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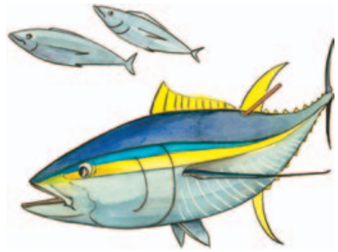

Pelagic Fisheries Research Program

university of hawai'i at mānoa

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Patterns of Change in Hawai'i's Small-Boat Commercial Handline Fisheries

Edward Glazier

Introduction

This article summarizes key findings from two recently completed Pelagic Fisheries Research Program (PFRP) projects, each designed to examine change in Hawai'i's small-boat commercial handline fisheries. The first study focused on factors associated with diminished activity in the *ika-shibi* fishery, a long-standing and once-lucrative yellowfin and bigeye tuna fishery specific to Hawai'i Island. The second study focused on small-boat tuna operations at Cross Seamount and at private fish-aggregating devices (PFADs) around the islands. (Please see figure 2 of the accompanying Drazen and De Forest/"The Influence of Hawaiian Seamounts…" article for map showing Cross Seamount and localities on Hawai'i Island.) The majority of project fieldwork was completed between 2005 and 2007 by Janna Shackeroff, who was then finishing her doctoral work at Duke University's Nicholas School of the Environment, and by Courtney Carothers, who was then finishing her doctoral work at the University of Washington, Department of Anthropology.

Rationale and Research Methods

In 1979 National Oceanic and Atmospheric Administration (NOAA) Fisheries biologist Heeny Yuen described a specialized nighttime fishery that had developed around Hilo on Hawai'i Island early in the 20th century in which *ika* (squid) was used as bait for *shibi* (tuna). Only four captains were using the method in the 1940s (Yuen 1979) but by the 1980s the *ika-shibi* fishery was a mainstay small-boat fishery around Hilo and Pohoiki (south of Hilo on the eastern coast of Hawai'i Island). Reported *ika-shibi* landings peaked in 2000 at 1,401,866 lbs. Participation peaked in 1997 with 304 captains making 3,985 *ika-shibi* trips and reporting a total of 1,250,435 lbs. As depicted in Figure 1, however, both effort and catch diminished rapidly thereafter. By 2007 landings were down to 329,559 lbs. as reported by only 120 fishermen.

Staff at the Western Pacific Regional Fishery Management Council (WPRFMC) and at NOAA Fisheries' Pacific Islands Fisheries Science Center had been observing this downward trend since 2001. This led the WPRFMC to request that the PFRP determine whether or not the decline had resulted from recent widespread use of PFADs. PFADs include any privately-owned device

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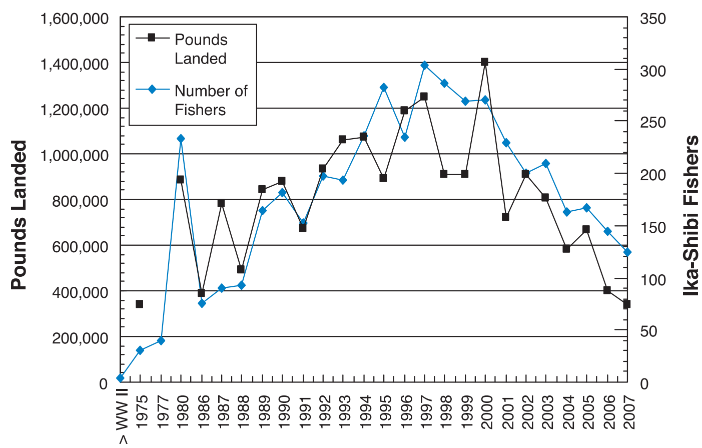

Figure 1. Trends in the Hawai'i Island *ika-shibi* fishery

COMING IN NOVEMBER! PFRP PI Workshop

November 18 and 19, 2008, are the dates for the upcoming PFRP Principal Investigators Workshop on "Tuna Forage and Synoptic Estimates of Mid-trophic Biomass." Meeting sessions will be held in the Koi Room of the Hawai'i Imin International Conference Center in Jefferson Hall of the East-West Center at the University of Hawai'i at Mānoa campus. Please visit the PFRP website http://www.soest.hawaii.edu/PFRP/nov08mtg/nov08mtg.html for the most up-to-date scheduling, program, registration, and accommodations information.

