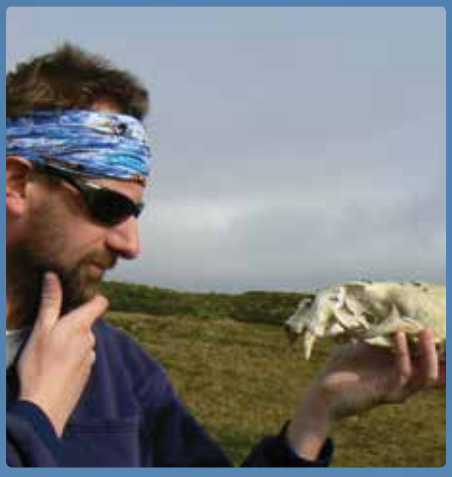
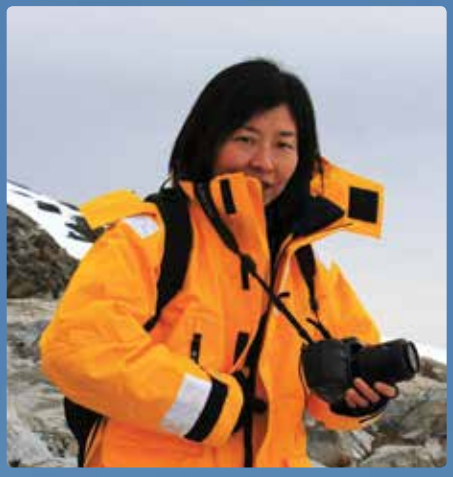
Where the wild things are

Pioneers in bio-logging technologies, **Drs Yan Ropert-Coudert** and **Akiko Kato** explain how their work in this area pushes boundaries when analysing factors of species adaptation in the wild

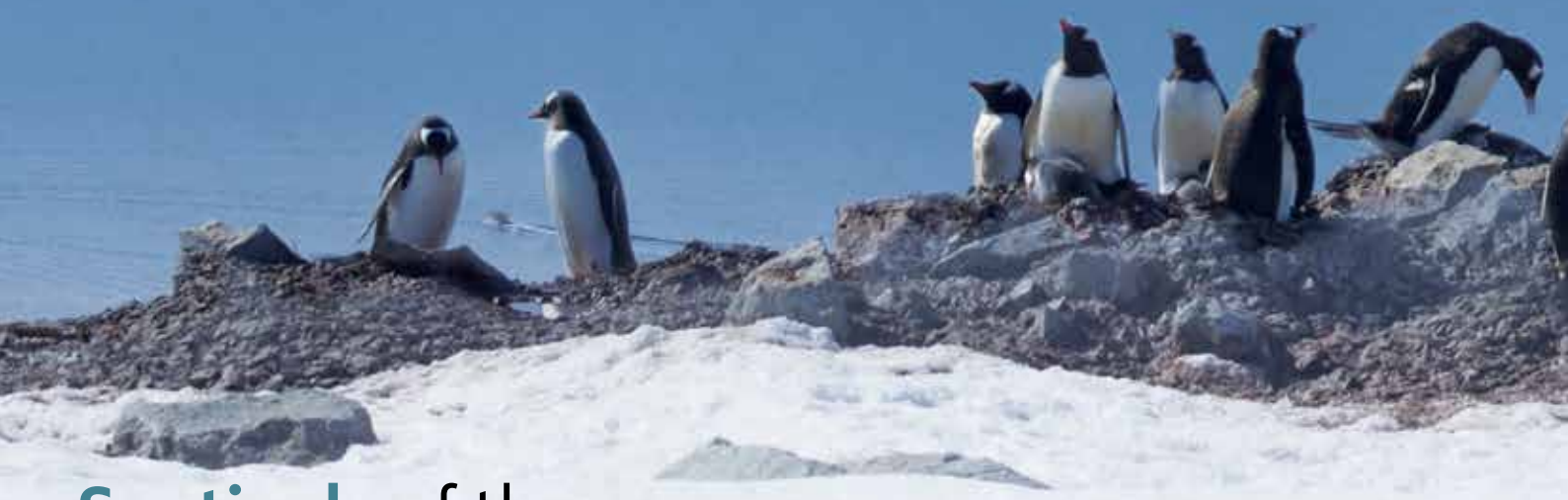
DR YAN ROPERT-COUDERT & DR AKIKO KATO





Could you begin by explaining the concept of bio-logging in layman's terms? How did you develop this approach?

