location, is not well understood. In preliminary analyses, we observed that bigeye tunas have a very clear, "deep" behavioural state that often occurs during the day. However, in some individuals measuring 60–70 cm, the depth associated with this behaviour actually becomes deeper over time, while the frequency of occurrence stays the same. It appears that these fish do not change their preference for diving deeper during the day, but rather gradually develop this already present "deep" behaviour by simply diving to even greater depths as they grow.

Methods such as these allow scientists to gain new knowledge from the excellent data that have been collected by SPC, its member countries and fishing companies, not only for describing and understanding the behaviour of tunas and other important species, but also to improve the models that are used to support scientific advice and provide information on the status of stocks. The impressive amount of data gained from archival tagging has provided a window into a world that has been previously hidden from us. However, the fact that we directly observe neither behaviour, nor the context that drives it, means that archival data will remain just that: a window. Further developments in this project and beyond will allow us to extract the maximum amount of useful information from this hugely valuable resource.

For more information:

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Inserting an archival tag in a yellowfin tuna belly (note the green tag antenna sticking out).