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that functions to attract biomass and hence pelagic predators in the upper levels of the water column. The WPRFMC is particularly interested in PFADs because: 1) they are, in effect, a highly efficient form of fishing gear; 2) the devices tend to be used in secret and therefore represent a difficult problem for measurement, quantification, and potential management; and 3) they present hazards to navigation unless deployed sufficiently below the surface so as to avoid collision or entanglement with passing vessels.

Research was designed to examine the full nature and extent of PFAD deployment and use around the islands and to determine whether the devices were significantly involved in the rapid decline of the *ika-shibi* fishery. The research involved analysis of commercial-fishing licensing and landings data compiled by the Hawai'i Division of Aquatic Resources (HDAR), direct observation of handline operations, review of pertinent literature, analysis of regional employment information and other relevant data, and a total of 210 interviews with fishery participants who were considered by their peers to be knowledgeable of Hawai'i's handline fisheries.

Origins of Handline Fishing in Hawai'i

Handline fishing methods have a long history of use in Hawai'i. Pelagic fishhooks found on O'ahu have been dated to the 4th century a.d. (Tuggle et al. 1978) and Kirch (1985) suggests that pelagic hooks found at Ka Lae on Hawai'i Island date from the same period. Goto (1986) asserts that the frequency of deep-sea fishing varied depending on the relative availability of nearshore resources and ease of access to the open ocean.

Hawaiian society was increasingly disrupted during the 19th century. While pockets of ancient cultural practices persisted (McGregor 2007), Hawaiians necessarily engaged in the new cash-based economy. Fishing typically became a means of subsistence and of income for individual families. Many Native Hawaiians became adept commercial fishermen during the late 19th century—only to soon find themselves in competition with newly arriving immigrants (Schug 2001).

The Growth and Decline of the *Ika-Shibi* Fishery

Immigrants brought their own fishing methods to the islands, some of which were also ancient in origin. For example, traditional fishermen from Okinawa Prefecture in Japan employed a "drop-stone" technique similar (if not identical) to one employed by ancient (and modern) Hawaiians. *Palu* (chopped bait) and baited hooks are folded into a bag weighted with a flat-sided stone, lowered into the ocean to the proper depth, and then a knot is pulled free to release the *palu* and expose the baited hooks.

Upon arriving in Hawai'i in the early 20th century, Okinawan immigrants often fished for *ika*. But when, in the deep waters around Hilo, *shibi* began taking the *ika* from their lines, these fishermen began developing a new technique targeting the tuna (Yuen 1979).

As fishing vessels and gear improved after World War II, the *ika-shibi* technique evolved into its present state. This involves deployment of a parachute-type sea anchor enabling the boat to slowly drift above productive fishing grounds. These grounds typically include *ko'a* (pockets and mounds of coral reef), the 600- and 1,000-fathom depth curves, thermoclines, and the waters around government FADs and PFADs. Freshly caught *ika* is the preferred bait but *'ōpelu* (mackerel scad) or frozen squid may also be used. Anchovies and/or sardines are often used for *palu*.

Most captains use three or four mainlines with strong leaders and size 14/0–16/0 baited circle hooks. Typically the hooks are lowered to depths of about ten to fifteen fathoms. Underwater lights are used to attract free-swimming bait and tuna. A short unweighted fishing line is kept ready on the boat for large fish surfacing in the *palu*.

The *ika-shibi* fishery grew rapidly in the 1970s. Modern hulls and engines were available and an onshore construction boom enabled many Hawai'i Island residents to earn the capital needed to get started. The *ika-shibi* technique grew in popularity and became a new form of traditional fishery. Successive years of abundant tuna and convenient marketing opportunities at the Suisan public fish auction were critical to the rapid growth of this fishery. Two-hundred-thirty-three captains were involved by 1980 (Ikehara 1981) and many made the shift from part-time fishing to full-time employment at sea.

Even during the boom years, however, there were challenges and problems. Commercial quantities of ice were initially not widely available and tuna "burn" (oxidation spoilage) was often unavoidable. Even after adequate icing became commonplace, small-boat-landed tuna was reportedly stigmatized at the marketplace. The high catch rates observed in the mid-1970s faltered later in the decade and, by the early 1980s, HDAR attributed the overall decline in the *ika-shibi* fishery to the diminished availability of large tuna, marketing challenges, and the financial burdens of heavily capitalized operations (HDAR 1986).

