Poster series illustrating a selection of ten grand challenges and priorities for marine research in the next decade identified during the Marine Board Navigating the Future IV Preparatory Workshop (March 2010).

Prepared by the Marine Board and Flanders Marine Institute (VLIZ) on the occasion of EurOCEAN 2010.

InnovOcean site
Wandelaarkaai 7
8400 Oostende
Belgium

EDUCATION AND OUTREACH

REINFORCING GENERAL KNOWLEDGE AND EXPERTISE ON THE SEAS IN EUROPE

"It is a major challenge to bring marine science to the public due to the fact that the underwater world is difficult to experience and communicate."

Europe today

- The closer people live to the coast, the more literate about seas and oceans they are [1].
- Most people associate the sea primarily with tourism and recreation and are unaware of other numerous goods and services provided by the sea [1].
- Marine science, as well as maritime activities, development and growth are restricted due to limited availability of interested students, trained scientists and staff, etc [2].

Europe tomorrow

Marine research and technology could be a critical driver towards:

- Improving marine science education in curricula inspired by successful experience [3];
- Increasing ocean literacy, and raising the awareness of the public at large;
- Turning vocations into qualifications of the highest standards for marine scientists and maritime professionals.




[1] **Ocean Literacy survey in Flanders/Belgium** - Tom Hoeberigs, Jan Seys & Evy Copejans, VLIZ.
[2] **Ocean School 10 "Education at Sea** – Education for the Sea". Conference, Ostend, February 16-17, 2010.
[3] **The National Marine Educators Association** (NMEA) - www.marine-ed.org

MARINE ECOSYSTEM FUNCTIONING

TRANSLATING FUNDAMENTAL KNOWLEDGE FOR THE SUSTAINABLE MANAGEMENT OF THE SEAS

"An improved understanding of ecosystem dynamics and functioning is critical to predict and manage the consequences of environmental change and human impact."

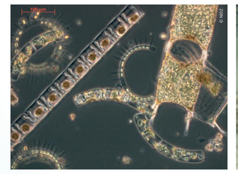
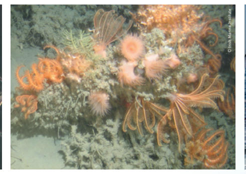
Europe today

- It is estimated that less than 5% of all marine species are known to science [1].
- Marine microbial communities account for a substantial part of the primary production (base of the food chain) in the marine environment and represent more than 90% of the marine biomass.
- Marine microorganisms play a critical role in regulating the cycle of carbon and nutrients in the sea, yet almost nothing is known about their biodiversity and variability over space and time [2].
- Marine ecosystems in Europe are increasingly influenced by human activity. In the Mediterranean Sea more than 600 invasive species have been introduced in the past 100 years with potentially significant impacts on marine ecosystems [3].

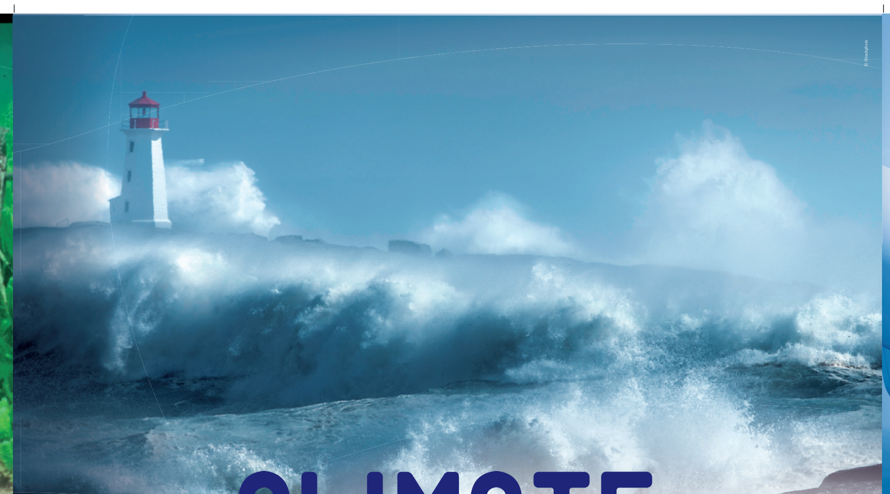
Europe tomorrow

Marine research and technology could be a critical driver towards:

