ECOLOGICAL EFFECTS OF VOLCANIC CO2 VENTS

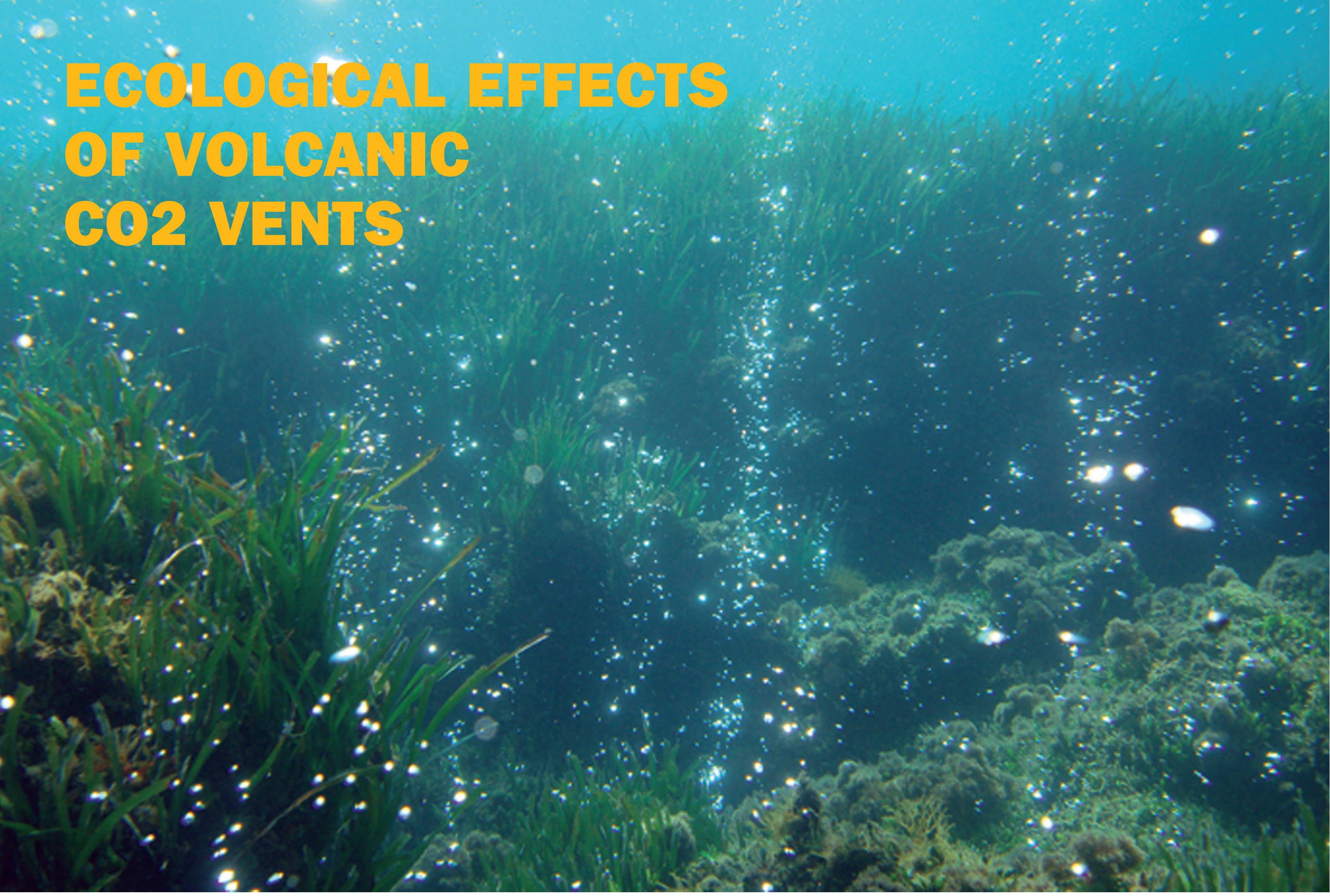

FIGURE 2: Carbon dioxide vents in shallow waters at 0-10 m depth off Ischia Island, Bay of Naples.