Challenges notwithstanding, the overall level of participation in the *ika-shibi* fishery climbed through 1997. Periods of abundance and the allure of the fishing lifestyle attracted new captains and held the enthusiasm of those who had long been involved in the fishery. This was also a period of general economic decline in Hawai'i. Construction activity had stalled, the plantation era was *pau* (finished), and fishing was one of few employment options for rural Hawai'i Island residents (Figure 2).

The year 2000 was a good one for small-boat commercial fishing in Hawai'i. Catch rates and landings were up all over the state. This upward spike, however, may have been the swan song for the *ika-shibi* fishery. By 2001 *ika-shibi* landings and catch rates fell below even the lowest points of the previous decade. Fishery participation and landings have since diminished even further.

The most recent downturn in the *ika-shibi* fishery was associated with both a relative lack of tuna and an improving regional economy. Additional factors were also involved. For example, the vast majority of research participants asserted that both fixed costs and rapidly rising short-term trip expenditures, especially fuel costs, have limited their ability to fish on a consistent basis. Numerous fishermen also reported that the 2001 closure of the

Suisan fish auction significantly constrained their *ika-shibi* operations by altering long-standing business relationships and rendering the pricing of seafood less openly competitive. Finally many formerly avid participants aged out of the labor-intensive *ika-shibi* fishery and current operational challenges have limited the recruitment of replacements.

The PFAD and Far-Offshore Fisheries

This research has generated evidence that counters the working hypothesis of a widespread shift from the *ika-shibi* style of fishing to fishing at PFADs. Convergence between a decline in the abundance of tuna and a variety of social, demographic, and economic constraints better explains the current status of the *ika-shibi* fishery.

A limited number of *ika-shibi* fishermen did become active in other small-boat tuna fisheries. A few such captains began handlining at Cross Seamount (southwest of the main Hawaiian Islands) in the mid-1970s and, later, at the offshore weather-data buoys. Up to six small-boat captains fished in this far-offshore zone in the 1980s and as many as twenty were making the long voyages when 1,072,233 lbs. of fish were reported landed from this region in 1995.

For those with suitable vessels and fortitude, the rich tuna resources in the far-offshore waters were an alternative to the increasingly crowded and decreasingly productive fishing grounds closer to the islands. A variety of methods were and are typically used in the far-offshore fisheries, including *palu-ahi*, trolling, and even the *ika-shibi* technique, among others.

Some small-boat captains also established and profitably fished at PFADs. This fishery is reported to have begun in the waters off of Kailua-Kona on the leeward or western side of Hawai'i Island as early as 1980. As PFADs are expensive to build and emplace, the fishery grew only gradually until proliferating off of Hilo on the eastern or windward side of Hawai'i Island in the mid-1990s. Roving captains have occasionally found and fished PFADs owned by others and conflicts with owners have been reported.

The difficulties involved in tracking this secretive fishery challenge a complete and accurate account of participation and production. Reliable interview data indicate that no more than about twenty captains have ever been consistently involved in establishing and fishing their own PFADs around Hawai'i Island—although some observers claim many more have been involved. At the apparent peak of the fishery in 2000, over 282,000 pounds of tuna were reportedly landed by eighteen persons known to fish PFADs.

While certain PFAD and far-offshore fishermen were historically highly productive and often generated large gross revenues, they ultimately encountered the same constraints as those using *ika-shibi* and other methods in the nearshore zone. Resource challenges and trip costs amplified by greater distances to the fishing grounds ultimately constrained both fisheries. By 2001 only ten captains reported landings from Cross Seamount and by 2007 the number of reporting captains was down to five. Use of PFADs also diminished dramatically and by 2007 only five captains were known to be regularly using the devices from the Hilo side of Hawai'i Island.

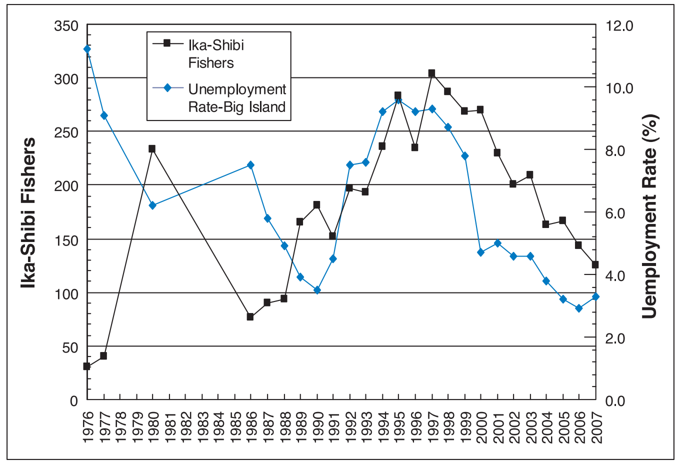

Figure 2. Participation in the *ika-shibi* fishery plotted against the Hawai'i Island unemployment rate

