Box 6.2 *continued*

decision mechanisms. These decision mechanisms use relationships between features associated with the images in a training set and the label provided by a human expert to classify images of unknown identity. Misclassification errors must be quantified with a confusion matrix. It should be noted that automated classification systems are at best, expected to perform as well as a human expert. Experts do make mistakes (Culverhouse *et al.* 2003). When mistakes are incorporated into the training set, boundaries between features associated with each taxon will be less well defined and accuracy will likely suffer. Ideally an expert system should be capable of learning from misclassification errors to improve overall classification accuracy.

There are currently several examples of software tools that incorporate most or all of the above activities to enable computerized classification. These include ZOOIMAGE (www.sciviews.org), ZooProcess and Plankton Identifier (www.zooscan.com), Visual Plankton (www.whoi.edu/instruments/vpr), and SIPPER software (http://figment.csee.usf.edu/~shallow/sipper/papers/SipperSoftwareManual.pdf). At present, each of these packages is primarily designed to function with a single instrument type, although ZOOIMAGE has the capability of functioning with both scanner-based instruments such as ZOOSCAN (Grosjean *et al.* 2004) and the FlowCAM (Sieracki *et al.* 1998).

Considerable progress is being made using computers to conduct the labour-intensive classification of plankton samples. Accuracies of 70–80% or better have been demonstrated for 10–20 class problems. A notable success has been the demonstration of an accuracy of 88% for a 22-class phytoplankton problem with individual class accuracies ranging from 69 to 99% (Sosik and Olsen 2007). Based on work with the Video Plankton Recorder (VPR) and other systems such as SIPPER, it appears likely that similar performance is achievable for mesozooplankton using support vector machine (SVM) and other classification algorithms.

Once we are able to employ computers to advance past our current image bottleneck, the oceanographic and plankton ecology communities will be able to tap into the wealth of information that imaging systems can provide about planktonic predators and their prey. Far too often the time lag between data collection and interpretation is unacceptably long. When computers are able to do the hard work while oceanographers are at sea collecting the data, we will be able to observe plankton ecology on time scales that permit real-time responses to interesting predator-prey interactions.

An example of the type of interactions that could be visualized while at sea is provided by Global Ocean Ecosystem Dynamics (GLOBEC) data collected with the VPR in Wilkinson Basin, Gulf of Maine. During 1998 and 1999, there were dramatic changes in the abundances of diapausing *Calanus finmarchicus* and their invertebrate predators (see Box 6.2, Fig. 1). For example, in 1998, relatively few *C. finmarchicus* were present while physonect siphonophores were very abundant. In contrast, *C. finmarchicus* were very abundant during 1999 while siphonophores were relatively sparse. This relationship may have been partially a consequence of predation pressure by siphonophores on *C. finmarchicus* because their regions of high densities were inversely distributed in 1998 (see Box 6.2, Fig. 1) while there was no obvious spatial relationship in 1999.

Although these spatial patterns illustrated in Box 6.2, Fig. 1 were not obtained using semi-automated techniques, we have begun using a new interactive sorting tool called Plankton Interactive Classification Tool (PICT) to rapidly separate VPR images into their constituent taxa. PICT was developed by the University of Massachusetts Computer Vision Laboratory as part of a project to develop flexible software tools to classify plankton images. PICT combines segmentation and feature extraction with a classifier to semi-automatically sort images into taxonomic categories. As images are placed into these by a human operator, all unknown images that share features with those

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