CIE Reviewer's Report on the Panel Review of the Pacific Islands Fisheries Science Center's Fisheries Oceanography Acoustic Applications in the Western Pacific

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Table of Contents

Executive Summary:

The CIE Panel for the Pacific Islands Fisheries Science Center's (PIFSC) "Fisheries Oceanography Acoustic Applications in the Western Pacific" review was held at the University of Hawaii's IMIN conference center in Honolulu between July 7th and 9th of 2010. The main objectives of the meeting were to provide an independent review of the PIFSC Ecosystem and Oceanography Division's acoustic program procedures, methods, analytical approaches, and acoustic applications, and to make recommendations for program improvements and guidance on the future direction of the program.

All travel arrangements were organized by the CIE coordinator, while the local venue and the meeting room were the responsibility of the PIFSC's program coordinator. No logistical problems were encountered with the travel or the meeting facility. The background material was available almost two weeks in advance, allowing plenty of time to prepare for the meeting. In general the Panel review adhered closely to the agenda provided to attendee's prior to the meeting, although because of the small number of participants the discussion and questions were more *ad hoc* during the presentations than structured. Much of the success of the Review was due to the preparation and presentations of the acoustic program scientific coordinator, who did an excellent job of providing the program and project overviews, and her willingness to respond to numerous Panel requests.

The current PIFSC Fisheries acoustic program, while young, has established a good foundation to undertake both stock assessment and ecosystem related acoustic research. In fact, it was the view of the panel members that the acoustic team had made some significant gains, and contributions, to the scientific community, in the integration of oceanography, biology, and acoustics over a broad geographical scale. These broad scale surveys may also be useful to investigate climate change and to explain the distribution of large pelagic predators relative to oceanographic features and their forage. The Center is encouraged to continue to pursue these areas of research. On the stock assessment side, acoustic surveys are following a classic transect design and should provide the bases for the development of a index of abundance (i.e., biomass) and the evaluation of management practices for several local stocks. However, a number of concerns and deficiencies were identified by the panel that should be addressed as they would greatly improve the scientific content of the research programs.

One of the more serious problems identified by the panel was the poor quality of acoustic data collected by, primarily the R\V *Oscar Elton Sette*, research vessels due to aeration and noise. A 40-60% signal loss after editing is unacceptable and several suggestions have been made to address this problem. Vessel sampling and equipment maintenance was also as a concern and should be improved.

Each survey should have a full complement of sampling gear necessary to meet the project goals and objectives. Biological sampling was identified as major deficiency in all projects. For one reason or another sampling was limited. Biological sampling is an important component of any acoustic program and sampling intervals and/or protocols for target identification/validation need to be built into the survey design.

The broad scope, geographical coverage, and diversity of the fisheries acoustic programs conducted at the PIFSC with so few permanent staff may be prohibitive to current activities and to future program development. Besides the demanding workload of FTE's, there is a real need for trained and experienced technical staff to maintain the scientific equipment and to undertake data analyses using complex analytical models and editing software. The isolated location of the PIFSC also places limitations on the amount of interaction, collaboration, and training that can occur with other institutes involved in fisheries acoustics. Mechanisms are suggested for improving this situation, however, whenever local expertise is available in other Divisions or at the University, cooperation and collaboration should be encouraged.

1. BACKGROUND.

The National Marine Fisheries Service (NMFS), Pacific Islands Fisheries Science Center (PIFSC), Ecosystems and Oceanography Division (EOD) in Honolulu, Hawaii has been conducting research and exploring potential applications of active acoustics for more than six years. The EOD has directed its acoustic research efforts in two key directions: The study of micronekton distribution and oceanic processes within the tropical and subtropical Pacific Ocean, and the development of fisheries independent methods to support the assessment of commercially important fisheries and their management. Inter-disciplinary studies have been initiated to develop an understanding of broad-scale ecosystem process of the Pacific Basin in relation to biomass, species composition, distribution, and movement of this group of organisms. For fisheries, the EOD has initiated programs to investigate the application of acoustics to develop indices of abundance for exploited fish stocks using several local fishing and nursery areas of commercial fishes. In addition, one study examined the linkages between the broad scale temporal and spatial oceanographic features and the distribution of the albacore fishery.

Overall, the EOD is involved with seven major research and development studies, each with its own goals and objectives. These projects, which will be discussed later, cover a broad spectrum of acoustic applications and a large geographical area of the Pacific Ocean. Linkages between their acoustic observations and physical characteristics may provide valuable insight into some of the large scale oceanographic process that will benefit not only regional initiatives, but the global scientific community as well, in the study of ecosystem scale processes and the effects of climate change in tropical waters. The fisheries projects will hopefully complement the fishery dependent abundance indices with a fishery independent index of abundance for several species and areas.

Given the geographical location of the PIFSC, the absence of other local researchers working in this field, and the potential applied nature of the research, a comprehensive external peer review of the program was requested by the EOD and the PIFSC. Independent peer reviews are coordinated and managed by the National Marine Fisheries Service's (NMFS) Office of Science and Technology through the Center for Independent Experts (CIE). CIE reviewers/experts are selected by the CIE Steering Committee and CIE Coordination Team to conduct an impartial and independent peer review of scientific activities without conflicts of interest. Under the terms of the contract each reviewer is to address predetermined Terms of Reference (Appendix 2).

The specific tasks to be undertaken by the CIE reviewers for the independent external Panel review were to:

1) Conduct pre-review preparations of background material and reports provided by the NMFS Project Contact.

2) Participate during the panel review meeting at the Pacific Islands Science Center in Honolulu, Hawaii, 7-9 July 2010.

3) While at the PIFSC in Honolulu, Hawaii, conduct an independent peer review of the acoustic program in accordance with the ToRs (Appendix 2).

4) Individually prepare an independent peer review report and submit it to the Center for Independent Experts.

1.1 Goals and Objectives:

The 2010 review meeting held in Honolulu provided an opportunity for review panel members to obtain a comprehensive overview and understand the EOD's acoustic program and directed research. The two main goals of this review were:

- To provide an independent review of the PIFSC acoustic program procedures, methods, analytical approaches, and the acoustic applications currently being undertaken by the Ecosystem and Oceanography Division.

- To provide, based on the material provided, presentations, and general discussion, recommendations for improvements to the acoustic program and guidance on the future direction of the program.

The following report to the CIE reflects my independent opinions and views on the issues and questions identified in the terms of reference, statement of work, and the above goals and objectives. The report is, however, generally consistent with the recommendations and conclusions of the other panel reviewers. Panel members met on the final day of the meeting to review their observations, conclusions, and recommendations. Overall, there was agreement amongst the panel members regarding their conclusions and recommendations.

2.0 REVIEW ACTIVITIES

The initial phase of the review process began with the provision of background material outlining past research initiatives (published literature), and a brief outline of the PIFSC acoustic program's two areas of focus, as well as generalized plans for the EOD's future activities. These documents were provided to the reviewers well in advance of the meeting (two weeks of the

review meeting via e-mail) allowing the panel members plenty of time to review prior to the site visit.

The Panel Review meeting by the Center for Independent Experts on “Fisheries Oceanography acoustic applications in the western Pacific” was held in the Pago Pago room of the IMIN International Conference Center of the University of Hawaii at Manoa from July 7-9 2010. The meeting was attended by the three review panel members and National Marine Fisheries Service Staff from the PIFSC. Participants in the review are listed in Appendix 3. However, the key presenter and only PIFSC staff present for the entire meeting was Dr. Reka Domokos. Details of the Terms of Reference and the Statement of Work for the review are provided in Appendix 2.

In general, the panel review adhered to the agenda provided to attendee’s prior to the meeting. However, because of the small number of participants and the inter relationship between topics/programs the discussion was open, flexible and in some cases covered a broader theme than that being presented. My review can be divided into several broad topics, each which are discussed in Section 3 below.

The review meeting began with introductions and a general welcome by the Director Samuel Pooley outlining the Pacific Islands Fisheries Science Center's organization and divisional responsibilities. This was followed by a broad brush overview of the Ecosystem and Oceanography Division by, Division Chief Jeffrey Polovina. After a short discussion, Reka Domokos began a series of in-depth presentations on the center’s acoustic programs. On Thursday afternoon Dr. Mike Seki, the PIFSC Deputy Director, joined the meeting for about an hour to discuss the Center's vision and to answer panel member questions. The panel comprised of three internationally recognized acoustic experts covering a broad knowledge base and diverse individual experience. Because of my background in stock assessment of pelagic fishes, I also fulfilled the role of a stock assessment expert. The following provides a summary of panel's observations, review activities, and conclusions.

The initial presentation on the Fisheries Acoustic program covered a wide spectrum of the topics associated with staffing, equipment, vessels, data quality, and collaboration. Thereafter, a detailed overview of the ongoing research projects, listed below, and their challenges was present.

1) American Samoa oceanographic/acoustic project - Combined broad scale oceanographic features with acoustic observations of the micronekton (forage) to characterize the distribution of the albacore tuna fishery in the EEZ.

2) Juvenile opakapaka acoustic project. Study explored the use of acoustics to document the distribution and potentially abundance of a bottom fish species for stock assessment.

3) Cross Seamount Study - Characterize the environment interactions of currents and topography, the micronekton community, and the spatial-temporal distribution/movement of juvenile bigeye tuna.