Summary Conclusions

Fishermen in Hawai'i will often share the news when tuna are feeding in local waters. News of the "bite" inspires many to make the necessary arrangements to go fishing, often regardless of prior land-based commitments. To the dismay of many, this has happened only infrequently since 2000. Given the lack of fish and a concurrent increase in the costs of fishing, many boats are now collecting dust in yards and garages across the state.

Yet commercial handline fishing around Hawai'i Island has not by any means ceased. There are indications that use of ancient *palu-ahi* methods—less time-consuming and labor-intensive than the *ika-shibi* approach—may be on the rise. More fishermen are working at land-based jobs than in years past but many continue to fish commercially on the side. Moreover a group of opportunistic full-time fishermen persists despite the challenges. They consistently seek new grounds and strategies and maintain strong relationships with buyers in Hilo and Honolulu.

History teaches that small-boat fisheries in Hawai'i have been alternately constrained and enabled by macro-social and economic forces and that fishermen will adapt and persist as long as fish are present. Although many fishing vessels are now inactive they can certainly be brought back into action if conditions improve. It is possible, in fact, that the latest economic downturn and reduction in onshore job opportunities may have the effect of increasing participation in commercial handline fishing around the islands.

The pivotal factor is the availability of tuna. When yellowfin and bigeye are abundant many of the costs and challenges associated with commercial fishing in Hawai'i can be overcome. When efforts at sea consistently yield good results, fishing can be a viable employment option even for prospective young recruits.

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Patterns of Change (continued from page 3)

The local availability of tuna is indeed a topic of great importance in Hawai‘i. Pursuing *‘ahi* (yellowfin) and *po‘onui* (bigeye) on the open ocean, consuming fish in an *‘ohana* (family) setting, sharing it in the larger community, and selling it to earn a living remain important aspects of life in Hawai‘i today (Glazier 2007).

But the dynamics of tuna populations involve a complex array of biological, oceanographic, and human interactions. While the full nature and extent of human effects on tuna populations is not yet clearly understood, it is clear that industrial-scale and small-boat commercial, recreational, and consumption-oriented fishing fleets are avidly pursuing tuna throughout the tropical Pacific. Given the importance of tuna as a source of food and income, such pressure is likely to continue. International governing bodies are responding with tuna conservation and management measures that will ultimately affect many nations and peoples. The need to deepen our understanding of pelagic resources and of the human context of their use and management in the Hawaiian Islands is now more compelling than ever.

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The Influence of Hawaiian Seamounts and Islands on the Forage Base for Oceanic Predators

Jeffrey C. Drazen and Lisa G. De Forest

Introduction

Mesopelagic micronekton are a diverse assemblage of small (~2–20 cm) fishes, shrimps, and squids (Fig. 1) forming a key trophic link between top predators and zooplankton.

Commercially important pelagic fishes—including albacore tuna, bigeye tuna, and swordfish—feed directly on micronekton, particularly mesopelagic micronekton. Increased understanding of the processes affecting micronekton distribution will contribute to an improved understanding of the distribution of commercially important oceanic fish stocks.

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. This implies that active behavior by these organisms, as well as physical processes in their environment, contribute to their distribution.

Within Hawaiian waters the capture of tunas and billfishes is not evenly distributed—some locations yield higher catch rates than others. Cross Seamount, located to the southwest of the main Hawaiian Islands, is a site of enhanced bigeye tuna catch-per-unit

