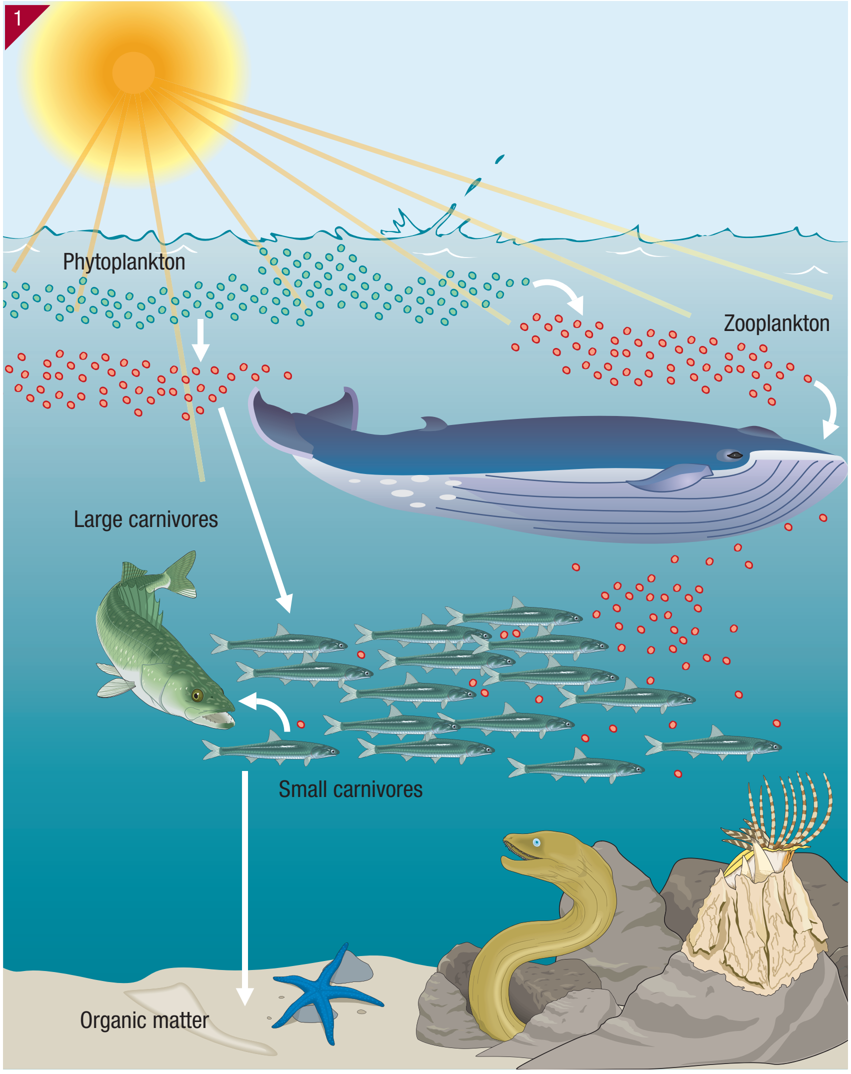
esa

7- Living species and their environments

European Space Agency
Agence spatiale européenne

the Living Planet

MARINE FOOD CHAINS



At the bottom of marine food chains are tiny algae suspended in sea water called phytoplankton. In the spring they increase rapidly in number due to the sun's rays, sometimes producing a "bloom". This form of marine vegetation can develop at sea over an area of several hundred square kilometres.