- A deeper understanding of the functioning of marine ecosystems and the influence of human impact and environmental change;
- Greater knowledge of marine microbial species and communities, their role in ecosystem functioning and biogeochemical cycling, and other critical goods and services they provide;
- New modeling approaches through integration of traditionally distinct models for examples ocean circulation, CO_2, chemistry and fish;
- The implementation of an ecosystem approach to management of human activities in the marine environment, and the implementation of the Marine Strategy Framework Directive and the achievement of Good Environmental Status in all European marine waters by 2020.


[1] **Census of Marine Life** (CoML) - http://www.coml.org
[2] **Marine Board-ESF Position Paper 8** (2006) - Navigating the Future-III.
[3] **Gollasch, S.** (2006). Overview of introduced aquatic species in European navigational and adjacent waters. Helgol. Mar. Res. (2006) 60:84-89



CLIMATE CHANGE

CHANGING OCEANS IN A CHANGING CLIMATE

"The oceans both influence, and are influenced by, climate change. Only knowledge generated through research will unlock the complexity of this relationship and allow us to predict and adapt to the consequences of changing oceans."

Europe today

- Globally the mean temperature of the sea surface has increased by 0.1°C over the last 50 years, with significant impacts on the coastal seas [1].
- Sea level rise has accelerated from 2mm/y to 3mm/y putting coastal zones at higher risk from increased coastal erosion and flooding [2].
- Each year the ocean absorbs approximately 25% of all CO_2 emissions resulting in a 30% increase of sea water acidity since the beginning of the industrial revolution [3]. This will have severe consequences for marine organisms with calcareous skeletons including plankton, corals, snails and clams.
- Climate change has already affected marine ecosystems significantly. In the North Sea for example, nearly two-thirds of the fish species have shifted their mean latitude and/or depth over the last 25 years [4].

Europe tomorrow

Marine research and technology could be a critical driver towards:

- Advanced systems of ocean observations providing long-term time series data for predictive models, trend analysis and measuring the effectiveness of climate change policy;
- More reliable predictive modeling approaches, with down-scaled models providing information on local and regional impacts of climate change;
- The understanding of the real rate and scale of environmental change in the marine environment and the knowledge to distinguish between natural and anthropogenic forcing;
- Accurate predictions of the potential socio-economic consequences of changing marine environment to allow for adaptation, mitigation and planning to protect society and economy.



[1] **Marine Board-ESF Position Paper 9** (2007). Impacts of climate change on the European Marine and Coastal Environment: Ecosystems approach.
[2] **Church, J A and White, N J** (2006) 'A 20th century acceleration in global sea-level rise'. Geophysical Research Letters 33(1):pdoi:10.1029/2005GL024826.
[3] **Ocean Acidification Reference User Group** (2009). Ocean Acidification: the facts. A special introductory guide for policy advisers and decision makers. Laffoley, D. d'A & J.M. Baxter (eds). European Project Ocean Acidification (EPOCA): 12pp.
[4] **Perry AL, Low PJ, Ellis JR, Reynolds JD** (2005). 70 Impacts of Climate Change on the European Marine and Coastal Environment Climate change and distribution shifts in marine fishes. Science 308, 1912-1915

BLUE ENERGY

PREPARING EUROPE FOR A NEW ENERGY ERA.

"A 100% renewable energy supply system by 2050 (...) is not a matter of technology, but rather a matter of making the right choices today to shape tomorrow.

