MARINE STUDIES

Ocean productivity and water colour

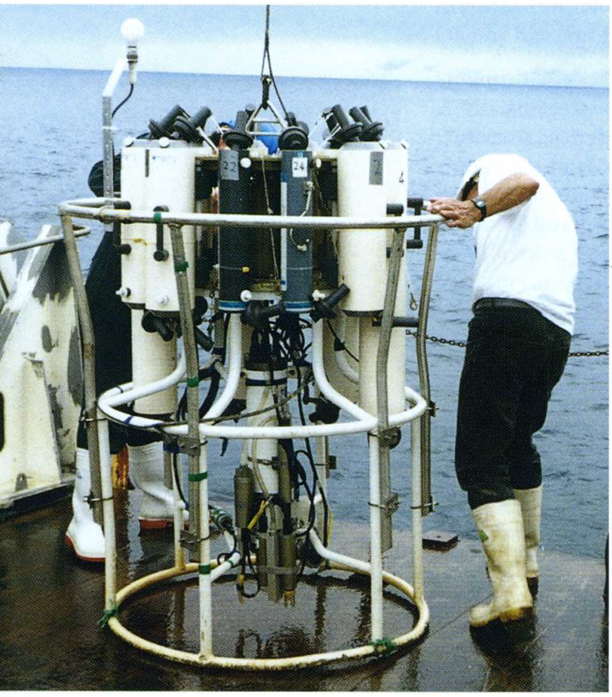
Rob Davies-Colley and
John Kirk

Satellite imagery holds great potential for vastly improving our knowledge of the oceans but interpreting such remotely sensed data is far from straightforward.

IT SEEMS amazing that useful information can be discovered about ocean waters by sampling perhaps one million-billionth (one part in 10^{15}) of their volume for laboratory analysis on a typical voyage of a research ship. However, that is how most of our present knowledge of the chemistry and microbiology of the oceans has been obtained. Samples of a few tens, or, at most, hundreds, of litres are taken to characterise, say, 100 km x 100 km of ocean with an average depth of 5 km!

Increasingly, however, information about the oceans is being obtained by remote sensing techniques which can markedly improve our coverage of these huge areas. Moored sensors can record physical and chemical characteristics over time at a fixed point in the ocean (e.g., NIWA's metbuoy, see *Water & Atmosphere 3*(3): 9–10). Airborne or satellite-borne instruments can produce instant images of the distribution of certain features of the ocean surface water over larger areas than conceivably could be characterised by whole fleets of research vessels.

Rosette sampler and CTD instrument package being checked by Dick Singleton (NIWA, Greta Point) before deployment from the deck of RV Giljanes*. The chlorophyll fluorometer is mounted at the same level as the conductivity, temperature and depth transducers. The white sphere mounted on top of the rosette sampler is the light (PAR) sensor. (Photo: Rob Davies-Colley)*



Sea surface imagery

Studies of the marine phytoplankton, bacteria and other organisms at the base of oceanic food webs will probably always depend ultimately on taking water samples as in traditional oceanography. But such sampling can be usefully supported by images of the ocean surface water temperature and colour. Sea surface temperature imagery from satellite sensors of the thermal infra-red is now almost routine (see cover of *Water & Atmosphere 2*(2)). Imagery of visible light ("optical imagery") within a selected range of wavelengths is also potentially very valuable. In particular, the concentration of phytoplankton – the tiny green plants which form the base of the marine food web – can be inferred from the "green-ness" of ocean water. For example, the mosaic of images from the coastal zone colour scanner (CZCS) carried by the Nimbus-7 satellite has given an unprecedented picture of phytoplankton densities over most of the world's ocean. (For more information refer to Robinson 1990 or Kirk 1994.)

Understanding essential

Obviously such imagery can "see" only a minuscule fraction (perhaps only 10 metres) of the average ocean depth of 5 km. However, sufficient light for algal photosynthesis penetrates down to only about 100 metres at most. Since most of that depth is usually fairly well-mixed, useful information on the ecologically crucial sunlit zone can be obtained by sensors imaging sunlight backscattered upwards from phytoplankton and associated particles in the surface waters.

Use of optical imagery for remote sensing of water features relies heavily on an understanding of how the optical properties of water relate to the phytoplankton and other light-absorbing and light-scattering constituents (see Sathyendranath and Platt 1990, Kirk 1994). Little work has been done on the optics of the ocean waters around New Zealand. To date, the only comprehensive survey of the "bio-optical" character of New Zealand's exclusive economic zone is that of Howard-Williams *et al.* (in press).

Research voyage

On a recent voyage of the RV *Giljanes* (chartered by NIWA), one of the major scientific objectives was to link phytoplankton abundance and productivity to the optical properties of the sea water, particularly its colour, with a view to future remote sensing applications. On this voyage 28 stations were sampled, mainly on two north–south transects across the Chatham Rise. We collected water samples using a rosette sampler with an attached CTD (conductivity–temperature–depth) instrument (shown left). This arrangement produced profiles of salinity (via conductivity) and temperature with depth. In addition, a fluorometer on the sampler measured depth profiles of fluorescence by chlorophyll *a* (the main pigment in the phytoplankton) and a spherical light sensor (see photograph, left) measured the amount of photosynthetically available radiation (PAR) – light usable by phytoplankton for photosynthesis – with depth in the water column.

Figure 1 shows profiles of variables measured with this package of instruments at Station 440 on the Chatham Rise. Such profiles were used to make "real time" decisions about sampling depths, as indicated on the graph.

We found that the water column at Station 440 was "stratified", with a marked temperature change (a