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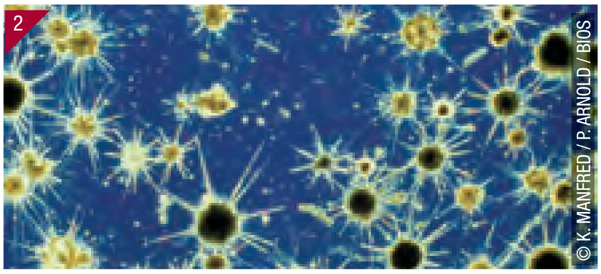
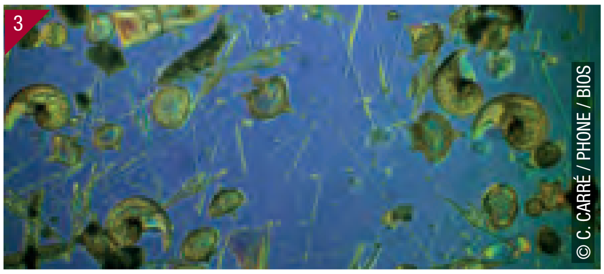
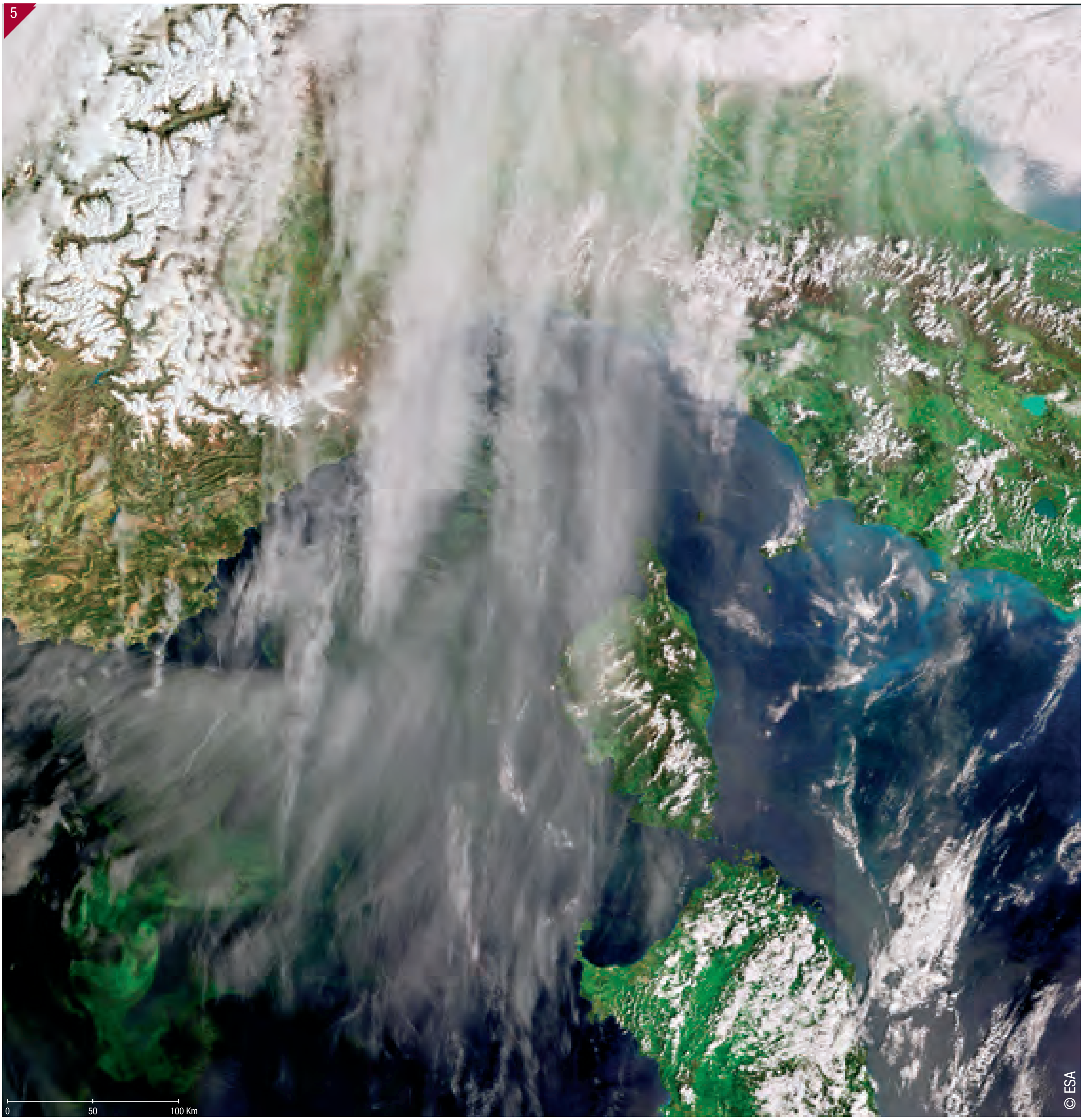


