'The 'PEGASEAS' project was selected under the European cross-border cooperation programme INTERREG IV A France (Channel) – England, funded by the ERDF."

Promoting Effective Governance of the Channel Ecosystem
Promouvoir une gouvernance efficace de l'écosystème de la Manche

03 The role of long term monitoring in short term policies.

ABSTRACT

Long term monitoring plays a crucial role in developing responsible and effective marine policy. It is vital any changes, environmentally driven or anthropogenic, are recognised and properly understood to ensure suitable measures are taken to help protect our marine ecosystem. These actions can only be proposed and implemented if there is a baseline of information against which to assess them, and this relies wholly on the wealth of information long term monitoring programmes provide. The projects within the PEGASEAS cluster demonstrate the importance of long term monitoring in promoting sustainable governance of the Channel's marine ecosystem.

KEY WORDS

BASELINE DATA
GOVERNANCE
HABITATS
INDICATORS
LONG TERM MONITORING
PRESSURES
TRENDS

DESCRIPTION OF KEY FINDINGS

Introduction

The natural marine environment is subject to fluctuations that occur on a broad range of time scales, from diurnal tidal rhythms, to seasonal cycles, to inter annual changes, to climate oscillations which operate on both decadal and multi-decadal time scales. In addition to natural variability, anthropogenic pressures and climate change exhort significant pressure on marine ecosystems.

Marine monitoring plays a key role in advancing understanding of our marine environment by providing important scientific information on how the physical, chemical and biological components interact and change over time. Data and research obtained through monitoring programmes, especially those which are decades in length, form an evidence base which support decision-making by government bodies and environmental managers.

Many monitoring programmes are set up as part of short term projects and are discontinued when the project ends. Government policy typically operates on short (3-6 year) time-scales and ecological change may not be observed over just one political term. In order to identify changes and cycles in the environment, we rely on established datasets, many of which are products of long term monitoring programmes that have the ability to reveal trends and patterns in the marine environment. Some changes occur so gradually, over many decades, that monitoring over extended periods of time is the only means of revealing these trends.

The purpose of this report is to highlight where products of long term monitoring have contributed to a series of projects, which together seek to improve our understanding and ultimately governance of the marine environment, on which we so heavily depend.

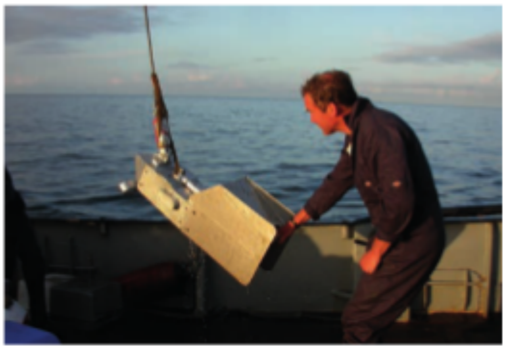
Biogeochemical dynamics

A Ferry Box system, installed onboard MV Armorique (Brittany Ferries). (© Yann Fontana / Station Biologique de Roscoff)

The biogeochemical properties of cross-Channel surface waters have been characterized along Channel Ferry crossing routes thanks to the installation of FerryBox systems onboard[1,2]. Continuous and high-frequency observations of physicochemical (e.g. temperature, light etc.) and biological (chlorophyll, phytoplankton species etc.) parameters were made, in order to understand factors controlling primary production and phytoplankton biomass. These measurements enabled areas within the Channel to be defined by different limiting environmental factors for primary production[3]. This contributes to an enhanced understanding of variability in ecosystem productivity as a whole. FerryBoxes were also used for the first time to investigate CO_2 system dynamics along a latitudinal gradient in the Western Channel[4]. Results highlighted the dynamics of the air-sea CO_2 fluxes, the main greenhouse gas, and more generally the dynamics of the ecosystems from diurnal to inter-annual time scales.

In addition to cross-Channel transects; coastal environment data series at fixed stations (Plymouth and Roscoff) were also sampled[5]. Biogeochemical parameters measured included Conductivity, Temperature and Depth (CTD), nutrient concentration, and optical parameters. The combined approach of a ferry line and fixed stations is a valuable strategy and provides a robust assessment of biogeochemical dynamics.

Plankton



Dr Walne deploying a CPR from a Brittany Ferries ship in the Channel (© Sir Alister Hardy Foundation for Ocean Science)

Plankton (the microscopic algae and animals at the base of the marine foodweb) are sensitive to changes in their environment, and as such can act as key indicators of the health of our seas.