4) Penguin Banks study. - Acoustic application to monitor effects of recent BFRA restrictions on the distribution and abundance of heavily exploited bottom fish species.

5) Characterization of broad scale micronekton changes in relation to the oceanographic features linking acoustic observations with environmental data and species composition. In essence, three similar projects in different tropical and subtropical regions of the Pacific:

- the Hawaiian Archipelago
- Western Equatorial - CNMI and Guam
- Central North Pacific –Transition Zone Chlorophyll Front

3.0 General Observations:

The CIE review undertaken at the PIFSC was unlike a typical STAR panel review with CIE expert participation. The primary goals and objectives of this review were to review current operational programs, practices, and procedures and to provide guidance/recommendations for improvements and future activities. As such, there was continuous interaction between the principal investigator and the review panel members. During the course of discussion and presentation a number of general observations were made regarding the acoustic program. These general observations are discussed independently below in this section.

3.1 Staffing:

At present the fisheries oceanography acoustic group is comprised of one full time researcher and several term or part time technical staff. Given the number of ongoing programs, their geographical distribution, the scope of programs, and the level of effort required to support these programs, it is very unlikely that this level of effort can be maintained. It was the opinion of the review members that an exceptional amount of work was being undertaken by very few individuals. The current coordinator/project leader is commended for her dedication and effort.

It was, however, evident from the program challenges, logistics, and technical problems associated with the acoustic program that additional permanent staff

(FTE's) are required to support this program. Most acoustic programs require full time technical support to maintain equipment, organize cruises, and assist with data analysis. A major barrier for the overall program has been the requirement to use temporary staff (one year terms or less). The application, deployment, and operation of acoustic equipment, and data analysis require experienced personnel that, in most cases, have undergone advanced training. This training is a time-consuming and expensive investment. Consequently, the use of temporary personnel is inefficient, not cost effective, and a general burden to the program.

The range of projects being conducted at the PIFSC is impressive; however, there is a need for the program to focus its research effort. At present there are two main research activities associated with the acoustic program: estimation of biomass in support of stock assessment, and broad-scale monitoring of the micronekton in response to climate and environmental change. Both these activities are worthy of directed research. However, given the limited resources, the broad geographical coverage, and the available staff to conduct these studies, in reality, there is limited scope to continue both. To do so will only compromise the viability of both areas of research. If funding and staffing remain limited, then the division should focus on one activity or the other. On the other hand, an enhanced program with additional staff would allow both activities to develop and potentially expand.

3.2 Vessels and Equipment:

The acoustic program at the PIFSC is conducted from two vessels: The NOAA R/V *Oscar Elton Sette* and the *Kumu*. The *Sette* is a relatively large ocean going research vessel, with EK60 multi-frequency (38,70,and 120 kHz) hull mounted split beam transducers used for all offshore programs, while the *Kuma* is a small 21 foot vessel with pole mounted EK 60 split beam transducers (38, 120, and sometimes 200 kHz) used for near-shore research activities. Both acoustic platforms are calibrated using standard internationally accepted methods, although some difficulties have been encountered due to the limited availability of suitable water depths. Several inherent problems are associated with each vessel.

The R/V *Oscar Elton Sette* appears to have a serious noise and bubble problem when operating at cruising speeds in the persistent swells of the tropical ocean. Based on the information/examples provided this vessel's bubble problem deteriorates the acoustic data to the point where 40 to 60% of the acoustic pings are lost from the analysis. Although there is no evidence to identify the source of the bubble problem, it is suspected that the port side bow thruster entraps air as the vessel heaves in the swell which is then released and flows aft directly over the transducers mounted on the hull. If possible a removable cover over this port should be tested to see if it reduces the amount of signal loss. Another issue that

was raised during the review was equipment failure on the research vessel. Research programs such as those being undertaken by the PIFSC require a complete complement of sampling tools to complete the goals and objectives of a cruise. On several occasions it was mentioned that the fishing/sampling gear was inoperable due to commonly occurring winch failure. The ability to sample acoustic targets is a prerequisite for any acoustic survey and necessary for target identification and size distribution.

The *Kuma* provides a reasonable platform (with less noise and bubble problems I believe) to undertake acoustic surveys in the inshore waters of Hawaii and is generally acoustic configured to estimate fish biomass. It is, however, limited if species identification methods using frequency response are to be employed. In this case it is important to equip the vessel with the appropriate frequency range of transducers (with a minimum of three frequencies) to achieve the goals of the survey. Calibration of the smaller vessel is also problematic given the requirements for calm waters and 20m water depth. Unfortunately, a major limitation of the vessel is its inability to capture fish or sample the microneckton for target identification/validation. It is also important that the available equipment be properly maintained.

3.3 Biological Sampling

Biological sampling is an important aspect of any acoustic survey. Without the ability to sample organisms observed acoustically, the researcher is unable to validate observations, species composition, or the size distribution of targets. While acoustic characteristics, such as target strength and frequency response, combined with local knowledge, may provide some information on the size and species composition, the researcher cannot make a direct comparison to the acoustic backscatter. In some cases, fish aggregations can be of a mixed composition without the acoustic differentiation. In the tropics most aggregations will contain multiple species which are not easily distinguished acoustically. It is likely that species in these aggregations will have to be grouped into the acoustically similar categories given the general diversity of the ecosystem. Target identification is needed to classify fish and aggregations of fish to group similar observations/backscatter. Furthermore, the target strength of an organism is normally a function of size. It would not be uncommon, in a mixed species aggregation, to have two different size species of fish with the same targets strength. It is therefore critical, especially during the early stages of a project, that biological sampling be undertaken in conjunction with acoustic surveying for characterization of the backscatter.

For most of the acoustic programs currently underway at the PIFSC, limited biological sampling has been undertaken to validate the observations to date. For many of the projects, species identification and size have been based on local knowledge and observed target strength of individual organisms isolated by the

acoustic software. Basing the species identification and size on the target strength of individual targets extracted from the acoustic data collected at normal operating speeds may be biased toward larger or stronger scatters. This was a concern for the reviewers. It also appeared from the information presented that biological sampling was a low priority or unavailable due to regular vessel equipment failure. Given the diversity of tropical ecosystems it is important to have the appropriate equipment to sample water column targets of interest and to use this equipment on a regular basis. Without this basic information, the conclusions of a study could be questioned.

Another aspect of biological sampling is the species identification. Those of us who work in a temperate environment usually only have a few species to content with. However, in tropical waters it is not uncommon for tens of species to occur in a single set. Proper identification of these organisms is a requirement if they are to be properly classified into acoustic groupings. More effort is required to ensure sufficient samples are collected, and properly identified, to meet the program's needs.

3.4 Data Quality

The raw data collected by the R\V *Oscar Elton Sette*, and presented to the review panel as not uncommon, was of very poor quality. Figure 3 of the review document, provided prior to the meeting, clearly illustrates the severity of noise and bubble effects during the operation of this vessel prior to filtering and editing. The figure provides a classic example of signal loss due to bubble effects and vessel noise in the upper panel and the edited echogram in the lower panel. Without access to the raw data, readers and reviewers could easily overlook the amount of information lost and draw potentially false or biased conclusions.

The review panel was very troubled about the amount of information lost due to the removal bad pings. The panel was informed that for this vessel it was not uncommon to have to remove 40 to 60% of the acoustic information from the echogram during a normal survey. This level of removal is unacceptable for analytical purposes. Much of the problem was attributed to sea state during the collection of acoustic data, especially when the vessel was running into the swell. To overcome this problem, it was common practice to collect acoustic data only while running with the swell to avoid even further deterioration of the acoustic data. This resulted in the loss of valuable survey time. Panel members were concerned about the potential removal of valid information and the misinterpretation of patterns based on such highly edited data. In fact members of the review panel suggested that if they encountered an echogram with this level of dropouts and noise they would reject the data as unsuitable for further analysis, and subsequently no information/analysis would be extracted from such poor quality data.

The poor quality of these data does not mean that interpretations presented are incorrect, but there is the question of what was lost or removed. If the Center continues to undertake acoustic research, then improvements must be made to the quality of the acoustic data. The exact causes/sources of the aeration and noise are unknown and need to be identified. During the review, it was suggested that transducers closer to the forward portion of the mounting pad showed greater dropouts than those further back. Another source of the bubble problem, identified above, was bow thruster port.

Much of the acoustic deterioration associated with signal loss, noise, and surface water aeration appears to be the result of typical sea state and winds of a tropical oceanic environment. There is really no simple solution to overcoming these problems. Because of the environment, it is critical that the transducers are deployed such that they are below the aerated surface waters or they are positioned on the hull of the vessel to minimize exposure to bubbles. Several options, each with its own configuration and cost, are available to address this issue. For the R/V *Oscar Elton Sette* it may be possible to reposition the transducer platform out the influence of the bow thrusters or at least place a temporary cover on the port to minimize bubble exposure. Installation of a drop keel may help, but would require a major refit of the vessel. Alternatively, the center could investigate deployment of the acoustic transducers from a towed body or an autonomous underwater vehicle. Both options could deploy the transducers away from the vessel noise, stabilize hardware's movement through the water, and position the equipment at depths out of the aeration zone. There are however incremental equipment and, especially maintenance, costs for both of these options. It is estimated that full-time technical support would be required to properly maintain and deploy this type equipment.

