Response by Dr. Réka Domokos

In the following paragraphs, Dr. Domokos provides clarifying comments on technical aspects of the acoustics research and addresses several questions raised by the panelists.

The report from the CIE review raised several important questions and provided invaluable advice, suggestions, and guidance for improvement for the fisheries acoustics program at PIFSC. As a small, relatively young program within the Ecosystems and Oceanography Division (EOD), activities thus far were exploratory in nature, investigating the possibility of describing micronekton characteristics and fish biomass estimation, as well as the effects of the environment on both micronekton and larger fish. Since the focus of EOD is to characterize the environment and its effects on our living resources, multiple objectives are tracked simultaneously during data collection.

In general, the main mission of cruises is to collect oceanographic data, such as salinity, temperature, oxygen, chloropigments, and currents, thus experiments generally are designed with an objective not appropriate for acoustic data collection. To conduct transects appropriate for acoustic data collection, more ship time would need to be allocated for acoustic surveys. The exceptions are the Cross Seamount, Penguin Banks, and juvenile opakapaka studies, where standard parallel, zigzag, and/or star surveys were used. These surveys were designed to study fish distribution and biomass using echo counting. These transects allow for unbiased estimation of acoustic quantities and optimal mapping over the study areas. Echo counting is performed on lower frequency data so that signal-to-noise ratios do not change with depth, although changes in sampling volume with depth must be taken into account. Data collected during these surveys are used to estimate biomass in kg/m^2, using the TS equation for bigeye, a generalized equation for the expected sizes for bottom fish with swim bladder, and the appropriate TS values obtained from live opakapaka at the nursery ground. However, data collected during these surveys are still not appropriate for biomass estimation in kg/m^3. Slow speeds required to reduce excessive noise in the acoustic data prevent mapping into a 3D domain to obtain biomass estimates in kg/m^3. Biomass estimates of bottom fish at Cross Seamount and Penguin Banks are exceptionally uncertain, as interpretation is based on apriory knowledge of the expected species occupying the plateau floor (sickle pomfret). More accurate biomass estimates of bottom fish at Penguin Banks will be obtained after analyzes of simultaneous stereo camera recordings.

Priorities to study different regions result in irregular and/or infrequent data collection at study sites, further preventing regular data collection and the development of a time series. At the juvenile opakapaka nursery grounds, weather is prohibitive during most of the year, resulting in infrequent and irregular data collection. For juvenile opakapaka, efforts have been made to identify and separate these fish from the other known species occupying the nursery grounds at expected depth-ranges;

however, failure and unavailability of more than one or two frequencies for most of the surveys result in identification of opakapaka uncertain.

In addition, limitations in TS detection negatively influences echo counting. That is, thresholding of TS, target distribution and tilt angles, as well as mean TS and TS curve are all affected by parameters applied during echo counting. For echo counting, all parameters were set to optimize TS detection, based on apriori knowledge of TS of species investigated. Mean TS and TS with specific tilt angles that were detected are appropriate of expected values from other sources, such as experimental TS values for species with certain size ranges, video records, experimental and commercial fishing, and tagging studies.

Estimation of micronekton biomass faces more difficulties. As composition of scattering layers is very diverse in tropical and subtropical waters, biomass of micronekton cannot be calculated using the inverse method. Further, S_v and/or TS of most micronektonic scatterers are unknown. In addition, experiments are not designed appropriately for absolute biomass estimates (mg/m^3) due to other priorities during data collection. Large-scale relative biomass, that is, biomass in one region relative to the other (in mg/m^2) could be estimated in some circumstances when trawl samples are available, using the forward method. However, frequent unavailability of sampling gear prevents the application of the forward method for micronekton biomass estimation from the acoustic backscatter. In areas where net samples are available, such as along the 158°W meridional, relative biomass, in mg/m^2, will be estimated from backscatter using the forward method.

Reviewers expressed concern that in most cases S_v and/or NASC were taken as proportional to biomass and used as indices for relative biomass comparing different regions. While composition of scattering layers are typically different from region to region, making S_v and/or NASC inappropriate as indices for biomass, data from net samples were carefully considered for the interpretation of backscatter at different frequencies. For example, higher S_v and NASC values over the plateau of Cross Seamount relative to regions away from it at all frequencies (38, 70, and 120 kHz), especially at the 38 kHz, were interpreted as higher biomass. Net samples collected over the plateau show that organisms were smaller and composed of a much smaller percentage of fish there relative to scattering layers away from it. The 38 kHz backscatter is dominated by gas bubbles; that is, fish with swimbladder as no gelatinous organisms with gas inclusions were found in the net samples, and its value should increase with the size of scatterers. Thus, the most prominent increase in S_v and NASC at the 38 kHz was interpreted as an increase in biomass over the plateau of Cross Seamount. More accurate micronekton biomass estimates will be calculated using the available trawl sample data and the forward method.

Regular availability of a sampling gear, with the addition of compartments that can be opened and closed at certain depths to separate samples would greatly improve the ability of micronekton biomass estimation using the forward method. As one of

the reviewers pointed out, “targeting the various migrant layers which migrate from the shallow layer to depth at different times during the crepuscular periods would help in biomass estimates”.

Another concern for the reviewers was the excessive noise in the acoustics data, when up to 60% of pings had to be rejected. However, data from which more than 30% of pings are removed are not used for quantitative analyzes, only for qualitative examination of depth of layers and changes in their relative spatiotemporal distribution. In addition, noise filtering does not affect pings that are kept in any way; thus, data that are available for qualitative analyzes are the original pings not altered by the filtering algorithm.