The Continuous Plankton Recorder (CPR) has monitored plankton in the North Atlantic for over 80 years and has accrued a vast and detailed time-series. The Marinexus project contributed to the CPR survey by

1 Station Biologique de Roscoff (undated). *Roscoff – FerryBox Project*. Available at: http://abims.sb-roscoff.fr/fr/

2 CHARM (undated). *Action 2: Phyto- and zoo-plankton*. Available at: http://www.charm-project.org/en/over/actions/97-action-2-phyto-and-zoo-plankton

3 Napoléon, C., V. Raimbault, L. Fiant, P. Riou, S. Lefebvre, L. Lampert and P Claquin. (2012). *Spatiotemporal dynamics of physicochemical and photosynthetic parameters in the central English Channel*. In: Journal of Sea Research 69: pp 43-52

4 Marrec, P., T. Cariou, E. Collin, A. Durand, M. Latimer, E. Macé, P. Morin, S. Raimund, M. Vernet and Y Bozec. (2013). *Seasonal and latitudinal variability of the CO2 system in the western English Channel based on Voluntary Observing Ship (VOS) measurements*. In: Marine Chemistry 155: pp. 29-41

5 MARINEXUS (2010). *Marinexus, our shared sea: mechanisms of ecosystem change in the western Channel*. Progress report # 1. Ref: 1956 / 4073 regularly collecting plankton community composition and biomass data over four years between Plymouth and Roscoff. These data support research progressing the wider understanding of the state of the marine environment in the western Channel, and serve to inform indicators for current national and European legislative drivers, including the Marine Strategy Framework Directive (MSFD[6]). The CPR survey provides a valuable data set as not only does it have a historic dataset which serves as a baseline for comparisons against new data, but it monitors plankton continuously across long distances, offering a regional picture of plankton dynamics. This information is essential if we are to understand variation in species diversity across the Channel, which is important to take into account when developing cross-Channel policy to promote effective governance.

Monitoring plankton is critical when assessing the replenishment of exploited commercial fish stocks. The early stages of fish life cycles take place within the plankton and are highly sensitive to a suite of environmental factors including temperature, salinity, currents and predation. The Eastern Channel is well known for hosting spawning grounds, however, the distribution of these early development stages and the way in which environmental factors affect the distribution have until now been poorly documented. The CHARM 3 project[7] produced annual and seasonal distribution and abundance maps of fish eggs[8] and larvae, which highlight both geographical and temporal differences of species and life cycle stages. The mapping of these habitats was an important step towards improving the understanding of processes that influence the critical phases of the fish life cycle. This information contributes directly to effective and sustainable management of Marine Protected Areas (MPAs) that aim to conserve and protect important habitats from potentially damaging anthropogenic activities.

The survival of larval fish is strongly related to the availability of their food supply, plankton. The timing and abundance of plankton is affected by water temperature and nutrient availability, both of which are predicted to alter as a result of climate change. The CHARM 3 project compared two long-term plankton time series in the western and eastern Channel and also collected new data to explore regional differences in biodiversity patterns and ecosystem function. These findings showed significant difference in sea surface temperature and, consequently, potential variation in phytoplankton species composition between the two sites[9].

Non-native species and sessile faunas

Marine organisms are naturally limited in their distribution by factors such as currents, winds and temperature. However, anthropogenic activity, principally the expansion of the shipping industry, has had a significant impact on the introduction of species' to new sites.

Harbours and marinas are recognised as key locations for the establishment and spread of non-native species. The Marinexus project carried out a series of experiments and surveys in these man-made habitats in north west Brittany and south west England, monitoring the prevalence of invasive species. Through this project the first record of a species of sea squirt (*Asterocarpa humilis*), previously only found in the Southern Hemisphere, was reported in Brittany.

Ballast water plays a key role in transporting species from port to port on an international scale. Analysis of cross-Channel ferry ballast water revealed not only the presence of invasive invertebrates, but also dinoflagellate cysts (phytoplankton) - a potential source of blooms, toxic to both marine life and man. These findings highlight the importance of monitoring 'at risk' localities in particular, as without these records introductions of potentially harmful non-native species may go unnoticed. Only by having a time series can we recognise the presence of non-native species, and determine whether they are one off recordings or represent the introduction and establishment of new populations. Monitoring the spread of non-native species is important as they often have significant economic impacts and serious negative consequences for biodiversity.

6 Marine Strategy Framework Directive Homepage. Available at http://www.msfd.eu/

7 CHARM (undated). *Action 8: Cartography & habitat modelling*. Available at: http://www.charm-project.org/en/over/actions/103-action-8-cartography-habitat-modelling

8 Lelièvre, S., E. Antajan and S. Vaz. (2012). *Comparison of traditional microscopy and digitized image analysis to identify and delineate pelagic fish egg spatial distribution.* In: Journal of Plankton Research 34(6): pp. 470-483.

