



# Why Ocean Colour?

The Societal Benefits of Ocean-Colour Radiometry



# Satellite Ocean Colour: Science at the Service of Society



The abundance of phytoplankton (chlorophyll concentration) can be mapped by measuring the light coming from the sea with an optical instrument carried on an earth-orbiting satellite. The technique is called ocean-colour radiometry, and it has proved to be one of the most fruitful of remote-sensing technologies. Started as a proof-of-concept mission in 1978 (Coastal Zone Color Scanner), it surpassed all expectations in the significance of the results and the breadth of the applications. During the intervening thirty years, its value to society has only intensified. There is also increased emphasis on earth observation in the intergovernmental arena (witness the formation in 2003 of the ministerial-level GEO, Group on Earth Observations) and a maturing consensus between governments that stewardship of the oceans should be carried out through ecosystem-based management.

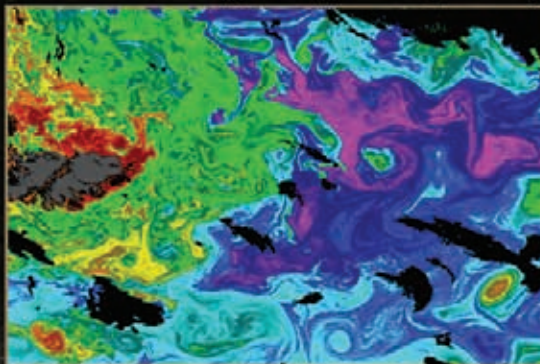
*Credit: European Space Agency*



*True colour image of the South Island of New Zealand on 28 October 2007 captured by Envisat's MERIS instrument in full resolution mode (300 m resolution). Fine wind-blown silt (loess) is transported by the currents and gives the water a turquoise colour.*

Chlorophyll concentration ( $\text{mg m}^{-3}$ )

0.05 0.5 5 50



*Credit: Ocean Biology Processing Group, MASA/GSFC*

*A phytoplankton bloom in the South Atlantic, captured by the MODIS-Aqua sensor on 22 November 2004. Ocean currents have formed a number of eddies (spirals) with elevated chlorophyll levels.*

In this brochure we show how investment in remote sensing is justified by its value to the general public. We begin by stating some of the problems facing society on a world scale, then we show how ocean colour is relevant to these issues, and finally we itemise the societal benefits of investment in ocean colour.



# Societal Issues Related to the Oceans

## Climate Change

The number one problem facing society today is climate change, a phenomenon that is truly global in scope. Of major concern is the increase in atmospheric carbon dioxide ( $\text{CO}_2$ ), leading to ocean acidification and rising sea temperatures.

## Overpopulation

There is also a growing problem of overpopulation in the world, and the rate of population growth is highest in the coastal fringes of the continents, leading to high human impact along the coastal zone (pollution, coastal erosion, river run-off). Coastal populations rely on protein from the sea, but there is a worldwide overexploitation of fisheries and other living resources.



Credit: Grant Pitcher, MCM, South Africa



Selection of phytoplankton species responsible for harmful algal blooms.

## Species at Risk

Public awareness of the plight of species at risk, and of the necessity to maintain biodiversity, is at an all-time high.



## Water Quality

Water quality in the coastal zone is of major concern for the world tourism industry and also for the developing economy of aquaculture. Coastal zone areas are vulnerable to outbreaks of harmful algal blooms, commonly known as red tides.

## National Sovereignty

The oceans continue to be of high strategic importance in the defence of national sovereignty.



Credit: Meena Kumari, Central Institute for Fisheries Technology Kochi, India



# Ocean Colour: Our Window into the Global Marine Ecosystem

Ocean colour provides our only window into the ocean ecosystem on synoptic scales. It is the sole method we have available to take a global view of the marine biosphere.

Climate change is accelerated by the enhanced greenhouse effect, an increase in atmospheric carbon dioxide caused by the activities of man. We need to understand the processes that control atmospheric concentrations of carbon dioxide and other greenhouse gases.

The Earth is a planetary system in which the land, oceans and atmosphere interact closely with each other requiring observing systems that show the linkages.

The Earth's carbon cycle includes two-way flows between all three components - the role of the ocean is especially important.

We are accustomed to thinking that to be Green is to be environmentally responsible and protective of the Earth. But the Earth is a Blue planet, three-quarters covered by water: we need to be aware of what is happening to both parts of the Earth's ecosystem, water as well as land.