Prof. Arthouros Zervos, President, European Renewable Energy Council [1]

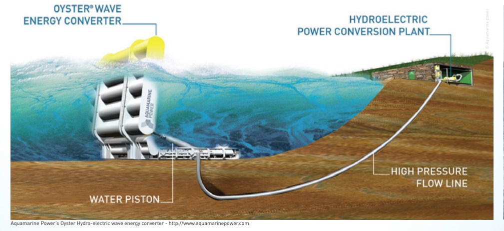
Europe today

- Marine Renewable Energy resources include offshore wind, wave, tidal range and currents, the salinity gradient, the thermal gradient and biomass sourced from microalgae and seaweeds.
- Europe's binding objective to source 20% of its energy from renewable resources by 2020, means that 35% of electricity has to be generated from renewable energy sources; Marine Renewable Energy can and should contribute substantially [2].
- Wave energy converter demonstration and pre-commercial test sites are currently being developed off the coastline of Ireland, UK, Norway, France, Portugal and Spain.
- Offshore winds are stronger and steadier than on land as there are no obstacles to disrupt the flow; offshore turbines can generate electricity 70% to 90% of the time [3].
- The world' largest tidal barrage, the French La Rance Barrage (1966-present) produces 0.54 TWh/y (1 terawatt = 10^{12} watt) [4].

Europe tomorrow

Marine research and technology, together with industry and policy actors, could be a critical driver towards:

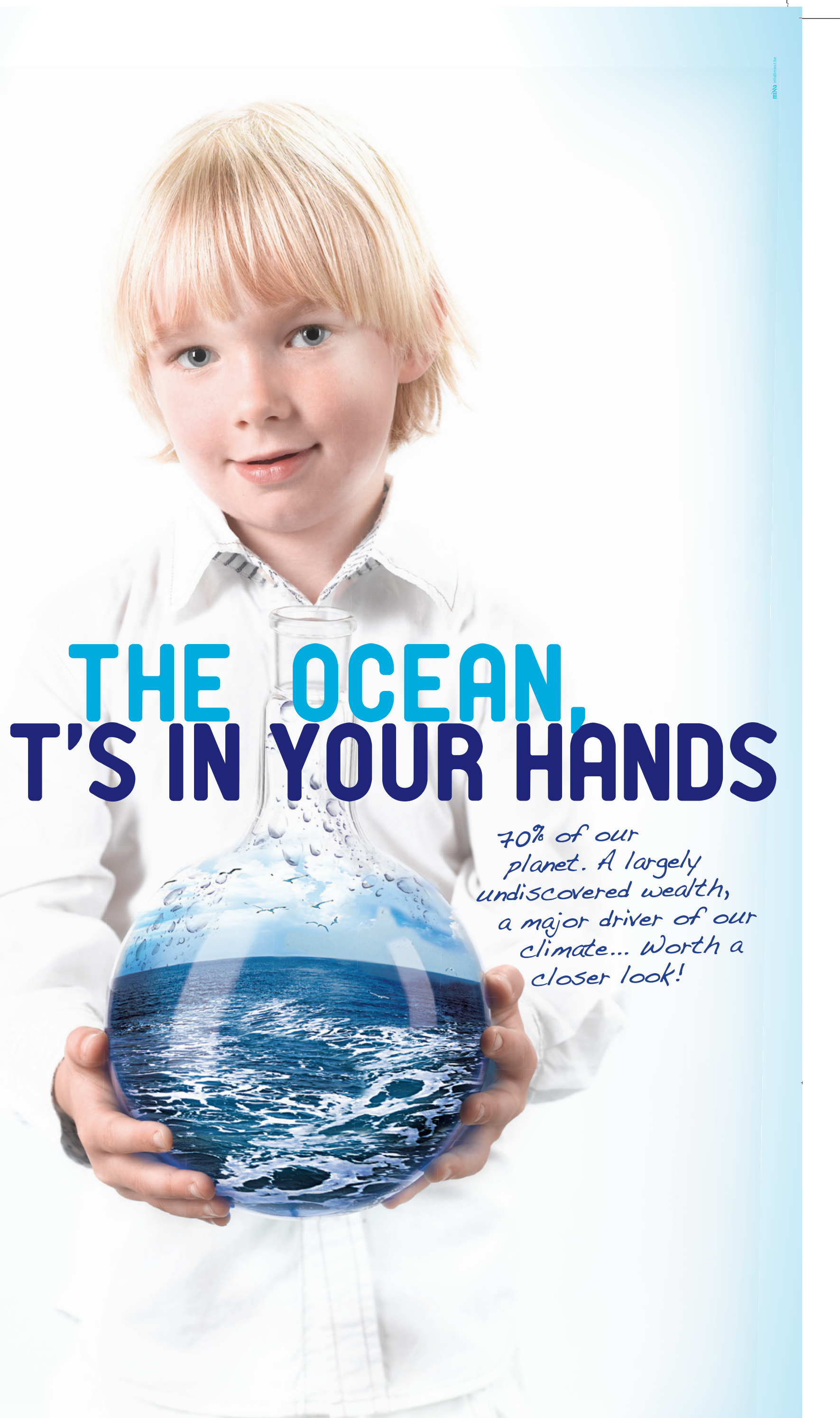
- Improving energy security and reducing dependence on foreign imports:
  - *by 2050 15% of European electricity could be provided by wave, tidal, thermal and osmotic resources [5]*
- The reduction of CO_2 and other green-house gases:
  - *In 2021, offshore wind power would avoid the emission of 100 Mt of CO_2, and possibly 292 Mt in 2030 [6]*
- The creation of new economic and employment opportunities:
  - *10 to 12 direct and indirect jobs would be created for each megawatt (10^6 watt) of ocean energy installed [5]*
- The implementation of Marine Spatial Planning for improved management with minimal environmental impacts:
  - *Facilitating the use of multi-purpose offshore platforms for Marine Renewable Energy generation and a range of other potential uses including aquaculture, marine observations and environmental monitoring.*



