Center for Independent Experts Panel Review of the Joint Pacific Sardine and Pacific hake (SaKe) acoustic –trawl survey

Summary Report of

Panel Proceedings

Final Report

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Executive Summary:

Recent estimates of declining Pacific sardine biomass and the contraction of their distribution, combined with declining Pacific hake the abundance and uncertainty associated with the 2010 hake biomass estimate, lead to concerns for both fish stocks. In addition, the 2011 hake survey indicated the lowest biomass estimate in the time series, wide confidence intervals around the estimate and provided little information on the strength of incoming year-classes of this important commercial fishery. Historically independent surveys were conducted for hake and sardine in alternating years. An integrated acoustic-trawl survey of both Pacific hake and Pacific sardine was implemented in 2012 as a result of collaboration and partnership between Southwest Fisheries Science Center (SWFSC) and Northwest Fisheries Science Center (NWFSC) fishery scientists, Canada's Department of Fisheries and Oceans (DFO) and the fishing industry. The objective of the program was to conduct a single survey to evaluate the distribution and abundance of both species as well as the collection of oceanographic and environmental data to estimate the physical oceanographic habitats for each target species. The SaKe survey was modified slightly to meet the requirements for both assessments and repeated in 2013. The 2012 survey results were used in the 2013 Pacific hake assessment and the 2013 survey results were being prepared for input into the 2014 assessment at the time of the Panel meeting. After the 2013 assessment it was recommended that a Review Panel be established to review the joint acoustic-trawl survey of Pacific hake and Pacific sardine survey methodology and analytical approaches to estimate abundance, distribution and biomass.

The CIE Experts Panel Review of the Joint Pacific Sardine and Pacific hake (SaKe) acoustic – trawl survey was held at the NOAA Western Regional Center, SandPoint Way, Seattle Washington between January 21 and 24, 2014 with representatives of the science teams from the SWFSC, the NWFSC, and both the sardine and hake fishing industry. The Review Panel consisted of Gorge Rose, Francois Gerlotto, Jon Helge Vølstad, and Gary Melvin (Chair). Appointed Rapporteurs were Stacey Miller and Steve Winter. The purpose of the Panel Review was to evaluate the survey methodology and analytical approaches to estimate abundance, distribution and biomass for the joint acoustic-trawl survey of Pacific hake and Pacific sardine in the context of the traditional individual independent surveys, to make research recommendations to address outstanding issues and to provide guidance on continuing with the SaKe survey with the possibility of evolving into ecosystem.

Currently there are two independent acoustic trawl surveys conducted to monitor the abundance and distribution of individual species; one directed at Pacific hake (*Merluccius productus*) by a scientific team from the NWFSC and the other at the sardine (*Sardinops sagax*) and other coastal pelagic stocks (CPS) by the SWFSC team. Both teams use similar techniques, methods and

devices for their respective surveys, and perform at least one summer survey all along the US coastline, with an additional coverage in Canada through international agreements and treaties. The Panel could identify no major problem in merging the two surveys into a single joint survey given the high inter-compatibility between both methods and techniques. A joint SaKe survey would not only continue to support stock assessments of sardine and hake, but also would improve the basis for broad scale ecosystem monitoring and modeling that can be used to investigate impacts of environmental and climate change. This would be consistent with national and international efforts to move towards ecosystem-based management of marine fisheries resources.

The Panel concluded that the direct and indirect benefits of a Joint Pacific Sardine and Pacific Hake survey (SaKe) far out weight the challenges or disadvantages of independent surveys. Collaboration and cooperation of the NWFSC and SWFSC scientists will add benefits to both groups in addressing survey, sampling and stock assessment issues. Combining the knowledge of advanced technology with the survey sampling expertize will lead to improvements and efficiencies in the survey. From an acoustic perspective the survey design and transect spacing provide adequate, possibly more than adequate coverage to estimate the biomass of both species, although some sampling and research demands need to be addressed. That being said, even with the challenges and compromises identified to the Panel, the joint (SaKe) survey has been used to inform the 2013 and 2014 assessment without major issues.

Whether or not the survey should be undertaken annually or biennially is still open to debate. Ideally a joint survey every year would address some of the uncertainty associated with the assessment and provide information on coming recruitment. This was demonstrated by the reduced confidence intervals of terminal year biomass estimates in years with the survey index. That being said there are several logistic, resource and personnel challenges that must be met before an annual survey can be recommended. The panel was informed that the move from biennial to annual surveys would put additional strain on staff and resources, as well as limit the ability to conduct research in support of the surveys, including making essential oceanographic measures. In addition, the assessment team will only accept survey years that cover the full range of hake distribution in US and Canadian waters. The current hake assessment uses a truncated time series (1995 to present) when complete coverage is available. The Panel is not in full agreement with this practice given the large proportion of the biomass observed in US waters. Another consideration in the annual versus biennial dilemma is that Canada has only committed to a biennial survey.

Extension of the joint survey to a multi-species CPS survey is difficult to evaluate given the information provided and presented to the Panel. The limited information presented on the life histories and distribution of CPS such as Northern anchovies, Pacific mackerel, Jack mackerel, market squid and krill, suggests there is potential to transition the survey from two species to a pelagic multi-species survey. The data could be used not only to inform stock assessments but

also broad scale ecosystems models that investigate impacts of environmental and climate change. This would be consistent with multi-national initiatives to complement single species assessments and move towards ecosystem-based management. The programs are encouraged to consider how this might be achieved and collaborate with other researchers to this end in future endeavours.

The Panel recommends that, under the current situation, a bi-annual summer SaKe survey with more flexible use of ship-time for research in intermittent years over a 5 year period would address most of the concerns expressed throughout this report. This approach will allow NOAA to develop effective survey methods in support of multiple objectives, and to improve the logistics and cost-efficiency of a joint survey with the goal to move the SaKe survey towards a more complete and annual fisheries ecosystem survey in the long-term. A biennial SaKe in the short term will also allow more focus on research to develop a long-term approach for an ecosystem survey and at the same time provide sufficiently and reliable data for the single-stock sardine and hake assessments. Shared development of survey methods and the shared expertise within NOAA (SWFSC, NWFSC, and AFSC) will be particularly beneficial for the development of efficient future sampling tools (optical, acoustic, nets). Combining the knowledge of advanced technology at SWFSC with the survey sampling expertise in the NWFSC will lead to improvements and efficiencies in the survey.

To facilitate this transition, a science-management working group should be formed that includes key survey scientists from both the SWFSC and NWFSC. The working group should have an administrative chair and meet at least twice a year to plan the survey and research as well as to work out any logistic difficulties. Regular communications between the two institutes is also encouraged. It is important to note that between the SWFSC and the NWFSC there is the administrative will, the historical data, vessels available, access to advanced technologies and the expertize to address the issues and concerns associated with a joint sardine-hake survey. At the end of the 5-year period a follow-up review should be convened to evaluate the progress made on addressing the issues from this review, identify outstanding issues, evaluate the potential to move to an annual multi-species survey and define the objectives of the annual ecosystem survey.

Overall the Panel Review provided an opportunity to evaluate the methods, approaches, analysis and issues associated with the Joint Pacific Sardine and Pacific hake (SaKe) acoustic-trawl survey. The composition of the individual review panel member's expertise and experience was broad and complemented the other members relative to the issues at hand. In addition the Panel Review was conducted in a professional and timely manner with ample opportunity for clarification and discussion of issues among all the participants. Throughout the meeting the CIE reviewers played an active role in the questioning, discussion, and request for additional information upon which to base the Panel's conclusions and make recommendations. The Panel

would like to thank the staff of both NWFSC and the SWFSC for their organization and hospitality, and the participants for their patience and cooperation during the meeting.

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1.0 Background:

A number of factors contributed to the request for an independent peer review of methodology for the Pacific sardine and Pacific hake joint acoustic-trawl survey conducted by the NMFS's Southwest Fisheries Science Center (SWFSC) and Northwest Fisheries Science Center (NWFSC). Recent estimates of declining Pacific sardine biomass and the contraction of their distribution, as well as a declining Pacific hake abundance and uncertainty associated with the 2010 hake biomass lead to concerns for both fish stocks. This was further complicated by the 2011 hake survey producing the lowest biomass estimate in the time series, uncertainty around the final years and the lack of information on the strength of incoming year-classes of this important commercial fishery. Traditionally independent surveys were conducted for hake and sardine in alternating years. An integrated acoustic-trawl survey of both Pacific Hake and Pacific sardine was implemented in 2012 in waters off the US and Canada as a result of collaboration and partnership between SWFSC and NWFSC fishery scientists, as well as Canada's Department of Fisheries and Oceans (DFO) and the fishing industry. The objective of the program was to conduct a single survey to evaluate the distribution and abundance of both species, as well as the collection of oceanographic and environmental data to estimate the physical oceanographic habitats for each target species. The SaKe survey was modified slightly to meet the requirements for both assessments and repeated in 2013. The 2012 survey results were used in the 2013 Pacific hake assessment and the 2013 survey results were being prepared for input into the 2014 assessment at the time of the Panel review. After the 2013 assessment it was recommended that a Panel be established to review the joint acoustic-trawl survey of Pacific hake and Pacific sardine survey methodology and analytical approaches to estimate abundance, distribution and biomass.