It is the aquatic biosphere that is monitored uniquely by ocean colour. The aquatic biosphere is under threat from global warming and ocean acidification. We want to know how it is responding to these and other perturbations.



# Societal Benefits of Ocean Colour

**Cost-effective ecological indicators** can be provided by remote sensing of ocean colour, and applied serially and operationally in ecosystem-based management. These indicators help to characterise ecosystem change following perturbations by natural or man-made causes.



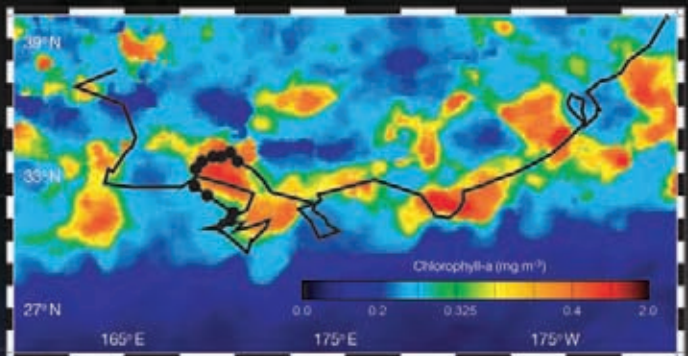
An extensive bloom of *Gonyaulax polygramma* causing a red tide in False Bay, South Africa on 23 February 2007 (from Pitcher et al., 2007, *Oceanography* 21(3): 82-91)

**Harmful algal blooms** can be monitored by ocean colour, tracking the onset, expansion and fate of a bloom, as an aid to the tourism and aquaculture industries.

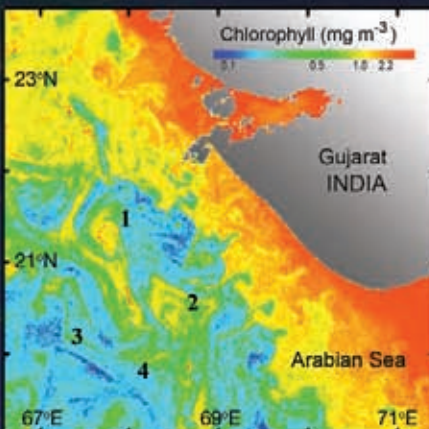
**Coastal water quality** can be monitored using ocean colour as a tool in coastal zone management, for example the degradation of coastal habitat through removal of mangroves.

**Marine protected areas** can be delineated with the help of ocean-colour data, and also the habitat of species at risk.

Track of a tagged Loggerhead turtle (black line) overlain on SeaWiFS chlorophyll data along the Transitional Zone Chlorophyll Front in the North Pacific Ocean (from Polovina et al., 2004, *Fish. Oceanogr.* 13: 36-51).



Credit: R.M. Dwivedi, ISRO, India.

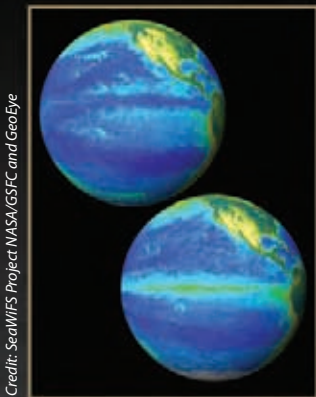
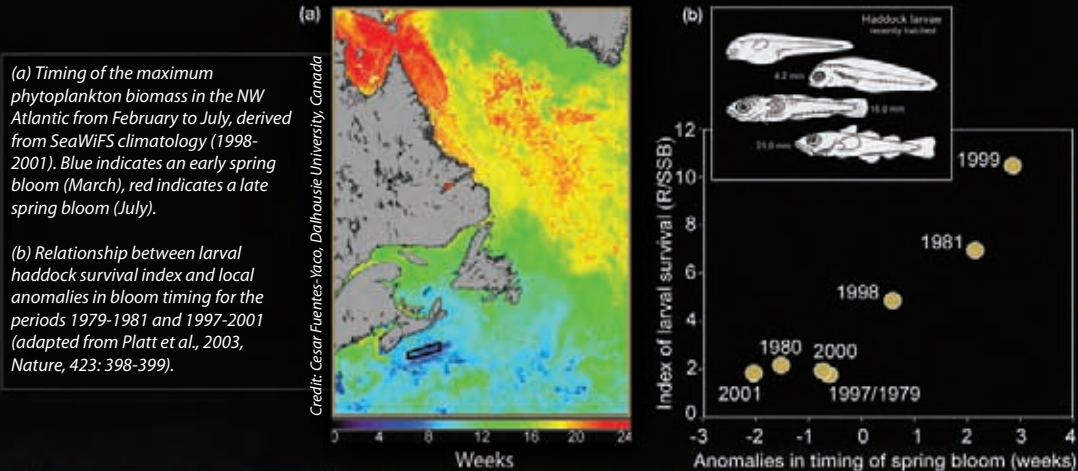


**Potential fishing zones** can be identified using ocean colour, allowing fishermen to work more effectively and economise on fuel. This is certainly not to encourage over-fishing, but merely to provide practical ways for sustainable management and more cost-effective harvesting.