Aquamarine Power's Oyster Hydro-electric wave energy converter - http://www.aquamarinepower.com

Open-Centre Turbine, a tidal stream device

[1] **European Renewable Energy Council** (2010) Rethinking 2050, A 100% Renewable Energy Vision for the European Union.
[2] **European Commission** - Directive 2009/28/EC of the European Parliament and of the Council of 23 April 2009 on the promotion of the use of energy from renewable sources - http://ec.europa.eu/energy/index_en.htm
[3] **Aquatic Renewable Energy Technologies** (Aqua-RET) - http://www.aqua-ret.com
[4] **EDF** - http://www.edf.com
[5] **European Ocean Energy Association** (EU-OEA) - http://www.eu-oea.com
[6] **European Wind Energy Association** (EWEA) - http://www.ewea.org



THE OCEAN, IT'S IN YOUR HANDS

70% of our planet. A largely undiscovered wealth, a major driver of our climate... Worth a closer look!

EurOCEAN 2010 CONFERENCE

Grand Challenges for Marine Research in the next decade

Thermae Palace, Ostend
12 & 13/10/2010

www.eurocean2010.eu

FOOD

TOWARDS A SUSTAINABLE HARVEST FROM THE SEAS

"Scientific knowledge, advice and innovation are critical for the future sustainability of fisheries and aquaculture in Europe, supporting jobs, protecting coastal communities and providing safe and healthy seafood products."

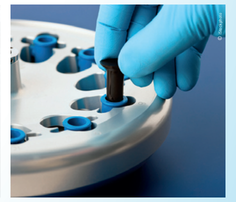
Europe today

- Europe is a major consumer (22 kg/person/year) and a world's top three importer of fishery and aquaculture products.
- In terms of value, the annual output of the European fish processing industry is €23 billion, or three times that of the catch sector [1].
- The EU aquaculture industry produced 1.3 million tonnes of fish, shellfish and crustaceans in 2006, generating a turnover of €3.2 billion and supporting 65,000 jobs [2].
- Globally, marine and inland aquaculture production is fast catching up with fisheries, representing 47% of food-fish output in 2006 [3]. EU aquaculture production, however, is static.
- Science programmes are beginning to focus on the significant opportunities for discovery and extraction from marine organisms of food and functional food ingredients for human consumption and animal feeds.