The Panel Review was held at the NOAA Western Regional Center, SandPoint Way, Seattle Washington between January 21 and 24, 2012 with representative of the science teams from the SWFSC, the NWFSC, and both the sardine and hake fishing industry. The Review Panel consisted of George Rose, Francois Gerlotto, Jon Helge Vølstad, and Gary Melvin (Chair). Appointed Rapporteurs were Stacey Miller and Steve Winter. The review essentially followed the Agenda with a few exceptions during the last two days of the meeting due general discussions consuming Panel discussion time in the first few days. Thursday's meeting was delayed an hour (from 8:30-9:30) to allow the Review Panel time to discuss several major issues. The meeting resumed on time and all presentations and general discussions were completed by around mid-morning on Thursday. A short meeting with the directors of each Center and Jason Link has held to obtain the upper level management perspective on the issues. Since all items on the agenda were addressed, the participants were dismissed for the afternoon so the Panel could begin to collate their concerns, views and recommendations. The meeting reconvened at 9:00am Friday morning for final discussions and was closed about 10:00am. A short wrap-up meeting with the reviewers and a few of the senior staff from both institutes occurred between 10:15 and noon. Thereafter the Panel spent the remainder of the day in discussion and report writing.

Prior to commencing the presentations the Panel Chair dealt with a number of housekeeping issues such as how he would like to proceed with questions and questioning order (Panel members, science teams and then participants) as well as the need to maintain a professional and respectful attitude throughout the meeting. The terms of Reference as defined by the CIE contract (Appendix 2) were reviewed before commencing the presentations. The Chair stressed that the Panel's mandate was to directly address these TOR's. Requests to address other issues and questions would be considered, but the Panel main objective was to obtain sufficient information to respond to the specific questions identified in TOR in their final reports.

2.0 Individual Reviewer's Role in the Review Activities.

The CIE Review Panel was comprised of four international experts, three reviewers and a chair, with a broad range of experience related to acoustic-trawl surveys and stock assessment methodologies. Each Reviewer has provided a general overview of their expertise and activities in their review reports. Dr. Gary Melvin acted as Panel Chair for this review. His expertise in fisheries acoustics and fish stock assessment covered both key topics to be addressed. His experience in independent research associated with single, split and multi-beam acoustic systems, working closely with the fishing industry to establish acoustic surveys, developed multi-purpose assessment surveys and as chair for technical reviews of international fish stock assessments has complemented the other Panel members. As the Panel Chair his primary role was to facilitate an impartial review panel and provide a summary report of the Panel Review proceedings. The summary report is meant to be a compilation of the individual reviewers' major findings and recommendations, not a consensus report.

3.0 Background information and Historical review of the Sardine and Hake Acoustic-Trawl surveys

The first day of the Review Panel provided a general overview of the species biology, the independent hake and sardine surveys as well as a history of the collaborative between SWFSC-NWFSC with presentations by Michele McClure and Russ Vetter. A summary of Primary Questions related the review of the joint Pacific Sardine and Pacific Hake (SaKe) acoustic trawl survey was presented to the Panel for consideration. This was followed by a history of acoustic-trawl surveys for Pacific Sardine (Dave Demer) and Pacific Hake (Rebecca Thomas).

3.1 Agenda Item A – Introduction and Background: Species Biology and Surveys.

The initial presentations provided general overviews of species biology and the fisheries before moving on to the individual surveys. In essence there were 2 independent acoustic trawl surveys that until recently have operated on alternative year, year 1 sardine and year 2 hake. The acoustic trawl survey for sardine was re-introduced in 2006 with broad scale coverage. Spring and fall surveys occurred in 2008 and a joint (SaKe) survey in 2012 and 2013. Pacific hake, the largest fishery along the western coast, has a long time series with intense sampling throughout the species range. Serious concern was expressed about the apparent declining stock abundance of both species between 2010 and 2011 and in particular the uncertainty associated with the hake assessment. Sardine numbers were declining at a rapid rate and their distribution was contracting consistent with cyclical nature of abundance during warn and cold periods. The fact that forecasts indicated the eastern Pacific was heading into a cold period, not conducive to sardine production, was a major concern. For hake, concern was expressed about the general declining biomass since 2003 and the uncertainty about large presence of the Humboldt squid on the assessment in 2010, followed by a very low biomass in 2011. Given the importance of hake, and the uncertainty of its status an inter-year survey was requested for 2012. Thus was born the joint Hake – Sardine acoustic trawl survey (SaKe).

3.2 Agenda Item B – Historical Individual Surveys

3.2.1 Sardine Acoustic –Trawl Survey

The presentation by Dave Demer on the history of the Pacific Sardine acoustic trawl survey provided an overview of the stock and fishery, environmental effects on recruitment, a description of potential sardine habitat, and the acoustic trawl surveys. Details were presented on the SWFSC on-going research related to broadband TS measurements, Optical sampling, Acoustic Imaging and remote and automated analysis of the acoustic data – all of which may lead to improvements and efficiencies in the survey. Additional points were made on how the acoustic trawl survey (ATS) provided information on the distributions and abundances of several Coastal Pelagic Species (CPS) not just sardine, diel and seasonal migratory behaviors, age and abundance-weighted lengths, recruitment, growth, natural mortality and the strength of cohorts. It was also noted that the sardine survey design and methods recently underwent a CIE review with general approval of the approach and methodology.

Several points were raised and clarified by the Panel and Participants related to uncertainty in the survey design, sampling and methods. Discussions centered around; the representativeness of night surface sampling to apportion day-time backscatter into species, the proximity of the fishing stations due to operational constraints, and the assumption that the gear catchability was

assumed equal to 1 for all species. It was further noted that although multi-frequency broadband acoustic data were collected, methods for the differentiation of species were not yet used due to variability. Only catches from the net samples were used to apportion the backscatter into species. A Sardine habitat model developed by the SWFSC appeared to correspond well with the general inter-annual observed distribution, but did not differentiate between feeding grounds and spawning areas. It was pointed out that habitats of the target species will differ for multi-species surveys and the surveys may have to adjust to accommodate alternative species or standardized for all. Temporal and spatial aspects of the individual species will have to be considered if a multi-species CPS survey is developed. Questions were also raised about the differentiation between North (USA-Canada) and south (Mexico) sub-population. The response was that due to the fact that spring and summer surveys provided the same abundance estimates (no significant difference), it was likely that the two populations were separated enough spatially to allow differentiation.

Otoliths are collected during the survey for ageing and the biomass (absolute) expressed in terms of abundance weighted length distributions by age for sardine. It was, however, noted that the length based assessment uses length distributions from the fishery developed from a separate age-length-key to determine the catch at age. The assessment provides a different view of the length distribution. Thus, any observed difference between the length at age for the survey and the fishery was likely a function of sampling. It was also suggested that the length at age can be biased due to spatial variation if the relationship is assumed to be fixed. Several other common acoustic sources of uncertainty related to vessel avoidance, target strength (TS), and sampling intensity were also discussed. A request was also made, and provided later in the Review, about the weighting of the sardine abundance index relative to the other indices used in the assessment.

The SWFSC scientists also provided an overview of their acoustic research strategies to improve the ATS using advanced technologies that will address a number of uncertainties associated with surveying and improve the assessment of single and multi-species. Wideband TS studies in the new building at SWFSC provide opportunities to investigate the frequency response of specific fish species while towed high resolution still and video cameras coupled with an array of environmental sensors are being tested for target identification. On the sampling gear/net side optical sampling is being investigated to aid in the quantification and identification of catches, observe fish behaviors and to quantify size selectivity. Other studies are focused on the integration of advanced technologies such as sonar and acoustic imaging for the automation of acoustic data from multiple technologies and the enhancement of near-shore sampling, especially in shallow water where the larger research vessels will not enter.

3.2.2 Hake acoustic-trawl Survey

A presentation by Rebecca Thomas of the NWFSC provided an informative overview of the resource and the hake survey design, methods, and analysis. The hake resources along the western coast of North America (US and Canada) are both ecologically and economically important. Biomass estimates often exceed 4 million tonnes. Hake landings represent by far the largest North America west coast catch (>40%) of all commercial species with ex-vessel landings in excess of $40 million. Pacific hake is managed jointly between the United States and Canada under a 2004 treaty with a quota sharing of approximately 74%/24%, respectively. The fishery is MSC certified.