Acoustic data collected by the *Kuma* does not seem to suffer from the same level of noise and aeration problems. This is not meant to imply that there is no noise interference or equipment problems for the vessel. Several problems were identified related to acoustic equipment failure. While some assessment surveys are conducted with a single frequency, if species identification in mixed aggregation is to be achieved at any level, a standard suite of multi-frequency transducers must be available for each survey. The vessel is limited by its small size to near-shore operations/surveying on relatively calm days. Sampling also is restricted to hand deployed gear types for target verification. For example, the pink snapper (opakapaka) survey in Kaneohe Bay, Oahu could not be sampled using a trawl or drag but, given the clarity of the water, might be investigated using a hand deployed underwater camera system.

3.5 Isolation/training:

The current fisheries acoustic program at the PIFSC consists of a permanent staff of one. According to the information provided during the overview, there are

no other active acoustic programs in the region. Design, implementation, maintenance, data analysis, and quality control of the multiple acoustic programs are the sole responsibility of the single individual. Unfortunately, this is not a healthy situation for any researcher, especially when their formal training is primarily in another field. Given the highly technical nature of acoustic technology and analytical procedures, there is a real need for advanced training, communication, collaboration, and peer networking to remain up-to-date on approaches and advancements in the field. While the principal investigator is to be commended for her efforts and commitment to the existing programs, she is still working very much in isolation without the regular interaction/collaboration of other acoustic researchers. Over time this can lead to practices that are inconsistent with the rest of the world. Several options are available to overcome this problem:

- One of the most up-to-date sources of information on acoustic technology, practices, and analytical procedures is the ICES Fisheries Acoustic Science and Technology (FAST) working group meeting held each year at a different location throughout the world. This meeting provides an opportunity to have research programs and analyzes reviewed, to be introduced to the latest acoustic approaches and technologies, and to network with the world's leading experts in the field. If only one acoustic conference/meeting can be attended annually, this is the one that would benefit the researcher and acoustic program the most. Funding for the principal investigator to attend FAST should be made available annually.

- Training is an important component for the collection and analysis of acoustic data. Staff members assigned to the program should have adequate training for the work they are requested to do. Acoustics is a field of study that is comprised of sophisticated electronic equipment and complex analytical models/software. As such, there is a need for staff to have a good understanding of acoustic theory and practices, as well as knowledge of the software package(s) used to undertake a variety of analyses. Additional training for the existing and new staff is required to fulfill the programs needs. Advanced training of temporary staff, while necessary, is not a cost effective way of developing an acoustic program.

- For any acoustic program dealing with natural processes and biology, there is a real benefit from interactions with researchers from other specialties. The PIFSC and the University of Hawaii have the number of research divisions/faculty that could complement the fisheries acoustic program. For example, acoustic programs with a stock assessment based goal should interact with the Center’s assessment group to obtain an understanding of the information required for input into an analytical model. From a biological perspective there is a requirement to identify the diverse organisms ensonified and captured during standard acoustic

surveys. The EOD's fisheries acoustic program must develop linkages and collaborate with other sources of expertise in the area.

- Another area of opportunity for the PIFSC would be to develop international collaboration with other fisheries institutes conducting acoustic research around the world. The diversity of programs ongoing at the PIFSC would have a broad interest for the acoustic community. The center should consider exploring opportunities for scientific exchanges, hosting an acoustic workshop, and/or straight collaboration with international scientists to enhance the Center's program and profile.

3.6 Program Direction

In essence, the current program has two primary directions, either of which requires a complement of 2-3 FTE's to fully support its efforts. The direction(s) the fisheries acoustic program should focus on will depend upon funding, available staff, and senior management's vision for the PIFSC. Given the scope of existing programs there are opportunities in support of stock assessment and in broad-scale tropical ecosystem characterization. From a local perspective, the acoustic surveying of near-shore areas such as Kaneohe Bay to develop a fisheries independent index of abundance for a native fish species (red snapper) will provide information to address local issues and the stock assessment with limited operational costs. This does, however, require a long-term commitment to continue these surveys, if the data are to be used as an index of abundance for stock assessment. Typically 7-10 years of data are required before they can be incorporated into, and influence, an analytical stock assessment model.

Moving offshore to the banks and seamounts, there are opportunities to contribute to the regional stock assessment of commercially exploited fish species and to explore the interaction of biological processes related to the distribution and abundance of target species. Studies such as the evaluation of the impact of implementing closed areas on the fish and fishery are important to stock assessment, fisheries management, and to the understanding of the ecosystem. Characterization of the physical environment at Cross Seamount and its effects on bigeye tuna and its forage (micronekton) at the seamount provides valuable information on factors affecting the distribution and the daily occurrence of this species. Outputs from all of these projects can be used to enhance the scientific knowledge for fisheries and ecosystem management. Programs associated with the offshore areas do, however, require a larger financial commitment, increased staff, and time, due to the requirement for a multi-task offshore R/V vessel.

Research programs associated with broad-scale oceanographic monitoring and the distribution of micronekton have by far the greatest opportunity/potential to make a significant contribution to the international scientific understanding of

large oceanic processes, species distribution, and potential effects of climate change. Current program such as the Hawaiian Archipelago, Western Equatorial (CNMI and Guam), and the Central North Pacific (Transition Zone Chlorophyll Front) clearly illustrate the significance of these studies on a global scale. In addition, studies such those in as the American Samoa EEZ, linking oceanographic currents, micronekton, and the variability in distribution of the albacore tuna fishery over a ten-year period, greatly enhance the scientific knowledge of the environmental process that potentially affect the distribution of these large pelagic predators. Continued research in this area may help to explain the annual variability in the catches of tuna on a broad geographical scale.

While it is the review panel's opinion that there are great opportunities for the PIFSC in the large scale ecosystem processes area of research, given its location, existing programs, and published results, it will require a major long term commitment in the Centers planning process by managers. Implementation of research programs that cover broad geographical areas also require a major commitment in terms of vessel time, resources, staff and for analysis. This area of research is no exception and increased resources and personnel will required to successfully proceed. It is also the panel's opinion that the Center cannot continue to conduct all their existing programs with the complement of staff that now exist. More resources are required to conduct successful programs (See section 4.0).

4.0 Recommendations and conclusions in accordance with Terms of Reference:

The following provides a summary of the panel's discussions, recommendations, and conclusions in accordance with the specific terms of reference assigned in the statement of work. Many of the responses to the specific questions are a bit redundant with the comments and recommendations presented in Section 2;however, they serve to reinforce the statements.

1) Evaluate whether the acoustic system is calibrated appropriately for high-quality data collection.

Proper calibration of acoustic equipment is a prerequisite for quantitative research and assessment, and as such is critical to any acoustic program. The availability of calm and suitable water depths for calibrations around the islands seems to be major challenge for the program. Trade wind induced swells and waves make the number of available days and locations for calibration limited. While it is generally recommended that a water depth of about 20m between the transducer face and the sphere be used to calibrate the standard frequency range of acoustic equipment used for surveying and assessment, it is not

uncommon for calibrations to occur at ranges of 10 to 15 m. If shallower water depths can be used then new and more new sheltered areas may be available for calibration.

Calibration Comments/Recommendations:

- Acoustic hardware calibrations follow standard international procedures and error measures, and should produce accurate quantitative measurements.

- Calibrations of both vessels appear to be undertaken at intervals of about one year. This timeframe is less than desirable and should be conducted at more regular intervals. Calibrations are normally undertaken before or after a survey, and preferably before and after a survey. However, given that there has been little change in the calibration parameters over several years, the systems appear to be relatively stable.

- Acceptance of a calibration is based on the residual mean square (RMS) of the error output by the LOBE calibration software. The recommendation for a good calibration is a RMS of <0.20, with values between 0.2 and 0.4 considered not good, but acceptable. Current calibration of the R/V *Oscar Elton Sette* fall into the latter group and effort should be made to reduce the RMS. Editing of outliers may help.

- Environmental parameters need to be measured at the time of calibration. Actual measurements of temperature and salinity are used to estimate the speed of sound and the absorption coefficient for the EK 60 calibration of the R/V *Oscar Elton Sette* using CTD data. However, for the *Kumu*, these environmental variables are based on mean data at the appropriate time of year, as no equipment is available to measure *in situ* temperature and salinity. A rather inexpensive and portable salinometer should be purchased to solve the data deficiency.

- Currently only the transducer gain and Sa correction are corrected during a calibration. The beam angles and offsets calculated by Simrad are based on environmental values for Norwegian Sea. Factory settings are thought to be a better estimate of the true beam angles and offsets than the calibrated ones in tropical and subtropical conditions. The equivalent beam angle (EBA) is sensitive to temperature changes and should be estimated for the tropical environment, as this is an important parameter in estimating backscatter.

- It was noted during the review that on occasion the pulse length setting used to collect data was not one that the system was calibrated for. Operators should ensure that all desired/operational pulse lengths are included in the calibration.

- As mentioned above, the 20m water depth requirement for calibrating has caused the investigators some difficulty. Those responsible should explore methods to calibrate in shallower water.

- The calibration equipment includes a motorized reel and outrigger polls that position the tungsten carbide ball under the transducer. While the current system is a perfectly acceptable method for calibrating, a computerized ball positioning system may help to reduce the time requirement for calibrating. Another suggestion to maintain the sphere in position would be to hang an additional weight below the calibration sphere.

