Food habits and trophic dynamics of structure-associated aggregations of yellowfin and bigeye tuna (*Thunnus albacares and Thunnus obesus*) in the Hawaiian Islands: Project description, rationale and preliminary results.

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INTRODUCTION

The formation of aggregations, groups of fishes attracted to a common resource (Freeman and Grossman 1992), is a common phenomenon among tropical tunas. These aggregations typically form in association with large physical entities that may be naturally occurring, such as cetacean pods, seamounts, and floating debris; or artificial such as weather buoys, drifting vessels, or structures deployed specifically as Fish Aggregating Devices (FADs). Regardless of the associated structure, the underlying biological significance of these aggregation behaviors is poorly understood (Dagorn and Fréon 1999, Holland et al. 1999). These unknowns are compounded when one considers mixed-species aggregations. Theoretically, aggregating may be highly adaptive, imparting several advantages to group members such as decreasing the risk of predation, increasing foraging efficiency, and increasing reproductive success. This behavior has the maladaptive side effect, however, of increasing the susceptibility to exploitation by modern fishing gear due by locally increasing fish density. Indeed, the majority of tropical tunas captured by commercial and recreational fishers worldwide are "associated". The construction of artificial fish aggregating devices (FADs) designed to increase catch rates of pelagic species began long ago and has become commonplace throughout the tropical Pacific (Brock 1985, Buckley et al.1989, Buckley and Miller 1994). The effects of the industrial-scale removal of aggregated tuna on tuna stocks and the ecosystem from which they are removed is largely unknown. Understanding the trophic dynamics of associated tuna is critical to properly evaluating these effects.

We recently began an intensive investigation into the trophic ecology of yellowfin tuna (Thunnus albacares) and bigeye tuna (T. obesus) aggregations in Hawaiian waters. Hawai′i offers an ideal setting to investigate the trophic ecology of tuna aggregations due to an abundance of aggregating sites, natural and artificial. Yellowfin and bigeye tuna occur in single-species and mixed-species aggregations around these structures. The primary aggregation sites of interest are four offshore NOAA weather buoys, the Cross Seamount (18°40' N, 158°10' W), the multitude of nearshore buoys and FADs, and the nearshore *ko′a* (traditional Hawaiian tuna holes).

METHODS

Samples are currently being collected via port sampling and field sampling. Occasionally, port samples are collected directly from returning commercial hand-line vessels, but most often port sampling is conducted with the cooperation of Honolulu seafood buyers. Samples are taken after fish are purchased at the United Fishing Agency auction. This allows the collection of samples from many different hand-line vessels fishing the various aggregation sites. Vessel captains are subsequently interviewed to obtain information concerning the location and date of capture as well as the bait and gear used. Port sampling also allows the collection of samples from "unassociated" fish caught by offshore longline vessels. These samples will be analyzed and used as 'control' samples for those collected from the various aggregations.

Field sampling is being conducted aboard commercial hand-line vessels. Samples are taken as soon as fish are brought aboard and immediately preserved in formalin to stop the digestion process. As with the port samples, the field samples will allow the comparison of prey species taken by the two tuna species while aggregated. In addition, and perhaps more importantly, the field samples will allow the determination and comparison of the timing of feeding in bigeye and yellowfin tuna. Additional information such as water depth and depth of capture is also available using field sampling.

The species, fork length, and weight (if available) are recorded for each fish. Samples are collected from fish destined for retail markets; therefore, the collection method must cause minimal damage to the flesh of the fish. Stomach contents are collected by entering the peritoneal cavity through the opercular opening, severing the esophagus, and excising the entire stomach. Large stomachs are initially injected with 10% phosphate-buffered formalin. All stomachs are immersed in the formalin solution for at least 72 hours to ensure preservation. Samples are then stored in 50% ethyl alcohol until lab analysis.

In the laboratory, stomachs are rinsed and all contents are removed. All prey items are identified to the lowest taxon possible. The number, wet volume, and digestion state of each prey species is recorded. All data are entered into a parent database using Microsoft Access for subsequent analysis.

PRELIMINARY RESULTS

Port Sampling

To date, 75 port samples have been collected and analyzed from six different vessels. Thunnus obesus and T. albacares have been represented comparably in samples collected from the NOAA weather buoys as well as in "unassociated" samples from a longline vessel, however, yellowfin have been underrepresented in the seamount-associated samples.

Field Sampling

Two five-day collection trips have been made aboard a commercial hand-line vessel, and a total of 276 samples have been collected. All samples were collected from the Cross Seamount. As with the port sampling of seamount-associated fish, T. obesus dominated these samples. To date, approximately 1/3 of these samples have been analyzed in the laboratory.

Early Results

This project is in its very early stages of development. A preliminary analysis of data obtained from port samples suggests the feeding ecologies of yellowfin and bigeye tuna, even at very immature sizes, are very different. Bigeye tuna associated with offshore weather buoys primarily preyed on vertically migrating fishes, primarily myctophids and Howella parini (pelagic basslet) while yellowfin appear more opportunistic, feeding on a variety of fishes and crustaceans found above the thermocline (Figure 1). An ecologically similar result was found for seamount-associated tuna as bigeye preyed primarily on Oplophorid shrimp while yellowfin prey was similar to that seen when associated with the offshore weather buoys (Figure 2). Unassociated tuna from the longline fishery were very different (Figure 3). Both bigeye and yellowfin tuna fed on a variety of mesopelagic fishes. Interestingly, yellowfin also fed heavily on salps, which may be concentrated near the thermocline. In addition to these trends, the data suggest that cephalopods are of low to moderate importance for both species across all three habitats for those fish sampled to date.

