MARINE ECOSYSTEMS

Let's get biophysical! – with BIOFISH

Mark Gall

A new instrument is contributing to a greater understanding of the dynamics of the ocean, especially in the coastal zone.

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Physical processes create the conditions for many biological processes in both open oceanic and coastal waters (see panel below). This biophysical coupling and the dynamics of the marine ecosystem determine the variability we observe. The expression "a drop in the ocean" exemplifies the problems of scale associated with sampling our oceans. The combination of vastness and variability requires multi-sampling strategies and novel approaches.

Multi-sampling strategies provide information over different scales. Observations from space complement measurements from moored instruments and data collected from ships. A range of instruments is used on ships, but NIWA's recent acquisition of a towed instrument – called BIOFISH – has made this collection method especially efficient in the coastal zone.

This article introduces BIOFISH, along with some questions that it can help address and an example of recent applications in Golden Bay and Tasman Bay, South Island.

The instrument

The BIOFISH is designed for use in small boats and is compact enough to be handled by just one person. It is typically towed through the water at speeds of up to 6 knots. As it moves through the water, the unit undulates from the surface down to 40 m.

The instrument contains a multi-sensor probe equipped with seven underwater sensors; these detect depth, temperature, conductivity, oxygen, **chlorophyll *a* fluorescence**, light transmission (water clarity), and ambient

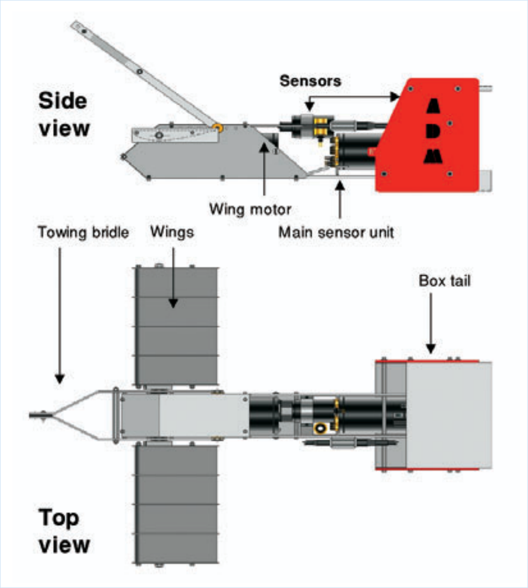
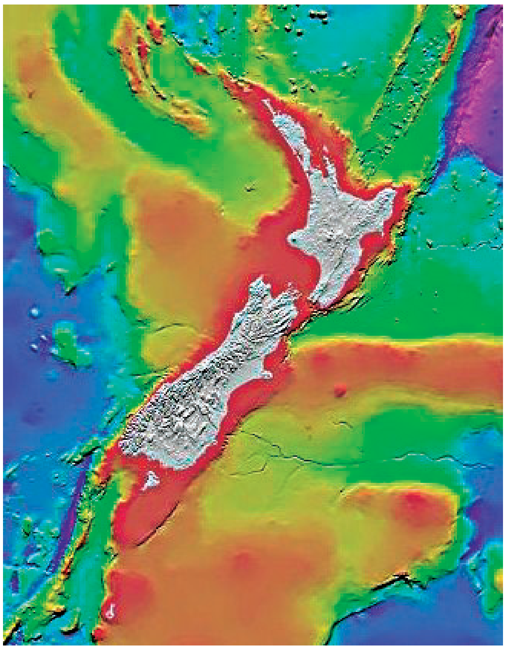


Diagram of the BIOFISH, showing the main components. The wings and towing bridle can be adjusted to alter the flight characteristics.

The coastal ocean of New Zealand



The New Zealand coastal zone (including estuaries and the coastal ocean) lies above the "continental shelf", bounded by land on one side and the continental slope (100–200-m water depth) on the other. The red area on the map illustrates the extent of our coastal zone. The water in this zone is constantly moving and mixing – a bit like atmospheric weather patterns, but on a much slower time scale.

Many factors contribute to the dynamics of this system: open ocean waters beyond the continental shelf; bathymetry and coastline topography; upwelling of deep bottom water; land run-off and riverine inputs; tides and internal waves; seasons and climate.

These factors alter the physical and chemical properties of the water column. By changing conditions for the biological community, in particular the growth of phytoplankton (unicellular microscopic plants), they influence the entire food web.

The vertical structure of the water column varies both in time (***temporal*** – minutes, hours, days, months and years) and space (***spatial*** – meters, kilometres and hundreds of kilometres).

In addition, there are some special management issues in the coastal zone, mostly related to effects from recreational and commercial use, and to the influences of human-induced runoff from land.

The BIOFISH on board NIWA's research vessel RV *Kaharoa*.

light levels. There are two extra ports for additional instrumentation. Surface sensors are: a GPS for position, an echo-sounder for bottom depth information, and a surface light sensor for correction for ambient light level fluctuations. The system samples four times per second.

