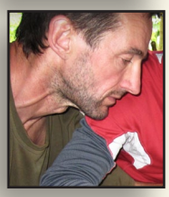
Oceanic Migrations of Tropical Pacific Eels




Robert Schabetsberger is a biologist at the University of Salzburg, Austria and started to work on tropical eels in 2012. Finn Økland is a fish telemetry specialist based at the Norwegian Institute of Nature Research, Trondheim and has tagged fish in 20 different countries. Ursula Sichrowsky is a Ph.D. Student from the University of Innsbruck, Austria working on the limnology of tropical lakes in Oceania. Meelis Tambets from Wildlife Estonia has worked with Finn on numerous tagging projects. Kim Aarestrup from Denmark Technical University has pioneered tagging of European eels with satellite tags.

Some tropical eels live in paradise. Among them are our eels living in Lake Letas, in the archipelago of Vanuatu. The Lake, sacred to locals, is a 100 m deep crater-lake in the middle of the tropical South Pacific island of Gaua, constantly fertilized by an active volcano and full of tasty shrimp. The only downside is the spawning migration back to their spawning grounds in the ocean. To accomplish this, they have to migrate through a gauntlet of difficulties. First, a header down a 120 m waterfall, then past fishermen hooking and dragging them ashore, on to hungry sharks ambushing them in the reef, and finally a 1000 km exhausting journey in the deep blue ocean, all of this without feeding. Finally, after spawning they die. Their eggs hatch within days and their weird looking, leaf-shaped larvae will drift back with the South Equatorial Current and develop into transparent glass eels. Some will smell the river running from the lake, swim up the river, and crawl up on vertical mossy cliffs alongside the waterfall, before they reach the Letas to grow for decades like their ancestors.

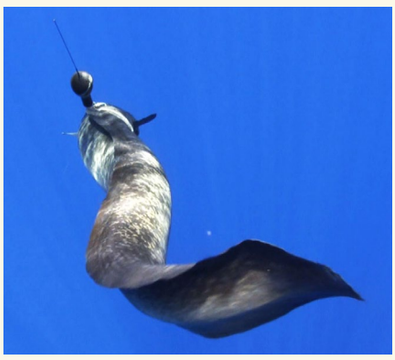


Photo by Robert Schabetsberger

A tagged eel diving into the deep blue ocean near Vanuatu.

Anguillid eels have captured the imagination of scientists and the general public because of their mysterious migrations to mostly unknown spawning areas. Fresh-water eels (Genus *Anguilla*) are major ecological components across the islands of the western South Pacific region and have been important mythical creatures for human societies for centuries. Yet, very little is known about their biology. The threatened status of the stocks of economically important temperate eel species, such as European (*Anguilla anguilla*), American (*A. rostrata*), or Japanese (*A. japonica*) eels has prompted a number of protective measures causing increases in harvesting of unprotected tropical anguillid species in some areas such as Indonesia, and this may be rapidly expanding.

So far, no adult eel has ever been tracked all the way to its spawning area. In 2012 and 2013, we tagged 3 different species with X-Tags to follow their ocean migrations. The fish were caught by local fishermen snorkeling in the torrent outflow (20 m^3s^{-1}) of Lake Letas. Once released in the ocean, the migrating eels exhibited pronounced diel vertical migration descending at dawn from a nighttime depth around 200 m to a daytime depth around 750 m and ascending again at dusk, much like the pattern observed in other *Anguilla* species. However, the corresponding temperature change experienced by the eels was an astonishing 22 – 6 °C on the approximately one hour long descent. Twelve hours later, the reverse temperature change was experienced on ascent, all together an impressive temperature tolerance over such a short period (Figure 1).

Another interesting feature is that the lunar cycle affected the upper limit of migration depths in two species, *A. marmorata* and *A. megastoma*. At full moon, the eels descended approximately 100 m deeper than at new moon (full moon ~250 m, new moon ~150 m) (Figure 2). We interpret this as predator avoidance, since sharks and swordfish have been shown to also extend their diving depths during full moon. Three eels (2 *A. marmorata*, 1 *A. megastoma*) exhibited long-distance migrations with their tags surfacing 634 – 874 km northeast of Gaua in an area (8°S – 11°S, 170°E – 175°E) at the border of the South Equatorial Current and the South Equatorial Countercurrent. Some of the smallest leptocephali collected so far were located close to the pop-up locations, indicating that the spawning area is located nearby. Additionally, a distinct salinity maximum at the pop-up locations coinciding to the thermocline and the upper nighttime eel migration depths was identified (discovered by Giorgio Dall'Olmo from Plymouth Marine Laboratory), potentially serving as a seamark for this potential spawning area. This is further supported because 15% of all eels sampled on Gaua were hybrids between *A. marmorata* and *A. megastoma* (discovered by Robert Jehle and his team from the University of Salford) implying that they must spawn at the same location.