Directly observing free-ranging animals is the traditional approach to investigate natural behaviour but has several drawbacks, such as observer bias and the fact that continuous observation can be impossible or difficult to maintain for long time periods. However, the temporary attachment of minute data recorders onto subjects allows us to build a continuous record of their activity, physiology and physical parameters in an animal's immediate surroundings, and the interaction between these variables. We both started our careers in a laboratory responsible for pioneering these approaches, helped organise the first symposium on the topic and also christened the approach – incidentally, while washing the dishes at home.



Sentinels of the sea

At Strasbourg's **Hubert Curien Multidisciplinary Institute**, novel bio-logging technologies are being applied to construct living observatories for the eco-physiological study of predators in remote marine locations

AT A TIME when the causes and implications of environmental change are the subject of ongoing debate, the importance of high quality research at all levels has never been greater. The effects of climate change are felt in various ways across the globe, from an increase in the frequency and severity of extreme weather events to the shifting of temperate habitat zones for climate sensitive species, and efforts to refine the models used by policy makers as they consider the course of action continue. Reducing the significant uncertainties inherent in climate change predictions remains a high priority.

The Intergovernmental Panel on Climate Change (IPCC)'s 2007 *Fourth Assessment Report* noted that a thorough understanding of marine and coastal ecosystems would be central to the ability to accurately assess and predict the effects of a changing climate. 99 per cent of observations from aquatic systems were consistent with global warming, a strong indication that such regions are particularly sensitive to climate change and that the effective monitoring of these ecosystems is highly relevant to assessing the bigger climatological picture. The report also identified a relative dearth of information on the response of marine environments to such variation. Given the significant role played by the world's oceans in regulating climate, it was recommended that serious consideration should be given to the factors underlying the relative paucity of evidential data from marine environments.

Historically, these factors have largely been connected to expense and the logistical difficulties associated with marine research. The scale of ocean regions greatly impacts observational capacity, with most research forays limited to coastal waters. Terrestrial researchers can draw on observations by amateur naturalists to contribute to large datasets, whereas the sheer inaccessibility of most marine systems prevents the opportunity for such sources of information. Only small portions of the overall expanse can be explored

Bio-logging represents a critical methodological advance in the study of free-ranging animals.

What major questions do you aim to address through this research?

Bio-logging can address an impressive number of questions. The best illustration is that we often go into the field with a set of bio-loggers to address a specific question, and return with multiple datasets with which we discover new ideas and concepts that challenge established paradigms. A particularly interesting area of bio-logging approaches is the possibility of linking animal activity with the physical characteristics of their immediate surroundings at a very fine scale. With this in mind, we have been testing how the presence or absence of environmental features like thermocline or sea ice can affect the hunting efficiency and physiological status of marine predators.

Can you describe your hypotheses regarding the activity of top marine predators at sea and links to the physical parameters of their environment?

Marine top predators are particularly interesting because they live at the upper levels of their food chains. As such, they adapt to changes that occur at lower levels making them good eco-indicators of trophic shifts or environmental perturbations. When monitoring the activity of predators at sea, we can highlight the physical characteristics that make certain oceanic zones so critical to their foraging activity. By repeating this on several species of predator, we can define Areas of Ecological Importance – zones that are used by several species simultaneously, and as such deserve particular protection from management bodies like the Marine Protected Areas. This is one of the tasks that the Expert Group on Birds and Marine Mammals of the Scientific Committee for Antarctic Research (in which Yan acts as a secretary) was set up to address.

