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# Micronekton abundance and biomass in Hawaiian waters as influenced by seamounts, eddies, and the moon

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ABSTRACT

Micronekton abundance, biomass, and community composition was determined from 58 Cobb trawl samples taken from 2005 to 2008 at several locations in the lee of the Hawaiian Islands. The results indicated a strong influence of the lunar illumination on micronekton abundance and biomass. This effect was evident in shallow night tows and probably was the result of lunar light affecting the nighttime depths of migrating species. The abundance and biomass of micronekton is remarkably consistent between years and areas in Hawaiian waters after the affects of moon phase are accounted for. Micronekton, principally migratory myctophids, were reduced over the summit of Cross Seamount but not Finch Seamount that has a summit below the daytime depth of most migrators. However, during a new moon, micronekton abundance over Cross seamount was similar to surrounding areas either because of altered migration patterns or because predators such as tunas cannot forage as effectively at night without lunar illumination. Species belonging to the Hawaiian mesopelagic boundary layer community were found to vary in presence and abundance between years at Cross Seamount suggesting that a consistent seamount associated fauna does not exist. Sparse sampling of a cyclonic mid-ocean eddy suggested very high micronekton abundance and biomass both in shallow waters at night but also at depth during the day. Although preliminary, these results suggest that eddies may aggregate the micronekton which probably feed on the enhanced secondary productivity.



## 1. Introduction

Oceanic micronekton are a diverse assemblage of small (~2–20 cm) fishes, shrimps, and squids forming a key trophic link between top predators and zooplankton (Brodeur and Yamamura, 2005). Commercially important pelagic fishes – including albacore tuna, bigeye tuna, and swordfish – feed directly on micronekton, particularly mesopelagic micronekton (Bertrand et al., 2002; Choy et al., 2009; Dagorn et al., 2000; Markaida and Sosa-Nishizaki, 1998; Palko et al., 1981; Tsarin, 1997). Knowledge of the processes affecting micronekton distribution would be of great value in estimating the distribution and yield of large oceanic fish stocks affected by patterning of food supply.

The dynamic oceanic environment includes mesoscale oceanographic and bathymetric features that influence the micronekton community. In Hawaii, there is an important commercial fishery for large pelagic fishes and the catch of tunas and billfishes is not evenly distributed—some locations have higher catch rates than others. For instance, Cross seamount located south of the island of Oahu, exhibits higher catch rates of bigeye tuna and it has been hypothesized that this is the result of concentrations of micronekton (Holland and Grubbs, 2007). In contrast, trawl studies at this seamount find reduced micronekton abundance and biomass, likely the result of the animals actively avoiding seamount summits shallower than their daytime depths (De Forest and Drazen, 2009). Studies of micronekton along island flanks and over seamount summits have often found a community of animals taxonomically distinct from the nearby open ocean, sometimes referred to as mesopelagic boundary layer communities (MBLC; Benoit-Bird and Au, 2006; Reid et al., 1991; Wilson and Boehlert, 2004). These animals migrate towards the surface and over shallow bathymetry each night presenting a distinct forage community for larger animals. This community is found close to shore over the 500–800 m contour during the day. It is not clear whether the islands also enhance the productivity of the oceanic micronekton community offshore of the boundary community zone through an island mass effect (Roger, 1986).

The predominant mesoscale oceanographic process in the Hawaiian islands is the formation of mid-ocean eddies (Calil et al., 2008). The influence of mid-ocean eddies on micronekton is not

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clear but bottom up or aggregation effects may occur because of enhanced primary and secondary production (Benitez-Nelson et al., 2007; Goldthwait and Steinberg, 2008; Rii et al., 2008). They are known to concentrate large fishes such as tuna (Murphy and Shomura, 1972; Owen, 1981; Sugimoto and Tameishi, 1992) and cetaceans (Davis et al., 2002; Olson et al., 1994).

Micronekton are, by definition, capable of swimming against currents. Most mesopelagic micronekton species undergo a diel vertical migration from depth during the day to shallower waters at night and then back. Migration patterns are finely tuned to light levels. Animals tend to follow a particular isolume which allows them to maintain bioluminescent counterillumination and simply to remain inconspicuous to predators under dim light (Kampa, 1971; Young, 1983). Some studies have found that the phase of the moon can alter their nighttime depth distributions (Hernandez-Leon et al., 2001; McManus et al., 2008). This implies that active behavior by these organisms, as well as physical processes in their environment, contribute to their distribution. To what extent such behavioral changes in distribution alter patterns observed spatially is unclear.

Here we assess spatial variability in micronekton abundance and biomass in Hawaiian waters in relation to oceanographic and bathymetric features. This field sampling was designed principally to assess the influence of Cross seamount on the oceanic micronekton (De Forest and Drazen, 2009). In the process, trawls were conducted from 2005 to 2008 at Cross seamount and opportunistically from a near island location (Keahole Pt), over Finch seamount, in the open ocean, and from the edge of a cyclonic mid-ocean eddy. A total of 58 trawls afford the opportunity to compare micronekton communities in Hawaiian waters. In addition, an examination of the influence of lunar illumination (moon phase) is conducted because the trawls were taken during different parts of the lunar cycle.