For the European and Japanese eels, expensive research cruises over two decades had been necessary to hunt down the small eel larvae and find the spawning areas. With a grant from the Austrian Academy of Sciences and the help of many colleagues, a spawning area of Pacific eels was narrowed down within only 3 years. This accomplishment will hopefully allow for better conservation efforts.

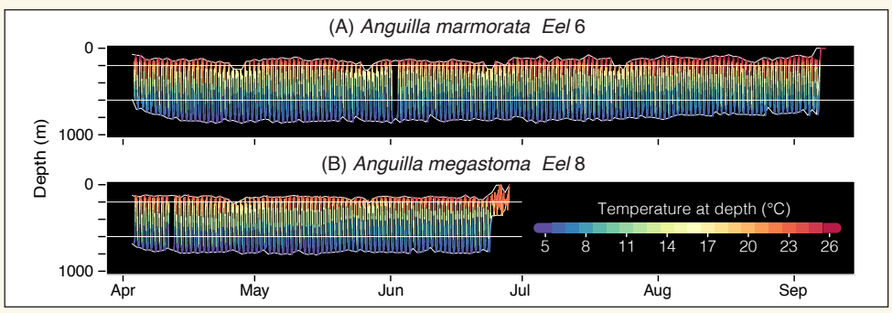


Figure 1. Time series depth profiles colored by temperature indicating diel vertical migration from Anguilla marmorata Eel 6 (A) and Anguilla megastoma Eel 8 (B).*

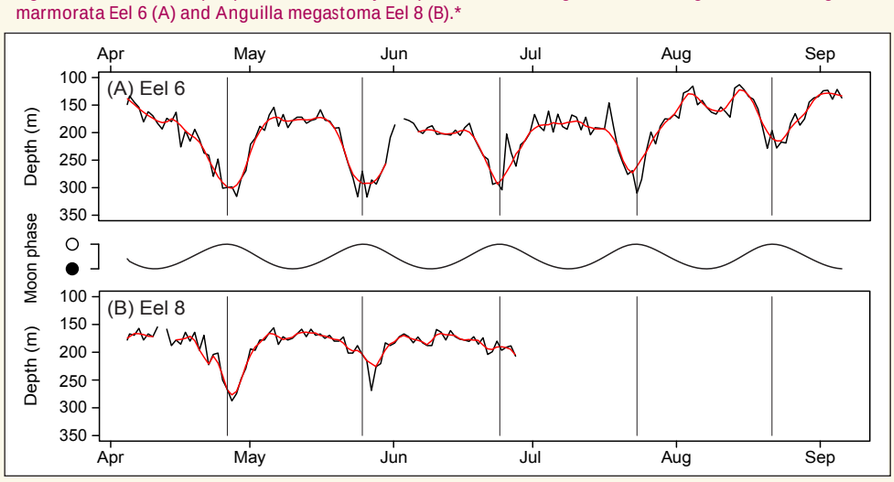


Figure 2. Nighttime mean depth (black) with smoothed nighttime mean depth (red) for Anguilla marmorata Eel 6 (A) and Anguilla megastoma Eel 8 (B). Corresponding moon phase indicated in center panel.*

*Figures courtesy of the Inter-Research's Marine Ecology Progress Series: SCHABETSBERGER, R., F. ØKLAND, D. KALFATAK, U. SICHROWSKY, M. TAMBETS, K. AARESTRUP, C. GUBILI, J. SARGINSON, B. BOUFANA, R. JEHLE, G. DALL'OLMO, M.J. MILLER, A. SCHECK, R. KAISER & G. QUARTLY (2015): Genetic and migratory evidence for sympatric spawning of tropical Pacific eels from Vanuatu. Mar. Ecol. Prog. Ser., 521: 171-187.