- The fact that calibrations are stable over time provides confidence in the procedures and processes currently being used at the PIFSC for calibrations, however, there is always room for improvement. A review of best practices will soon be released by the ICES FAST working group. This review will provide guidance and address a number of issues associated with calibration. Participation in the annual FAST meeting would also benefit program.

2) Evaluate whether surveys are designed appropriately for estimating relative biomass of top predators, such as tuna from active acoustics data.

Surveys are designed to meet specific goals and objectives defined by a research program or management issue. In most cases they are designed specifically for one or two species or groups of organisms based on historical information of life history, behavior, and distribution. Regarding tuna, the survey approach to date has been exploratory and provides a good description of geographical distribution in the areas of interest. It is now time to use this information to design a survey with specific goals and objectives. As for relative biomass, the use of the nautical area scattering coefficient (NASC) or area backscatter (Sa) can be misleading in that it does not take into account species diversity and size variability. Attempts should be made to estimate absolute biomass based on species composition, size of the organisms, target strength information, and backscatter at the time of surveying. The data were not carried forward to produce biomass estimate.

Comments\Recommendations

- The specific design of a survey will depend upon many factors such as the target species (or organism groups), statistical theory, what information is to be collected, and how the information is to be used. On Cross Seamount several designs have been explored to address the primary goal to “Characterize the physical environment at Cross Seamount and its effects on bigeye tuna and its forage”. A survey design now needs to be

developed, in consultation with a statistician, to integrate the specific objectives, thereby creating efficiencies and saving time.

- The type and objectives of a survey need to be defined and incorporated into the survey design - Is it for a mapping/distribution or biomass survey? Survey bias and sources of errors also need to be identified. For stock assessment purposes both relative and absolute biomass estimates require information on how representative the information is on the total stock. For mapping surveys, a geostatistical approach may be appropriate.

- A serious oversight in the survey design is the limited biological sampling undertaken during any of the surveys conducted by the PIFSC acoustic program. As mentioned above, it does not seem to be a high priority. Equipment failure has been identified to be a major problem in deploying sampling gear. However, even when samples of the micronekton are collected there is limited capability to identify the organisms. This needs to be improved.

- Direct sampling of larger organisms does not seem to occur on a regular basis. This information is required to validate targets and to determine their size distribution. Simply using a hook and line to collect a few samples does not provide sufficient data. Basing their size and species on observed TS distribution is not reliable. Ground truthing of the acoustical signal is an important component of any acoustic program.

- There is a real need to collect and to integrate biological, acoustical, and oceanographic information. The current program seems to do well at bringing together the oceanographic, environmental, physical, and acoustical data. However, there is a real absence of biological data in any of the survey summaries.

- All surveys are plagued by excessive noise and/or interference which in many cases is associated with sea state and a function of the vessel's steaming direction of vessel. This issue needs to be resolved before good quality quantitative can be collected.

- No biomass estimate estimates were provided during the review.

3) Evaluate whether active acoustics data are pre-processed appropriately using Myriax Echoview Software for estimating relative biomass of top predators, such as tuna.

Echoview by Myriax is one of several internationally accepted acoustic logging and editing software packages. As such, it contains a number of analytical modules that are complex and that require advanced training/experience to properly utilize the software. Without this knowledge the researcher is using the software as a black box where something goes in and something comes out. Detailed knowledge of the automated editing procedures is also necessary to understand what is actually occurring with the data.

Comments/Recommendations

- Poor quality of data due to signal loss and noise is a serious problem for surveys conducted using the R/V *Oscar Elton Sette*. Currently there is 40-60% ping loss on specific transects. Most analysts would reject these data. The level of data loss is unacceptable for acoustic surveys.

- Although the transducers are clean whenever the vessels are all out of the water, there may be a necessity to clean the transducers at regular intervals when operating in tropical waters due to the warm water and rapid growth of attached organisms. This may help to improve the data quality.

- There is a high reliance of the software's noise subtraction and ping removal (bad/dropped pings) algorithms, as well as thresholding to improve the data quality. Unfortunately, the large percent of pings removed and the lack of knowledge of what is actually being removed limits the quality of the data and potentially biases data interpretation.

- Improving the quality of data collected will help to reduce the overall processing time. Currently, a significant amount of time is spent preparing the data for analysis by removing noisy and bad pings. Good data require far less effort to prepare for quantitative analysis.

- Internal TS algorithms and target tracks have been used to determine tilt the angle of single targets. While these extractions are generally based on acoustic theory, there is a need to understand the processes involved. Many of these algorithms are sensitive to the input or filtering parameters. Simply accepting the output from the software can be misleading and lead to false conclusions.

- A minimum of 10 dB signal to noise separation in the S_v data at a -75 dB threshold was established for processing. However, in reviewing some of the data, this may not always be the case.

- Enhanced knowledge of acoustic theory and the analytical software are needed by the scientific staff. Specifically, those involved in the processing of data need to know the implication of implementing various algorithms and input parameters on edited and filtered data.

4) Evaluate whether surveys are designed appropriately for estimating relative biomass of micronekton, forage for top predators, from active acoustics data.

As discussed in item 2, survey design will depend upon the goals and objectives of the survey. In this case, broad geographical areas are covered to investigate the distribution and abundance of micronekton, the forage for top predators. Standard acoustic surveys usually involve an estimate of biomass and error. The surveys currently being conducted by the EOD include one or more relatively long transects. This type of data is not amenable to estimating biomass in the classic sense where the total biomass is representative of a specific area. Here the relative or actual biomass is expressed in terms of NASC, Sv, or number per unit area and as such would be more appropriately termed a density or concentration that various spatially and temporally. Whether or not the surveys are appropriately designed depends on the study. In the case of broad-scale oceanographic features and climate change, the current design provides a reasonable approach. However, for more focused studies such as linkages between oceanographic features, micronekton distribution, and the distribution of top predators, some improvements could likely be made. Again, it is important that biological sampling the undertaken at regular intervals and at various depths to quantify and identify species composition throughout the survey range and the water column.

Comments\Recommendations

- The search for specific oceanographic features to test a hypothesis of linkages to the abundance and distribution of top predators requires careful consideration of the survey design. The current approach of using satellite information to identify the location of these features (e.g., eddies) for surveying is a valid approach.

- Efficiencies may be gained by using a more structured survey design with a two phased approach. Broad scale transects could be used to identify the real time location of the features of interest and the second phase to focus on the areas of interest. This could be tested using simulation studies.

- Another approach may be to use drifters in features of interest to obtain information about density/concentrations.

- The current approach is to collect acoustic data in one or two of these oceanographic current/eddy systems to demonstrate coherence with albacore catches. If this method is to be applied elsewhere there is a need to sample multiple eddies over several years for comparison in time and space.

- Access to logbook data and catch statistics would be an asset when trying to compare acoustic densities of micronekton, catches, and CPUE with the oceanographic features. It might be worthwhile trying to collaborate with the fishing industry to get additional information about the fish and fishery.

- The collection of oceanographic data does not seem to be much of problem and is done so at regular intervals. Finer resolution may however require shorter sampling intervals. Satellite data are also available in near real-time for the areas of interest.

- Unfortunately, little if any ground truthing of targets was undertaken during the surveys. More biological sampling of acoustic layers is required to characterize the species composition and to ground truth acoustic targets. Unlike temperate environments where the number of species in small, tropical waters usually contain a large number of different organisms. Consideration will likely have to be given to pooling organisms into acoustic classes/groups of similar reflective properties once they are identified.

- In general, the objective of both the broad-scale surveys and the oceanographic feature/fishery studies is to estimate biomass in terms of gm/m^2 for examination of latitudinal change and fishing fleet activities. This is more a measure of density variability and physical features than an actual biomass estimate. If the investigators were interested in the total biomass of micronekton in an area, a completely different survey design would be used. No biomass estimates were presented and NASC or Sv is used as a surrogate/proxy for density.

- Some of the information presented assumes a Sv to weight relationship. This assumption needs to be tested. Sv can be affected by a number of factors such as species composition, length, and the tilt angle of organisms. Investigators should looks at simulation studies of changes in species composition or use actual data if available.

- There is often confusion about the concept of relative versus absolute abundance. From the point of view of acoustic surveys, the estimate should be considered as absolute abundance at the time of the survey. However, when put into the context of a stock assessment, it is likely an

estimate of relative biomass given that it only represents a portion of the total stock biomass.

- There are a number of inconsistencies in the reporting of NASC and Sv in the background reports and the presentations. Integration and depth intervals should be presented with the data to make the data comparable with other studies.

5) Evaluate whether active acoustics data re-processed appropriately using Myriax Echoview Software for estimating relative biomass and composition of micronekton.

Echoview software contains the appropriate algorithms and analytical procedures to estimate relative biomass and composition of the micronekton using standard acoustic processing procedures. Options are available to identify specific layers, organism groupings, aggregations, and frequency differences for the independent analysis of backscatter and the subsequent estimation of biomass based on specific targets. Advanced knowledge of the software procedures and its options/selection criteria is required to optimize these functions.

- No analyses were actually carried forward to estimate biomass although sufficient data may be available to do so. Relative biomass was determined by estimating the total backscatter (NASC or Sv) within a depth interval and this was used as a proxy for biomass.