Phytoplankton

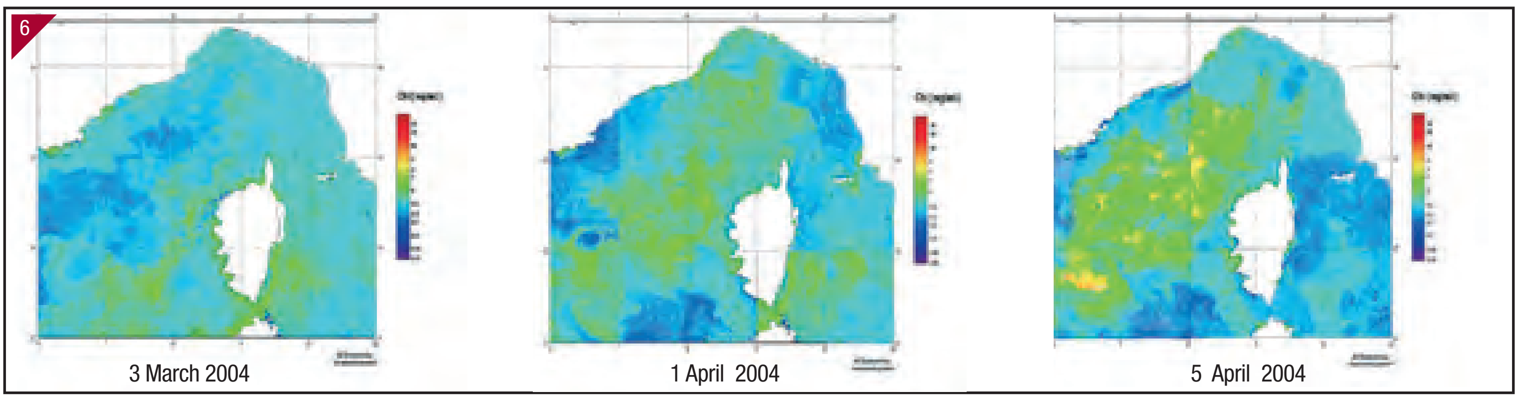


Zooplankton

The fin whale (Balaenoptera physalus), at 22 metres and over 50 tonnes, is the second largest animal after the blue whale. These mammals are estimated to number 3,000 to 4,000 in the western Mediterranean. During the summer, the largest numbers of fin whales are to be found in the Ligurian Sea north of Corsica, since it is there that they find large quantities of their favourite food, pelagic shrimps (or krill), swimming in tightly packed schools.



Bloom observed in the Ligurian Sea between Corsica and the French coast (bottom left in the image above) in April 2004. In this picture the bloom is recognisable due to the green colour of the water.



Graphs showing chlorophyll concentration levels recorded by the Envisat satellite's MERIS instrument between March and April 2004.

WHALES IN THE MEDITERRANEAN

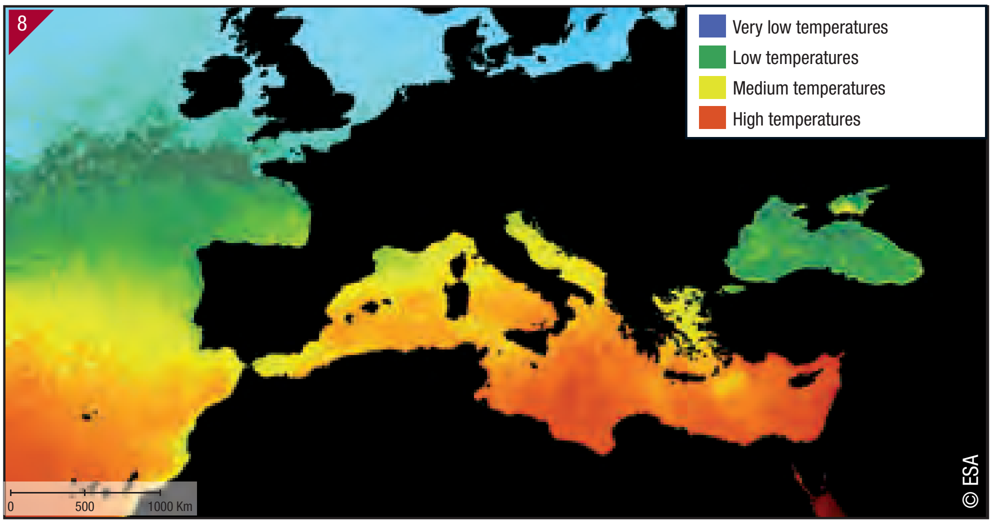
The western Mediterranean is a veritable marine sanctuary for cetaceans but is also subject to heavy maritime traffic. Knowledge of the area and when these mammals are present—and especially when they reproduce—is very important in limiting the causes and risks of disturbances to them.

As a result of observation carried out at sea by specialists and scientists, it has been possible to verify the connection between the appearance of food (biomass and consequently zooplankton) as observed by satellite, and the presence of large schools of whales. These studies have shown that whales naturally adapt their movements to the quantity of food available.

