time scales. Animal-collected oceanic data can complement traditional methods for assimilation into oceanographic models. The feasibility of marine animals as autonomous ocean profilers has been proven by deployments of temperature and salinity tags on a variety of marine species, such as marine mammals (e.g. Boehlert *et al.* 2001; Hooker and Boyd 2003; Campagna *et al.* 2006; Biuw *et al.* 2007; Costa *et al.* 2008), seabirds (e.g. Weimerskirch *et al.* 1995; Charrassin *et al.* 2002), turtles (McMahon *et al.* 2005), and fish (Weng *et al.* 2005). While the acquisition of such environmental data has been ongoing, only recently have these data begun to be used to address specific oceanographic questions (Charrassin *et al.* 2002; Costa *et al.* 2008).

The most advanced oceanographic tag is the Sea Mammal Research Unit 9000 CTD~SRDL (Satellite Relay Data Logger; www.smru.st-andrews.ac.uk). In addition to collecting data on the animal's location and diving behaviour it collects conductivity, temperature, and depth (CTD) profiles. The tag looks for the deepest dive for a 1- or 2-hour interval. Every time a deeper dive is detected for that 1–2-hour interval, the tag begins rapidly sampling (2 Hz) CTD from the bottom of the dive to the surface. These high-resolution data are then summarized into a set of 20 depth points with corresponding temperatures and conductivities. These 20 depth points include 10 predefined depths and 10 inflection points chosen via a 'broken stick' selection algorithm. These data are then held in a buffer for transmission via ARGOS. Given the limitations of the ARGOS system, all records cannot be transmitted; therefore a pseudo-random method is used to transmit an unbiased sample of stored records. If the SRDLs are recovered, all data collected for transmission, whether or not they were successfully relayed, can be recovered. An example of the kind of coverage provided by these tags can be seen in Figure 6.4.

6.4 Advances in shipboard, laboratory, and *in situ* process studies

GLOBEC process studies have required new experimental approaches to investigating specific mechanisms which are thought to link ecosystem responses with environmental variability. Innovative methods to understand key components of the population dynamics of target species, both zooplankton and fish, have been used, focusing particularly on reproduction, growth and mortality, and between-species interactions. An extensive programme of laboratory experimentation on zooplankton and fish maintained under controlled conditions has been fostered. These experiments have focused on determining vital rates, such as feeding, growth, and reproduction of target species and this information has been especially valuable for model parameterization.

The GLOBEC focus on the influence of global change on marine animal populations required investigation of processes controlling abundance and productivity and how these processes are affected by environmental variability. The abundance

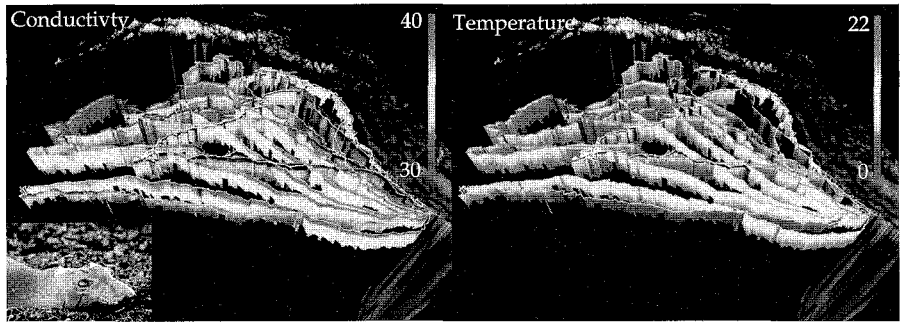

Figure 6.4 Left: conductivity and right: temperature profiles obtained from seven female elephant seals migrating across the North Pacific Ocean. The different coloured lines refer to the tracks of individual seals and the 'curtain' effect shows the depth over which the CTD data were obtained. The coloured bars are the scale for conductivity (mS/cm) and temperature (°C). Inset lower left: female elephant seal with CTD tag on her head. (From Costa, unpublished data). (See Plate 19).