PC-based software enables manual or automatic control. Real-time graphs of the data can be displayed, as well as the position of BIOFISH in the water column relative to the bottom.

BIOFISH was built in Germany by ADM-Elektronik to NIWA sensor specifications.

Wide-ranging applications

Spatial surveys using BIOFISH have potential to contribute to answering a wide range of questions relating to New Zealand's coastal zone. For example:

- What are the biophysical properties in different regions of the coastal zone? How do they vary and on what spatial scales?
- How do human influences, such as marine farms and discharges into rivers and estuaries, affect water-column structure and phytoplankton populations?
- How well do satellite maps of chlorophyll *a* and temperature in the coastal zone agree with *in situ* surface measurements and how well do these represent the underlying water column? What is the variability?
- How localised are phytoplankton blooms? What are the physical properties associated with these features?

BIOFISH in action

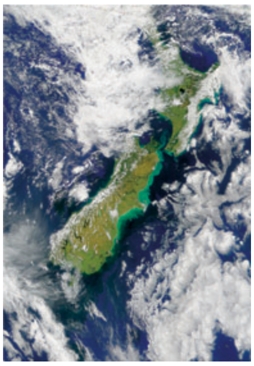
NIWA has a current research programme in Cook Strait, Tasman Bay and Golden Bay, called C-STAG. The goal of the programme is to determine the factors controlling phytoplankton abundance in these bays by studying the seasonal climatology of hydrographic, nutrient, optical and plankton properties. We are collecting data from satellites, moored instruments and ship observations to achieve these objectives.

During 12 BIOFISH deployments in December 2001, we sampled over 128 km at an average

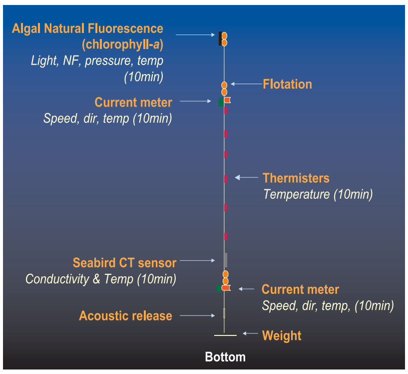
Multi-sampling strategies

A: *Satellites* observe our planet's land and oceans from space. At present satellites can measure four things:
- *ocean colour* – a measure of chlorophyll *a* concentration**,** suspended particulates and bathymetry;
- *temperature* – mixed layer and planet skin;
- *roughness* – winds, wave height, internal waves and surface slicks;
- *height/slope* – currents and sea-floor bathymetry.

Satellite sensors provide us with invaluable and detailed data, but receive information only from the surface layer. Atmospheric interference, cloud cover and closeness to land can compromise images. The key to the usefulness of satellite maps is calibration with real data.



C: *Ship collections* enable detailed *in situ* sampling of the chemical, physical and optical properties of the water column and the biological properties and processes. Ship samplings also provide calibration opportunities for satellite data. Sampling at fixed locations is time-consuming, expensive, and limited to broad temporal and spatial sampling scales. Automated instruments that can collect data while the ship is underway are more efficient and provide more detail.



B: *Moored instruments* provide observations over various time scales at fixed locations and depths. They can provide high temporal detail *in situ* and the data can be used to calibrate satellite data. Biological fouling can be a problem and coastal moorings require regular servicing (every 1–3 months).

speed of 5 knots. This equates to 380 undulations, each one comparable to a conventional fixed-station cast from a ship.