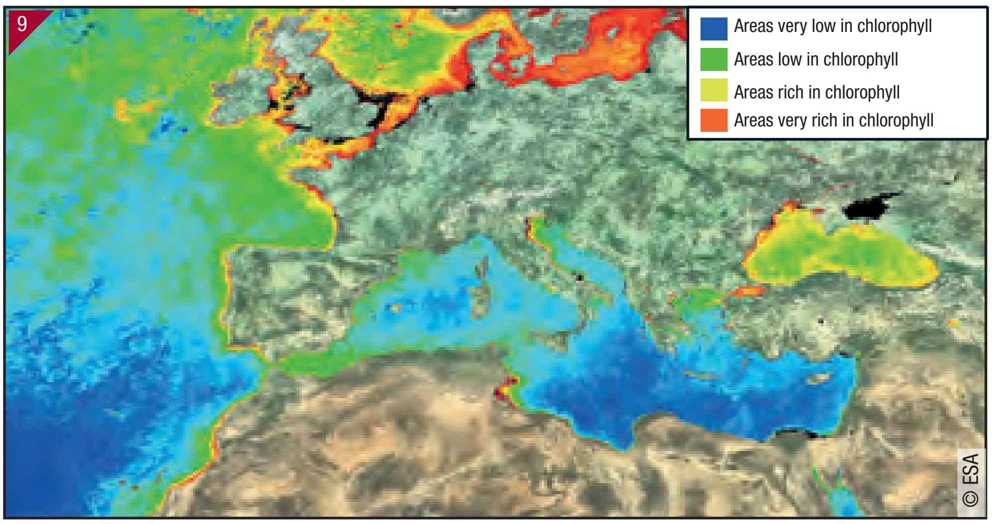
REGULAR SATELLITE MONITORING

Nutritional resources in the Mediterranean are subject to significant seasonal and annual variations. With the use of satellite images it is possible to evaluate the quantity of biomass (photosynthetic organisms and zooplankton) over a large area and over long periods. This is done by measuring chlorophyll concentrations and sea surface temperature variations from space.

A certain amount of time elapses between chlorophyll peaks and the development of zooplankton. Therefore, by analysing satellite images it is possible to predict the areas in which whales are likely to gather.



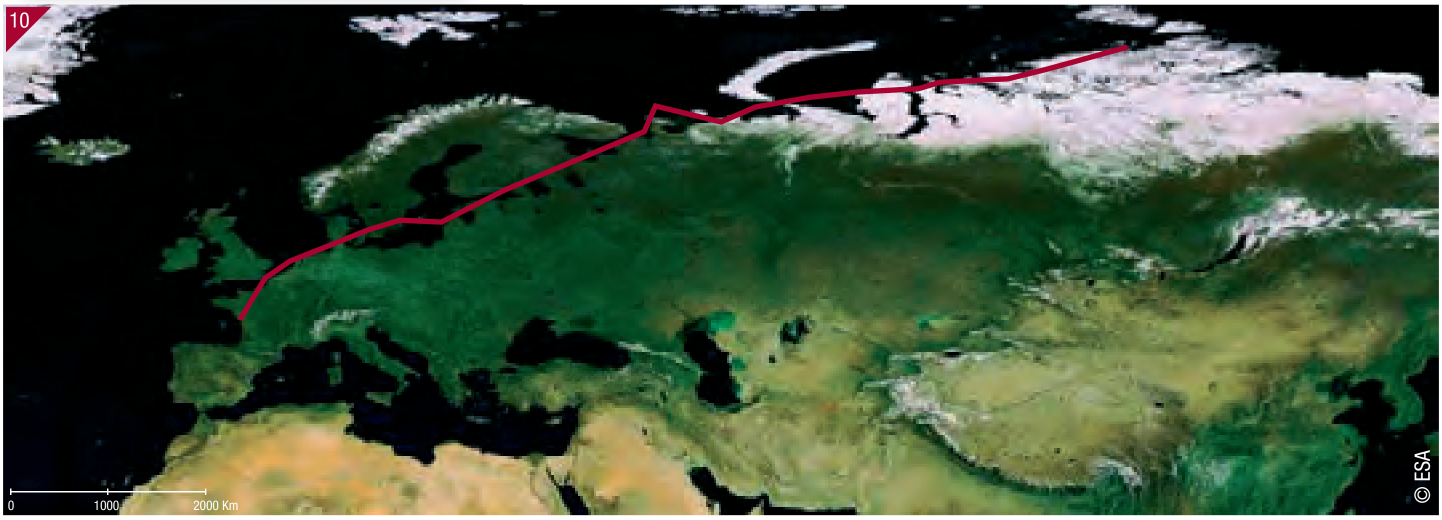
Sea surface temperatures



The photosynthetic organisms present in the sea is highly dependent on sea surface temperatures, but also on nutrients from rivers, which gradually come to contain more and more suspended matter as they flow towards the sea.

The colour of the sea is determined by the interaction of the sun's rays with the substances and particles present in the water. Suspended matter is largely composed of phytoplankton, photosynthetic organisms that contain chlorophyll. Chlorophyll is a pigment which absorbs light in the red and blue wavelengths and transmits it in green, which explains its colour.

THE MIGRATION OF BRENT GEESE



This satellite image, taken at the end of autumn, shows Europe and the north of the Asian continent. Siberia is already covered in snow. Soon ice will engulf the entire coastline. There will be insufficient vegetation and food, especially for young birds fledged in the course of the year. Brent geese therefore leave this northern region behind to winter on the coast of Europe, where they will find all the necessary food. The red line indicates the route they will take.

