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Introduction

Changes and Crises in the Mediterranean Sea: Current problems

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Abstract
As a contribution to the World Environment Day 2017, the Accademia Nazionale dei Lincei promoted the meeting "Changes and Crises in the Mediterranean Sea" devoted to the effects of climate change and human impact on the Mediterranean ecosystems and biodiversity. Here is presented a selection of papers given at the meeting held in Rome, on October 17, 2017. Studies deal with structural changes in the marine communities, the impact of thermal stress, acidification, pollution and fishing activities on benthic communities, and on deep-sea biodiversity and ecosystems. Understanding human impact on the Mediterranean Sea is the first step to manage and protect marine environments in a sustainable way.

Keywords Mediterranean Sea · Biodiversity · Ecosystems · Global change · Human impact

1 Background

Three years after the meeting "Sustainable Management of the Mediterranean" (Boero et al. 2015) the Accademia Nazionale dei Lincei promoted a second meeting focused on the effects of climate change and human impact on the ecosystems and biodiversity in the Mediterranean Sea (Rome, 17 October 2017). This special section contains a selection of papers presented at the meeting.

The pluri-decadal trend of climate change continues unabated, with some signs of acceleration. Global energy-related CO_2 emission grew to the historic record of 32.5 Gt in 2017 (IEA 2018). The mean annual global atmospheric CO_2 concentration reached 405 ppm in 2017, with a mean annual growth rate during the last 10 years (2008–2017) of 2.23 ppm, more than twice the rate in the decade 1959–1968 (0.7 ppm), when continuous accurate measurements started (NOAA 2018).

The mean annual global surface temperature in 2017 was about 1.1 °C above pre-industrial levels (1850–1900), with 70% of the increase realized during the last three decades (WMO 2018). The goal to keep the global mean annual temperature at the end of this century below 2 °C (and possibly 1.5 °C) compared to the pre-industrial value, is nowadays considered arduous to achieve.

The mean global sea level has risen more than 20 cm since 1900, with an increase of more than 7 cm since 1993, when satellite measurements started. The mean rate of global sea level rise increased from 0.6 mm/year in the first three decades of the past century to 3 mm/year over the last 25 years. Since 1953–2017, an acceleration of 0.08 mm/year^2 has been recently detected (Nerem et al. 2018). The present rate of global sea level rise is 40% due to thermal expansion of the ocean water, and 60% to water added by glacier ice melting. This second component is increasing: both polar and mountain glaciers all over the world are retreating, the Greenland ice sheet is subject to increasing ice mass loss due to surface melting and dynamic thinning,

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the Antarctic ice sheets have a negative total mass balance, due to increased ocean-driven ice loss and ice-shelf collapse.

The growth of the atmospheric CO_2 concentration caused an increase of the ocean CO_2 uptake, with a slight decline of the water pH. This "Ocean acidification" has a negative impact on marine calcifying organisms and, more generally, is a threat to the ocean food chain. These changes are expected to cause major and widespread, although not homogeneous, impacts on marine ecosystems and their biodiversity, with cascade effects on the delivery of goods and services to humans.

The Mediterranean Sea, for its physiography, may be considered as a sort of a "miniature ocean" and it is subject to enhanced effects of climate change. The surface temperature in the last decades increased with an annual growth rate three times higher than the global mean value, occurring with a strong N–S gradient and with most evident impacts on the structure of marine communities. Other changes observed are the increase of deep waters temperature and salinity, and more frequent episodes of altered stratification leading to a deepening of the summer thermocline, in its turn causing mass mortalities of species that do not tolerate high temperatures, such as gorgonians.

A rapid demographic increase is taking place in the countries facing the southern Mediterranean shores. At the half of the past century, the Southern Europe population was the double of that of North Africa. At the end of the century, the North African population matched the European one, and now it is largely over it. In 2050, it is expected that two-thirds of the circum-Mediterranean population will be in Africa (Golini et al. 2015). Moreover, socio-economic and industrial development produced a huge increase of resource consumption, waste generation, maritime traffic, tourist activities, fishery, aquaculture, etc., with a worsening of environmental conditions. Data accumulated in the last decades provide evidence of the acceleration and extension of the impacts of human activities over the world ocean and Mediterranean ecosystems, which superimpose those related to global change with synergistic effects (Mora et al. 2013).

2 Main topics

The papers here collected deal with climate change and human impacts on coastal, open sea and deep water communities, and with peculiar aspects of Mediterranean biodiversity. The structural changes in the marine communities in the Ligurian Sea, faced by a densely inhabited coast, subject to an intensive urban, touristic and industrial development, are reviewed by Cattaneo-Vietti (2018). The effects of thermal stress anomalies on the communities and on the primary production, the arrival of tropical species, and other changes never observed in historical times, are summarized.

Danovaro (2018) reviews climate change impacts on deep Mediterranean Sea biota and habitats. Temperature changes, food limitation, oxygen decline, and acidification have profound effects on both the biodiversity and the ecosystems of the deep Mediterranean Sea. An assessment of the vulnerability of different ecosystems and of the impacts on ecosystem services complete the review.

Porzio et al. (2018) describe an experiment on the ecophysiological response of *Jania rubens* to water acidification. Benthic foraminiferal assemblages are the topic of two papers. The first by Bergamin et al. (2018) describes the foraminiferal ecozones in two submarine caves of Sardinia, while Ferraro et al. (2018) describe live benthic foraminifera communities at the mouth of the Volturno River, in correlation with physical parameters such as turbidity, dissolved oxygen, salinity, temperature and runoff. The impact of breakwater structures on benthic biodiversity, associated with seagrass meadows of Northern Adriatic Sea, is studied by Carugati et al. (2018). Two papers by Capezzuto et al. (2018) and by Chimienti et al. (2018), deal with cold-water coral communities and the impact of fishing activities. Micaroni et al. (2018) report of an interesting and promising project of citizen science on coastal and marine biodiversity, initiated in 2016 at the marine station of Tricase (Lecce, Apulia). Finally, a short paper by Sammartino et al. (2018), concerns preliminary water analysis of sources in the Roman Forum.

Understanding human impacts on the Mediterranean Sea is conducive to predict what will happen to the world ocean. In a review on marine sustainability (Thiede et al. 2016), the European Academies Science Advisory Council provided a set of guidelines to manage and protect marine environments in a sustainable way. The main principle of sustainability is that the growth of the economic capital cannot be obtained while having the erosion of the natural capital as a side effect. At present, our way of life is not sustainable, and this poses a great opportunity of cultural and technological advances leading to a novel relationship between humans and the rest of nature. Science is providing all evidence that a new deal between us and nature cannot be postponed any longer, and that we must radically modify our production systems. This is the most stringent priority for humankind, as recognized in many international treaties, from the Rio De Janeiro Convention on Biodiversity to the Encyclical *Laudato Si'*, by Pope Francis, asking for an ecological conversion.

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