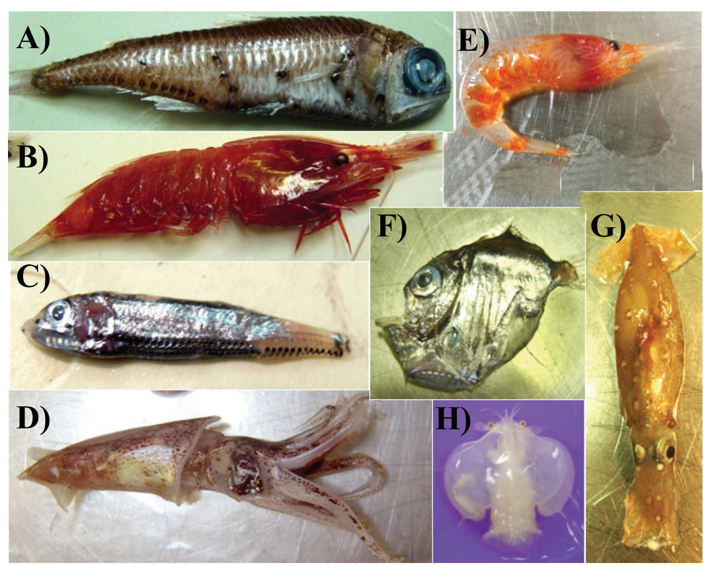

Figure 1. Representative mesopelagic micronekton: A) *Myctophum lychnobium* (Myctophidae); B) *Oplophorus gracilorostris* (Oplophoridae); C) *Vinciguerria nimbaria* (Gonostomatidae); D) *Pyroteuthis addolux* (Pyroteuthidae); E) *Janicella spinacauda* (Oplophoridae); F) *Sternoptyx* sp. (Sternoptychidae); G) *Hyaloteuthis pelagica* (Ommastrephidae); and H) Stomatopod larvae.