The global oceans currently absorb over 25 million tons of CO2 every day. This has caused surface waters to become 30% more acidic since wide-spread burning of fossil fuels began. As well as lowering pH, increased CO2 levels are altering surface water chemistry, causing a decline in carbonate ions, an increase in bicarbonate ions and lowering calcium carbonate saturation states. Falling calcite and aragonite levels are a concern since these are the building-blocks of shells for a range of marine organisms from tiny coccolithophores to giant coral reefs. Research into the marine environmental effects of increased oceanic CO2 levels is mainly being carried out using short-term-shock experiments whereby pH or CO2 levels are manipulated in aquaria and enclosures over short timescales.

FIGURE 1: Anton Dohrn's summer house on Ischia island, now part of Stazione Zoologica Naples, the oldest marine biology institute in the world.

Plymouth researchers teamed-up with scientists from labs in France, the UK, Israel and Italy to document the first ecosystem-wide responses to long-term changes in ocean pH. The effects were studied on marine communities around underwater volcanic vents off Ischia island (Figure 1), where carbon dioxide bubbles-up like a Jacuzzi (Figure 2). Gas analyses showed that the vents released millions of litres of CO2 per day (Figure 3) causing seawater acidification but the gas was at ambient temperature and lacked poisonous sulphur compounds which typify most volcanic vents. Impacts on marine life included 30% reductions in biodiversity in areas where average pH had dropped by 0.4 units compared with areas at normal seawater pH (8.2).

Natural CO2 vents can provide insights into which species are tolerant of long-term high CO2 levels and can be used to test predictions based on modelling and laboratory work, such as what levels of CO2 exposure restrict the ability of marine organisms to build shells (Figure 3). Although lush stands of seagrasses thrived at increased CO2 levels (Figure 4), major groups such as corals, sea urchins and bivalves were removed from the ecosystem and replaced by algae such as Sargassum sp. and Caulerpa spp. In brief, the research showed:

- major ecological tipping points along a gradient of increasing CO2 levels
- acidification dissolved the shells of calcified species such as corals, sea urchins and snails, which were absent in areas with a pH less than 7.4