- No data were presented on the actual species composition from biological sampling, but changes in backscatter were used to imply changes species composition based changing Sv. This may not be true. Change in species composition can be dependent upon the bin sizes selected for the analysis. Again there is limited ground truthing of layer composition to evaluate.

- The target strength of individual targets extracted by the software has been used to estimate or imply fish size. In the case of the juvenile opakapake study in Kaneohe Bay summary showed no change was observed in TS over a period of six months suggesting that there was no increase in the mean length of these fish at a time when they should be growing rapidly, or there was a constant turnover of fish on the juvenile nursery grounds. Direct sampling of the fish targets would overcome this uncertainty.

- Multi-frequency acoustic data and the frequency response of fish species, groups of fishes, and aggregations can be a valuable tool in categorizing targets or groups of targets. This approach was used in several of the

studies; however, inconsistencies in the available frequencies limited its application in all cases.

- In the analysis, micronekton have been separated from aggregations of fish using automated procedures in Echoview. The extraction, identification, and masking of schools rely on a number of input parameters which can affect the outcome. In the example shown several schools that were identified by eye were not detected by the algorithm. A question which immediately comes to mind is what else was included or excluded by this procedure. Basic understanding of what is actually being done in the software, and how filter parameters affect the output for local conditions, is required to evaluate the analysis.

6) Evaluate whether environmental data are applied appropriately to obtain information on environmental effects on the distribution and biomass of micronekton.

The PIFSC approaches to the collection and analysis of environmental data seem well founded and appropriate for the studies being undertaken. In fact, the application and linking of these data by the EOD's acoustic team have put forward have, and will, make a significant contribution to the integration of these data sets into an ecosystem evaluation and the evaluation of climate change. The approach links broad geographical environmental data and satellite information with acoustic observations on the distribution and abundance of the micronekton. It is nice to see a fresh look at this problem and researchers at the PIFSC have made significant progress in the analysis and presentation of these complex data sets.

- No information on light was presented during the review. These data may be an important parameter given the large latitudinal variation of the observations and the clarity of the water.

- Care should be taken when using kriging or contouring algorithms within analytical software. Very different patterns can be facilitated by slight changes in the extrapolation distance.

- The hypothesis proposed for the distribution of micronekton based on the spatial and temporal location of water masses is important. It is also nice to see the inclusion and linkage of this information to fishery conservation.

- Again no biomass analyses were undertaken for or presented at the review, except the use of NASC or backscatter (Sv) as a relative index of biomass.

7) Evaluate whether the adequacy, appropriateness, and application of oceanographic data and analytical methods used represent the best available science to characterize the environment and give recommendations for improvements.

While this is beyond my areas of expertise, I feel the methods used are generally adequate and appropriate for the oceanographic data. However, whether or not it is the best available science is another question. As with any scientific approach/method there are always ways for improvement. One comment that was made during the course of discussions concerned the possibility that the contouring may be smoothing the data sets so that it potentially creates false paths or patterns at depth. This could be examined and evaluated with a finer resolution sampling interval over a smaller area.

8) Evaluate whether the adequacy, appropriateness, and application of bioacoustics data in combination of trawl samples to estimate relative biomass and composition of the scattering layers (micronekton) represents the best available science and give recommendations for improvements.

The limited sampling or ground truth of acoustic targets has been discussed throughout this report. Based on the information provided the only conclusion the panel could reach is that the amount of sampling is inadequate to meet goals and objectives of projects currently being undertaken at the PIFSC. Insufficient information is available from the few trawl samples to adequately determine species composition.

- Biological sampling needs to become an integral component of all acoustic surveys with increased sampling frequency at a variety of depths built into the survey design. At a minimum sampling should occur whenever structural or distributional changes in the echogram are observed.

- Vessel equipment needs to be maintained at a dependable level so that sampling equipment can be deployed when required.

- A number of options are available to collect biological samples from various water depths during survey. One of the main concerns of sampling with a mid-water trawl that has a closed cod-end is contamination of organisms from depths above the layer of interest. A possible solution is the procurement and use of a multi-sampler with flow-through capabilities until it reaches the sampling depth.

- Given the visibility of tropical waters ground truthing or the identification of species present may be viable using camera or optical technology,

especially for shallow water depths. Other solutions such as towed Ditson high-resolution imaging sonar should be investigated.

- Avoidance of sampling by mobile organisms may be a significant problem in tropical waters, especially during the day, due to visual detection of the gear. This could affect the catchability of different organisms and bias the observations on species abundance. Studies should to be designed to examine selectivity and catchability of the sampling gear.

9) Give recommendations on the application of Movies+ "Inversion algorithm" to multifrequency acoustic data to estimate absolute micronekton biomass and composition.

No information was presented to the review panel on the application of the Movies+ acoustic software inverse algorithm nor was any analysis undertaken using this methodology. The approach, which takes multi-frequency observations from the echograms, uses the inverse to length distribution from several scattering model to estimate the composition. This forward process assumes a representative sample was taken to project back from the acoustics. It must be stressed that this is a complex acoustic analytical package with many input options and a good understanding of the software is necessary to utilize this module. Slight changes to the optional input parameters can make a significant difference in the output.

- Species composition in tropical waters may be a problem for this analytical approach. Most algorithms in these advanced software packages are typically built for a small number of species in temperate waters. Inclusion of a large number of species such as occur in tropical waters may induce uncertain and even miss leading results. The initial approach to this type analysis is to see if there are any patterns in the data, test for homogeneity, and eventually build up to the analysis of complex/mixed data.

- Another option may be to investigate the use of the Norwegian "Large Scale Survey System" (LSSS) which has many functions that may be helpful in analyzing large quantities of acoustic data collected by the fisheries oceanography acoustic program.

- Use of these sophisticated and expensive software packages require a major commitment in time/personnel and training. It is likely that a dedicated individual would be required to operate and to undertake the analysis using either Movies+ or LSSS software. This goes along with the understanding of acoustical principles and theory. The training requirement for these software packages is such that the use of temporary

or short term staff is not recommended. The conversion of acoustic data to absolute biomass and species composition will take time and effort.

10) Evaluate whether the adequacy, appropriateness, and application of data used to estimate fish abundance represents the best available science and give recommendations for improvements.

No fish biomass estimates were presented to the review panel. However, that being said, the general approach being used provides an adequate foundation for the estimate of fish biomass. This does not mean that it represents the best available science. Improvements are needed in noise reduction, survey design, biological sampling, and analytical approach to carry the acoustic data currently being collected forward to estimate biomass. Recommendations for improvements in these areas are discussed throughout this report. Some subtle, but important, differences occur when estimating fish biomass (usually measured in tonnes) for assessment purposes and estimating density (kg/m2) over relatively large areas for the monitoring ecosystem and climate change.

- Before collecting and using acoustic biomass estimates in support of stock assessment, consultations should be undertaken with assessment scientists at the Center to ensure the output data meet their requirements. The survey design should incorporate the biology, behavior, and distribution of the target species such that it provides a representative sample of a constant component/portion of the total stock.

- Species composition and size distributions are required for accurate estimates of fish biomass. Some mechanism is required to obtain this dynamic information which can vary significantly over time and space.

- Survey area boundaries need to be based on biological and/or fishery information to insure the coverage area includes the entire area of interest.

11) Evaluate whether the science reviewed is considered to be the best scientific information available.

Unfortunately, like any scientific program, there is always room for improvement. It is the panel's opinion that the science reviewed does not represent the best scientific information available. The PIFSC acoustic research team is to be commended for the effort they have put in to the acoustic program and for the diversity of ongoing applications. However, they require additional support to maintain this level of effort. New exploratory analyses could be undertaken to enhance the information available from the data already collected. Simulation studies could be utilized to investigate areas of uncertainty in analytical

procedures if time permitted. Continuation of the analytical procedures to actually estimate biomass based on the backscatter and target strength information would greatly improve the interpretation of these data. There is also need for a better understanding of acoustic principles and theory, as well the effects of software input parameters on outputs, within the team, to evaluate the implications of utilizing a particular analytical method or approach. A number of deficiencies have been identified throughout the text of this report. In many of the examples the raw acoustic data are of poor quality.

12) Recommend future direction and improvements to the science reviewed.

After reviewing the PIFSC Fisheries Oceanography acoustic applications and current research programs, the following recommendations are made to improve the scientific approach and to provide guidance for future direction. The list is not all inclusive, but more a general guide to help the acoustic team develop and to identify research opportunities for the PIFSC in the future. Some recommendations relate to specific ongoing program activities, while others cover a broad spectrum of the program.

Improvements to the Science will require the implementation and/or consideration of the recommendations discussed throughout the text of this report. However, the future direction of the PIFSC's acoustic program future will depend on the available resources and the long term commitment and planning by managers. The review Panel reached a consensus agreement on the broad program issues and recommendations. These are divided into four broad categories: Program Focus, Resources, Equipment, and Collaboration/Training. Although much of what is stated below has already been discussed above, the key points are reiterated here

1) Program Focus. The Acoustic program at the PIFSC has focused its activities in two important research directions with about 11 total projects between them. The first is acoustic programs in support of fish stock assessment and, the second, the characterization of broad scale ecosystem changes related to the oceanographic features. Both program directions can, and do, make a significant contribution to the Center's scientific research program. Unfortunately, given the broad scope of programs, their geographical coverage, and the current complement of staff and resources, it is unlikely that the current level of effort can be maintained with compromising some of the existing projects. Assuming no change in personnel, Center managers will have to make a decision on where they will focus their effort, and even then there may have to be a reduction in the number of programs. A small team will limit the research capacity of the Division to undertake such a broad scope of acoustic

activities. However, if the program is enhanced there are several opportunities in both stock assessment and ecosystem monitoring.