9 Halsband-Lenk, C. and E. Antajan (2010). *Zooplankton time-series analyses in the English Channel: potential for regional multimetric foodweb indices.* In: Proceedings of the Joint ICES/CIESM Workshop to Compare Zooplankton Ecology and Methodologies between the Mediterranean and the North Atlantic (WKZEM)

Species composition and trophic structure of macrobenthic communities vary naturally over time. The Marinexus project enabled the continuation of a long term data series using the well-established MarClim protocol for rocky shore species and also expansion of a 35 year long monitoring programme of a sub-tidal fine sand macrobenthic community in the Bay of Morlaix (Brittany). Both studies revealed a high variety of temporal changes among species, suggesting that responses to environmental changes are mainly species specific. The latter programme also highlighted that changes occurring in the macrobenthic community as a result of environmental change affected communities in terms of trophic structure and function[10]. In marine environments, separating global environmental change from the effects of natural variability in regional areas in time and space relies wholly on sustained broad scale and long-term observations.

Recommendations are often made at the planning level to assess potential impacts on environments as a consequence of proposed human activity. For example, experimental sites in the Marine Natural Park of Iroise have been selected to monitor the effects of seaweed dredging over a 10 year time scale, before this practice is authorised for the region. Established datasets are uncommon, and it is important to recognise there is significant value in starting a long term monitoring programme, where none currently exist.

Mega vertebrates

European herring gull by the cliffs at Etretat, Upper Normandy (© CRT Normandie)

Changes in climate variability are predicted to have important implications for marine top predators. These animals are typically long lived and produce few offspring, so long term datasets are required to study population changes. The CHARM 3 project examined datasets on seabird's reproductive biology and foraging behaviour in the Channel and prey availability of marine predators. By integrating these datasets, more accurate predictions of current and future consequences of changes to the Channel ecosystem are able to be made.

The Channel consists of many habitat types, each hosting a diverse array of marine life. Determining species actual and potential distributions is essential for effective conservation and management. A key output of the CHARM 3 project was the development of a series of interactive, freely available online maps[11], which offer significant insight into the habitats, flora and fauna of the Channel.

10 Mieszkowska, N., R. Leaper, P. Moore, M.A. Kendall, M.T. Burrows, D. Lear, E. Poloczanska, K. Hiscock, P.S. Moschella, R.C. Thompson, R.J. Herbert, D. Laffoley, J. Baxter, A.J. Southward and S.J. Hawkins. (2005). *Marine biodiversity and climate change: assessing and predicting the influence of climatic change using intertidal rocky shore biota*. In: Marine Biological Association of The United Kingdom. Occasional Publications 20(2005): pp. 1-53.

11 CHARM 2 and 3 (undated): *Metadata catalog of spatial data sets*. Available at: http://www.ifremer.fr/sextant/en/web/charm/geocatalogue

Monitoring spatial and temporal variation in species abundance is important if we are to conserve and manage populations. Long term data sets contribute to our understanding of where best to set up MPAs for transient megafauna and to develop appropriate and effective conservation management plans in cross-Channel partnerships[12] (as observed in PANACHE).

Marine Protected Area monitoring

At the European level, diverse policies and frameworks are in place to ensure the continued monitoring of the state of the marine environment, e.g. OSPAR convention[13], the MSFD, the EU Water Framework Directive[14], the Habitats Directive[15] and the Common Fisheries Policy[16]. Legislation to include monitoring has also been developed and implemented at the national level; in the UK, the criteria to select and maintain MPAs (which include Special Areas of Conservation and Special Protected Areas) stem from the application of the Habitats Directive; in France this directive has been translated into the "Code de l'Environnement". In order to fulfil the EU requirements, member states have in place frameworks to guide organised monitoring programmes. For example, the UK Marine Monitoring and Assessment Strategy co-ordinates the provision of monitoring information required to support policy, operational and management decisions.

Monitoring data for MPAs' management plans can be obtained through two different approaches. The first one is a top-down approach in which referral organisations provide MPAs managers with advices. This has mainly been established in the UK but has also occured at the scale of the Channel coast in France. The second, implemented at the MPAs scale, traces the data back up through a bottom-up approach. It is necessary to combine the two approaches in order to provide a regional context to data that has been locally collected to ensure a good assessment of MPAs effectiveness.

Most monitoring involves the identification of features, such as habitat type and species composition; however social and economic features are now also starting to be recorded in both countries, which offer a more holistic view. In the UK, monitoring frequencies differ considerably between features, MPAs and MPA categories. Most monitoring occurs on a multi-annual basis (approximately every 6 years), although in some MPAs, annual or even monthly monitoring takes place. Endangered features or those at a higher risk of degradation are generally more frequently monitored. In France, the majority of monitoring activities are not standardised, however efforts are being made to create an inventory of monitoring protocols.