Migrating geese have been known to gather in the tens of thousands.

Brent geese wintering on the coast of Poitou-Charentes, France.

Their diet includes seeds, buds, grass, worms and insects, but also small fish, shellfish, and green algae. In the daytime Brent geese feed on sea grass in shallow waters. By night they gather in groups out at sea.

The Atlantic coast close to the Garonne estuary, France. Brent geese often gather on the islands on the Atlantic coast, where they can enjoy relative tranquillity (image by Envisat).

How do satellites work?

Satellite positioning systems

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15

The geese leave Europe at the end of May to return to Siberia. It takes them about 3 weeks to cover the 5,000 km that separate Europe from western Siberia, but they often stop off for a few days on the White Sea (near Arkhangelsk) where they find eelgrass (*zostera marina*), which is only just beginning to emerge as the sea ice starts to melt.

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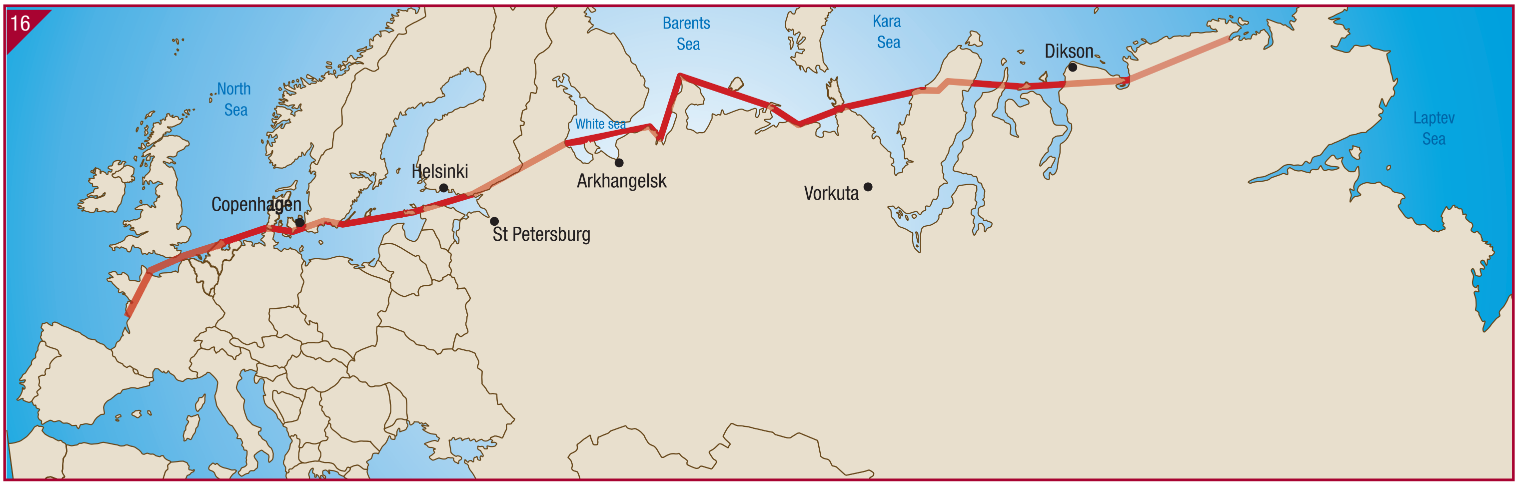

This scientific study monitored 8 birds fitted with tracking devices during their migration from the coasts of Europe to the Taymir Peninsula in northern Siberia, which provides a suitable environment for mating and where they return to nest each year.

One can see by the route taken, indicated by the coloured line, that the geese always stop off on the coast in areas where they can find food.

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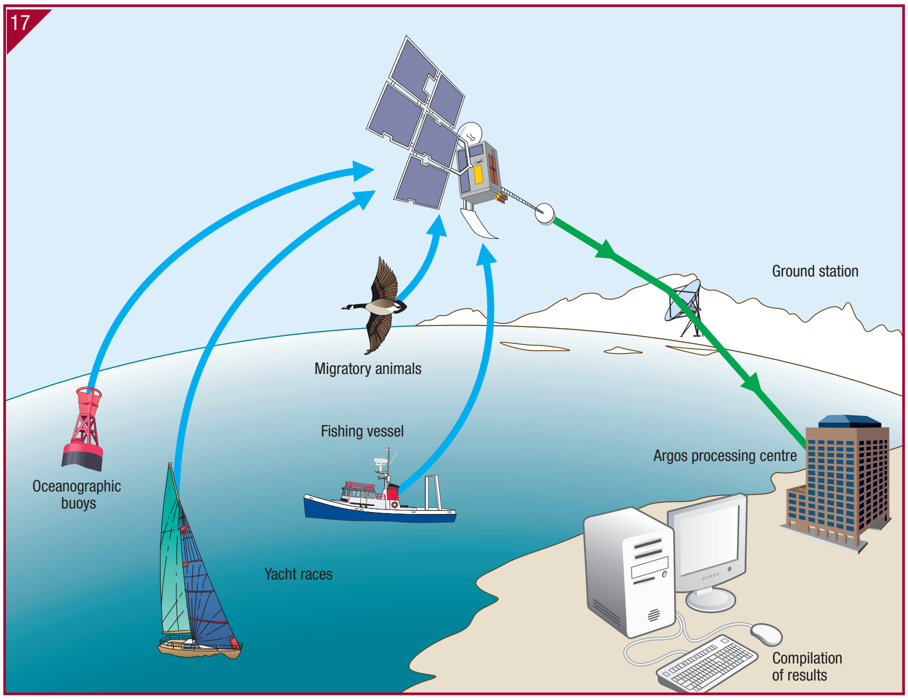