From the stock assessment perspective, there are opportunities to undertake research and monitoring activities through the development, over time, of fishery independent indices of abundance for several local fish stocks, as well as to evaluate the effects of various management imposed restrictions. These are however long-term program commitments and usually require annual input and activities. On the ecosystem side there are real opportunities to make a significant contribution to both the local and international scientific community in the development of methods to monitor broad scale ecosystem changes, annual variability, and potential effects of climate change. The PIFSC is ideally situated to undertake this research and has already conducted the exploratory studies upon which to base a more elaborate program. There are also additional research opportunities in linking the physical, environmental, and biological oceanography with the distribution and abundance of large migratory pelagic species such as tuna. The final decision of where the Center should put its efforts rests in the hands of the current managers and their vision of the PIFSC's and the EOD's Fisheries Acoustic program's future.

2) Resources. The current Fisheries Acoustic program is understaffed given the number of projects and geographical coverage. Simply put, there are not enough permanent personnel, and major commitments in support and training are required for the acoustic program to maintain its viability. The programs reliance on temporary staff for support and analyses means constant re-training and a lack of temporal consistency in procedures. Focusing the program will help; however, there is still a need to have a team of permanent staff for the acoustic work if the program is to develop. Ideally the team would comprise of minimum three individuals: a scientist to develop, coordinate, analyze, and report program/project findings; a biologist to deal with sampling, ground-truthing, taxonomy, and analysis, and a technician to support the gear and maintain the acoustic and sampling equipment. The availability of funding was not discussed during the review, except the opportunities for training, collaboration, and conference travel were limited.

3) Vessels and Equipment: The procurement and maintenance of the appropriate acoustic equipment and it deployment is an important aspect of an acoustic program. Several serious deficiencies/concerns were identified regarding the R/V *Oscar Elton Sette* and *Kuma*, including bubble noise, transducer problems, data quality, fishing gear failure, and gear deployment, are all discussed above in this report. These issues represent a major limitation to the PIFSC's fisheries acoustic program and they need to be resolved.

Another major concern of the reviewers, partly related to the RV's, is the limited amount of biological sampling and target validation being undertaken during most surveys. For the R\V *Oscar Elton Sette* it seems that sampling/fishing equipment failure is a common occurrence, while for the *Kuma*, the type of sampling gear is limited due to its small size. There is a requirement to sample at multiple depths without contamination to investigate layers. Possible solutions/alternatives include:

- Procurement and utilization of a multi-sampler cod end to avoid deployment and retrieval contamination.
- Explore opportunities for optical sampling, especially in shallow water areas.
- Investigate opportunities with the Advance Technology group to design and procure some specialized equipment for sampling micronekton that could be used on a regional or national level.
- Look at sampling technologies that can be deployed from a small boat for target validation, such as stereo underwater cameras.

Technical Support is needed to maintain the acoustic equipment, to calibrate, and to identify any problems, if and when they occur, and to arrange for the repair or replacement of malfunctioning equipment. A project that requires three frequencies to examine frequency response cannot meet its objectives if only two frequencies are operational.

4) Collaboration/Training: The PIFSC is located near the equator in the mid Pacific Ocean. Because of this geographical location it is isolated from other major centers that have fisheries acoustic programs. There is a real need and benefit for members of the acoustic team to network and to develop linkages with experts in the field of acoustics, especially the team is relatively new to fisheries acoustics. Many national researchers have been working in the field for decades and have encountered some, if not most, of the problems/uncertainties being encountered by the PIFSC acoustic program. These national and international researchers are very approachable and can provide invaluable guidance and solutions to the challenges being faced by the PIFSC. The acoustic program would be improved and enhanced through internal and external collaboration, and advanced training. The following are several suggestions to facilitate networking and collaboration.

   - Participate in the annual ICES Fisheries Acoustic Science and Technology (FAST) working group meetings and other related meetings such as CLTOP. These meetings provide an excellent

opportunity to meet the world experts, discuss problems, and to get an update on the latest technical and analytical approaches.

- Encourage local or internal collaboration. There is broad expertise within the other Center divisions and the university that could make a valuable contribution to the acoustic program.
- Explore opportunities for collaboration with National acoustic experts and advance technical groups throughout continental USA.
- Implement an exchange program for National and International acoustic researchers either through the PIFSC or the University of Hawaii.
- Fund adequate training to meet the program requirements.
- Possibly host an international workshop on a topic or topics of interest to the Fisheries acoustic program. This would bring experts from around the world. A suggested theme is "Acoustic monitoring of large scale oceanographic processes".

13) Describe briefly the panel review proceedings highlighting pertinent discussions, issues, effectiveness, and recommendations.

This review was slightly different from the STAR Panel assessment related review I previously participated in as a CIE expert. In this case, the goals were primarily to review the current acoustic programs, identify issues, make recommendations for improvements, and to provide some guidance for the program's future. The review panel met for three days (July 7-9) to discuss the Fishery Oceanography Division's acoustic program. During this time, we were provided with both overviews and general presentations on the programs projects goals and objectives, as well as operational and analytical procedures. While there was a general overview of all acoustic projects currently being undertaken by the group, there was limited focus on a detailed review on the individual projects. Throughout the presentations we had extensive question and answer sessions to gain a reasonable understanding of each programs objectives, operational procedure, challenges, and desired outcomes. We were provided access to all levels of scientific staff and management (Division Chief, and the Center's Director and Deputy Director). The data and material were available on time and the few requests for additional information were met during the meeting. The meeting was not held at PIFSC as originally planned, but at the Pago Pago room, IMIN International Conference Center, University of Hawaii at Manoa. The meeting room was well equipped and ideal for the small number of participants to have open discussions. The review panel met for most of Friday (without PIFSC staff participation) to discuss and summarize their findings and conclusions. This report reflects those deliberations and summarizes my observations and recommendations.

5.0 Summary

The CIE review process provides an opportunity for scientific programs and projects to undergo an independent comprehensive review of survey/experimental design, practices, technology, and analytical procedures. The goal of these reviews is to provide a form of quality control to ensure appropriate scientific methods are being applied and to make recommendations that will improve or enhance the programs. Based on the information presented to the panel the PIFSC has established a good foundation to undertake stock assessment and ecosystem related acoustic research. In fact, it was the view of the panel that the PIFSC has made some significant strides in the integration of oceanography, biology, and acoustics over a broad geographical scale. The Center is encouraged to continue to pursue this area of research. However, a number of deficiencies were identified that would greatly improve the program and scientific output of the research projects.

Recommendations on how to overcome these deficiencies are identified throughout the text. Some of these recommendations require immediate action (e.g., data quality) while others can be implemented over time. However, if the fisheries acoustic program is to continue with the number of programs and geographical coverage, additional permanent and appropriately trained scientific staff must be recruited.

Recommendations on how might the process be improved in the future

The current review provided essential information on how and why certain methods and procedures were applied so deficiencies could be identified and recommendations developed. In general I found the process interesting, informative, and hopefully helpful to the program and its future direction. However, given the extensive practical experience of the reviewers, a day or so of detailed data analysis involving the acoustic research team and the reviewers (or a single reviewer), may benefit the program and the team members. I would also like to thank the staff of the PIFSC for their hospitality and cooperation throughout the review.

DISCLAIMER

The information in this report has been provided for review purposes only. The author makes no representation, express or implied, as to the accuracy of the information and accepts no liability whatsoever for either its use or any reliance placed on it.

Appendix 1: Bibliography of materials provided for review.

The following is a list of background documents provided prior to the meeting:

1) R Domokos, M.P. Seki, J.J. Polovina, and D.R. Hawn. Oceanographic investigation of the American Samoa albacore (Thunnus alalunga) habitat and longline fishing habitat. Fisheries Oceanography, 16:555-572. 18 pages.
2) R. Domokos. Environmental effects on forage and longline fishery performance for albacore (Thunnus alalunga) in the American Samoa Exclusive Economic Zone. Fisheries Oceanography, 18:419-438. 20 pages.
3) Overview of active acoustic Work of Progress at the PIFSC, 13 pages (about half of them figures).

All references seem to be included in the proper appendix. All three required appendixes have been included in the review.

Appendix 2: Statement of Work for Dr. Gary Melvin

External Independent Peer Review by the Center for Independent Experts

Fisheries Oceanography Acoustics Applications in Western Pacific

Scope of Work and CIE Process: The National Marine Fisheries Service's (NMFS) Office of Science and Technology coordinates and manages a contract providing external expertise through the Center for Independent Experts (CIE) to conduct independent peer reviews of NMFS scientific projects. The Statement of Work (SoW) described herein was established by the NMFS Project Contact and Contracting Officer's Technical Representative (COTR), and reviewed by CIE for compliance with their policy for providing independent expertise that can provide impartial and independent peer review without conflicts of interest. CIE reviewers are selected by the CIE Steering Committee and CIE Coordination Team to conduct the independent peer review of NMFS science in compliance the predetermined Terms of Reference (ToRs) of the peer review. Each CIE reviewer is contracted to deliver an independent peer review report to be approved by the CIE Steering Committee and the report is to be formatted with content requirements as specified in **Annex 1**. This SoW describes the work tasks and deliverables of the CIE reviewer for conducting an independent peer review of the following NMFS project. Further information on the CIE process can be obtained from www.ciereviews.org.