The hake survey represents a long time series that began in 1977 and became a joint-survey with Canada in 1992. However, the current assessment only uses data from 1995 onward when the survey was expanded both vertically and horizontally. The joint survey (US and Canada) was typically conducted on biannual bases in late June /July from 2003 to 2012 when the SaKe survey was implemented due to concerns over the stock status. The SaKe survey, a joint Hake/Sardine survey between the SWFSC and the NWFSC, was conducted in both 2012 and 2013.

The joint hake survey traditionally covered a large portion of the US and Canadian Pacific coast depending upon the year. Southern and northern boundaries are determined via a set of protocols regarding the observed distribution, or lack of observations, of hake in a transect. In some years the boundary can extend from south of Morro Bay in the south and to Dixon Entrance in the north. The eastern limit of a transect is defined by shallow water (<50m) and the western end by a maximum depth (1500m) or the presence/absence of hake. The survey begins in the south with a random starting point and 10nmi transect spacing over the entire latitudinal range. By comparison, the SaKe survey used a depth range of 30-1500m or 35nmi offshore to define the transect length. A strong 2010 year-class required the westward extension of the survey lines in some areas the SaKe surveys of 2012 and 2013. The hake survey transitioned from a traditional area density estimate of biomass to geostatistics analysis in 2011 for error estimation. Unlike the Sardine survey, hake biological and target sampling was conducted at irregular intervals. Major reviews of the hake survey were conducted in recent years and supported the approach and methodologies.

Discussion by the panel and participants focused on a few main areas such as intensity of coverage, design-based methods for systematic acoustic-trawl surveys vs geostatistics for estimating biomass, migration, and ageing. The Panel's initial impression was that the intensity of sampling may be a bit excessive since either systematic transects were so densely spaced that biomass for neighboring transects were correlated, or kriging approach to estimating biomass. Under the classical design-based approach for estimating variance the number of primary

sampling units (transects) drives the CV while kriging provides an estimate of spatial variance based on only a high-resolution modelling of spatial correlation. It was noted that a single isotropic variogram was used for all areas in the north and south. There was therefore specially also concern that the variogram was based on only the east/west transects with no North/South data except at the 10nm resolution. This issue was revisited several times during the review and will be discussed later in the report. Several panel members suggested that the survey may possibly be oversampling and that the team should utilize the existing data to look at inter-transect spacing and autocorrelation to evaluate the effects of reduced transect coverage.

Under the current approach the survey is assumed to provide synoptic coverage of hake distribution and abundance, however, given the elapsed time (80 days) for this extensive survey the assumption may not be valid. The rate of migration may affect the biomass estimate. If both the fish and the survey are moving north there are a number of factors to be considered. Double counting of fish may occur for fast movement and the observed distribution may be artificially protracted over time. However, surveying against the migration (i.e., survey from North to South) would likely contract the distribution. Consideration might be given to 2 vessels in leap frog configuration or starting at opposite ends may help to address some of the issues related to the elapsed time.

The Panel had a number of questions related to the observed ages in the survey. A critical characteristic of any age disaggregated index of abundance is the ability to track year-classes and that the numbers generally make sense under reasonable assumptions about yearly mortality. The proportional data presented did not lend itself to easily determine if these factors were true so a request was made to have the numbers at age made available. This information was provided on Wednesday and while not exactly in the form requested the new data did suggest that year-classes may be tracked and that the numbers in general were consistent with assumed mortality patterns. However, this may not be true for the raw survey output. Year effects need to be further examined and removed using proportions need to be examined to confirm.

3.2.3 General discussions on the surveys

After specific questions relating to the hake survey were finished a general discussion ensued on both surveys, exploring a variety of scenarios need to address uncertainty issues and the surveys. There was some discussion on the difference between the spring and summer surveys. Industry expressed the opinion that the summer survey better served their perception of the resource and science indicated that there was no significant difference in biomass estimate from the spring and summer survey for sardine. Both surveys were considered to be key inputs to the assessment where for sardines the estimate is an absolute estimate of abundance while for hake it was relative index. It was pointed out that the hake acoustic trawl abundance index is the only tuning index used in the assessment model while for sardine it is one of two. To examine the importance

of the sardine index the Panel requested the weighting of the indices in the sardine assessment. The assessment team later informed the Panel that the weight in was about 50%.

Some preliminary discussion also occurred on the subject of a single, joint hake sardine, and CPS/ecosystem survey during the first day. However, no real conclusion or recommendations were drawn as the SaKe survey had not been presented.

The Panel had a brief and open discussion on the scope of the Review mandate and the potential for a multiple CPS and ecosystem survey. The concern expressed by the Panel members was how to deal with the endless possibilities if multiple species were involved. The day ended with the Panel having a short meeting and the decision to wait until after the presentations had been completed before addressing the issues.

Overall the first provided the necessary background information on both the Sardine and Hake acoustic trawl surveys. The Panel would like to thank the staff of the SWFSC and the NWFSC for their comprehensive and informative presentations, as well as their openness to discuss whatever questions were raised.

3.3.0 Agenda Topic C – Joint SaKe Survey - Day 2

The second day of the Panel Review began with an overview of previous day's presentations and discussions related to the background information and historical overview of the independent Pacific Sardine and Pacific Hake acoustic trawl surveys. This was followed by a discussion of what sardine surveys occurred when and which surveys were included in the assessment. The Panel was having a difficult time keeping track of the surveys. A summary table of surveys and their relationship with the assessment was requested and subsequently provided by the Sardine group. After several clarifications the meeting proceed to the first presentation of the day. It should be noted that the discussion after each presentation included subjects discussed later in the day given their close relationship.

3.3.1 Joint SaKe Survey (Strengths and Challenges of Current Solutions)

Dave Demer and Larry Hufnagle provided an overview on the development of a Collaborative Sardine and Hake surveys (SaKe): Personnel, Equipment, Transects, and Acoustic, Biological, and Ecological Sampling. In planning the SaKe survey the primary goal was to develop a single survey that focused on the needs of both hake and sardine assessments, keeping in mind the continuation hake time-series and sardine distributions and abundances. A team approach was used in the planning of logistics, protocols, and timing of both surveys from a single NOAA FSV. It was determined that the vessel should be equipped with acoustic-trawl sampling gear

such as multi-frequency echosounders (18, 38, 70, 120, & 200 kHz) for surveying from 50 to 1500m and capable of deploying both a mid-water and bottom trawl for the collection of species composition and biological characteristics. There was also a requirement for oceanography technology such as ADCP, CTD, XBT, TSG. Rationale for moving from a spring to a summer survey for sardines included; sardine being distributed near-shore is shallow water, constriction by water properties (Temperature and Chlorophyll), longer days, better weather and better separation of the Coastal Pelagic Species. The summer separation of hake and sardine make the apportioning of backscatter easier and more reliable. There was also overlap with the NWFSC trawl survey, the industry aerial survey, the Salmon surveys, and the Summer CalCOFI, thereby providing an opportunity for the integration of multiple survey data. It was further apparent that such a survey would provide valuable information of other CPS such as mackerel (Pacific and Jack), anchovy, and herring.

A proposal for a joint hake and sardine acoustic trawl survey was developed in 2011 with the intent of conducting gear trials that year, however, the gear trials did not occur. The conflicting results of the 2011 hake survey with an essentially declining biomass since 2003 (excluding 2009 with uncertainty due to the presence of Humboldt squid) lead to serious concerns and uncertainty about the status of the hake stock and the need for an interim year survey of this extremely important resource in 2012.

The first joint sardine hake acoustic trawl was conducted in 2012 using two vessels: the NOAA FRV "Bell M. Shimada" for acoustics and oceanographic operations and the industry volunteered the FV "Forum Star" as a catcher vessel. The survey used 10mn transect spacing, survey speed of 10knots, 35mn transects to with 2 nm of shore, and conducted two day trawls for hake and 3 night trawls for sardine. The Forum Star did not sample in Canadian waters, instead the RV Ricker surveyed and sampled. Eighty-five east west transects were completed between June 25 to July 24 (60 days at sea), with 98 trawls. This resulted in 31 clusters for apportioning backscatter and sardine length. Data were also collected on Pacific and jack mackerel and herring.

The 2013 SaKe acoustic trawl survey was similar to the 2012 survey except it was conducted from a single vessel in US waters and transects extended south into the Southern California Bight. The NOAA Ship *Bell M. Shimada* surveyed up to the Northern end Vancouver Island. The Canadian RV *Ricker* was used to survey and fish in Canadian waters. Transects extended from the near shore navigable (~40 m depth or 2 km from shore) to the longer of 35 nm or to 1500 m depth with a spacing remained at 10nmi. A total of 80 days were spent at sea at a nominal speed of 9-10knots. Daytime hours were utilized for acoustics and hake fishing while nighttime hours for sardine fishing, 1 CTD on the transect line, and bongos before sardine trawls. An underway CTD was used in good weather, but the ADCP could not be operated during the survey due to interference. Larry Hufnagle provided a summary of the SaKe survey strengths and challenges from a hake perspective. Many of the strengths and challenges were common to both hake and

sardine. Some of the challenges included: complications with coordination; changes in survey design; communications; a change in the ping rate introducing false bottom in the echogram; change in transect length; dropping transects due to time constraints; and extra time for change-over of fishing gear from surface to mid water trawl. Biological sampling was also a major challenge as to when and where given the independent survey designs. In 2012 a separate industry vessel was responsible for most of the fishing but in 2013 the NOAA vessel did everything in an extended time period.