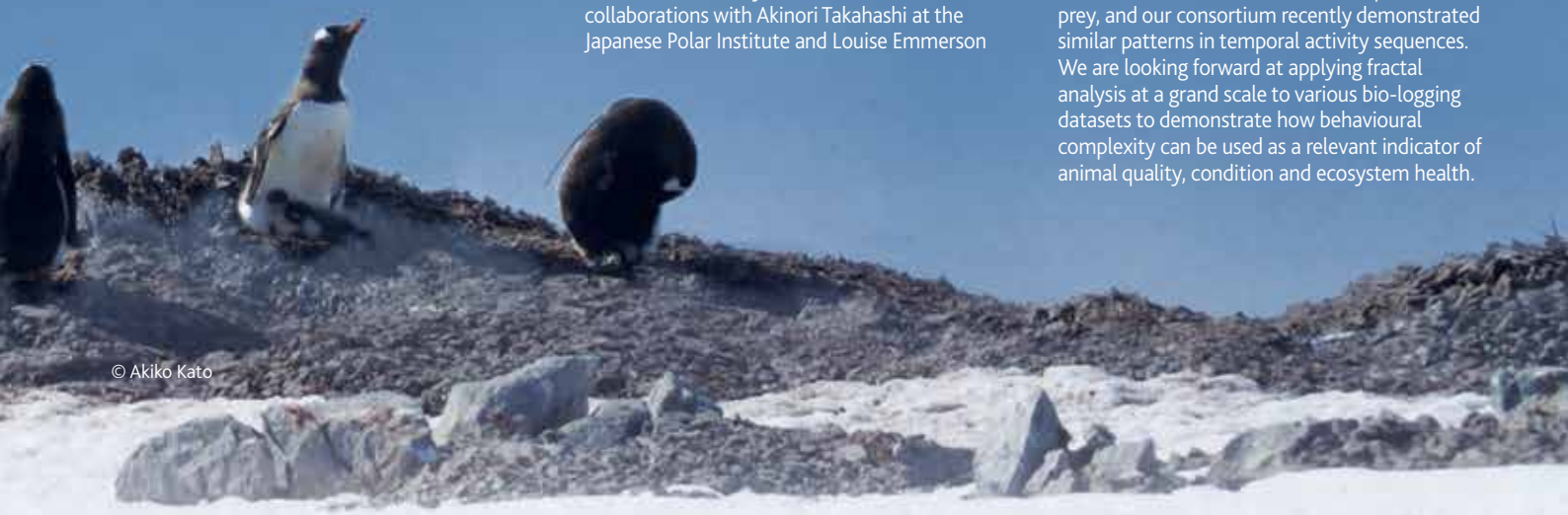
Do you collaborate with other researchers, laboratories or organisations during your research?

From the start of our careers we have witnessed the advantages associated with international collaboration, and as such it is vital to all of our projects. Through our polar programme 1091 l'AMMER, supported by the French Polar Institute (IPEV) and the World Wide Fund for Nature (WWF), we are conducting simultaneous deployments of bio-logging tools in Japanese and Australian study sites, thanks to our collaborations with Akinori Takahashi at the Japanese Polar Institute and Louise Emmerson and Ben Raymond at the Australian Antarctic Division, respectively.

Despite being relatively new, the collaboration with Andrew MacIntosh from the Japanese Primate Institute of the University of Kyoto is paramount to our future projects: his expertise in fractal analysis allows us to enter a totally new domain of research. We could also cite our long-term collaborations with Andre Chiaradia at the Phillip Island Nature Park in Australia, Peter Ryan at the University of Cape Town in South Africa, or Mark Hindell at the University of Tasmania, amongst others. Important assets we look for in collaborators include being reliable, fun to work with, open-minded, dedicated and bon vivant!

What makes your research approach novel and what ultimate impact do you hope it will have?

Our consortium – especially Akiko and Andrew MacIntosh – are recognised leaders in designing novel methods to analyse bio-logged data or behavioural processes. Fractal structure, for example, is inherent in a wide range of biological and ecological processes including spatial and temporal patterns in animal behaviour. Complex, fractal movements (ie. Lévy flights) are known to maximise the contact area between predator and prey, and our consortium recently demonstrated similar patterns in temporal activity sequences. We are looking forward at applying fractal analysis at a grand scale to various bio-logging datasets to demonstrate how behavioural complexity can be used as a relevant indicator of animal quality, condition and ecosystem health.



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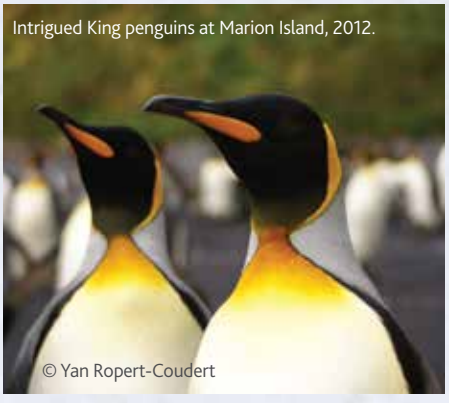
at a time – even shallow marine ecosystems are hidden from the view of satellite observation systems, and investigating phenomena taking place in offshore pelagic regions or abyssal zones requires significant investment in vessels and equipment. In polar regions, where monitoring is most crucial for detecting the early signs of climate change, rough weather and sea ice exacerbate these problems.

MONITORING THE SENTINELS

One of the best means of addressing the lack of data on remote marine and coastal ecosystems is the long-term monitoring of the ecology of key animal species. By centralising long-term data series in the Antarctic, international efforts are underway to improve knowledge of ecological processes in high latitude regions. However, whilst international programmes such as the Census of Antarctic Marine Life (CAML) surveys have compiled and spatially analysed sightings data from several taxa levels in a highly coordinated way, fine-scale activity and location data from top predators have not yet been standardised to the same level. Scientists from the French National Centre for Scientific Research, France, are pioneering bio-logging technologies and techniques specifically to address this significant issue.