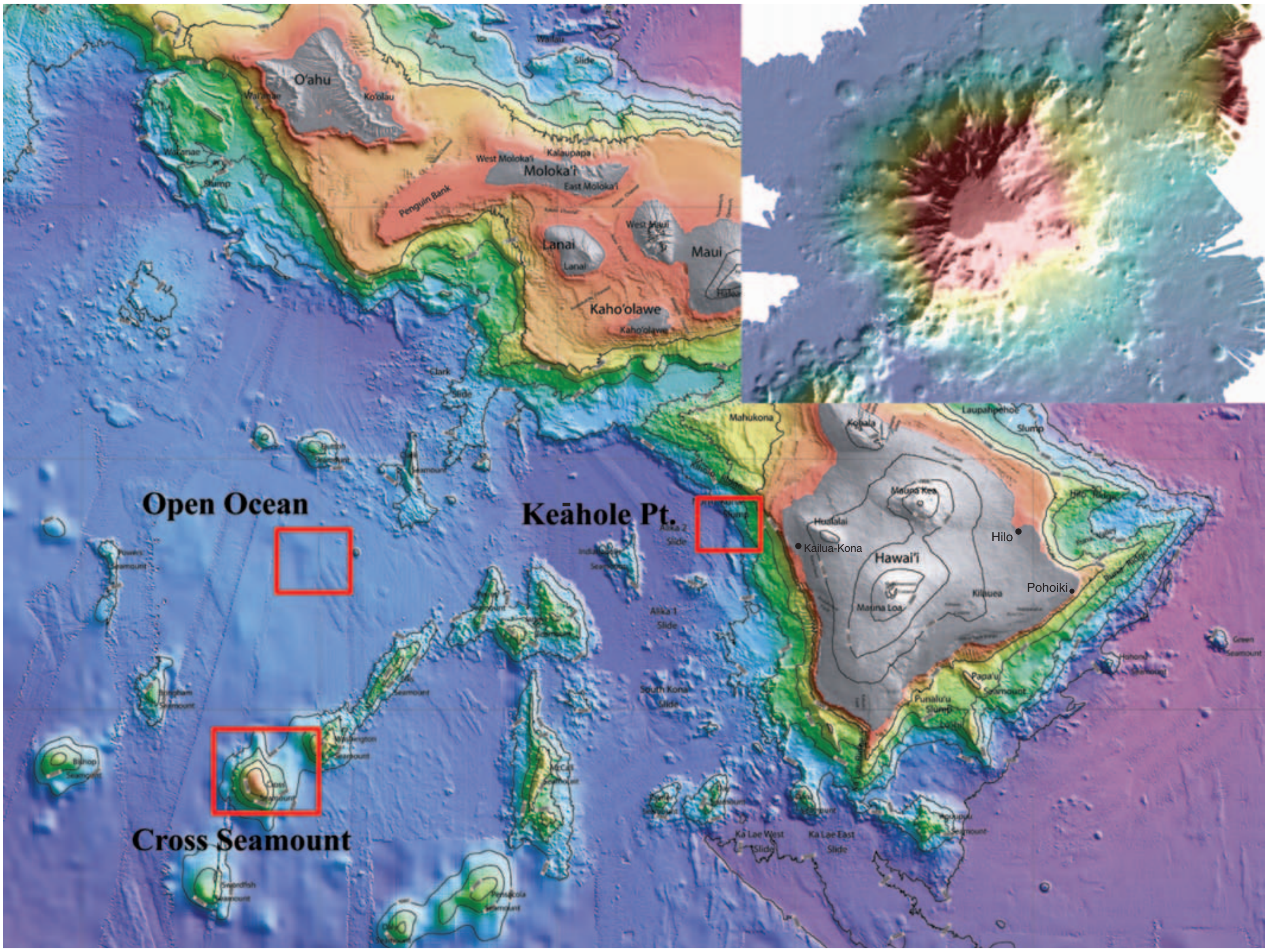

Figure 2. Micronekton sampling sites around the Hawaiian Islands with an inset of Cross Seamount. Modified from bathymetric image created by Eakins et al. (2003) available at http://geopubs.wr.usgs.gov/i-map/i2809.

effort. The longstanding general belief has been that the seamount somehow generates greater abundances of micronekton forage for the deep-diving tunas. Bigeye tuna caught at Cross Seamount are found to have fuller stomachs than those caught at other Hawaiian Island locations, lending support to this hypothesis.

Potential influences—Preliminary acoustic evidence also suggested increased nighttime concentrations of micronekton, and/or zooplankton, above Cross Seamount's summit and along its flanks. This apparent increased concentration could be due to active attraction if the flow around the seamount injects nutrients and enhances phytoplankton and zooplankton production.

Alternatively, nighttime schools of micronekton may become compacted above the seamount summit (which rises to 330 m below the surface and is shallower than the general daytime micronekton depth range of 300 to 1000 m). As the schools of micronekton, which were located (advected) above the seamount summit during the night, descend to their daytime depths, the

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schools encounter the summit and may become compacted into denser layers.

In addition to Cross Seamount, the main Hawaiian Islands may also act to enhance micronekton abundance. Primary productivity is often higher downstream of oceanic islands, termed the island-mass effect, because of current eddies generated by the islands and the injection of nutrients from the terrestrial environment. Along with increased micronekton abundance there is a well-defined Hawaiian mesopelagic boundary-layer community (MBLC) composed of species in high abundance along the islands' flanks but rare or absent in waters further offshore.

Goals—Our research utilized data gathered through multiple research-trawl samplings to describe mesopelagic micronekton abundance, biomass, and community composition at various locations in Hawaiian waters. The primary goal was to ascertain the influence of Cross Seamount on the tuna-forage base. Our secondary goal was to examine micronekton in the lee of Hawai'i Island to determine the extent of the island's influence on mesopelagic micronekton outside the zone typically inhabited by the MBLC.

Methods

We collected samples during two cruises aboard the National Oceanic and Atmospheric Administration RV *Oscar Elton Sette* during the springs of 2005 and 2007. During both years we sampled only during the full moon and only when there was little or no eddy activity in the sampling region. We used a dual-warp modified Cobb trawl with an opening of approximately 140 m^2. The net mesh-size ranged from 152 mm at the mouth to a cod-end lined with 3.2 mm knotless nylon delta-mesh netting.

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 minutes at depth at an average speed of 3 knots. This resulted in approximately 802,600 m^3 of water filtered per trawl.

Sampling areas were 1) at or near Cross Seamount, 2) offshore of Keāhole Point (in the lee of Hawai'i Island), and 3) an open-ocean site located between Cross Seamount and the island of O'ahu (Fig. 2). Samples from offshore of Keāhole Point were taken only in 2005.

At or near Cross Seamount we conducted three types of trawls: 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 of Cross Seamount because of the shallow bathymetry. Flank trawls ran (day trawls at 400–650 m and night trawls at 0–200 m) alongside the slopes immediately surrounding the summit in waters with bottom depths between 500 and 1500 m. "Away" trawls ran (day trawls at 400–650 m and night trawls at 0–200 m) in waters with bottom depths greater than 1500 m near—no farther than 14 km from—the summit of Cross Seamount.

Specimens collected were preserved in buffered formalin. Following collection, in the laboratory all preserved specimens were sorted to the lowest taxonomic level possible, counted, and weighed. Abundance and biomass, calculated on a per-trawl basis, were compared using Mann-Whitney U-tests. Additionally the relatedness of the communities sampled in each area was examined by constructing a cluster analysis based on a Bray-Curtis similarity matrix computed using the square-root-transformed abundance data for all taxa from each trawl.