Monitoring in MPAs is an important tool in implementing marine policies, developing marine spatial plans and can provide supportive information in designating new protected areas. For example, data on seagrass habitat was used to identify a Marine Conservation Zone for the Solent Seagrass project[17] and data from long term monitoring of seed mussels were used to assess potential impacts of a proposed fishery[18].

Monitoring is essential in assessing the effectiveness of protected areas and should form the basis of adaptive and effective management. An MPA indicator "dashboard" is currently being developed by the Agence des aires marines protégées in partnership with MPA managers, research institutions and other stakeholders. It uses a common assessment framework based on indicators that are integrated at different scales: from individual MPAs, to indicate the evolution of each indicator at each new management plan, to regional and national scales, to obtain a strategic overview of the network. Assessing the ecological coherence of MPA networks as a whole requires the use the long term monitoring data to characterise the criteria needed for the assessment methods.

12 Hastie, G.D, B. Wilson and P.M. Thompson (2003 cited in Pikesley, S. K., M.J. Witt, T. Hardy, J. Loveridge, J. Loveridge, R. Williams and B.J. Godley. (2012). *Cetacean sightings and strandings: evidence for spatial and temporal trends.* In: Journal of the Marine Biological Association of the United Kingdom 92(08): pp. 1809-1820.

13 OSPAR Commission website. Available at: http://www.ospar.org/

14 European Commission (2000): The EU Water Framework Directive: integrated river basin management for Europe. Directive 2000/60/EC. Available at: http://ec.europa.eu/environment/water/water-framework/index_en.html

15 European Commission. The Habitats Directive: About the Habitats Directive. Available at: http://ec.europa.eu/environment/nature/legislation/habitatsdirective/index_en.htm

16 European Commission. The Common Fisheries Policy. Available at: http://ec.europa.eu/fisheries/cfp/index_en.htm

17 PANACHE (2014), *Report on Marine Monitoring by Wildlife Trusts along the south coast of England.* Available at: http://www.panache.eu.com

18 PANACHE (2014), *Report on Inshore Fisheries and Conservation Authorities and Marine Protected Area Monitoring and Management (temporary title).* Available at: http://www.panache.eu.com

CONCLUSIONS

Baseline data is crucial when setting environmental targets for policy, e.g. the Good Environmental Status targets as part of the MSFD. Baselines provide the context against which to interpret changes observed during new policy-led initiatives. Long term monitoring datasets afford unique value in developing models that influence management decisions and policy. Correctly identifying ecosystem responses to anthropogenic or climatic drivers is essential if we are to select appropriate indicators, set attainable environmental targets and ultimately help decision-makers allocate management resources most effectively. Multi-decadal data sets are fundamentally the most valuable tool in informing the advancement of our understanding of changes in the marine ecosystems, reducing scientific uncertainty and ultimately increasing the robustness of management decisions[19].

Despite their recognised importance in informing policy and ultimately contributing to recognising and managing change in our ecosystems, the number of established long term monitoring programmes currently in existence is low. Duarte et al.[20] declared that 'long-term monitoring programs are, paradoxically, among the shortest projects in marine science: many are initiated, but few survive a decade'. Funding bodies are more likely to support short term projects with clearly defined deliverables/results, rather than long term monitoring programmes, which may not yield results during the life of the project.

In conclusion, long-term data series are of significant interest and value for short-term policies for 3 key reasons:

- A complement of monitoring systems is required in order to obtain a realistic and comprehensive understanding of our marine ecosystem. Automated or semi-automated systems, e.g. CPRs and FerryBoxes, can be instrumented with oceanographic sensors, and allow an expansive and cost efficient geographical coverage for a subset of the ecosystem components e.g. plankton and physico-chemical parameters. Other monitoring platforms such as scientific cruises, planes or satellites enable data to be collected on higher trophic levels e.g. top predators and fish.
- Long term high frequency data series enable us to better understand trends and shifts in ecosystems and how they respond to both anthropogenic and environmental pressures.
- This knowledge is fundamental in selecting appropriate indicators, setting attainable environmental targets, allocating resources most effectively and informing current and future national and European legislative drivers.

19 McQuatters-Gollop, A. (2012). Challenges for implementing the Marine Strategy Framework Directive in a climate of macroecological change. In: Philosophical Transactions of the Royal Society A: Mathematical, Physical and Engineering Sciences 370(1980): pp. 5636-5655.

20 Duarte, C.M., J. Cebrian, and N Marbà. (1992). Uncertainty of detecting sea change. In: Nature 356(6366): pp. 190-190.

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