Shift-eDNA : Using environmental DNA to improve the prediction of marine fish range shifts under global change

Context

Atmospheric and oceanic warming are now accelerating at an unprecedented rate (1) with consequences on biodiversity such as the modification of species geographic distribution, hereafter range shift (2, 3). Marine ectotherms, like most fish species, are certainly among the more sensitive species to temperature changes because several biological processes such as growth, reproduction or recruitment are directly influenced by temperature (4, 5). At leading range boundaries (the cold margins, *i.e.* Arctic and Antarctic), fishes can expand their distribution and colonize new regions as environmental conditions become more favorable (5). At trailing edges (the warm margins, *i.e.* tropics), population extirpations can cause species range contractions (5).

These modifications in species assemblages generally induce functional reorganizations and disturbances on ecosystem processes, which ultimately affect ecosystem services and thus human welfare (6, 7, 8). Recent modelling efforts predict that, under a 'business-as-usual' scenario, the maximum potential catch in the world's exclusive economic zones would decrease between 7 and 12% by 2050 (9). Thus, to anticipate how species range shifts may impact ecosystem composition, functioning and services, we need to better understand the capacity of species from various taxonomic and functional groups and from different habitats to shift their geographic distributions and track their shifting isotherms. Yet, current models are based on fish occurrences, and these occurrences in the marine realm are generally limited to data derived from fisheries or visual surveys (cameras or divers) or biodiversity atlases, which notoriously miss rare, elusive, small and crypto-benthic species (10). Besides, the poles, but also remote areas or islands, are generally poorly sampled, which leads to a biased assessment of species environmental niches and geographic ranges. Last, many occurrences in global databases are generally decades old (11), so global distributions may partially reflect current species ranges. In that context, we urgently need an alternative approach for the collection of contemporary fish species occurrences with broader species coverage in the most critical locations (warm and cold edges, isolated areas) to better quantify and predict species range shifts.

Environmental DNA (eDNA) metabarcoding, a method retrieving and analyzing DNA naturally released by organisms in their environment, has the potential to revolutionize the monitoring of fish biodiversity (12). Its application to marine fishes (13) reveals species occurrences even at low density (14), but also the presence of furtive (10) or crypto-benthic species (15). This method is particularly relevant to detect early species arrival in the poles or to reveal species extirpation in the tropics; yet this potential has not been exploited so far at large scale (but see West *et al.*, (16)). The goals of this project are to (i) model up-to-date species distributions of most marine fish species, based on OBIS occurrence data in response to multiple factors and to predict range shifts, (ii) to evaluate the model forecasts with an independent eDNA database collected from pole to pole and detect species arrival at the poles (iii) to re-evaluate species distribution models and provide update range shift predictions until the end of the 21st century.

Material

- Main material:

    - Peristaltic pumps (Athena)
    - Car or boat battery
    - Cables
    - 10 VigiDNA sampling capsules
    - 10 VigiDNA tubing kits
    - 10 buffer solutions
    - 4kg weights and cordage

- Miscellaneous:

    - WD40; Plastic ties; Spare gloves; Duct Tape; Permanent markers; Scissors, Fuse

Sampling protocol : surface sampling

It is mandatory to wear gloves at all steps, and to change gloves between each sampling, or before adding the buffer solution.

- First, attach and set the pump on the side of the boat, pump head towards the water (Fig. 1).

- Attach the tubing kit to the sampling capsule (Fig. 2), itself attached with a rubber band or plastic tie to the pump, and make sure to leave the stopper on the exit side until you start pumping. To avoid contamination, protect the suction strainer with a glove.

- Set the tubing kit into the pump head.

- Attach the weight to the suction strainer with the nylon string, and attach the weight to the boat with cordage. This cordage should be shorter than the nylon string provided with the kit so that all the weight is supported by the cordage and not the nylon string.

- Remove the stopper and the glove on the suction strainer, put the weight underwater (the suction strainer should follow) and turn on the pump. Each pump has a different setting that will be communicated to the technician. Start a 30 minute timer (it is needed to filter 30L and the pump filters 1L/minute).

    NB: when filtering in waters saturated with organic matter, the filter may clog. In this case, the pump must be stopped. Keep track of the timer when this happens.

- Start sailing at approximately 4km/hour on the transect. In order to detect as much species as possible, the boat should follow the coastline at a depth of less than 10 meters.

- Stop the pump after 30 minutes. Put back the stopper on the sampling capsule.

- Remove the capsule from the tubing kit and fill it with the buffer solution. The whole solution must be used to fill the capsule. Put the second stopper on the other side, and shake in all directions for at least 1 minute.

- A sticker was provided in the packaging of the sampling capsule; put the sticker on the capsule and use the permanent marker to write down the date, site, and name of the project on the sticker but also on the packaging, where the sampling capsule will finally be stored, at room temperature.

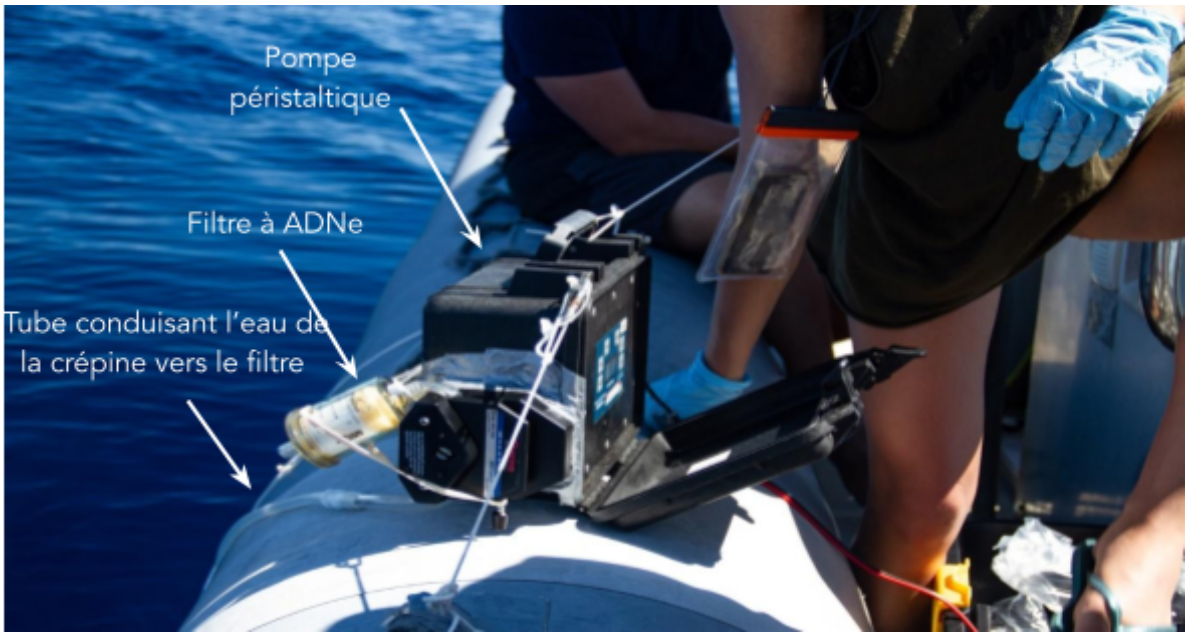

Figure 1 : Peristaltic pump with the capsule set on the pump head. On the side of the boat, you can see the tube going underwater. The weight is pulling it down, tied to the suction strainer.

Figure 2 : Sampling capsule (provided by our partner SPYGEN). After sampling, these capsules need to be stored at room temperature in an upright position.

References:

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