Europe tomorrow

Marine research and technology could be a critical driver towards:

- The management of European fisheries according to the best available science, utilising an ecosystem approach at relevant local and regional scales and supported by integrated and dynamic policies at EU and national level;
- A European aquaculture sector producing high quality, high value food products, utilising science-based management and advanced technologies and occupying marine space according to the best principles of marine spatial planning;
- Europe achieving the status of world leader in aquaculture technologies, exporting knowledge and services to a globally expanding aquaculture sector;
- A coordinated, sustainable and ethical framework for bioprospecting for bioactive molecules and compounds from marine organisms for delivery of new food additives and ingredients, creating commercial opportunities and healthy food products.



[1] **Facts and figures on the Common Fisheries Policy - Basic Statistical Data** (2010 Edition), European Commission Publication, 45p (ISBN 978-92-79-14127-0)
[2] **Building a sustainable future for aquaculture - A new impetus for the Strategy for the Sustainable Development of European Aquaculture** (2009). Communication from the Commission to the European Parliament and the Council COM(2009) 162 final.
[3] **The state of world fisheries and aquaculture - 2008** (2009), Food and Agriculture Organisation (FAO) (ISSN 1020-5489)

OCEANS AND HUMAN HEALTH

RISKS AND REMEDIES FOR HUMAN HEALTH AND WELL-BEING

"Life on earth is fundamentally and inextricably linked to the oceans. Oceanic processes affect climate, influence the spread of pathogens and determine food and material resource upon which we depend. How we use the sea can influence those processes to our benefit or detriment."

John Stegeman, Director, Woods Hole Center for Oceans and Human Health (USA)

Europe today

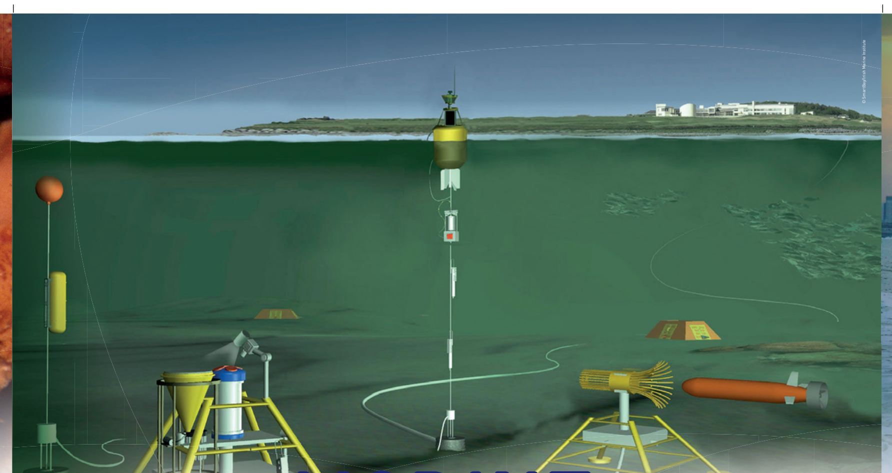
- Harmful Algal Bloom (HAB) events have increased over the past decades along the European coasts, leading to an increase of related diseases and economic losses in the fisheries and aquaculture sector [1] with a total cost estimated at €64 million/year in the U.S and more than €627 million/year in the EU [2].
- More than 100,000 chemicals are currently on the EU market; some of which eventually end up in the marine environment as a micro-pollutants. The effects of this chemical cocktail on the marine ecosystem and human health remain largely unknown [3].
- Around 15 natural products from marine organisms are currently in clinical development for novel drugs (mainly for treatment of cancers) with several already on the market [4]. The oceans and seas – although hardly explored – have a high potential for discoveries of bioactive compounds, given the rich marine biodiversity [5].
- Seafood is an important component of a healthy balanced diet, e.g. providing a vital source of omega-3 fatty acids.