Several concerns were expressed by the presenters' related to comparison of catch rates from the different vessels involved in the survey, changes to transect length, acoustic gear difference among vessels, biennial commitment of the Canadian RV Ricker, change-over times, length of the survey, and the loss of night time hake habitat work and ecosystem/oceanographic data collections. Several other general logistic concerns were identified but were not discussed in any detail.

3.3.2 General Discussion

The Review panel had a number of questions and comments related to the concerns expressed by the Hake and Sardine teams. A Panel member pointed out that it is generally considered more complicated for hake survey than CPS survey when merging the two surveys as a summer survey for sardine didn't exist very long before the joint survey, but the hake survey represents a relative long time series. It was also noted there is the Hake Management Process and that changes to the survey need to be approved before being implemented.

A fair amount of time was spent on discussing the elapsed time for the survey, the transect spacing and how it is used to estimate biomass. During both days the Panel discussed the length of time required to conduct the joint survey, the assumption of it being synoptic, the implications of the assumption on abundance and distribution and the possibility of reducing the survey time - potentially allowing more time for other research. Many of the Panel members felt that the intensity of transect sampling using a 10nm spacing may be excessive. The primary concern by the hake team was a likely increase in CV of the biomass estimate if the transect spacing was increased. A Panel member pointed out that given the autocorrelation between transects the expected increase in the CV may not be as large as anticipated for some distance greater than 10nmi. There is however a trade-off between bias and precision. It may be more important to reduce bias. That being said there is a large amount of data available to investigate the impact of changing the spacing. In a joint survey consideration must also be given to the distribution differences of the two species. Hake is more evenly distributed throughout it range than sardine which tends to occur in several patches of high density along the US coast.

A number of issues were put forward on the use of a single variogram over the full range of the survey being based on the east/west density of fish and how it was extrapolated to determine the boundaries and subsequent biomass. Migration rate, direction of the survey, northern coverage dependent on the use of the RV Ricker, and sampling rate were discussed several times throughout the Review and recommendations are made later in the report to address these issues. The question was also raised about how the assessment team felt about the data resulting from a joint survey. Are trends consistent between years? It might be possible to put year effects in the model if proportions are consistent, then take it out in the modeling process. A presentation by the assessment team occurred later in the day.

Some discussion occurred about what was lost by conducting a joint survey in the time allocated. The loss of survey time due to sampling for the other species, habitat work for hake, and opportunities for collaboration with others was discussed. Sampling done in first two SaKe surveys didn't leave much time for oceanographic studies, however it was pointed out that neither group has done a huge amount of work with oceanographic data collected. Future survey sampling could incorporate increases in CTD and bongo stations, higher density / higher frequency of oceanography sampling and present an opportunity to employ advanced technology for data collections.

The concern about the limited time constraining what could be undertaken during the SaKe survey could be accommodated by using multiple vessels. This brought up an argument about inter-vessel difference and calibration of acoustic and fishing gear. In a previous review other reviewers implied that multiple vessels were problematic and that it was better to have a longer duration with fewer (one) vessel. The Panel did not completely agree with this argument. From an acoustic perspective two properly calibrated vessels should be fully comparable, especially if they are sister ships with essentially the same characteristics. While it was agreed that no two vessels will fish exactly the same, it is very probable that sister ships using the same fishing/sampling gear and protocols should be comparable. The NOAA vessels *Lasker* and *Shimada* are sister ships but are not identical vessels and are rigged differently for fishing. The vessel concerns were mainly associated with sampling logistics and time series. The Panel's view was that vessels will change over time and if it is a major concern then calibration or simulation studies for the fishing gear should be undertaken when the new vessel becomes available.

It was evident from the presentation and discussions that there was a real concern about change, especially within the hake group, and about how modifications to the survey might impact the survey results and assessment inputs. The Panel identified a number of options to the group in this regard, as mentioned previously there is a good time series and dataset to undertake simulation studies to investigate some of the issues. In the absence of appropriate data new studies could be initiated to obtain the data, either through a dedicated survey or during the

ongoing survey; remembering not everything can be done in a single year. The availability of the new RV will help with the limitation on available time.

3.3.3 Strengths and Challenges of Jointly conducting the survey

Presentations on the strengths and challenges of jointly conducting the survey were presented by Dave Demer and Rebecca Thomas. Many of the strengths and challenges of a joint survey were brought up and discussed in earlier sessions, however, they are repeated and expanded here for the purpose of the discussions that evolved. Both the SWFSC and the NWFSC identified several important strengths associated with a Joint Hake-Sardine survey. From a sardine perspective the current design of the SaKe survey provided precise (moderate to poor precision for sardine) and accurate multi-species (not just sardine and hake) observations from closely spaced transects covering the entire sardine range in an efficient manner. The timing of the survey overlapped with other surveys, as well as provided information on abundance, distribution, recruitment, growth and natural mortality. From the hake perspective it allowed the 2012 survey to occur thereby diminishing the uncertainty about the stock status and the possibility of a strong year-class coming into the fishery. Surveying two species at once was also seen as a strength as well as joint calibrations, collaboration between the two centers, and creativity to resolve issues as they arose, including the deployment of advance technologies.

Challenges were also discussed in terms of each program. Commonly expressed concerns were the survey design, extent of the survey (SCB and Canada), transect spacing, synoptic coverage, ecosystem sampling, coordination of logistics, and reporting resources. On a more technical aspect challenges were expressed about target strength estimation, data analysis/archiving, ping rate, and fishing effort. It was noted that the more candidate species involved in the survey the more complex the survey and the analysis could become. Loses due to time constraints included the hake bottom trawls, the collection of hake habitat/environment/prey data, collaborations and additional environmental data sets as well as survey time for value-added projects and the constraints in terms of resources for analysis and research imposed by an annual survey.

It was noted in the hake presentation that one complication for the joint survey was the limited number of science berths aboard the vessel with specific allocations to the hake and sardine teams. All members of the Panel interpreted this point to imply that they were not working on a joint survey, but on their individual components of the survey. By definition SaKe is supposed to be a joint survey, therefore it is necessary for the SWFSC and the NWFSC to work together as a team complementing each other with their expertise. It is the view of the Panel that until such time that the survey staff work together as a coherent group there will always be some underlying conflict as those setting the operations will be biased.

Coordinating logistics was identified as being very difficult, especially for hake, given the long and lean shape of the survey area and the variable latitudinal distance to be covered in any given year. It was suggested by one panel member that before the survey industry might do swaths to assist in determining the boundaries. For a SaKe survey the southern extent is not necessarily an issue, but the northern distribution has been extremely variable from year to year. The Panel was informed that at sea prioritizing and logistical coordination was also a concern, especially when hierarchal priority wasn't clear. While at sea the Field Party Chiefs (FPC) for each team alternated as Chief Scientist from leg to leg during the survey. Because of their independent objectives it was sometimes unclear which species should have priority. From the Panel's perspective this leads directly into the concept of a team approach. If the joint survey is to continue it must not be considered as a hake or a sardine survey but as a SaKe survey where protocols, procedures and objectives are defined before each survey and the scientific team works together toward meeting the defined objectives.

As mentioned previously the length of the survey and the assumption of a synoptic survey has a number of implications related to the observed distribution, especially since the fish are moving north, the same direction as the vessel. This will likely result in a protraction of the distribution for a south to north survey and a contraction for a north to south survey. Several suggestions were made to deal with this problem, but the key to resolving the issues were to complete the coverage in a shorter period of time and an understanding of the migration. The suggestions included determination of northern and southern boundaries first and then allocate sampling over the whole range, adaptive sampling, stratification and increasing transect spacing, as well as using two vessels to decrease the time required to cover the area. Other suggestions were to start at northern end of the range and head south to accommodate the largest variability observed at the north end, develop a survey design that meets the objectives within fixed number of days at sea, and/or get industry input on observed distribution and oceanographic conditions prior to starting the survey

Other challenges included trying to incorporate research and improvements in the survey when there is very little available time under the current design. The SaKe survey is fully subscribed with the assigned number of days at sea and the survey requirements. There are recommendations to increasing fishing (Star Panel Recommendation), improve coverage in Canada, and continue the collection of environmental and oceanographic data. The inability to operate the ADCP during the 2013 survey due to interference was considered a loss. Yet given a little time the ADCP could be synchronized with the other acoustic technology on the vessel and operated continuously throughout the survey.

