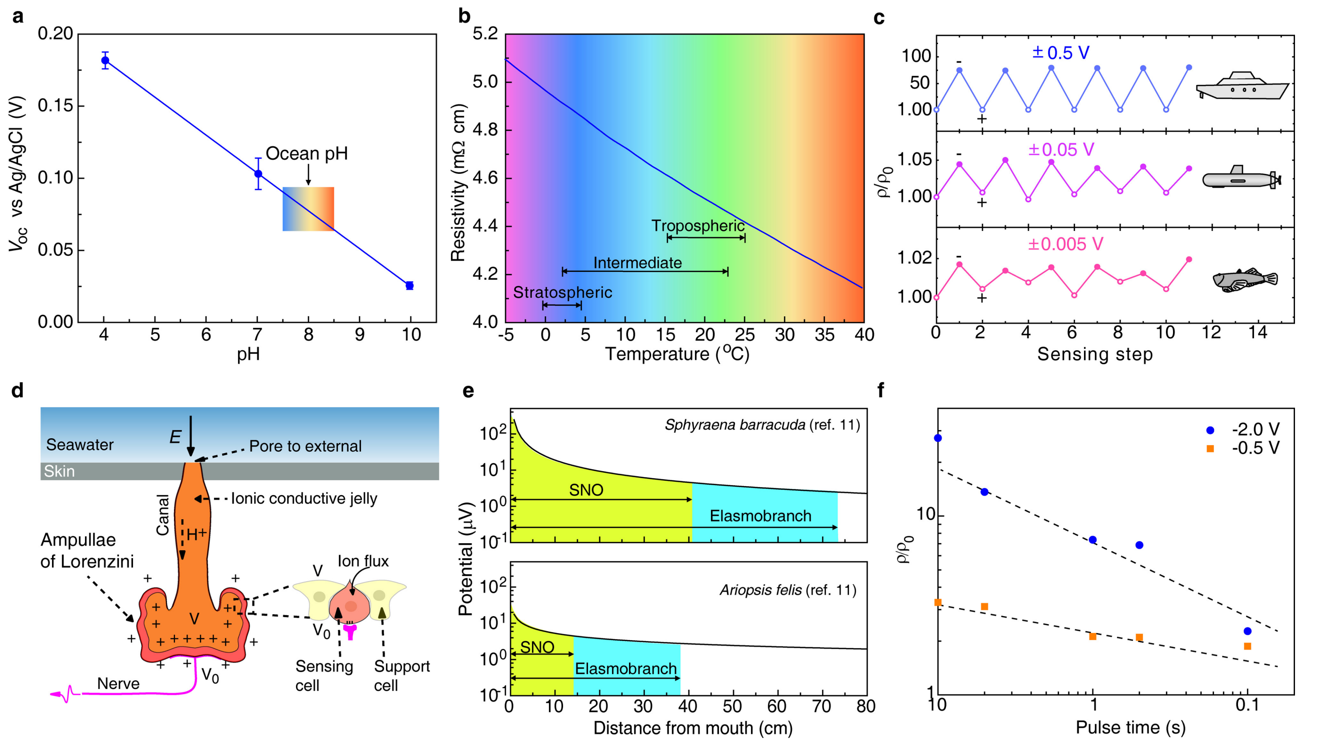

Extended Data Figure 2 | pH, temperature and electric potential sensing of SNO. a, Open-circuit potential (V_{OC}) of SNO relative to a standard Ag/AgCl electrode in standard aqueous buffers with pH values covering the pH range of Earth's oceans[42]. Error bars show the standard deviation. The potential V_{OC} decreases monotonically with increasing pH. This linear relationship between proton activity (and the corresponding surface adsorption) and V_{OC} enables SNO to operate as a pH sensor. **b**, Temperature-dependent electrical resistivity of SNO in the temperature range of Earth's oceans[43]. The electrical resistivity increases with cooling; this is consistent with the insulating nature of SNO around room temperature, which enables it to function as a thermistor. **c**, Modulation of normalized electrical resistivity of SNO in an aqueous environment after the application of bias potentials over multiple sensing steps. The bias potentials (versus Ag/AgCl) were $\pm$0.5 V, $\pm$0.05 V and $\pm$0.005 V and their duration was 10 s. The aqueous environment was a 0.6 M NaCl solution with salinity close to that of sea water. The normalized resistivity increases and then decreases following the reversal of the bias potential. The reversibility of the water-mediated phase transition and the facile migration of protons enable SNO to detect the local fluctuation of electric signals in water. This sensing capability persists over multiple cycles, indicating their robustness in aqueous environments. **d**, Schematic of an ampulla of Lorenzini, an electroreception organ located around the mouth of sharks. **e**, Electric potential as a function of distance for teleost fishes (*Sphyraena barracuda* and *Ariopsis felis*)[11]. The detection range of elasmobranch predators[11] and SNO sensors are shaded with blue and yellow colour, respectively. The calculated detection range of SNO includes the regime where the bioelectric potential of prey fishes is higher than the sensitivity of SNO (about 4.5 μV) experimentally determined from Fig. 1g. The nickelate device is estimated to detect field stimuli over a distance of tens of centimetres, which is similar in range to that of elasmobranch species. **f**, Experimentally measured resistance modulation of pristine SNO upon the application of pulsed bias potential at −2.0 V and −0.5 V respectively. The response times of the SNO sensor studied here are as low as 0.1 s.