Europe tomorrow

Marine research and technology could be a critical driver towards:

- The reduction of the health risks and identification of new resources and benefits from the oceans and seas;
- This would require an integrated approach combining disciplines as disparate as physical oceanography, chemistry, genomics, epidemiology and social science and focus *inter alia* on:
  - *Better identification and prediction of the occurrence, distributions, toxicity and other deleterious effects of HABs and pathogenic organisms;*
  - *Development of novel diagnostics, drugs and treatments for human diseases;*
  - *Securing supply of healthy and safe marine food from fisheries and aquaculture;*
  - *Better understanding of-and preparation for current global changes which will affect the health benefits and risks of the marine environment;*
  - *Better understanding of the positive (therapeutic) impacts on people of the proximity to the sea.*

[1] Glibert, P.M., Anderson, D.M., Gentien, P. Graneli, E., & K.G. Sellner (2005). **The global, complex phenomena of harmful algal blooms**. Oceanography 18(2): 136-147
[2] **Adapted from**: Hoagland, P.; Scatasta, S. (2006). **The economic effects of harmful algal blooms**, *in*: Granéli, E.; Turner, J.T. (Ed.) (2006). Ecology of harmful algae. **Ecological Studies**: analysis and synthesis, 189: pp. 391-402, and exchange rate $ to €: September 2010
[3] http://www.vliz.be/inram
[4] **Marine Board-ESF Position Paper 15** (2010). Marine Biotechnology: *A new Vision and Strategy for Europe.*
[5] **Fenical, W.** (2006). Marine pharmaceuticals – Past, present and future. *Oceanography 19(2): 111-119*



MARINE OBSERVATIONS AND INFORMATION

TOWARDS AN INTEGRATED EUROPEAN OCEAN OBSERVING SYSTEM

"We need sustained observations because today's observations cannot be taken tomorrow [1]."

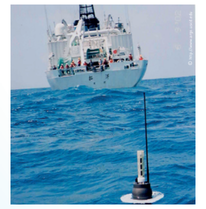
Europe today

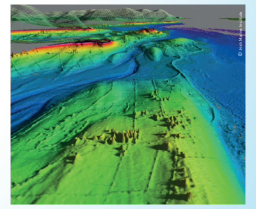
- The annual costs of ocean observations in Europe amount €1 billion for *in situ* data and €0.4 billion for space data [2].
- Marine observations and data are essential for monitoring the rate and scale of environmental change. For instance it is estimated that a 25% reduction in uncertainty in future sea-level rise alone would save €100 million annually in European coastal defenses [3].
- Marine observations are limited to a small number of parameters (mainly physical) and have large spatial and temporal gaps especially at shelf and coastal areas.
- Some components of the global ocean observing system are addressed through large international research efforts whilst others rely on uncoordinated national initiatives, resulting in a very fragmented picture.
- Numerous European initiatives aim at mobilising and coordinating the marine data management field, and developing common standards and protocols for quality control procedures, metadata formats and descriptions, and data exchange formats.

Europe tomorrow

Marine research and technology could be a critical driver towards:

- The establishment of an end-to-end, integrated and inter-operable network of systems of European marine observations and data communications, management and delivery systems, supported by a comprehensive user-oriented toolkit to enable implementation of the Integrated Maritime Policy for Europe [4];
- The development of mutually compatible and multi-dimensional mapping of Member State waters and of a European Atlas of the Seas, as tools for managers and stakeholders to sustainably develop maritime activities;
- The production of information and services required at local, regional, European and global scales that meet identified commercial, societal and environmental needs in a cost efficient way. Stakeholders in need of information products include policy makers, private sector, researchers and the general public;
- The development of necessary supporting technologies (e.g. deep sea observatories) and new sensors to help fill identified observation and data gaps.





[1] **Global Ocean Observing System**: A Summary for Policy Makers (2010). IOC UNESCO.
[2] **European Commission** (2010).
[3] **European Commission** (2010). Financing Marine Knowledge 2011-2013.
[4] **Marine Board - ESF Vision Document 1** (2008). Joint Marine Board and EuroGOOS perspective on the European Marine and Observation Data Network (2008).