Results and Discussion

This analysis includes 33 trawls with the majority at or near Cross Seamount. More than 53,000 individual organisms were identified to 167 discrete taxa of varying levels (family, genus, or species). No significant differences between the 2005 and 2007 trawls were identified for either trawl type for any of the taxonomic categories analyzed.

Decreased Abundance—Contrary to initial expectations, the summit of Cross Seamount exhibited a significant negative impact on the micronekton community. Night-shallow trawls over the Cross Seamount summit found significantly lower ($P<0.05$) abundance and biomass compared to night-shallow trawls at "away" locations and offshore of Keāhole Point (Fig. 3). These findings involved many of the micronekton components including total myctophids (which comprised more than half the abundance and biomass) as well as total squids and shrimps.

Five species of myctophids and three shrimps common in the Cross Seamount "away" trawls were completely absent over the summit. Only two species were found in greater abundance over the summit: the squid *Liocranchia reinhardti* and the myctophid *Benthosema fibulatum*, both previously identified as members of the Hawaiian MBLC. Other members of the MBLC were either absent over the summit or not significantly more abundant over the summit. Cluster analysis revealed that night-shallow summit trawls sampled a different community of micronekton from those collected away from the summit (Fig. 4). At depth during the day, trawls from the flank were not significantly different from those "away" from the seamount or from other areas (Fig. 3).

Other studies of seamount micronekton have also found significant reductions in abundance and biomass over summits. Predation by pelagic and benthic predators and/or active avoidance of the summits by the micronekton are likely contributing causes.

Tuna-diet studies have indicated that bigeye caught over the Cross Seamount have fuller stomachs than those caught away from the seamount. Stomach content of bigeye tuna caught over the Cross Seamount has consisted largely of cephalopods, myctophid fishes, and sergestid shrimps—all of which exhibited reduced nighttime abundances over the summit. Benthopelagic fishes that are also micronekton predators, such as monchong and alfonsinos, are also found in abundance over Cross Seamount.

However predation alone does not seem adequate to fully explain the reduction in micronekton abundance over the summit. Active avoidance of the seamount by the micronekton may

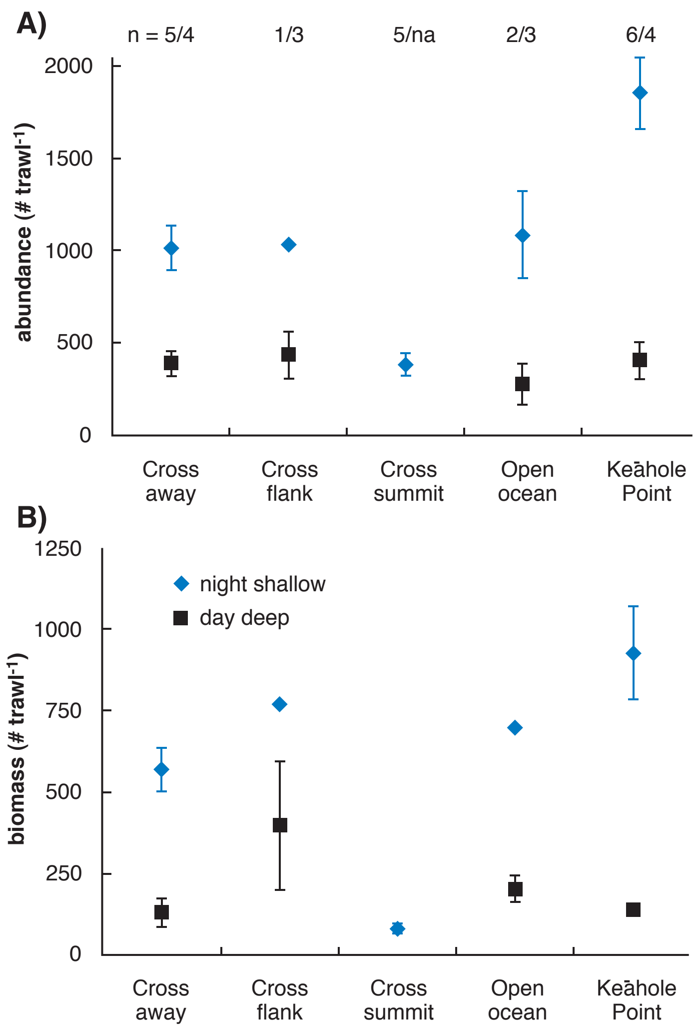

Figure 3. Figure 3. Variation in night-shallow and day-deep micronekton: A) abundance and B) biomass by sampling location. Values are means and standard errors. Samples sizes (night-shallow/day-deep) are given in A.