The concept of bio-logging is at the heart of the research activity led by Drs Yan Ropert-Coudert and Akiko Kato to describe the method of continuously recording the activity and physiology of individual animals via tiny data recorders attached to the body – known, unsurprisingly, as bio-loggers. Technological advances in recent years have led to improvements in the performance of these devices, with data storage capacity increasing as size and cost has fallen. To further reduce the development costs of technology specifically adapted to their needs, Ropert-Coudert and Kato have been road-testing prototypes in close coordination with the engineers who design them, in a productive union of the fields of biology, electronics and informatics. The team's current focus is on the use of bio-loggers to record the foraging and breeding activities of



Intrigued King penguins at Marion Island, 2012.

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OBSERVATORY AND ECO-PHYSIOLOGICAL RESEARCH USING KEY ANIMAL SPECIES TO STUDY ECOSYSTEMS

OBJECTIVES

To use species as sentinels of environmental changes while simultaneously highlighting the role of individual quality in the expression of an immediate physical/behavioural performance that takes place in a variable environment.

KEY COLLABORATORS

Andre Chiaradia, Phillip Island Nature Park, Australia

Mark Hindell, University of Tasmania, Australia

Ben Raymond, Australian Antarctic Division, Australia

Peter Ryan, Percy FitzPatrick Institute of African Ornithology, South Africa

Sébastien Descamps, Norsk Polarinstitutt, Norway

Akinori Takahashi, National Institute of Polar Research, Japan

Kyle Elliot, University of Manitoba, Canada

Olivier Chastel; Frédéric Angelier, Centre d'Etudes Biologiques de Chizé, France

Thierry Raclot; François Criscuolo, IPHC-CNRS, France

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French Polar Institute Paul-Emile Victor
World Wide Fund for Nature (WWF)

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DRS YAN ROPERT-COUDERT and AKIKO KATO are experts in seabird ecology and bio-logging approaches. They have spent several months in various sub-Antarctic and Antarctic field sites. They are organising the 5th International Bio-logging Science Symposium in September 2014 (http://bls5.sciencesconf.org).

several species of seabirds that are top predators at the pinnacle of their respective food chains.

Top predators can act as sentinel species – ideal indicators of environmental impact – providing an advanced warning of ecosystem trophic dynamics in response to environmental change and shifts in the availability of food. Effects of climate forcing at the primary and secondary levels of oceanic food webs are intensified at higher trophic levels, meaning that top-level predators are more sensitive to these changes, hence their suitability for biomonitoring. Dependent on marine life for survival, periodically accessible to researchers on land and sufficiently sturdy to be fitted with bio-logging devices, seabirds represent a valuable source of information for changes occurring at sea, in remote, hardly accessible marine ecosystems.

A TWOFOLD APPROACH

The team has evolved two synergistic projects to deal with the separate aspects of their research programme. The first – 'Using key species to understand ecosystem and trophic structure' – focuses on an observatory approach and using bio-loggers to record the foraging and breeding activities of several seabird species each year during the breeding season.

This aspect makes use of the long-term monitoring programmes that Kato and Ropert-Coudert set up or have collaborated with over the years, which are already in place for several populations:

- Adélie penguins in Adélie Land, monitored since 1998
- Little penguins in Phillip Island, since 2003
- Brunnich's guillemots in Svalbard and Nunavut, since 2007
- African penguins in South Africa, since 2007
- Macaroni and rockhopper penguins in Marion Island, since 2009