There were a number of challenges identified to the Panel regarding the question of an annual or biennial survey. Currently the hake survey is scheduled for a biennial cycle, with 2012 and 2013 the exception. Canada has not committed to annual survey and there are a lot of issues that need

to be addressed. It was noted that between survey years are used for research and an annual survey would limit the ability to address survey methods and other issues for both countries. Furthermore, if Canada does not do their portion of the hake survey, then the stock assessment team claimed that they cannot use the data. The Panel was not in full agreement with this last statement as a large portion of the biomass is observed in the US waters and that some assessment related information is likely contained in these data. Although in surveys where sampling did not continue north into Canada, the data were not used in the assessment. It was also noted that 2014 is a research year for Canada. If the SaKe survey were to be conducted annually, negotiations to participate with Canada could be initiated and/or simulation studies be undertaken to explore the use of only US data.

Each of the challenges identified above were discussed in general, and some in more detail, by the Panel and the participants. From the Panel's perspective it is important to note that both acoustic trawl surveys were, or will be, used in the 2013 and 2014 hake assessments. The Panel felt that many of the challenges were not insurmountable and in fact had been or could be addressed through communication, collaboration and cooperation. The remaining issues, excluding personnel and funding, could be handled through simulation studies or experiments to address specific issues. Much of what has been achieved to date is from actually conducting the survey and meeting the challenges to improve the survey. Strategies for improving the survey were to explore sampling in the near shore and the Southern California Bight, sampling with scanning, multi-beam and 3-D imaging sonar, concurrent surveying with two vessels, optical sampling, the incorporation of fishery data, telemeter acoustic data, and automated data processing, reporting and achieving to mention a few.

3.3.3 Ecosystem Considerations

Mid-afternoon on Wednesday the Panel had an opportunity to discuss with Jason Link (NOAA Ecosystem Chief Scientist) a number of issues related to single species stock assessment and the ecosystem approach as they related to the SaKe review. Issues such as the trade-offs between stock assessment requirements and ecosystem information, current US approaches, what are the fundamental objectives and does NOAA have a ranking for these trade-offs. Around the world there is an emphasis toward broader scale ecosystem type approaches to surveying and supporting research. Jason's response was that as resources tighten the main question is how to maintain resources to do future and innovative science as well as the mandated "bread and butter". What we lose in depth in any one species but gain in breadth maybe something that can and needs to be measured. The general trend internationally is to be more exhaustive and inclusive – but that has both fiscal and data costs to government agencies, as well as to stakeholders. There is a need to lay out the objectives and to undertake a portfolio analysis to ensure that ability is maintained to do innovative science. In many cases cases the incremental cost and time to collect ancillary information is minimal on NOAA white vessels. At the moment

predictability is low so it is important to collect the environmental data to potentially help understand the impact of environmental shifts.

Industry also wants to know what is coming down the road. Councils want estimates for all species and the concept of a Coastal Pelagic Species survey should be encouraged. Industry commented that ecosystem components and predictability are important.

3.4 Hake stock Assessment Overview and MSE

Late on Wednesday afternoon the Panel listened to two members of the assessment team give presentations on the hake assessment (Allen Hicks) and preliminary results of an MSE modelling (Ian Taylor) for background information. From an assessment perspective Allen stressed the need for consistency with survey estimates and illustrated how two consecutive surveys (e.g., 2011 and 2012) can have major impacts on the assessment, especially given the 2011 uncertainty in hake stock status. In past years survey data which did not include complete coverage of the hake distribution were not included in the assessment. The panel asked if any evaluations or simulations had been undertaken to explore what happens if the assessment used only biomass estimates from the US survey data as well as an investigation into the transect spacing. The response was that although these studies or simulation studies had not been undertaken there was a reluctance to change due to the likely increase in the variance estimates. The current CV of around 5% is exceptionally precise for and survey. It was also pointed out that the real benefit of an annual survey was an increase in precision of the assessment estimate provided to managers. A survey which estimated Age-1 fish would also improve the assessment. The Panel noted that the 2013 hake assessment utilized the 2012 SaKe data, and the 2014 was going to use the 2013 survey data in the assessment without any major concerns for the changes that had occurred in the transition from a single species survey to a joint sardine hake survey.

MSC evaluations for the hake assessment are to be considered preliminary and work in progress. The first run a few years ago was reported to be too simplistic for an operating model. In this year's analysis no real difference was observed in the short term between annual and biennial survey for depletion, average variability and median catch as well as probability of being below B0 by 10%. However, in the long term there are estimated benefits in an annual survey relative to evaluation metric criteria. Unfortunately, MSE model does not seem to capture the observed variability. Very broad confidence intervals occur without the survey.

Given the lateness of the day and the fact that all of the background information had been presented, the full meeting was adjourned until the next morning at 9:30am with the Panel convening at 8:30am for discussions. This was to give the panel some organizational/reflection time before the final presentation on Evaluations of trade-off (Strengths and challenges for the future).

3.5 Agenda Topic D - Evaluations of trade-offs - Day 3

The Panel reconvened as planned to discuss the direction of the review and how to proceed now that all of the background information had been presented. Prior to reconvening the open review, 3 key conclusions were drafted and agreed to in principal by the panel. Revisions to the conclusion would be reviewed on Friday. It was further agreed that although each reviewer would prepare and independent report, the general conclusions would form the foundation for the Review Panels response to the terms of reference, recommendations and additional conclusions.

3.5.1 Strengths and challenges for the future

No formal presentation was made on the evaluations of trade-offs relating to strengths and challenges of proposed future solutions. Instead Michele presented a verbal conceptual overview of the short (next 5 years) and long term (beyond 5 years). A number of potentials options were identified ranging from a single species surveys to a hake-CPS survey and most combinations in between. Under the single species scenario with a two-year cycle, one year was reserved for surveying while the alternative year used to undertake research in support of the survey. However, for the annual SaKe survey the time is primarily allocated to surveying with everyone fully subscribed and very little room if any for research. Examples of viable option included:

1) Status Quo – Joint P. sardine and P. hake survey every year. No "off-years."
2) Focus on developing and implementing joint CPS and demersal species survey. During the off-year, undertake research on oceanographic drivers as well as survey improvements.
3) Alternate years of focus on hake 1 year and on sardine/CPS the next. Not excluding everything but still produce something that just focus with associated physical and biological environmental data collection. Research would be worked into cruises or additional time used specifically for research. Every year time would be allocated for research within survey time.
4) Surveys happen in alternate years. Additionally, each team in their off-year gets sea time to work on off-year research. i.e., separate research time.

The discussion quickly expanded to far too many combinations to deal with so the group refocused on the objectives.

The surveys essentially have two functions: to obtain assessment related data and to conduct research in support of the survey as well as the collection of ecosystem data. If in the short-term

an annual survey was to be undertaken it would leave little time for research given the commitments of the survey groups. The Panel recognized the necessity to allocate some time to research. One of the key questions to be addressed is "How to make the most efficient use of the time currently available and free up time for research" and "How do you deal with the time that you have?" (e.g., Decrease the number transects in the design so there is more time for research). It was noted that the survey is very unique and important and has set a new way of approaching joint surveys, research surveys and stock assessment surveys. If required, additional resources could likely be found for a survey that turns a new leaf in fulfilling both research and fishery assessment mandates. The new vessel schedule for delivery this year could help to address the research needs and relieve the demands on a single vessel survey. Industry is generally supportive of research, but stressed there needs to be flexibility in the plan to allow for what happened with hake in 2011. If something doesn't look right on the stock assessment side, adjustments can be made.

The discussion moved on to the research. The question was raised by a participant as to what is being defined as research. This was clarified using research topics such as the study of migration, target strength, and multi-frequency species identification as examples. What was not clear was what is best; to incorporate this research into a survey or undertake a separate survey to address the issues. Again there are many possible scenarios. Additional issues to be addressed included; general research in support of the survey, survey design to capture Southern Cal Bight extension offshore, and validation of observations in periods of great uncertainty. There were some strong differences of opinion between the participants and the panel.

After a short discussion it was decided to suspend the review meeting for the morning and have closed discussions with the directors of both the SWFSC and the NWFSC to clarify the situation and issues that were causing a bit of tension. In essence, it is becoming more and more difficult to defend single objective surveys and joint or multi-focus surveys are the way of the future. The panel also expressed the opinion that there is the need to have a good understanding of single species before moving to a multi-species approach and the need to set aside time for research. The question arose as to what amount of time was considered appropriate with a national debate putting it at about 5-10%. At the moment there is no recruitment index of abundance for either species. Development of a recruitment index from the joint survey would be an added benefit. The Panel noted that combined the Centers were in an envious position in that between them they had expertize, technology, vessels and management will to address most, if not all of the issues identified during the review. Management was looking for suggestions on how to move forward. It was also acknowledged that the new vessel could be taken into the equation on suggestions to move forward.