MARINE SPATIAL PLANNING

TOWARDS EFFECTIVE MANAGEMENT STRATEGIES OF HUMAN ACTIVITIES IN THE MARINE ENVIRONMENT

"Marine Spatial Planning has emerged as a means to address growing competition for finite marine space and reducing human pressure on marine ecosystems and habitats [1]."

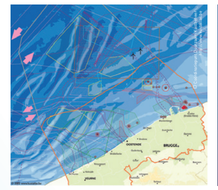
Europe today

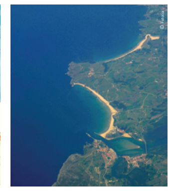
- Seas and oceans represent over 50% of the territory of the European Union.
- In 2008, the European Commission produced a roadmap for Marine Spatial Planning (MSP) which provides the framework for Member States to implement management strategies of human activities [2].
- Some coastal Member States have already implemented MSP strategies and practices (e.g. UK, Greece, Poland, France, and Germany) [1].
- Despite the growing interest of Member States to implement MSP, the scope to do so is limited in international waters (beyond 200 nautical miles) [1].
- Improving MSP could generate up €1.3 billion of revenue by 2020 [3].

Europe tomorrow

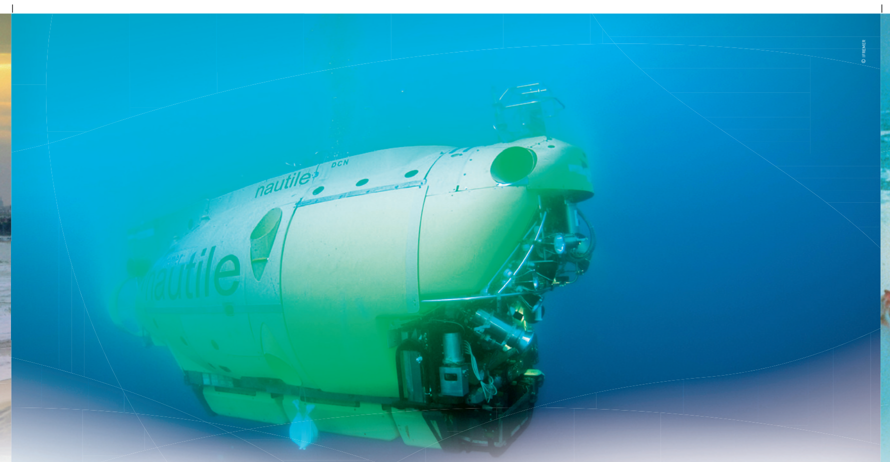
Marine research and technology could be a significant driver towards:

- The effective implementation of flexible and adapted MSP processes supported by a strong data and knowledge base (e.g. EMODNET);
- The use of new tools and integrated assessments to improve the ability of decision-making to take into account the important interactions between human activities and marine ecosystems [4];
- An extensive knowledge of how ecological systems (e.g. food webs) are linked to the provision of goods and services which benefit to humans [5];
- The implementation of a coherent network of Marine Protected Areas in EU waters [4];
- The enhanced competitiveness of the EU maritime economy: improved cross-border cooperation, enhanced legal certainty and improved coherence of sectoral approaches and planning systems [6].





[1] **European Commission** (2009). Legal aspects of maritime spatial planning - Summary report.
[2] **European Commission** (2008). Roadmap for Maritime Spatial Planning: Achieving Common Principles in the EU.
[3] **Maria Damanaki Member of the European Commission, responsible for Maritime Affairs and Fisheries** – speech at "The Integrated Maritime Policy as a catalyst for sustainable economic development for the EU maritime industry" Global Maritime Environmental Congress (GMEC) Hamburg, 6 September 2010
[4] **Marine Board-ESF Position Paper 14** (2010). Science dimensions of an Ecosystem Approach to Management of Biotic Ocean Resources (SEAMBOR).
[5] **European Environment Agency** (2010). 10 messages for 2010: Marine Ecosystems.
[6] **European Commission** (commissioned by) (2010). Study on the economic effects of Maritime Spatial Planning: Final report.



