Introduction

Mesoscale eddies are generally thought to play important roles in ocean circulation, heat and mass transport, mixing, biological productivity, upper ocean ecology, and biogeochemistry including elemental cycling and fluxes (e.g., Cheney and Richardson, 1976; Olson, 1980; Falkowski et al., 1991; Allen et al., 1996; McGillicuddy and Robinson, 1997; Dickey et al., 1998; McGillicuddy et al., 1998; Oschlies and Garcon, 1998; Honjo et al., 1999; McNeil et al., 1999; Letelier et al., 2000; Fischer et al., 2001; Garcon et al., 2001; Leonard et al., 2001; Oschlies, 2001; Seki et al., 2001; Flierl and McGillicuddy, 2002; Lewis, 2002; Bidigare et al., 2003; Taupier-Letage et al., 2003; Sakamoto et al., 2004). The horizontal dimensions of mid-latitude mesoscale eddy features generally range from about 100 to 250 km in diameter with scaling roughly dictated by the Rossby radius of deformation (e.g., Richman et al., 1977). Fully developed eddies are often in near geostrophic balance though the ageostrophic component can be important as well. A variety of physical processes have been hypothesized to contribute to mesoscale eddy formation. For example, eddies or rings in the vicinity of western boundary currents like the Gulf Stream and the Kuroshio may be generated through inertial instabilities, open ocean eddies may be produced through baroclinic instabilities, and eddies formed in the vicinity of sea mounts may be caused by barotropic instabilities.

Mesoscale eddies are also often evident near islands as indicated by the observations reported here and elsewhere (e.g., Barton, 2001). It has been suggested that instabilities associated with current flow past islands or through island passages can generate eddies (e.g., Aristegui et al., 1994, 1997; Barton et al., 2000, 2001). Another mechanism for generating eddies involves the acceleration of winds through island channels with high mountains on either side. Gradients in the wind fields on the lee sides of such islands can produce wind stress curl distributions that result in localized oceanic upwelling and downwelling and both warm-core and cold-core mesoscale eddies. The latter mechanism appears to explain the production of eddies in the lee of the Hawaiian Islands based on the results of previous investigators and our current study (e.g., Patzert, 1969; Lumpkin, 1998; Chavanne et al., 2002).

The central goal of the E-Flux experiment was to improve our fundamental understanding of the coupling of physical, biological, and biogeochemical processes that occur within mesoscale eddies. This problem bears directly on establishing the roles and modeling of mesoscale features as they may impact elemental budgets, fluxes, and the ecology of the upper ocean. In particular, some researchers have suggested that mesoscale eddies are major contributors of carbon to the deep sea (e.g., McGillicuddy et al., 1998) while others argue that they may have relatively little impact (e.g., Oschlies and Garcon, 1998). Thus, the impacts of such features on nutrient availability, primary production, biological community structures and size distributions, and fluxes of elements including carbon to the deep sea remain contentious.

The recurrent nature of eddies to the west of the Hawaiian Islands during persistent trade wind conditions was a primary stimulus for the present E-Flux experiment. Previous studies in the lee of the Hawaiian Islands and North Pacific environs have demonstrated that cold-core mesoscale eddies play significant roles in the region's biogeochemistry, biology, and fisheries (e.g., Falkowski et al., 1991; Leonard et al., 2001; Seki et al., 2001, 2003; Bidigare et al., 2003; Vaillancourt et al., 2003). Thus, E-Flux investigators conducted a series of three dedicated field