The meeting was then adjourned until Friday morning so the Panel could discuss how they would address the terms of reference and to finalize their general conclusions. Friday would be used to address any outstanding issues/questions for the panel and to have a short wrap-up with

the senior staff members from both Centers. It was proposed to start the meeting at 9:00am with a target completion time of 12:00.

3.6 Wrap-up Discussion

The final day of the meeting was set aside to deal with any outstanding issues or questions from the panel, hold a short wrap-up meeting with managers from both centers, and for the panel to come to a general consensus on the reports direction recognizing that each reviewer would be preparing an independent report to address the specific terms of reference. The formal meeting ended about 10:00 with the Chair thanking the participants and the repertoires for efforts. A short wrap-up meeting occurred after coffee. Thereafter the Panel returned to their hotel to prepare their thoughts. A final gathering of the Panel occurred at 3:00pm to finalize the next steps and to warp-up the meeting.

Two outstanding questions were addressed to the scientific team. The first was "Who does the editing of the acoustic data. Are the transects scrutinized by the SWFC and the NWFC for sardine, hake and other species, or does each center do their own thing?". The response implied that while there was some collaboration on the editing much of the final categorization was done independently and the output data used according to each Center's protocols. The Panel was looking for efficiencies, collaboration and knowledge transfer potential for a joint or multi-species survey.

The second question was related to the hake survey and how the distribution boundaries were determined. For example, it is evident from the echogram where the hake distribution ends for each transect. "Is the outer boundary defined using the transect data or is it extrapolated, based on the variogram and the last observations?". The latter was reported to be the practice and could result in an overestimate. The bias in the biomass estimate caused by the increased boundary area could be as large as the Canadian portion of the total biomass. The boundaries may be better defined from the echograms.

After a brief discussion on the questions the Chair closed the meeting and thanked everyone for their contribution and patience during the meeting. The managers remained and a brief wrap-up was presented by the Chair and Panel members with a general discussion following. No great conclusion or recommendations were identified during the briefing although a general direction of the Panel's conclusions and recommendations was implied. The meeting was adjourned at 11:15 am.

4.0 Summary of Findings for each TOR

The CIE statement of work Terms of Reference (TOR) identified 7 specific questions to be addressed by the Review Panel (Appendix 2) related to the Joint Pacific Sardine and Hake (SaKe) acoustic-trawl surveys. Throughout the week presentations were made covering key aspects of the TOR's in terms of background, survey design, sampling methods, analytical approaches and outputs for the independent surveys and the combined SaKe survey. As the proceedings imply numerous questions were raised by the Panel for clarification and understanding of the issues and concerns. Each reviewer prepared an independent report on the process and addressed the specific TORs in their reports to the CIE. The following represents the assembly or collation of the comments, conclusions and recommendations of the individual reviewers prepared by the Review Panel Chair. Much of the material identified and discussed in the Proceedings section of this report is repeated in response to the TORs, but expanded in this section.

4.1 TOR 1. Review background materials and documents that detail acoustic-trawl survey design and methods, and data analysis methods and results for Pacific sardine surveys, Pacific hake surveys, Joint sardine and hake (SaKe) surveys.

Approximately two weeks prior to the Review Panel meeting, NOAA provided the background documents, reports and primary publications required for the review. This material summarized most of the available information on the Pacific sardine and Hake independent surveys as well as the joint sardine-hake acoustic trawl (SaKe) surveys (Appendix 3). It was noted during the presentations that both the sardine and hake surveys had undergone extensive reviews within the past few years, but the review documents were not included the background material. Provision of this material may have helped some with technical aspects of the review; however, no major concerns were identified. Given that the surveys methods and design had already been approved, the Review Panel limited questions on the technical details of the independent surveys and focused their efforts on the material presented and the joint sardine hake survey (SaKe).

After reviewing the background material and the presentations it was concluded that technically the two surveys were likely candidates for merging, but there were some difference that must be considered if the two surveys were to be merged.

1) Survey timing: The general timing was considered appropriate for a joint survey in that CPS and hake distributions were separate during the summer survey. Furthermore the summer surveys occurred during periods of extended day light hours allowing more time for acoustic surveying.
2) Survey focus: While the CPS survey focused on sardines it was multi-specific in that information on the distribution and abundance of jack mackerel, Pacific mackerel, and anchovy were also collected. The hake survey was mono-specific making more difficult to transform from a single species to a multi-species survey. Because of the multi-specific nature of the sardine survey there is no major technical or

methodological problem to accommodate a joint survey, contrarily to the hake survey.

3) Species distribution: Target species distributions and behavioral characteristics are different between the two surveys. For the sardine survey the CPS are pelagic while for hake they are semi pelagic. Sardines are considered to be a coastal species and hake offshore with the former occurring in patchy highly concentrated areas along the coast and the latter more broadly and evenly distributed through its range. The SWFSC developed a potential habitat model for sardines to assist with survey design and evaluation. This has not been done for hake.
4) Physical and biological Sampling: Several potential conflicts for sampling time occurred during the SaKe survey. Both species are surveyed acoustically during the day, but hake are also sampled by day (trawling) and sardine by night, creating some conflict. Hydrological sampling (XBT, CTD etc.) and differences in sampling gear lead to conflicts due changing the gear (and doors) every dusk and dawn.
5) Stock boundaries: Hake are considered a single stock and the survey covers the entire distribution of the species along the Pacific coast. Two sardine stocks occur along the west coast of North America: The Northern Stock extending from the SCB into Canada and the southern independent population occurring mostly in Mexican waters. The "border" between the two populations, according to the potential habitat studies, is defined by the isotherm 16.4ºC. This characteristic must be taken into consideration for the survey design in order to separate the two populations.
6) International Aspects: Hake is a binational (Canada-USA) resource and surveyed jointly by the two countries every other year. Sardine on the other hand is tri-national, Mexico-USA in winter and spring and USA-Canada in summer although only US scientists survey currently undertake surveys. The SaKe survey could provide an opportunity to standardize the surveys of the three countries to provide a general overview of the whole California Current Ecosystem as far as CPS and hake are concerned.
7) Stock Assessment: From an economic perspective hake is much more important than sardine. The independent sardine and hake surveys and the joint (SaKe) survey have been used to inform the assessment for both species without major issues. Scientists predict that the sardine stock is now entering a low abundance phase given the declining water temperatures. This will likely soon result in a lack of economic interest in the sardine fishery. Abundance estimates have been declining for 7 years, the stock in contracting and no fishery occurred in Canada in 2013.
8) Scientific Expertise: The scientific teams from the SWFSC and the NWFSC have slightly different centers of interest and backgrounds. The SWFSC team has a strong acoustic and advanced technology expertise focus while the NWFSC team is more centered on ecology and stock assessment. Combined, the Centers cover the full set of expertise (ecologists and assessment scientists are also present in the SW and

acousticians in the NW teams) necessary to undertake a joint sardine-hake acoustic trawl survey.

4.2 TOR 2. Evaluate the historic, independent sardine and hake survey designs, methods, and analytical approaches including data preparations and statistical (e.g. geostatistical) analyses to estimate target species abundances, distributions, and biomasses, and associated uncertainties.

The historic and independent acoustic trawl surveys for both sardine and hake have recently undergone a review and evaluation that include their survey designs, methods and analytical approaches and the outcome outlined in the Background section of this report. Panel members concurred with the finding of earlier reviews as presented (the background of the reviews was not provided to the Panel), and only addressed some of the apparent and general uncertainties associated with the surveys of this type.

Most of the issues associated with the individual surveys and discussed by the Panel are common to all acoustic-trawl surveys conducted around the globe. Generally these issues can cause both bias and imprecision in the acoustic biomass estimates. The historic individual surveys and the present (SaKe) survey biomass estimates for year-classes of hake appear to be relatively sensible for proportions, but not so much for absolute values. This situation typically indicates that there are significant "year effects" in the acoustic survey data (biases), such that for unknown reasons in one year the results are low and in another high. In effect this makes the acoustic data less useful, as really it is the fish size from the fishing set data that determine the consistency of the proportionality, and not the acoustic data. There is need here for research on the potential biases that could cause significant "year effects". These would include bio-ecological factors such as changes in distribution (range), migration rates or vertical distribution (all of which may influence availability to the survey), in addition to acoustic factors.

Many methodology components of both surveys are similar or the same. The same acoustic frequencies (38 kHz and 120 kHz as references and 18, 70 and 200 kHz as ancillary) are used to collect backscatter. Acoustic observations are conducted by day for both species but with different fishing operations for biological sampling. Fishing operations/stations are selected according to the acoustic information but with a different strategy imposed by the species behavior. Hake are sampled during day in the layers where they are easily caught and little contamination by other species occurs. However, sardines are found in small individual schools by day that are not easily caught (high avoidance speed). At night the sardines are move into the near surface waters with other species and are easily captured. The catch composition is then used to apportion the acoustic backscatter. The two populations are observed by day (schools for the sardine and dense layers for the hake) and fish are scattered by night and mixed with other organisms (making the echo integration by night difficult or impossible).

