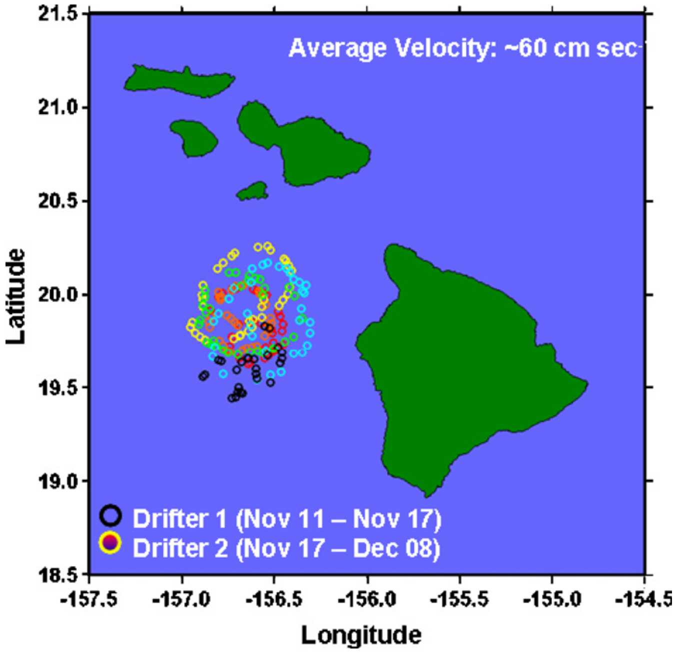

Fig. 14. ARGOS positions of the surface temperature-string *Drifter 1* (black circles) and the METOCEAN bio-optical *Drifter 2* (colored circles) during E-Flux I. Results suggest that both surface drifters made multiple revolutions around the eddy's center as it slowly moved north after the shipboard survey.

instability and elliptical instability may indicate that an eddy is decaying (Ikeda, 1981; Horton and Baylor, 1991). Another indication of possible physical spin-down in the core of an eddy would be the subsidence of isopleths within the eddy core. However, our allotted time for the field survey was insufficient to observe such vertical displacements of isopleths.

The geometric center of *Noah* varies with depth (Figs. 10 and 12), as evidenced by a tilted axis of rotation of the eddy. Surface contour plots of the differential density anomalies and sigma-$t = 23$ and $24\,kg\,m^{-3}$ isopycnal layers show that the eddy center is shifted slightly northward at 100 m depth (Fig. 12). Similar variability of the position of the eddy's center was evident in the ADCP vector analysis. It is possible that this tilt may vary in time and could result in an effective 'nutation' or 'wobble' effect causing significant variability in the physical–biological–biogeochemical coupling within the mesoscale feature.

Another suggestion of temporal variability in the physical characteristics of *Noah* can be seen in the vertical temperature profiles (Fig. 3) of the IN_{AVG} and OUT_{AVG} stations as well as the temperature–salinity curve (Fig. 4). It appears that the near-surface salinity is similar to that of the subtropical surface waters typically (STSW) found at ~150 m, indicating surface waters near the center of the eddy were dominated by STSW upwelled waters. However, the surface waters close to the eddy's center are relatively warm suggesting that this water mass may have been isolated long enough to absorb significant shortwave radiation resulting in enhanced surface heating. This pattern is consistent with the disappearance of the eddy feature from SST remote sensing satellite imagery. If Cyclone *Noah* were actively upwelling, we would expect to see cooler surface waters in addition to higher salinity. The observed thermodynamic and water property evolution supports the conjecture that *Noah* was a physically mature mesoscale feature. The inference that the physical characteristics of *Noah* were in a decaying phase is difficult to verify based on hydrography and velocity data alone as much longer time series observations for the eddy would be needed.

4.2. Tale of two eddies: Noah and Opal

Both Cyclone *Noah* and Cyclone *Opal* developed during strong, persistent northeasterly trade wind conditions. The production mechanism for both mesoscale features involved wind stress curl-induced upwelling (Dickey et al., 2008). Here we compare and contrast the physical differences observed for *Noah* and those observed during the third field experiment (E-Flux III; March 10–28, 2005) when a larger eddy (*Opal*) was surveyed (Nencioli et al., 2008). Comparison of the two eddies, which developed in the same region under similar wind induced conditions, is helpful for inferring the respective life-cycle stages and subsequent biological–biogeochemical impacts.

Vertical contours of the density (sigma-$t = 24\,kg\,m^{-3}$ structure suggest that *Opal* was conservatively estimated to be ~180 km in diameter, whereas *Noah* was ~100 km along its estimated major axis based on the same isopycnal layer. When the sigma-$t = 23\,kg\,m^{-3}$ isopycnal layer is utilized as a reference (which was more relevant for *Noah*) to determine the size of each respective eddy, *Opal* and *Noah* would have been on the order of ~200 and ~144 km in diameter, respectively. In the case of *Opal*, the sigma-$t = 23\,kg\,m^{-3}$ isopycnal doming would have penetrated the water surface with a diameter of ~100 km whereas *Noah's* sigma-$t = 23\,kg\,m^{-3}$ layer was submerged at approximately 50 m depth. The most significant difference between the hydrography of Cyclones *Opal* and *Noah* was the contrast in the vertical displacements of isopycnal layers. *Opal's* isopycnal displacements were from ~150 m to the surface. *Noah* showed shallower vertical displacements of ~50 m. These differences in doming of isopycnal layers (roughly indicative of nutricline displacements) proved to be significant for the respective coupling of physical–biogeochemical–biological processes (Rii et al., 2008). Differential property anomalies (DPAs) for temperature, salinity and density did not show substantial differences between the two eddies. Both eddies showed similar DPA depth ranges (~50–150 m) and horizontal extents (~60–100 km). The contrasting legacy of each cyclonic eddy suggests that mesoscale features are uniquely dependent on spatial and temporal evolutionary conditions and their interactions with surrounding waters.

Maximum measurements of near-surface (40 m) tangential velocities were higher during *Noah* (~80 cm s^{-1}) than during *Opal* (~60 cm s^{-1}). STAR-stations for *Noah* revealed fluctuating tangential velocity including some jet-like regions as well as reduced currents near the coast. On the other hand, *Opal* displayed relatively similar radial sections of velocity and more symmetric property and velocity distributions as expected for eddies that are in near geostrophic balance. Analyses show that *Opal* was further offshore than *Noah*; thus, coastal island effects could have been important for the latter. Another distinction between the two eddies is the differences between the vertical distribution of tangential and angular velocities. Cyclone *Opal* displayed maximum currents ~25 km from the center to depths of ~100 m, whereas *Noah* showed maximum currents at ~20 km from the center to depths of roughly ~75 m. Comparisons of the vertical sections of angular velocity show that the portions of each eddy in approximate solid body rotation are quite similar.

Opal appears to have been in a relatively biologically productive phase whereas *Noah* is thought to have been in a declining phase (Bibby et al., 2008; McAndrew et al., 2008; Rii et al., 2008). The DCML in the Hawaiian region is generally found at a depth between 100 and 125 m for the region (i.e. Falkowski et al., 1991). Vertical comparisons of IN_{AVG} and OUT_{AVG} stations showed *Opal's* subsurface chlorophyll *a* reached 0.70 mg m^{-3} at ~75 m depth whereas *Noah* displayed a maximum of 0.35 mg m^{-3} at ~100 m depth, which was not significantly different from the OUT_{AVG} station. Inorganic macronutrients observed during *Opal*