Figure 1: Stomach Contents of FAD-associated Tuna

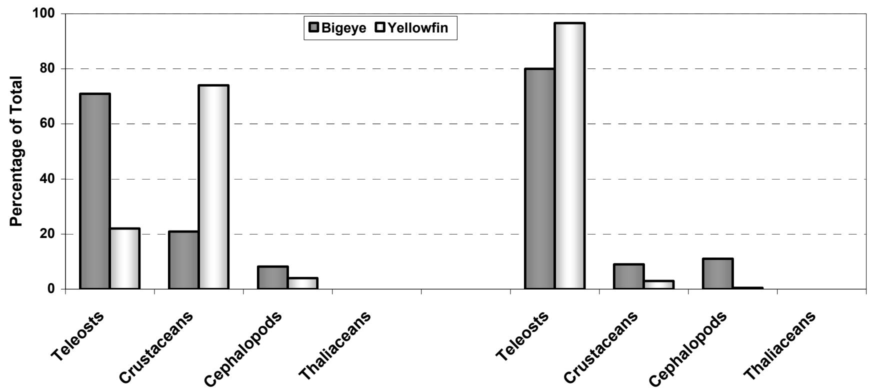


Figure 2: Stomach Contents of Seamount-associated Tuna

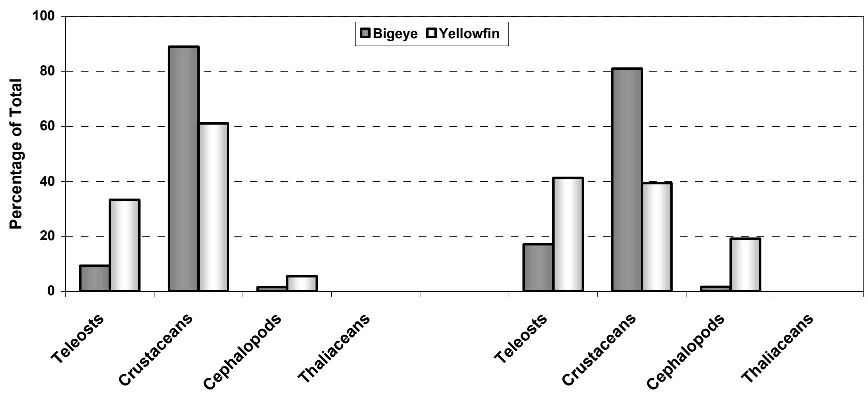
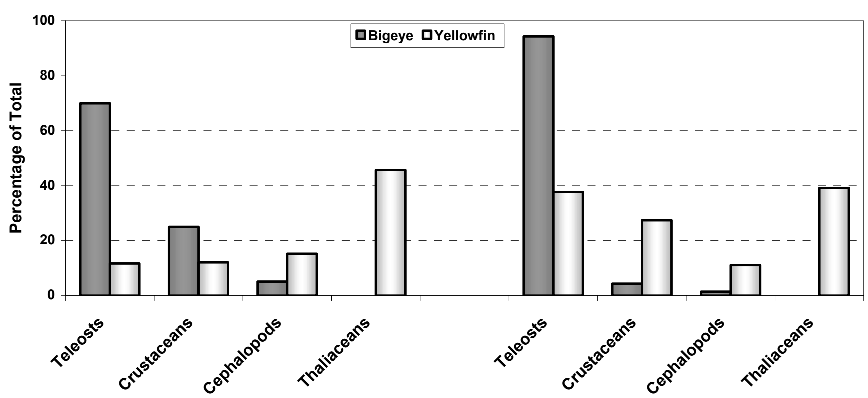


Figure 3: Stomach Contents of Unassociated Tuna



DISCUSSION AND FUTURE DIRECTIONS

The vertical distribution of yellowfin and bigeye tuna is known to differ (Holland et al 1990). Bigeye tuna generally select deeper, colder waters (150 to 250 meters) while yellowfin are known to be concentrated near the thermocline and the mixed surface layer, or less than 75 meters deep (Brill et al. 1999, Holland et al. 1990). Telemetry data suggests that this pattern breaks down near FADs and the two species overlap considerably (Holland et al. 1990), though residence times differ (Holland et al. 1999). In fact, both species are primarily caught in near-surface schools at the offshore weather buoys and the Cross Seamount. The preliminary analysis of these data suggests that the separation in vertical distribution may actually be maintained during feeding, with yellowfin tuna feeding primarily on mixed-layer prey while bigeye tuna feed on deep scattering-layer prey.

The results presented here are very preliminary, but they provide an example of the interesting questions concerning tuna trophic ecology that may be answered. As the study progresses, these data will provide a more complete picture of the complex trophic dynamics of mixed-species tuna aggregations, as well as seasonal trends in feeding and aggregation behavior. Port sampling will continue in order to gain 'control' data for unassociated fish from the longline fishery, as well as provide samples from an increased number of aggregation sites. Field sampling aboard commercial vessels will continue at four to six-week intervals throughout the year. In addition to providing basic trophic data, the samples obtained on these trips will allow the determination of the timing of feeding by aggregated yellowfin and bigeye tuna and the description of seasonal trends in local trophic dynamics. These findings will greatly further our understanding of the ecological function of aggregations and the ramifications that exploiting aggregations may have on tuna populations.

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