The survey designs for both surveys are based on the distribution, migration and behavior of the individual species. For hake, the population is generally evenly distributed in a large layer located above given isobaths by day. This very favorable pattern for acoustic surveys applies standard survey method of equidistant transects perpendicular to the axis of the layer. Inter-

transect distance is rather narrow (10 nautical miles) for such aggregation characteristics. No acoustic observation is made by night, the reason being that hake is mixed with other species and micronekton, making the results difficult to analyze. As the summer distribution of hake is located both in US and Canadian waters, each country operates its own research vessel and the survey area is split in two parts, each one surveyed by a research vessel. The hake survey is performed in alternate years jointly by the two countries, with coverage including part of Canadian distribution. The population is assumed stable (not migrating) during the survey period (up to 90 days) and no correction is considered on this point.

For Sardine the population is more patchy and concentrated in small areas inside the potential habitat and the survey area (in the case of summer surveys; this is slightly different for spring surveys that are not to be considered in this review). Another characteristic is that sardines occur in shallower water than hake. This combination of shallow distribution and schooling behavior can lead biases due to blind zones near the surface (out of reach of the vertical echo sounder) and fish avoidance. It also makes the sampling strategy more difficult to establish. Another important consideration is that the sardine survey is also a CPS survey, adding to the sampling difficulties. For instance, anchovies are extremely close to the shore and difficult to observe with the standard sampling strategy. To overcome these problems a potential habitat model was developed to define the habitat, within which the survey design is fitted and to use multibeam sonar approaches to evaluate the possible biases fish behavior may introduce; particularly school avoidance and occupation of the blind zone (0 to 10 m depth). The results indicated the biases induced by these characteristics are small enough to be ignored. Apart from this effort on sonar observations and potential habitat design, no real care is given to this high level of patchiness in CPS surveys. The survey follows standard procedures with parallel transects, perpendicular to the coastline. The effects of potential contamination of the northern (US) stock biomass by the southern (Mexico) stock has been considered by comparing the results of the spring and summer surveys and the conclusion reached that no real effect of the southern stock was visible (i.e., no significant difference in biomass estimates from spring to summer). As in the case of the hake, it is assumed that the sardine population does not migrate during the period of the survey (also around 90 days). When the sardine stock crosses the USA-Canada border, the US survey is extended to Canadian waters. In some cases a fishing vessel is used jointly with the research vessel in order to perform fish sampling and observations in shallow waters.

The potential problem of boat avoidance by pelagic species was highlighted in the earlier CIE review. There are various views on this but a final judgment was not made. Some specific experiments could be done to address this issue, but these have been pointed out in the earlier CIE review and there is no need to reiterate them here.

A fundamental problem with both surveys, but especially with the SaKe, is that they potentially take too long to conduct. Both hake and sardine are migrating in late spring and summer when the surveys take place. In some years both species migrate out of U.S. waters to northern Vancouver Island and even further north occasionally. That the migration is variable with ocean climate and the strength of the California Current makes the situation even more difficult. In other years the data indicate an unknown portion of the sardine stock may be in Mexican waters. It is possible that some of the "year-effect" (low or high density estimates from year to year not attributable to a known cause) may be the result of either multiple counts or non-counts of migrating fish. The ideal situation for a survey is a stationary population where the distribution

of all members is known. This is not the case for either species. It would be satisfactory if the northward advance of the surveys exceeded the northward movement of the fish, but this is unknown. It is understood that other conditions may dictate a spring-summer survey, including ship availability and inclement weather earlier in the year; hence it is imperative to either reduce the duration of the surveys and/or estimate the migration rates of these species northward. As the rates of migration may very well be variable from year to year, as are the distributions, reducing the survey time would be the optimal solution.

Both surveys follow international standard procedures for calibration using a tungsten carbide sphere for calibrating their acoustic echo-sounders and as such no further comment is required. The Panel also noted that no clear information on inter-calibrations of the survey vessels was presented, in the case of hake (US and Canadian R/Vs) as well as in the case of sardine (US R/V and fishing vessel). It was assumed that no such comparisons were made although there were some opportunities to do so in some years with the existing data.

For the pelagic surveys, the target strength (TS) of some species is not well known; hence any conversions from backscatter to a biological index must rely on approximations. Currently, target strengths are calculated using the standard equations developed by K. Foote, following protocols defined by the ICES WGFAST, for a transformation of NASC to absolute biomass estimates per length (Foote et al., 1987). Target strength bias and uncertainty is a common problem. For hake, the length to TS model is as good as any used internationally, but there remains uncertainty about how the variable vertical distribution of this species impacts the TS. For Atlantic cod, a related species with similar acoustic properties, it has been shown that vertical migration reduces the TS value of individual fish significantly (Rose, 2009). Therefore using the standard TS model for cod would lead to biased estimates. It is important to stress that variations in mean TS from survey to survey will impact the index of abundance or biomass regardless of whether the index is considered to be relative or absolute. For hake the biomass in considered a relative index of abundance while for sardine in is an absolute estimate of abundance.

There is a need in both surveys to continue research on TS of at least the principle species, to investigate any inter-survey variability. If there is no inter-survey variability, but the mean TS used is not accurate, then the backscatter will lead to a relative index (if the TS is accurate then the index can be considered to be absolute). If there is inter-survey variability, then a "year effect" will be present in the data that could be substantial. In such cases the acoustic data become far less useful (reflective of trends in abundance) for stock assessment, and more a function of the proportions of age classes determined by either research trawling or from the fishery.

Biological sampling protocols are slightly different for two species although they use similar equipment – a mid-water trawl configured differently depending on the target species. Some bottom trawling has also been used for hake in the past. Hake sampling and acoustic data collections occur during the day. For the SaKe survey transects are interrupted in order to sample any noticeable detections. The data are then processed and analyzed in a completely standard way. Contrarily to the hake survey and due to different distribution characteristics, the biological

sampling for sardine and other CPS (with a gear different from the one used for hake), is achieved by night sampling to take advantage of a lower reaction of fish to the gear (sardines are dispersed and passive). In this case the interesting concentrations are noted by day and the vessel comes back to the location by night when the same vessel is used or the fishing vessel is informed and goes to the location for a night catch. This last method has the advantage of avoiding any interruption of the acoustic sampling, and the inconvenience of requiring the assumption that what is sampled by night is effectively what was recorded by the echosounder during the day (about 12 hours ago). Nevertheless the assumption is probably reasonable and the method acceptable. The samples are then processed in the same way as hake, following the recommendations of the ICES WGFAST.

The classification or assignment of acoustic backscatter to species in the echograms can be problematic. Hake appear from the echograms to be fairly well isolated from other species and like most gadoids, not difficult to recognize and classify on modern digital echograms. Nevertheless, it was noteworthy that the cause of one hake survey being biased was thought to be the presence of abundant squid. How this actually impacted the hake results was not entirely clear, but it is certain that the identification of backscatter attributable to hake was made more difficult by the presence of squid. As large abundance of squid may re-occur, some effort should be taken to ensure the accurate separation of the two species.

A different method is used to apportion Sardine backscatter and is based on the direct proportions of research trawl catch composition (multiple samples) from nearby sampling. This method has a potentially major flaw in that it assumes that the catchability of the various species (and sizes) is equal, which almost certainly is not true. How much bias is introduced into the backscatter portioning is difficult to know. It was reported at the meeting by Dr. Stephane Gauthier from Canada that their method for pelagics has used net mounted cameras to assist in species identification and that this approach has provided very interesting results (no elaboration was given). It was also reported by Dr. David Demer of the SWFSC that they were developing a camera system. Another approach would be to use the various frequency responses in attempts to separate known species (in the beginning of such research different spatial groups of backscatter). If the fish community composition is changing, and present there is evidence that it is, being able to distinguish among species within the acoustic backscatter may become more difficult and more important all at once.

Different analytical methods are used to estimate mean densities based on the sampling along transects. The hake survey has adapted geostatistical methods whereas the CPS survey uses more conventional design-based methods. Which is the more useful and appropriate method will depend on the correlation structure both along and between transects. If there is no strong correlation then the resultant variogram will be flat and the sampling units can be regarded as being independent samples to be treated with bootstrapping methods. It was not entirely clear at the meeting, or in the documents, what the correlation structure is, and how variable it is in both

directions. It would not be appropriate to treat correlation at higher resolution along transects as being the same as between transects. It was also not clear what the sampling unit was in terms of distance. The bootstrapping methods are more straight-forward, but any variance estimate relies on the assumption that the transects are selected randomly and independent, while the actual selection is systematic-random... It would be interesting to see a summary report of the historic data and various analytical techniques to determine which methods give the more consistent and precise estimates over a period of years.