Chlorophyll image of NW India on 29 February 2006 generated from the Indian OCM sensor. Oceanic features such as cyclonic eddies (1 and 2) and fronts (3 and 4) are known to be productive sites and are hence relevant for fishery exploration.

# More Societal Benefits of Ocean Colour

**Interannual variability in marine ecosystems** can be monitored using ocean-colour data, helping to explain, for example, the effect of environmental fluctuations on the survival of larval fish.



**Major perturbations** at the regional level, for example El Niño, can be visualised using ocean colour, and the effect on the marine ecosystem quantified.

SeaWiFS images of the Pacific Ocean during the peak of the 1997-1998 El Niño (top), during which phytoplankton activity in the Equatorial Upwelling Zone was significantly reduced, and (bottom) during the subsequent La Niña when phytoplankton activity in the Equatorial Upwelling Zone was elevated.

## Climate Change

Phytoplankton take up CO<sub>2</sub> during photosynthesis making them potentially important carbon sinks. The annual uptake of CO<sub>2</sub> on a global scale (~50 gigatonnes) can be quantified using ocean-colour data, which also provides essential information for initialising and validating ocean ecosystem models (used to study climate change and global carbon cycles).

## A broad range of marine problems

(e.g. sediment transport) can be addressed using the priceless information provided by ocean colour, unobtainable by any other method.

Total suspended matter derived from a MERIS scene over the North Sea, acquired on 27 March 2007.

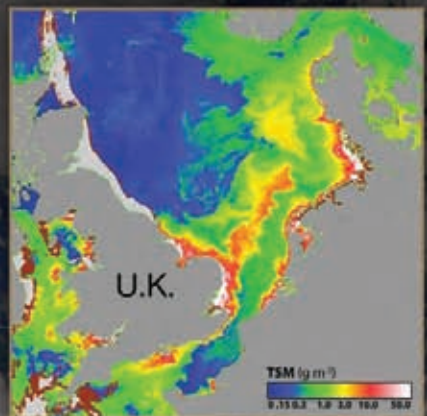
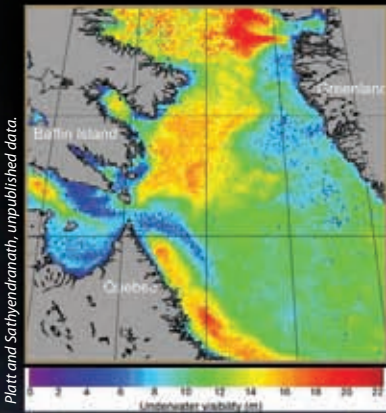


Image by R. Doerffer (GKSS), MERIS data from ESA.





**Outstanding material for education** at all levels can be provided by ocean colour. Information is readily available to the general public through the world-wide web and other publications. Ocean-colour imagery has been of great significance in developing public awareness of ocean processes. These images are icons of our time. However, their striking beauty should not be allowed to obscure the reality that they are based on the most rigorous physical science.



Platt and Sathyendranath, unpublished data.

Estimated underwater visibility (m) in the eastern Canadian Arctic for the month of August, based on SeaWiFS climatological records.

**International governance** on the high seas can be addressed using information provided by ocean colour. Furthermore, ocean colour can provide important information on the underwater light field that is useful for strategic and tactical purposes in national defence.

Ocean colour is one of the most useful remote-sensing missions to society, for both science and operations. We need a broad and secure commitment for an integrated **constellation of ocean-colour sensors** to provide continuing ocean-colour data of the highest quality, thus ensuring that this capability will exist uninterrupted into the future.



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**The International Ocean-Colour Coordinating Group (IOCCG)** is an international Committee of experts comprising representatives from various space agencies as well as the user community. It was established in 1996. The main objectives of the IOCCG are to develop consensus and synthesis at the world scale in the subject area of satellite ocean colour.

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