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Monitoring a submarine strike-slip fault, using a fiber optic strain cable

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The goal of the ERC (European Research Council) funded project - FOCUS is to apply laser reflectometry on submarine fiber optic cables to detect deformation at the seafloor in real time using BOTDR (Brillouin Optical Time Domain Reflectometry). This technique is commonly used monitoring large-scale engineering infrastructures (e.g. - bridges, dams, pipelines, etc.) and can measure very small strains (<< 1 mm/m) at very large distances (10 - 200 km), but until now has never been used to study tectonic faults and deformation on the seafloor.

Here, we report that BOTDR measurements detected movement at the seafloor consistent with ≥1 cm dextral strike-slip on the North Alfeo fault, 25 km offshore Catania, Sicily over the past 10 months. In Oct. 2020 a dedicated 6-km long fiber-optic strain cable was connected to the INFN-LNS (Catania physics institute) cabled seafloor observatory at 2060 m depth and deployed across this submarine fault, thus providing continuous monitoring of seafloor deformation at a spatial resolution of 2 m. The laser observations indicate significant elongation (20 - 40 microstrain) at two fault crossings, with most of the movement occurring between 19 and 21 Nov. 2020. A network of 8 seafloor geodetic stations for direct path measurements was also deployed in Oct. 2020, on both sides of the fault to provide an independent measure of relative seafloor movements. These positioning data are being downloaded during ongoing oceanographic expeditions to the working area (Aug. 2021 R/V Tethys; Jan. 2022 R/V PourquoiPas) using an acoustic modem to communicate with the stations on the seafloor. An additional experiment was performed in Sept. 2021 using an ROV on the Fugro vessel Handin Tide, by weighing down unburied portions of the submarine cable with pellet bags and sandbags (~25kg each) spaced every 5m. The response was observed

simultaneously by DAS (Distributed Acoustic Sensing) recordings using two DAS interrogators (a Febus and a Silixa). The strain caused by the bag deployments was observed using BOTDR and typically produced a 50 - 100 microstrain signal across the 120 meter-long segments which were weighed down. In Jan. 2022 during the FocusX2 marine expedition, 21 ocean bottom seismometers were deployed for 12-14 months, which together with 15 temporary land-stations as well as the existing network of permanent stations (both operated by INGV) will allow us to perform a regional land-sea passive seismological monitoring experiment.