## 2. Methods

Samples were collected from three cruises during late April and early May of 2005, 2007, and 2008 aboard the NOAA research vessel *Oscar Elton Sette*. A dual warp modified Cobb trawl was used for collection. The open mouth area was approximately 140 $m^2$ with a mesh size of 152 mm stretched at the mouth to a cod end lined with 3.2-mm knotless nylon delta mesh netting. In an attempt to reduce damage to specimens during the trawl, the cod-end of the net was modified for the 2007 and 2008 cruises. A 1-m diameter, 5-m long plankton net with a mesh size of 1 mm was added to the end of the original cod end. At the end of the plankton net, a cod-end bag was attached. It was constructed from plasticized canvas with dimensions of 30 cm diameter by 61 cm length.

We conducted two types of trawls: day-deep and night-shallow. Day-deep trawls were at depths between 400 and 650 m and night-shallow trawls were at depths between 0 and 200 m. Trawl depths were selected based on concurrently conducted acoustic surveys indicating the depths showing the greatest density of sound-scattering organisms. We fished each trawl for 60 min at depth at a speed of 3 knots. This resulted in approximately 802,600 $m^3$ of water filtered per trawl. The data are given on a per trawl basis. To determine and record the depths fished a Northstar Electronics Netmind trawl monitoring system was used. The Netminds were attached to the headrope and the wings of the trawl and sent data to the ship via acoustic telemetry on latitude, longitude, temperature and depth. Unfortunately, this system behaved erratically often failing to report data or reporting data that was incorrect. In 2007 and 2008 a small TDR (time-depth recorder) was attached to the net in addition to the Netminds.

Several regions in the vicinity of the main Hawaiian Islands were sampled. Sampling areas were (1) at or near Cross Seamount, (2) over the summit of Finch seamount, (3) offshore of Keahole Point, in the lee of Hawaii Island, (4) an open-ocean site located between Cross Seamount and the island of O'ahu, and (5) at the edge of a cyclonic eddy located between Cross Seamount and the island of Oahu (Fig. 1). Cross seamount rises to 330 m and has a relatively flat plateau with a diameter of ~8 km. At or near Cross Seamount three types of trawls were conducted: summit, flank, and "away." Summit trawls ran directly over the flat-plateau summit in waters less than 500 m. No day-deep trawls were conducted over the summit because of the shallow bathymetry. Flank trawls ran alongside the

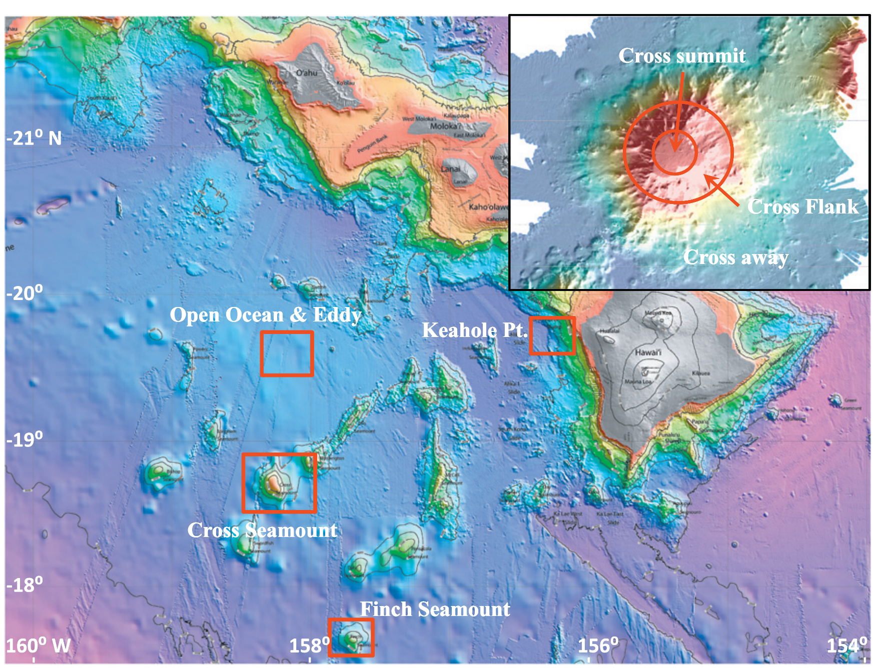


**Fig. 1.** Micronekton sampling sites around the Hawaiian Islands with an inset of Cross Seamount. Bathymetric image modified from Eakins et al. (2003) available at http://geopubs.wr.usgs.gov/i-map/i2809.