also be occurring. Micronekton may avoid the summit because of the presence of hard substrate as well as the increased predator abundance. The summit of Cross Seamount is 330 m below the sea surface at its shallowest. All the micronekton taxa that are completely absent over the summit have average daytime depths ≥500 m. Those taxa that are still present over the summit, though reduced in numbers, have shallower daytime depths, generally between 200 and 500 m.

Increased Abundance—Night-shallow micronekton abundance and biomass are about twice as high at the sampling area offshore of Keāhole Point compared to the Cross Seamount "away" and open-ocean areas (Fig. 3). These differences were evident in the myctophid fishes, squids, and shrimps. All night trawls offshore of Keāhole Point were taken at 0–200 m depth at least 14 km from shoreline and in waters with bottom depths greater than 1500 m. Typical MBLC species were not significantly more abundant in

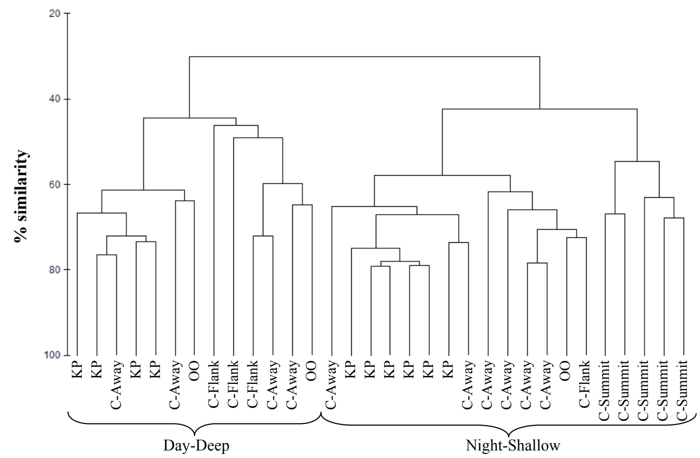

Figure 4. Cluster analysis of the trawls constructed using the Bray-Curtis similarity matrix with square-root transformation of abundance data. Similarity reported in percentages. C—Cross Seamount, KP—Keahole Point, and OO—open ocean.

these samples compared to other areas. Cluster analysis groups these trawls offshore of Keāhole Point together and indicates they are similar in composition to the open ocean and Cross Seamount "away" samples (Fig. 4). Thus it seems that the increased nighttime micronekton abundance offshore of Keāhole Point represents an enhanced community of open-ocean micronekton.

The relatively high abundance and biomass of the night trawls offshore of Keāhole Point may be the result of local nutrient enrichment, called the island-mass effect. Cyclonic upwelling eddies regularly form in the lee of Hawai'i Island and these may also be important to the increased abundance and biomass found there. The nature of the influence of the eddies on micronekton and the duration of their potential effects are not known. No eddies were present during our sampling.

Regardless of the mechanism, the lee of the islands may provide a habitat capable of sustaining increased micronekton abundance and biomass. Many earlier studies of Hawaiian micronekton have been conducted in the lee of the islands, often within 15 km of shore. While these studies were adequately offshore to avoid the MBLC, because of their relative proximity to the lee of the islands their estimates of community abundance and biomass are probably greater than would be valid for the open-ocean region as a whole.

Other Conclusions—Seamounts and islands are highly variable in their attributes. This study has shown that seamounts and islands create a patchy distribution for the forage base of large oceanic predators. Our results add to a growing body of literature allowing us to improve our predictions of the impact such seamounts and islands have on mesopelagic micronekton. Additional details of this research will be found in our recently accepted article to appear in *Deep-Sea Research* (De Forest and Drazen, in press).

Future work—Future work will focus on the flanks of Cross Seamount both to determine if prey is concentrated at these locations

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The Influence of Hawaiian Seamounts (continued from page 7)

and to help identify the mechanisms behind the reductions in nighttime abundance and biomass over the summit. The results from the Cross Seamount summit trawls stand in contrast to preliminary acoustic data. This conundrum will be evaluated soon using concurrently collected acoustic transects.

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