Introduction to the Special Theme:

Blue Growth

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Ocean-based industrial development and growth are important to the economic and social development of many countries, and both the EU and the US agree on the urgency of implementing an integrated maritime strategy with the aim of coordinating policies for the different sectors of the sea. The growth of the maritime economy (blue growth) is an opportunity that Europe cannot wait to seize [1] to create new job opportunities, support systemic competitiveness, and strengthen social cohesion. This approach is also fully aligned with the objectives of the UN Agenda 2030 for Sustainable Development, in particular, Objective 14 (SDG 14): "Conserve and sustainably use the oceans, seas and marine resources for sustainable development". International strategic documents [1] define the areas of blue growth as: coastal and maritime tourism, blue energy (renewable energy from offshore wind farms, onshore/offshore wave energy, salinity gradient, marine current, ocean thermal energy, biomass), marine environment and coastal strip preservation, abiotic and biotic marine resources, fisheries and blue biotechnologies, shipbuilding and marine robotics, smart ports, sustainable maritime transportation, maritime surveillance and safety, sustainability and economic uses of the sea.

The EU Blue Economy Report prepared by the Directorate-General Maritime Affairs and Fisheries (DG-MARE), provides "support to policymakers and stakeholders in the quest for a sustainable development of oceans, coastal resources and, most notably, to the development and implementation of policies and initiatives under the European Green Deal in line with the new approach for a sustainable Blue Economy".

Accordingly, the EU policies are designed to reinforce the efforts of the Member States and regions and provide common building blocks for a blue economy. EU funding under the 2014–2020 financial framework can reinforce these efforts. Ongoing EU initiatives are already encouraging innovation in different sectors and have identified the following five value chains that can deliver sustainable growth and jobs in the blue economy: blue energy, aquaculture, maritime, coastal and cruise tourism, marine mineral resources, and blue biotechnology [2].

Most of the EU funding programmes have the scope to finance projects in blue growth. The European Commission and the DG-MARE fund innovative projects and regularly announce calls for submissions. The European Maritime and Fisheries Fund (EMFF) is focused on seas and coasts, supporting the diversification and sustainable development of maritime economies. The European Regional Development Fund (ERDF) offers numerous opportunities for investing in blue growth, supporting programmes (such as INTERREG and Operational Programmes in each Member State) in the subsectors of sustainable tourism, protection of biodiversity, renewable energy, marine transport and fisheries. Many calls within the framework of "Horizon 2020", EU's largest research and innovation Programme, are focused on blue energy and new technologies in blue growth. Projects co-funded by the European Social Fund (ESF) could assist in strengthening training and education in the marine and maritime sectors, while the Cohesion Fund (CF) supports trans-European networks and environmental projects. The "Competitiveness of Enterprises and SMEs" (COSME) Programme provides financing opportunities to SMEs within blue growth. The "Connecting Europe Facility" (CEF) Programme finances blue growth projects related to port infrastructure, lowering the carbon footprint and compliance with air quality legislation. The EU Emissions Trading System (EU ETS) and the "NER 300" Programme support the deployment of innovative renewable energy technologies and low carbon energy demonstration projects.

While information and communication technologies are being increasingly widely used in industry and transportation, the maritime sector can also benefit from embracing the most promising technological solutions for the blue economy.

Open innovation model for the blue economy

An open innovation model (OIM) is a paradigm under which companies develop competency networks that link suppliers, universities and research centres to cooperate in solving complex problems. Campana and Ferro outline how the external knowledge of the CNR provided fuel to shipbuilding company Fincantieri's business model, enabling research and development to be converted into commercial value. Fincantieri applied a "coupled innovation process", a variant of the OIM, to six projects in the maritime field. Each project addresses a different technological issue within the maritime sector. The E-Cabin project creates a set of advanced technological solutions for cruise ship cabins to improve the onboard experience of passengers. The PiTER on-Board (Technological Platform for High-Efficiency Waste-to-Energy Thermo-Conversion on-board) project focuses on evaluating and developing poly-generation systems for onboard energy use and storage to deal with sustainable maritime transportation. The High-efficiency Vessel project is devoted to designing and conducting experiments on an advanced energy system, to increase the overall energy efficiency of ships, and the GEI Innovative Electric Generation project aims to develop new technologies to improve the efficiency and sustainability of the ship's electrical power plant, considering different aspects, including electrical generation, power distribution and energy management. The E-Navigation project addresses maritime surveillance and safety by developing a virtual dashboard showing digital information to support navigation and reusing a piece of it to suggest an adequate control of propulsion and navigation route, in order to avoid collisions with other objects sighted at sea. These features increase the number of operations that the ship can perform without the direct intervention of a human operator. The Secure Platform project addresses maritime surveillance and safety through two objectives: (i) To develop an advanced security system to protect passengers and personnel in both routine situations and emergencies. (ii) To realise a completely novel system to search and assist a passenger overboard.

Big data infrastructure

The BLUE-CLOUD flagship project of the Directorate-General (DG) for Research and Innovation Unit of the European Commission is establishing a thematic marine cloud serving the blue economy, marine environment and marine knowledge agendas and the European Open Science Cloud. The project links the horizontal e-infrastructures supported by DG-CONNECT and DG-GROW, long-term marine data initiatives supported by DG-MARE, research infrastructures supported by DG for Research and Innovation Unit and other recently funded thematic clouds. BLUE-CLOUD is also developing pilot demonstrator applications with the goal of establishing a marine-themed European Open Science Cloud (EOSC) for the blue economy and marine environment. "Fish, a matter of scales" is one of these demonstrators that aims to improve data management and analytical capabilities of fisheries. These topics are addressed in articles by Candela and Pagano as well as Tzitzikas and Marketakis.

Pendleton's paper presents the Centre for the Fourth Industrial Revolution – Ocean. The Centre, supported by the World Economic Forum, was established to pilot Fourth Industrial Revolution (4IR) solutions to problems facing the world's oceans. The Ocean Data Platform (ODP) is a new data infrastructure to pilot and scale data-oriented solutions to help chart a sustainable blue economy.

Planas-Bielsa et al. describe the World Coral Conservatory (WCC), which will function as a global network, sharing biological material via a big data platform based on a big data structure. It will contribute to the development of biomedical and cosmetic applications and will help to conserve coral reefs as an ecological and economic resource for future generations.

Toward intelligent autonomous and connected systems

Digital connection and situational awareness are becoming increasingly important in the naval field with the development of autonomous systems. The ship of the future will rely on a range of technologies, including satellite communications, navigation monitoring and control systems, sensor networks, machine-learning solutions, artificial intelligence techniques and prediction models. These technologies, which have the potential to improve the safety, security, efficiency, and sustainability of the maritime industry, are discussed in several articles in this issue.

Martelli et al. describe a distributed computing platform that enables automatic control for maritime services, with likely economic and social benefits. In this context, the nodes involved in the computing tasks are autonomous complex cyber-physical systems, i.e., ships. The platform allows node computing cooperation through a high-level abstraction of the underlying sensor system. The computing tasks are related to predictive analysis, employing artifi-