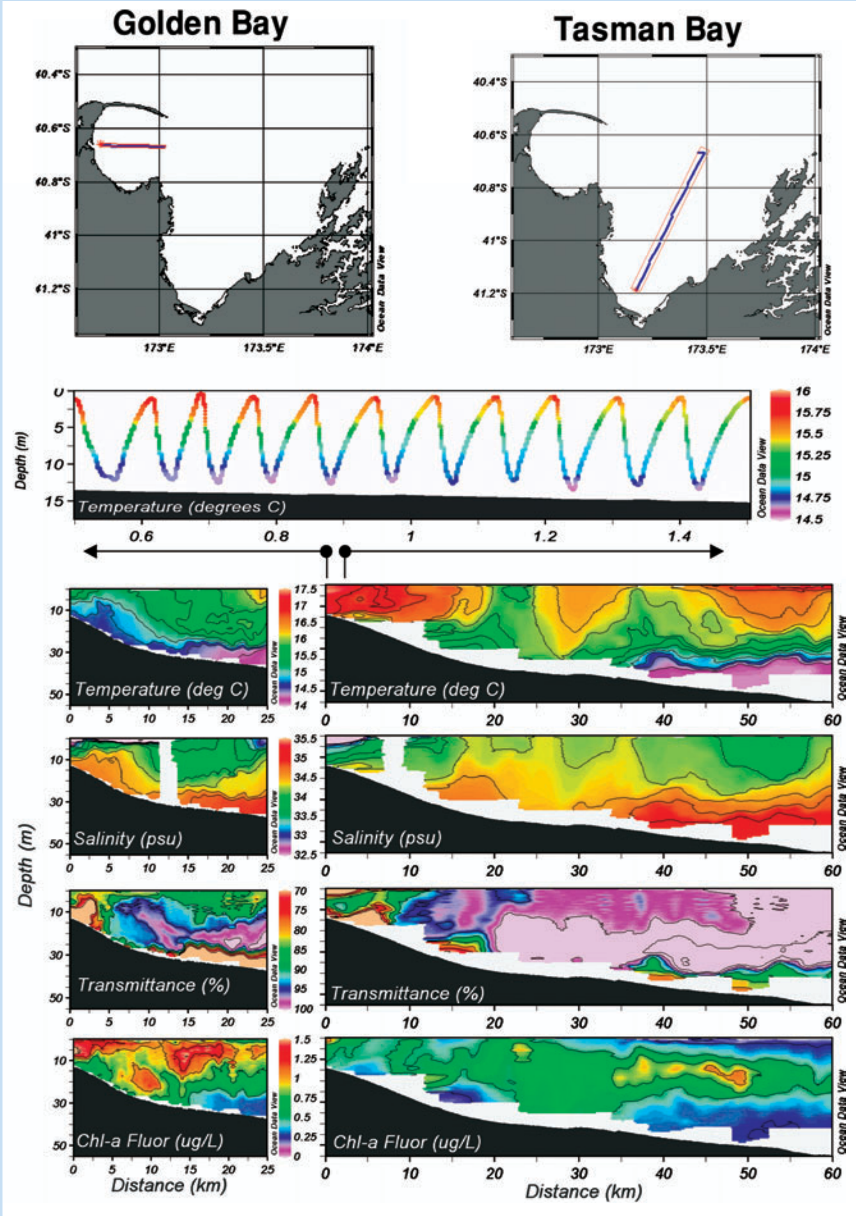
Examples of some of the BIOFISH data (right) illustrate the level of complexity and variability within both Golden Bay and Tasman Bay. The transects were sampled in early summer, and in both bays display the typical estuarine characteristic of low-salinity surface layers from freshwater riverine input. **Stratification** in the water column varies between and within bays. Tasman Bay waters are saltier and cooler, and have higher light transmittance (water clarity) and chlorophyll *a* than Golden Bay waters. Bottom waters are turbid in both bays, especially Golden Bay. The distribution of chlorophyll-*a* varies both vertically and horizontally, displaying deep maxima around the **thermocline** and **pycnocline**.

Water-column current speed and direction, measured simultaneously during BIOFISH transects (data not shown), correlated with certain biophysical features. Further analysis of these datasets will determine the magnitude and nature of the variability in biophysical properties within and between the two bays.

Future jobs for BIOFISH

- The ability of BIOFISH to make rapid measurements – both vertically and horizontally – makes it suitable for rhodamine fluorometer dye-tracer measurements to track the movement and mixing of water bodies (for example, to trace discharge plumes).
- With more sophisticated optical sensors we can improve validation of satellite ocean-colour data and details of water column biooptical characteristics in the coastal zone.
- By adding optical plankton-counter sensors to the instrument we could examine spatial distributions of plankton size and abundance.

Therefore with the addition of new sensors BIOFISH should prove even more useful in mapping a whole range of features in the ocean. The instrument holds great potential for improving our understanding of the coupling of biology and physics in the ocean by measuring both on the same scale. ■



BIOFISH flight paths in Golden Bay and Tasman Bay (December 2001). The top plot shows raw BIOFISH temperature data over a short sector (1.5 km) of the Tasman Bay flight path. The lower plots are the resulting maps over the entire flight paths for temperature, salinity, transmittance (water clarity) and chlorophyll *a* fluorescence (abundance of algae). The data were plotted in Ocean Data View (R. Schlitzer – www.awi-bremerhaven.de/GEO/ODV/).

Definitions of terms

Chlorophyll *a* fluorescence: chlorophyll *a* is the green pigment found in plants, which includes algae (phytoplankton). The pigment has unique light absorbance and emission (fluorescence) characteristics that are used for the quantitative detection of algal abundance in water.

Stratification: forming layers; in summer the sun warms the sea surface, producing a less dense surface layer. Fresh water is less dense than seawater and floats in the surface layer. Thus temperature and salinity combine to produce layers of different densities, whose depth depends on the level of mixing, driven by winds and tides.

Thermocline: the depth at which there is a large temperature change between water layers of different density.

Pycnocline: the depth at which there is a large salinity change between water layers of different density.