MARINE RESEARCH INFRASTRUCTURES

TOWARDS WORLD-CLASS MARINE RESEARCH INFRASTRUCTURES IN EUROPE

"As a research arena, the ocean is special in two distinct ways: it is costly to access, and highly variable and unpredictable. Marine Research Infrastructures provide unique facilities to the international scientific community to address major marine scientific challenges."

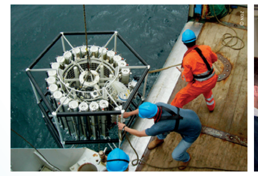
Europe today

- Marine Research Infrastructures (MRIs) include research vessels and associated equipment, satellites, observing and monitoring networks, data, computer centres and laboratories.
- The total construction costs of all the research infrastructures listed in the European Strategic Forum for Research Infrastructures (ESFRI) road-map represent 70% of EU-27 capital expenditure on R&D in one year [1].
- The average age of regional research vessels is more than 20 years in Europe. Without decisive planning and investment, the regional research fleet will decline significantly in the next decade [2].
- Almost 2,000 research institutes, data holding centres, monitoring agencies, governmental and private organisations are engaged in oceanographic and marine research activities, data acquisition and information management [3].

Europe tomorrow

Continued European scientific excellence and competitiveness on a global scale will rely on:

- Technological innovations including e-infrastructure and observing platforms;
- The alignment of national and European strategies towards the sharing and joint management of existing and new MRIs;
- The use of dedicated legal framework (e.g. European Research Infrastructure Consortium - ERIC) facilitating the joint development and operation of MRIs;
- The use of innovative funding mechanisms for the delivery and flexible operation of new MRI of strategic importance;
- Effective coordination between different MRIs such as observing systems (e.g. observatories) and platforms (e.g. research vessels).



[1] **European Commission** (2009). A more research-intensive and integrated ERA - key figures report 2008/2009.
[2] **Marine Board-ESF Position paper 10** (2007). European Ocean Research Fleets - Towards a common strategy and enhanced use.
[3] **SEADATANET**. European Directory of Marine Organisations (EDMO).

MARITIME TRANSPORT

MAINTAINING EUROPE'S POLE POSITION IN SUSTAINABLE SHIPPING

"As a major European industry, sustainable shipping should meet new transport needs, deliver and use innovative technologies, and minimise environmental impacts."

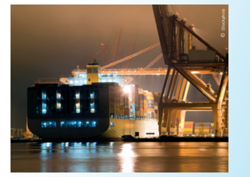
Europe today

- Almost 90% of external freight trade in the EU is carried by sea. 40% of internal trade is by short sea shipping [1].
- Around 3,500 million metric tonnes of cargo [2] and 350 million passengers [3] pass through Europe's ports each year.
- The maritime transport sector in Europe employs 303,000 people directly and 88,000 in related services [3].
- Emissions from maritime transport – Carbon dioxide (CO_2), Nitrogen oxides (NOx), Sulfur oxides (SOx) - represent 4.5% of global emissions [4].
- European investment in maritime research amounts to €1.5 billion each year [5].

Europe tomorrow

Marine and maritime research and technology could be a significant driver towards:

- The development of safe, sustainable and efficient waterborne transport operations, of crashworthy vessels, with low emissions and enhanced maritime security.
- A competitive European maritime construction sector producing innovative vessels and equipment, new floating structures and materials for a global market.
- The implementation of an innovative maritime transport system management including new port infrastructure facilities, new interoperability models, use of intelligent transportation technologies and integrated ICT solutions.



[1] **European Parliament** (2007). Towards a future maritime policy for the Union: a European vision for the oceans and seas (2006/2299(INI))
[2] **The Atlas of European Seas and Oceans** (Spanish Ministry of Education and Science, 2007)
[3] http://ec.europa.eu/maritimeaffairs/, http://ec.europa.eu/transport/maritime/index_en.htm
[4] **Intergovernmental Panel on Climate Change** (2008)
[5] **Waterborne** (2008). *Vision 2020 Waterborne transport & operations* – a key asset for Europe's Development and Future.