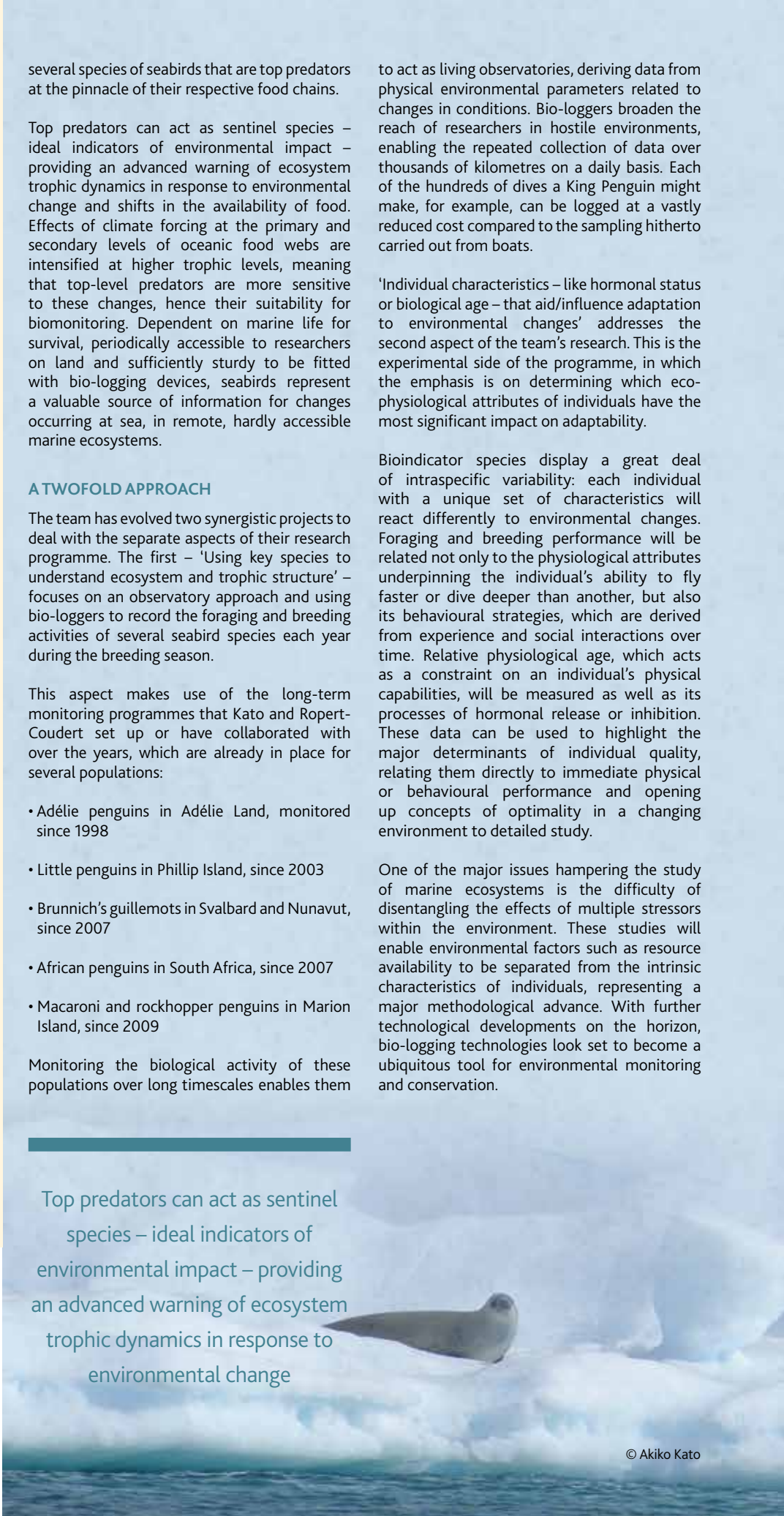
Monitoring the biological activity of these populations over long timescales enables them to act as living observatories, deriving data from physical environmental parameters related to changes in conditions. Bio-loggers broaden the reach of researchers in hostile environments, enabling the repeated collection of data over thousands of kilometres on a daily basis. Each of the hundreds of dives a King Penguin might make, for example, can be logged at a vastly reduced cost compared to the sampling hitherto carried out from boats.

'Individual characteristics – like hormonal status or biological age – that aid/influence adaptation to environmental changes' addresses the second aspect of the team's research. This is the experimental side of the programme, in which the emphasis is on determining which eco-physiological attributes of individuals have the most significant impact on adaptability.

Bioindicator species display a great deal of intraspecific variability: each individual with a unique set of characteristics will react differently to environmental changes. Foraging and breeding performance will be related not only to the physiological attributes underpinning the individual's ability to fly faster or dive deeper than another, but also its behavioural strategies, which are derived from experience and social interactions over time. Relative physiological age, which acts as a constraint on an individual's physical capabilities, will be measured as well as its processes of hormonal release or inhibition. These data can be used to highlight the major determinants of individual quality, relating them directly to immediate physical or behavioural performance and opening up concepts of optimality in a changing environment to detailed study.

One of the major issues hampering the study of marine ecosystems is the difficulty of disentangling the effects of multiple stressors within the environment. These studies will enable environmental factors such as resource availability to be separated from the intrinsic characteristics of individuals, representing a major methodological advance. With further technological developments on the horizon, bio-logging technologies look set to become a ubiquitous tool for environmental monitoring and conservation.

Top predators can act as sentinel species – ideal indicators of environmental impact – providing an advanced warning of ecosystem trophic dynamics in response to environmental change



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