Project Description: PIFSC is conducting a broad range of fisheries applications using active acoustics that have generated a good number of publications. The active acoustic program commenced in 2004 at the center and utilizes two Simrad EK60 systems. One system is installed on the NOAA ship *Oscar Elton Sette* with a home port in Pearl Harbor, while the other one is operated on a small (21-foot) boat, the *Kumu*. The *Sette* is equipped with hull-mounted, split-beam, 7° beam-width transducers, originally operating at the 38 and 120 kHz frequencies. During the FY08 drydock period, an additional 70 kHz transducer was installed, bringing the number of frequencies to three. The Sette is slated to receive the full suite of the split, narrow-beam frequencies available from Simrad with the installation of an 18 and a 200 kHz transducer during the next drydock period, scheduled for FY11. The small boat, *Kumu,* is equipped with a portable split-beam system, operating at 38 and 120 kHz frequencies. Acoustic data obtained by these systems are pre-processed using Echoview software then further processed and analyzed using Mathworks' Matlab software. IRD's Movies+ software has also been used occasionally for processing acoustic data. The Movies+ software will be utilized more in the future as the availability of more frequencies will make identification of organisms and absolute biomass estimates possible by Movies+ "inversion algorithm", not available in Echoview.

Presently, there are two major foci of this work. One is the study of micronekton within the tropical and subtropical Pacific Ocean. Micronekton are smaller organisms that are forage for our economically important fishes, such as tunas. To characterize micronekton biomass, composition, and spatiotemporal distribution, acoustic data is collected on board

the *Sette*, typically 24-34 days per year. To ground-truth the acoustics data thus allowing for better interpretation, micronekton samples are collected via a large trawl. Work has been conducted at American Samoa, within the Hawaiian archipelago, in the north central Pacific, with the Mariana Islands scheduled for FY10. During all cruises, the physical environment is monitored via CTD casts (temperature, salinity, oxygen, and chloropigments) and an Acoustic Doppler Current Profiler (ADCP) down to 1000 and 700-800 m, respectively. Using *in situ* environmental data in combination with remotely sensed data, such as satellite altimetry and ocean color, the effects of the changing environment on micronekton are investigated.

Another focus of the active acoustic program is the development of a fisheries independent method to study commercially important fish with management issues. As for micronekton, both *in situ* and satellite data are used to examine the effects of the environment on these fish. One example of these organisms is bigeye tuna. A relatively homogeneous area occupied with mostly bigeye was selected for this study: Cross seamount, located in the Hawaiian archipelago and exploited by the local fishery. As the acoustic characteristics of bigeye tuna are well known, this effort focuses on the *in situ* acoustic identification of bigeye tuna and the development of a study design to convert the 2D data collected along transects to a 3D map. The results of this study are so far very promising as determined by acoustics data collection and simultaneous handline fishing. Another example of this type of work is the development of a time-series of bottom fish in Hawaii, heavily targeted by the local fisheries. For this work, both the *Kumu* with the portable acoustics system and the *Sette* are utilized. Using the *Kumu*, *in situ* acoustic target strength measurements with simultaneous video camera recordings were conducted on juvenile pink snappers in an insular nursing area, as well as a time-series is being developed of their biomass along transect lines In the nursery grounds. In addition, a time-series is being developed on the biomass of adult bottom fish with the aid of simultaneous "Botcam" video recordings.

Future plans include obtaining more acoustic data on micronekton at different regions within the Pacific basin to develop an understanding of large-scale differences in biomass, composition, and movement patterns of micronekton. The development of fisheries independent methods to produce biomass time-series of economically important fish and the study of the effects of environmental factors is expected to continue. Acoustic data will be collected at various seamounts and their effects on micronekton and fish will be examined. This work will enable us to have a better understanding of the processes affecting micronekton and fish at seamounts, as seamount environments are known to aggregate these organisms. With the development of new projects, the presently one-person "program" should also increase.

Due to the applied nature of this work, a thorough review of the approach would be justified. Further, this program would greatly benefit from a review because of the isolation it faces, as no one else is using this method in the state of Hawaii. A review would be additionally beneficial as this program faces special challenges due to the highly heterogeneous nature of tropical and subtropical environments, making acoustic identification of organisms difficult.

The Terms of Reference (ToRs) of the peer review are attached in **Annex 2**. The tentative agenda of the panel review meeting is attached in **Annex 3**.

Requirements for CIE Reviewers: Three CIE reviewers shall conduct an impartial and independent peer review in accordance with the SoW and ToRs herein. CIE reviewers shall have working knowledge and recent experience in the application of active fisheries acoustics, and it is desirable to have experience with the acoustic processing software including Echoview and Movies+ and the application of acoustics to sampling subtropical micronecktonand tuna. At least one reviewer should have expertise in the application of acoustic fish surveys in stock assessment. Each CIE reviewer's duties shall not exceed a maximum of 14 days to complete all work tasks of the peer review described herein.

Location of Peer Review: Each CIE reviewer shall conduct an independent peer review during the panel review meeting scheduled at the Pacific Islands Science Center in Honolulu, Hawaii during 7-9 July, 2010.

Statement of Tasks: Each CIE reviewers shall complete the following tasks in accordance with the SoW and Schedule of Milestones and Deliverables herein.

Prior to the Peer Review: Upon completion of the CIE reviewer selection by the CIE Steering Committee, the CIE shall provide the CIE reviewer information (full name, title, affiliation, country, address, email) to the COTR, who forwards this information to the NMFS Project Contact no later the date specified in the Schedule of Milestones and Deliverables. The CIE is responsible for providing the SoW and ToRs to the CIE reviewers. The NMFS Project Contact is responsible for providing the CIE reviewers with the background documents, reports, foreign national security clearance, and other information concerning pertinent meeting arrangements. The NMFS Project Contact is also responsible for providing the Chair a copy of the SoW in advance of the panel review meeting. Any changes to the SoW or ToRs must be made through the COTR prior to the commencement of the peer review.

Foreign National Security Clearance: When CIE reviewers participate during a panel review meeting at a government facility, the NMFS Project Contact is responsible for obtaining the Foreign National Security Clearance approval for CIE reviewers who are non-US citizens. For this reason, the CIE reviewers shall provide requested information (e.g., first and last name, contact information, gender, birth date, passport number, country of passport, travel dates, country of citizenship, country of current residence, and home country) to the NMFS Project Contact for the purpose of their security clearance, and this information shall be submitted at least 30 days before the peer review in accordance with the NOAA Deemed Export Technology Control Program NAO 207-12 regulations available at the Deemed Exports NAO website: http://deemedexports.noaa.gov/sponsor.html).

Pre-review Background Documents: Two weeks before the peer review, the NMFS Project Contact will send (by electronic mail or make available at an FTP site) to the CIE reviewers the necessary background information and reports for the peer review. In the case where the documents need to be mailed, the NMFS Project Contact will consult with the CIE Lead Coordinator on where to send documents. CIE reviewers are responsible only for the pre-review documents that are delivered to the reviewer in accordance to the SoW scheduled deadlines specified herein. The CIE reviewers shall read all documents in preparation for the peer review.

Tentative list of background documents:

1.) R Domokos, M.P. Seki, J.J. Polovina, and D.R. Hawn. Oceanographic investigation of the American Samoa albacore (Thunnus alalunga) habitat and longline fishing habitat. Fisheries Oceanography, 16:555-572. 18 pages.
2.) R. Domokos. Environmental effects on forage and longline fishery performance for albacore (Thunnus alalunga) in the American Samoa Exclusive Economic Zone. Fisheries Oceanography, 18:419-438. 20 pages.
3.) Overview of active acoustic Work of Progress at the PIFSC, 13 pages (about half of them figures).

Panel Review Meeting: Each CIE reviewer shall conduct the independent peer review in accordance with the SoW and ToRs, and shall not serve in any other role unless specified herein. **Modifications to the SoW and ToRs can not be made during the peer review, and any SoW or ToRs modifications prior to the peer review shall be approved by the COTR and CIE Lead Coordinator.** Each CIE reviewer shall actively participate in a professional and respectful manner as a member of the meeting review panel, and their peer review tasks shall be focused on the ToRs as specified herein. The NMFS Project Contact is responsible for any facility arrangements (e.g., conference room for panel review meetings or teleconference arrangements). The NMFS Project Contact is responsible for ensuring that the Chair understands the contractual role of the CIE reviewers as specified herein. The CIE Lead Coordinator can contact the Project Contact to confirm any peer review arrangements, including the meeting facility arrangements.

Contract Deliverables - Independent CIE Peer Review Reports: Each CIE reviewer shall complete an independent peer review report in accordance with the SoW. Each CIE reviewer shall complete the independent peer review according to required format and content as described in Annex 1. Each CIE reviewer shall complete the independent peer review addressing each ToR as described in Annex 2.