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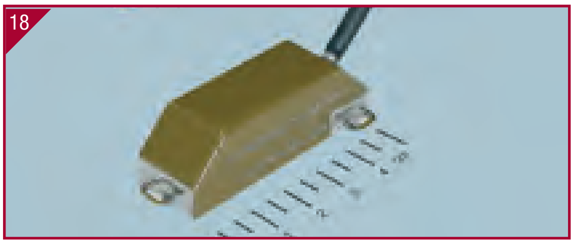


This small tracking device weighing only 30 grams is the one most commonly used to monitor the migrations of many bird species. It contains a transmitter linked to the Argos satellite system with which it is possible to monitor the routes the birds take.

Different types of device exist for tracking other animals such as sea turtles and penguins.

Applying the same principle, it is also possible to track the movements of shipping, land convoys and weather probes which are carried along by wind and by sea currents.

Information for teachers

The "Information for teachers" sheets are designed to offer assistance with the preparation of classes and complement the worksheets handed out to pupils. They contain useful information for the presentation of the subject, additional information relating to the satellite images, and a list of websites dealing with the subjects concerned.

Worksheet 7: Living species and their environments

Worksheet 7 discusses living species in their environments.

This worksheet, and the illustrations, charts and satellite images it contains, can be used to:

- discover and construct the concepts of ecosystem and food chain;
- track the evolution of food supply for marine species such as whales;
- track the path of migratory birds such as Brent geese.

Ecosystems and food chains

To better understand the relationships between different species and their environments, it is necessary to gain a deeper understanding of the concepts of ecosystem and food chain.
An ecosystem can be defined as a complex biological system created by different organisms living together—a biocenosis—in a given environment, and by the elements of this environment which affect the organisms' existence, often referred to as the biotope. This fragment of the biosphere constitutes an entity that is relatively autonomous with respect to the neighbouring ecosystems.

Within an ecosystem, green chlorophyll-containing plants, as autotrophic organisms, are the primary producers. They can use solar energy through the photosynthesis process: after having absorbed carbon dioxide (contained either in water or in air) and water, these plants use chlorophyll to produce organic substances (for example, carbohydrates) that can become very complex; certain molecules can be set aside as reserves, sometimes for long time periods (in the form of grains, wood, bulbs, and rhizomes). Herbivores (insects, birds, mammals, etc.) are the first consumers: they transform organic vegetal matter into organic animal matter. For this reason, they are considered to be secondary producers, just like carnivores which develop their own organic molecules based on the organic molecules present in other animals. Therefore, herbivores, carnivores and omnivores are all considered to be secondary producers. These are heterotrophic organisms.

Within an ecosystem, living beings are all interdependent through a trophic network—a set of food chains that intersect and interact with each other. Both matter and energy move through the different links in the food chain.

All the species in a given ecosystem continuously give back to the environment the substances they have taken from it, albeit in more or less transformed state: photosynthesis, breathing, catabolic waste, and finally death constantly throw numerous mineral and organic products out of the vital cycle. These could be "lost", carried into the atmosphere, drained into the ground, or transformed into materials that are biologically stored more or less for the long term (coal, petroleum, etc.). Most of the organic deposits are taken up by microscopic organisms (bacteria, fungus, etc.)—the reducers—which "simplify" the residual organic material, transform it into mineral substances and make it once again accessible to green plants which use it in the biosynthesis process.

Each habitat contains a more or less wide variety of organisms, each one carrying out the functions written in its genome. Green plants, herbivores, carnivores, and reducers maintain a local equilibrium (with regard to space) over a period of time (temporarily), this equilibrium depending on the compatibility of these different organisms. Some of these have taken root and are permanent elements, other organisms are symbiotic, either saprophytes or epiphytes; still others are herbivores and carnivores, whether sedentary or migratory. The equilibrium between production and consumption is struck thanks to a large number of connections between the species that may have to share the resources of a given site (an especially interesting case is how migratory birds harvest the "surplus" production in temperate forests and tropical savannas).