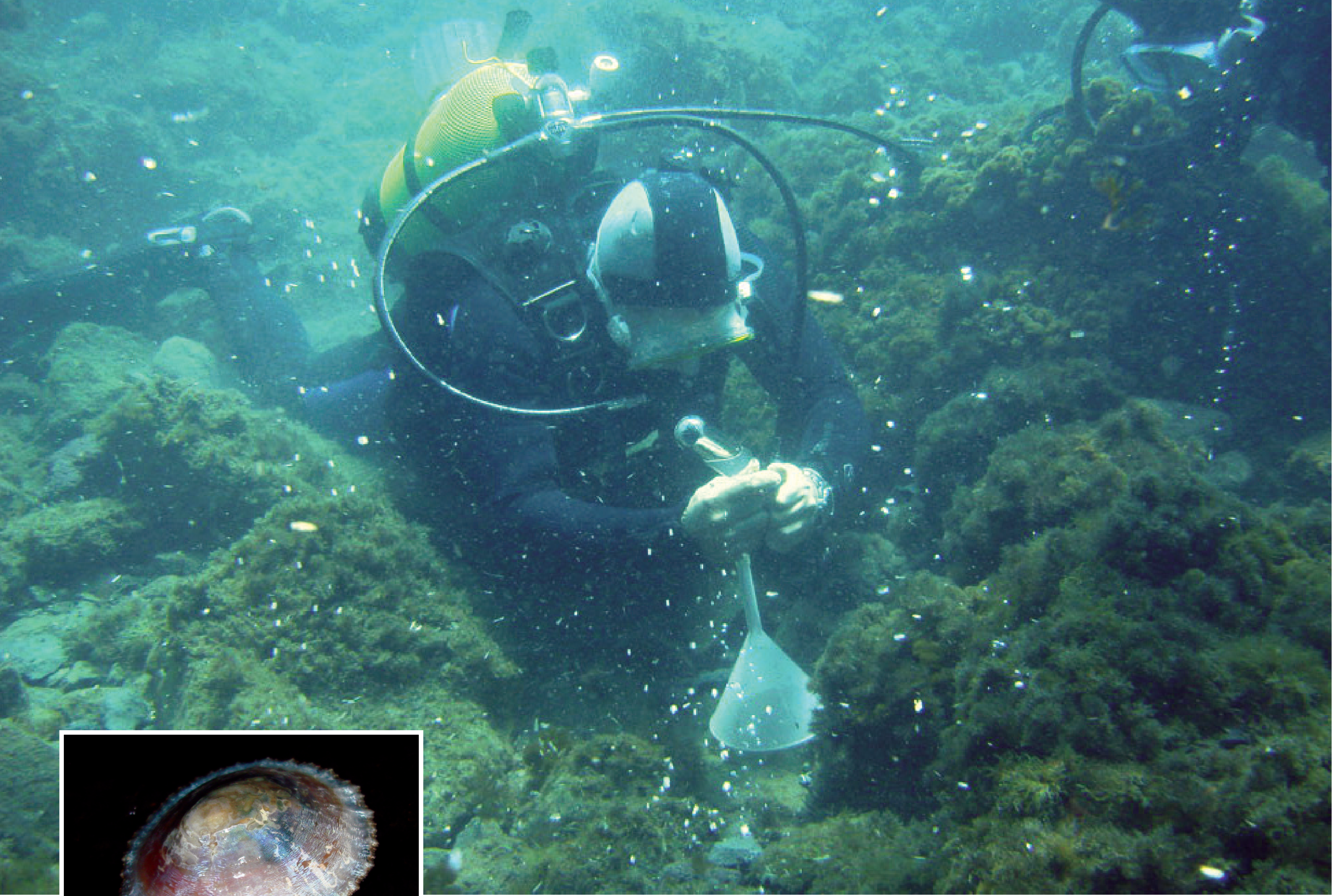

FIGURE 4: Dramatic dissolution of intertidal limpet (Patella caerulea) living near CO2 vents

FIGURE 3: SCUBA diver collecting volcanic gasses for analyses

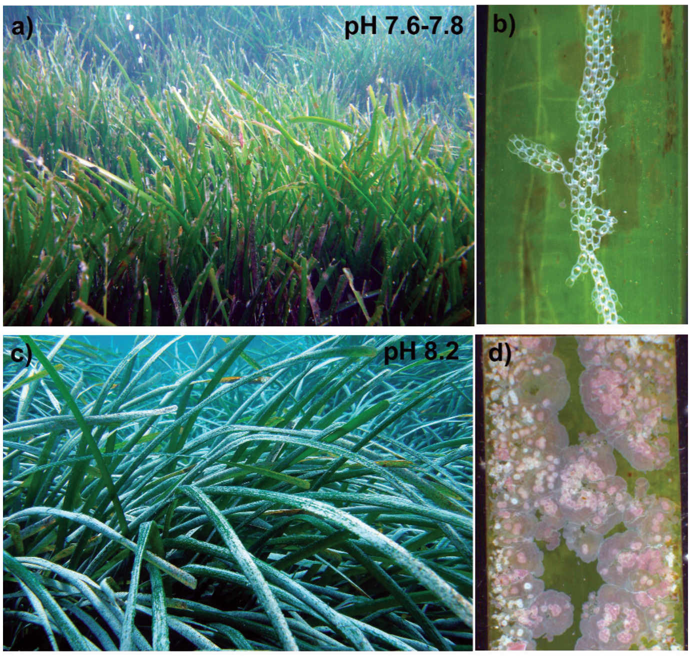

FIGURE 5: Posidonia oceanica seagrass meadow a) growing in acidified water with few calcified epiphytes such as b) the bryozoan Electra posidoniae, c) growing in normal seawater with abundant calcified epiphytes such as d) coralline algae.

- high CO2 favoured the production of seagrass and removed its calcareous epiphytes
- the amount of calcified algae, which bind coral reefs together in the tropics, fell from more than 60 per cent cover outside the vent areas to zero within these areas
- invasive alien species, which cause damage to ecosystems worldwide, may thrive at high CO2 levels

This study demonstrates, for the first time, what happens to marine ecosystems when key groups of species are killed due to rising CO2 levels. We are now undergoing the fastest rate of ocean acidification the Earth has seen for at least the past 20 million years so this study adds urgency to the international policy drive to reduce CO2 emissions.

Riccardo Rodolfo-Metalpa and Jason Hall-Spencer
Marine Institute, University of Plymouth, PL4 8AA.

FURTHER READING

Hall-Spencer JM, Rodolfo-Metalpa R, Martin S, Ransome E, Fine M, Turner SM, Rowley S, Tedesco D & Buia M-C. (2008) Volcanic carbon dioxide vents reveal ecosystem effects of ocean acidification. *Nature* **454**, 96–99.

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