Specific Tasks for CIE Reviewers: The following chronological list of tasks shall be completed by each CIE reviewer in a timely manner as specified in the **Schedule of Milestones and Deliverables**.

5) Conduct necessary pre-review preparations, including the review of background material and reports provided by the NMFS Project Contact in advance of the peer review.
6) Participate during the panel review meeting at the Pacific Islands Science Center in Honolulu, Hawaii during 7-9 July 2010.
7) At the Pacific Islands Science Center in Honolulu, Hawaii during 7-9 July 2010 as specified herein, and conduct an independent peer review in accordance with the ToRs (**Annex 2**).
8) No later than 23 July 2010, each CIE reviewer shall submit an independent peer review report addressed to the "Center for Independent Experts," and sent to Mr. Manoj Shivlani, CIE Lead Coordinator, via email to shivlanim@bellsouth.net, and CIE Regional Coordinator, David Die, via email to ddie@rsmas.miami.edu. Each CIE report shall be written using the format and content requirements specified in Annex 1, and address each ToR in **Annex 2**.

Schedule of Milestones and Deliverables: CIE shall complete the tasks and deliverables described in this SoW in accordance with the following schedule.

4 June 2010	CIE sends reviewer contact information to the COTR, who then sends this to the NMFS Project Contact
18 June 2010	NMFS Project Contact sends the CIE Reviewers the pre-review documents
7-9 July 2010	Each reviewer participates and conducts an independent peer review during the panel review meeting
23 July 2010	CIE reviewers submit draft CIE independent peer review reports to the CIE Lead Coordinator and CIE Regional Coordinator
6 August 2010	CIE submits CIE independent peer review reports to the COTR
13 August 2010	The COTR distributes the final CIE reports to the NMFS Project Contact and regional Center Director

Modifications to the Statement of Work: Requests to modify this SoW must be approved by the Contracting Officer at least 15 working days prior to making any permanent substitutions. The Contracting Officer will notify the COTR within 10 working days after receipt of all required information of the decision on substitutions. The COTR can approve changes to the milestone dates, list of pre-review documents, and ToRs within the SoW as long as the role and ability of the CIE reviewers to complete the deliverable in accordance with the SoW is not adversely impacted. The SoW and ToRs shall not be changed once the peer review has begun.

Acceptance of Deliverables: Upon review and acceptance of the CIE independent peer review reports by the CIE Lead Coordinator, Regional Coordinator, and Steering Committee, these reports shall be sent to the COTR for final approval as contract deliverables based on compliance with the SoW and ToRs. As specified in the Schedule of Milestones and Deliverables, the CIE shall send via e-mail the contract deliverables (CIE independent peer review reports) to the COTR (William Michaels, via William.Michaels@noaa.gov).

Applicable Performance Standards: The contract is successfully completed when the COTR provides final approval of the contract deliverables. The acceptance of the contract deliverables shall be based on three performance standards:
(1) Each CIE report shall completed with the format and content in accordance with **Annex 1**,
(2) Each CIE report shall address each ToR as specified in **Annex 2**,
(3) The CIE reports shall be delivered in a timely manner as specified in the schedule of milestones and deliverables.

Distribution of Approved Deliverables: Upon acceptance by the COTR, the CIE Lead Coordinator shall send via e-mail the final CIE reports in *.PDF format to the COTR. The COTR will distribute the CIE reports to the NMFS Project Contact and Center Director.

Support Personnel:

William Michaels, Contracting Officer's Technical Representative (COTR)
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1315 East West Hwy, SSMC3, F/ST4, Silver Spring, MD 20910
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Roger W. Peretti, Executive Vice President
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Key Personnel - NMFS Project Contact:

Jeffrey Polovina, Jeffrey.Polovina@noaa.gov
Pacific Islands Science Center, 2570 Dole Street, Honolulu, Hawaii
Phone:808-983-5390

Dr. Reka Domokos, Reka.Domokos@noaa.gov,
Pacific Islands Science Center, 2570 Dole Street, Honolulu, Hawaii
Phone: 808-983-5368

Annex 1: Format and Contents of CIE Independent Peer Review Report

1. The CIE independent report shall be prefaced with an Executive Summary providing a concise summary of the findings and recommendations, and specify whether the science reviewed is the best scientific information available.

2. The main body of the reviewer report shall consist of a Background, Description of the Individual Reviewer's Role in the Review Activities, Summary of Findings for each ToR in which the weaknesses and strengths are described, and Conclusions and Recommendations in accordance with the ToRs.

   a. Reviewers should describe in their own words the review activities completed during the panel review meeting, including providing a brief summary of findings, of the science, conclusions, and recommendations.

   b. Reviewers should discuss their independent views on each ToR even if these were consistent with those of other panelists, and especially where there were divergent views.

   c. Reviewers shall provide a critique of the NMFS review process, including suggestions for improvements of both process and products.

3. The reviewer report shall include the following appendices:

   Appendix 1: Bibliography of materials provided for review
   Appendix 2: A copy of the CIE Statement of Work
   Appendix 3: Panel Membership or other pertinent information from the panel review meeting.

Annex 2: Terms of Reference for the Peer Review Fisheries Oceanography Acoustics Applications in Western Pacific

1) Evaluate whether the acoustic system is calibrated appropriately for high-quality data collection.

2) Evaluate whether surveys are designed appropriately for estimating relative biomass of top predators, such as tuna from active acoustics data.

3) Evaluate whether active acoustics data are pre-processed appropriately using Myriax Echoview Software for estimating relative biomass of top predators, such as tuna.

4) Evaluate whether surveys are designed appropriately for estimating relative biomass of micronekton, forage for top predators, from active acoustics data.

5) Evaluate whether active acoustics data are re-processed appropriately using Myriax Echoview Software for estimating relative biomass and composition of micronekton.

6) Evaluate whether environmental data are applied appropriately to obtain information on environmental effects on the distribution and biomass of micronekton.

7) Evaluate whether the adequacy, appropriateness, and application of oceanographic data and analytical methods used represent the best available science to characterize the environment and give recommendations for improvements.

8) Evaluate whether the adequacy, appropriateness, and application of bioacoustics data in combination of trawl samples to estimate relative biomass and composition of the scattering layers (micronekton) represents the best available science and give recommendations for improvements.

9) Give recommendations on the application of Movies+ "Inversion algorithm" to multifrequency acoustic data to estimate absolute micronekton biomass and composition.

10) Evaluate whether the adequacy, appropriateness, and application of data used to estimate fish abundance represents the best available science and give recommendations for improvements.

11) Evaluate whether the science reviewed is considered to be the best scientific information available.

12) Recommend future direction and improvements to the science reviewed.

13) Describe briefly the panel review proceedings highlighting pertinent discussions, issues, effectiveness, and recommendations.

Agenda

External Independent Peer Review by the Center for Independent Experts

Fisheries Oceanography Acoustics Applications in Western Pacific

July 7-9, 2010

Pago Pago room, IMIN International Conference Center
University of Hawaii at Manoa
1777 East West Road, Honolulu, HI 96822

Doors open at 8:30 am and close at 5:00 pm each day

Wednesday, July 7

9:00 am	Welcome by Samuel Pooley, Director, Pacific Islands Fisheries Science Center
9:15 am	Introduction by Jeffrey Polovina, Chief of Ecosystems and Oceanography Division
9:30 am	Overview of the acoustic program at the center
10:00 am	Example of use of oceanographic data in combination with acoustics: American Samoa work
12:00 pm	Lunch
1:30 pm	Intercomparison of acoustics and net sampling gear
2:00 pm	Acoustic data to study bottom fish: juvenile opakapaka work
2:30 pm	Acoustic data to study bottom fish: Penguin Banks work
3:00 pm	Discussion

Thursday, July 8

9:00 am	Acoustic data to study tuna and its forage, micronekton: Cross Seamount work
11:00 am	Acoustic data to study charactersistics of micronekton and the effects of environment: TZCF and CNMI work
12:00 pm	Lunch
1:30 pm	Use of Movies+ inversion algorithm to estimate micronekton biomass
2:00 pm	Discussion

Friday, July 9

9:00 am	Discussion among review panel and writing of report

Appendix 3: Panel Membership and pertinent information for the External Independent Peer Review by the Center for Independent Experts of the PISC Fisheries Oceanography Acoustics Applications in the Western Pacific.

The review panel consisted of 3 external and independent reviewers from the Center for Independent Experts (CIE), researchers from the Pacific Island Fisheries Center, and the University of Hawaii.

Review Panel Members:

1) Dr. Gary Melvin, Center for Independent Experts (CIE) – Small Pelagics Stock Assessment Scientist and Acoustic Expert.

2) Dr. Rudy Kloser, Center for Independent Experts (CIE) – Acoustic expert and researcher.

3) Dr Yvan Simard, Center for Independent Experts (CIE) – Acoustic expert and researcher.

Pacific Islands Scientific Center Staff:

1) Dr Reka Domokos, Research Oceanographer, Ecosystems and Oceanography Division PIFSC. (Point of Contact for Review and acoustic program scientific coordinator).

2) Jeffrey Polovina, Chief of Ecosystems and Oceanography Division (PIFSC).

3) Sam Pooley, Director, Pacific Islands Fisheries Science Center.

4) Mike Seki, Deputy Director, Pacific Islands Fisheries Science Center