The ecosystem, therefore, sets the stage for a process that connects spatial and temporal elements, as matter and energy flow through the links in different food chains. The living matter produced this way—the biomass—is eventually transformed (through various means), from living to dead organic matter, which is gradually mineralised, and later recycled.

The satellite images

Cover page

Cover image: The English Channel north of Brittany (Envisat/MERIS)

Of particular interest in this image is the bloom (rapid development of phytoplankton) visible off the coast of Brittany, which extends over a distance of 400 km. Blooms often occur in the spring or early summer. During those periods the concentration of phytoplankton is 300 to 400 times the normal level.

Core content

Image 5: Bloom in the Ligurian Sea (Envisat/MERIS, 5 April 2004)

Phytoplankton are photosynthetic organisms that contain chlorophyll, a pigment which absorbs light in the red and blue wavelengths and transmits it in green (making it visible to the human eye) and especially in the near infrared with the result that it can be clearly identified in satellite images acquired over oceans.

The different spectral bands used by Envisat's MERIS instrument allow specific studies of ocean colour. Most sunlight shines through the surface of the ocean, interfering with water molecules and suspended matter. Absorption by the water shuts out the longest wavelengths (red) but allows the reflection of the shortest wavelengths (blue), hence the generally blue colour of the seas. MERIS detects concentrations of chlorophyll above 1/10,000,000 of a gram per litre.

Image 6: Chlorophyll levels in the Ligurian Sea (Envisat/MERIS, March-April 2004)

In image 5, trailing cloud partially compromises observation of this bloom extending up to northern Corsica. When the satellite passed over, these clouds prevented the capture of certain data. The images in this worksheet have therefore been processed in such a way as to extrapolate readings and allow pupils to better appreciate the connection between the image of the bloom and the three graphs showing its development.

Image 8: Sea surface temperatures (Envisat)

Phytoplankton growth depends on the abundance of nutrients (nitrates, phosphates, silicates etc.). These are to be found in large quantities in the cold deep waters of oceans and are brought to the surface by the cold sea currents. The quantity of phytoplankton is therefore closely linked to surface water temperatures.

There are other ways in which nutrients are added to the oceans, notably when fresh water (including polluted water) flows into the sea, having first gathered nutrients on its journey through the ground. The correlation between chlorophyll concentration and ocean surface temperature is a way of differentiating natural additions of nutrients and additions of anthropic (human) origin.

Image 9: Chlorophyll concentration (Envisat)

Thanks to remote sensing of chlorophyll concentration, it is possible to estimate primary productivity, that is to say the amount of carbon absorbed by plants in the form of organic matter during chlorophyll photosynthesis. Phytoplankton has an important role in the carbon cycle and produces more than half of the oxygen we breathe.
Remote sensing of chlorophyll concentration also makes it possible to locate areas of intense biological production, visualise the interaction between marine currents (phytoplankton, since it is carried by currents, is a marker) and to monitor coastal eutrophication, pollution and other phenomena.

Page 5 - The migration of Brent Geese

Image 10: Northern Eurasia (Envisat/MERIS)

This image shows the snow already covering northern regions and the Alps. To avoid cloudy regions and periods, it has been produced by combining several images recorded over about a month at the end of autumn 2004. Seas and oceans are in black because their data are not taken into account.

Image 13: The French Atlantic coast (Envisat/MERIS)

This image shows sediment expelled by the Garonne river as it moves northwards up the coast. Certain islands constitute the favoured habitats of migratory birds.

Page 6 – "How do satellites work?"

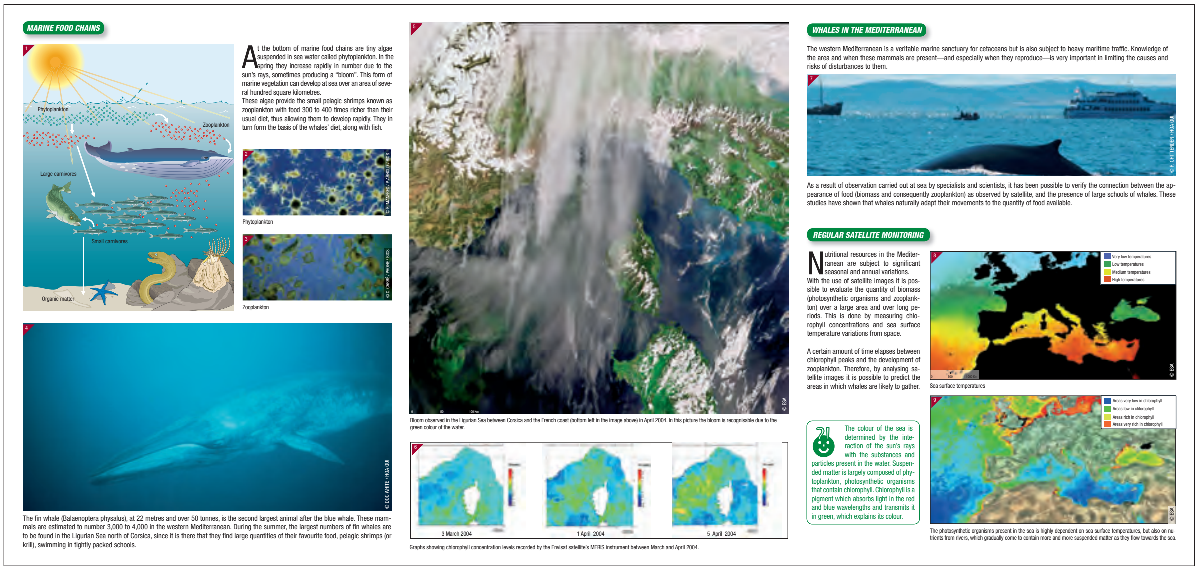
Image 17: Diagram showing the Argos positioning system

Argos is a global positioning and data gathering system. It can be used to monitor bird migrations, map marine currents, track shipping fleets and monitor the transport of hazardous substances.

The movements of a buoy, boat, animal or any platform fitted with an Argos transmitter are monitored to within 300 metres anywhere in the world. Satellites in low-Earth orbits (850 km) relay the messages to ground stations. At any given moment, each satellite sees all the beacons located in a 5,000 km diameter circle.

On average, satellites see each beacon for ten minutes with each pass. The closer the beacon to one of the Poles, the more frequently the satellites pass overhead. Results can be displayed in the form of a map showing the movements of the beacon or of a drifting buoy.

The transmitter can also transmit different types of data, For example, sea surface temperature (SST), wind speed or an animal's heart rate.



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Online resources

www.esa.int	ESA (European Space Agency) website
www.esa.int/SPECIALS/ESRIN_SITE/index.html	ESRIN (European Space Research Institute) website ESRIN is ESA's centre for Earth observation
www.esa.int/eo	ESA Earth observation website
earth.esa.int/earthimages	Gallery of ESA satellite imagery
www.esa.int/education	ESA educational website
www.eduspace.esa.int	Earth observation educational website (EDUSPACE)
www.cnes.fr	CNES (Centre National d'Etudes Spatiales) website Presentation of the French national space agency's missions and activities
www.cnes-edu.fr	CNES educational website
www.spotimage.fr	SPOT IMAGE gallery

THE MARINE ENVIRONMENT

www.defra.gov.uk/environment/water/marine/uk/stateofsea	DEFRA (department for Environment Food and Rural Affairs) website. Marine science and monitoring
www.whaleresearch.org	Website of the "Center for Cetacean Research and Conservation"
www.bnsc.gov.uk/content.aspx?nid=5676	BNSC website: the marine environment

SATELLITE IMAGES

earth.esa.int/cgi-bin/satimgsql.pl?search=bloom&sat=0	Envisat images of blooms
envisat.esa.int/level3/meris/chl1_2006.html	Chlorophyll measurements
www.medspiration.org	Sea surface temperature
dup.esrin.esa.int/ionia/medspiration/year.asp	Temperatures in the Mediterranean. Maps and animations

BRENT GEESE

www.geese.nl/gsg/Gorid.htm	Detailed information on the migration of Brent geese
www2.dmu.dk/CoastalZoneEcology/satellite/index_uk.htm	Following light-bellied brent geese by satellite-telemetry

ARGOS SYSTEM

www.cls.fr/html/argos/welcome_en.html	CLS website (information on the Argos system)

Satellite images

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Production	Europimages - Aliette Cremer

Worksheet N° 7 – Living species and their environments

Once you have read and carefully examined the worksheet, please answer the following questions :

1 – What is the first link in the food chain in the marine environment?
Briefly describe a possible food chain.

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2 – What is the energy source used by phytoplankton? During what season does it grow fastest? What is a “phytoplankton bloom”?

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3 – What is the largest marine mammal living in the Mediterranean Sea? What can be said of its behavioural patterns?

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4 – Carefully look at the satellite image in the middle of the worksheet. Do you notice anything unusual about the sea? What associations can you draw between it and the 3 diagrams shown at the bottom of the page?

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5 – What connection is there between the distribution of phytoplankton and the temperature of sea water?

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6 – One page in the worksheet discusses the migration patterns of Brent geese. Why do Brent geese follow the path marked in red on the satellite image?

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7 – What other ways are there to identify the paths followed by migratory birds? Give examples of other functions of this system.

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