The duration of both surveys is rather long (between 60 and 100 days), the area observed protracted and both populations migratory. Hake and sardine move southward in autumn and northward in spring. The summer survey assumes that the migration has ended at the time of the survey, but this has not been tested. If false, then a bias can occur, either overestimating the biomass if the migration goes northward, as both surveys go from south to north or an underestimate if the migration is southward. Although the assumptions are realistic and corresponding biases unlikely, it could be important to test this hypothesis.

The delimitation of distribution area for sardine is not difficulty as the stock is highly concentrated in small areas; however for hake, the delimitation has not been clearly described. A geostatistical estimate of abundance requires definition of the boundaries of the distribution. For hake, the boundaries of some transects in some years are not identified and the biomass estimates extended to arbitrary limits. Although this is unlikely to create a significant bias in the estimates, research is required to define the boundaries in a less arbitrary way. Works on potential habitat should be encouraged, as well as the use of information from the fishery (use of acoustic data collected aboard fishing vessels, see Karp, 2007).

No correction for anisotropy was made (or at least was detailed to the panel) in the case of sardine because of the patchy distribution of the stock. In the case of hake, a sophisticated method for taking into consideration the anisotropy is applied. Whether or not this completely corrects the anisotropy, or even if it is necessary is unknown. A CIE evaluation commented on this point and the recommendation should have been made available in the ad hoc expert panel report. The characteristics of the distribution of hake are such that anisotropy could be an issue and should be investigated.

The hake survey started in 1977 and was conducted tri-annually by AFSC in the US till 1992, when the joint hake survey with Canada started. Triennial hake surveys from 1977–1992 are not used in the assessment because the survey covered a reduced depth range mainly in U.S. waters. This strict position is nevertheless difficult to understand given the large proportion of the biomass observed in US waters (~ 95%). Since 1995, the survey design and acoustic methods in the US-Canadian bi-annual joint survey for hake have been consistent, with a South/North coverage from near Morro Bay to Dixon Entrance, AK, covering distribution of all of the age 2+

hake. AFSC conducted the US survey of hake till 2001, and since 2003 the US component of the survey has been conducted by NWFSC.

In conclusion, under independent survey strategies, analytical methods have evolved that are different due to the differing objectives, distribution (vertical and horizontal) of the species, fish behavior, assessment methods and the scientific expertize at the Centers. This has not been a problem to date, but bringing the survey demands and research interests together is likely to have both inherent challenges and unforeseen synergistic benefits that do not occur with independent surveys. Although some concerns, uncertainties and research suggestions have been expressed above, the reviewers all agree that there is no major incompatibility between the two biomass estimates and survey strategies between the two groups.

4.3 TOR 3. Evaluate the current joint SaKe survey design, methods, and analytical approaches including data preparations and statistical (e.g. geostatistical) analyses to estimate target species abundances, distributions, and biomasses, and associated uncertainties.

The current SaKe survey design evolved from a very low estimate of hake abundance for 2011 and the need to address the uncertainty associated with the hake stock status. This resulted in a joint (US and Canadian) survey during summer of 2012. Biological sampling was conducted using FV Forum Star in US waters. The collaboration with the industry allowed extra trawling for hake during day while RV Shimada continued acoustic transects and trawl sampling for sardine at night. The joint sardine and hake survey (SaKe) was again conducted in 2013, with slight modifications, using the vessel R/V Bell M. Shimada in US waters and the WE Ricker in Canadian waters. Transects were extended to 35 nm offshore (or 1500 m water depth, whichever greater) to cover sardine habitat. The NOAA Ship Bell M. Shimada was used to survey up to North end Vancouver Island (Canada), while the vessel W.E. Ricker conducted standard survey operations in Canada. The joint Pacific sardine and hake surveys (SaKe) to date have essentially been more or less the straight combination of the methods used in the historic independent surveys. The basic methods for both species have not changed substantially since the merging of the independent surveys. The hake team has requested consistency in coverage and intensity from survey to survey to ensure the assessment inputs are comparable. While consistency has merit, it may at the times limit improvements. It was the Panel's view that improvements can be made without compromising the consistency of the time series of biomass for either species.

The systematic design for the SaKe acoustic-trawl survey has proven to provide highly precise annual estimates of abundance and biomass for assessment of hake, and moderately precise estimates for sardine. The equal spacing of transects are robust for multiple coastal pelagic species with varying areas of occupancy, provided that the spatial coverage E-W and N-S is

adequate. The acoustic-trawl survey with 10 nm spacing of transects provides estimates of abundance and biomass for hake with relative standard errors (RSE = SE/Mean) in 2012 and 2013 around 5%, while biomass estimates for sardine based on the 2012 and 2013 SaKe surveys had moderate to low precision with RSE of approximately 33% and 28%, respectively.

The intense transect spacing has incredible resolution and several benefits with 10 nmi spacing over much of an extended coastline spanning potentially 3 countries and 20 degrees of latitude (>1200 n-miles), but it also has liabilities. The spacing between acoustic transects in the SaKe surveys is so dense that biomass estimates for neighboring primary sampling units (transects) are correlated for hake. This suggests little loss in precision in biomass estimates for hake if the spacing between transects is reduced to, say, 15 nm, in the baseline SaKe survey. Furthermore, the current kriging method employed to estimate the precision in abundance and biomass estimates for hake is based on the assumption of an isotropic (direction-invariant) variogram. This is a fairly strong assumption since for lags less than 10 nm between observations (the spacing between transects) the spatial autocorrelation in hake density is primarily derived from data along transects in the E-W direction. The systematic spacing of transects employed in the SaKe survey maximizes the distance between transects in each stratum, and therefore little information is available to model the spatial correlation at shorter lags than the spacing between regular transects.

Given the survey progresses from South to North, the same general direction of the migration of both sardine and hake, there is a risk of multiple or non-measurement as a result of migration rates (unknown) exceeding survey progress to the north. Currently the survey takes too long to complete to be considered a synoptic survey for stock assessment purposes. Not only could there be migration effects, but even life history parameters under consideration, such as size and growth, reproductive status and ecosystem measures are unlikely to be stationary over such a long period. The survey time should be shortened if possible.

The effects of sample size (number of transects) on the relative error of biomass estimates can be evaluated through simulations based on historic data. Some increase in spacing of the baseline transects along the coast would allow an increase in sample sizes for CPS with more limited area of occupancy. Also, the accuracy of hake and sardine biomass estimates may be improved if the length of transects E-W are extended when needed to improve coverage. A simulation study presented during the review has already shown that the random removing of 10 transects had negligible (0.2% reduction) in the relative standard error of the hake biomass estimate.

The biological sampling of hake reduces the time devoted to survey for the sardine during the day, and the night catch for sardine reduces the time devoted to hydrological and other biological studies for the hake by night. In both cases the integration of the two surveys results in a

reduction of the overall time allocated to the research program of a single species survey. The other point of concern is the fact that each species requires a different sampling gear. This imposes extra work on the crew and requires time to change the gear each dusk and dawn. The good news is that there is no need to change gear at every moment, as sardine are caught only by night and hake only by day.

Although the SaKe survey has as a prime directive of producing biomass estimates for stock assessment for hake and sardine, the collection of supporting data for research will benefit not only the understanding of the ecosystem but the fishery forces that drive population dynamics, and ultimately the survey and stock assessments. This includes the oceanography. Good examples are the work of Zwolinski and Demer (2013) in attempting to estimate natural mortality of Pacific sardine, Zwolinski et al. (2011) to predict habitat to optimize survey design for Pacific sardine and Agostini et al. (2006) on the relationship between hake distribution and northern flows of the California Current. This research is thought to be essential not only to the understanding of the production of these species, and their resultant fisheries, but also to more efficient surveys and more predictive stock assessments. It appears that the development of the SaKe survey, which was spurred by the low biomass result of the 2011 hake-only survey, led to the hake related oceanography being short-changed somewhat.

Annual versus biennial surveys. In the case of sardines there is a need for annual surveys due to the high variability of recruitment and the short life span. Annual surveys are less critical for hake based on their life history. Experience shown that a biennial survey is usually sufficient for a correct assessment of the longer lived species, although on some occasions (e.g. 2011) unexpected results may make it necessary for an additional survey (e.g. the incorporation of "hake scientists" in a CPS survey in 2012). In the case of hake, the uncertainties associated with the assessment of this very important resource would have remained unresolved without back to back surveys.

There are differences in the "scientific culture" of the teams from the SWFSC and the NWFSC. Although this is not strictly speaking related to survey design, the fact that the two teams have developed different approaches for their respective survey programs will require some adaptations and habituation of each other before the SaKe survey can become fully operational. Simply put the SWFSC team is specialized in fisheries acoustics and uses sardine to develop its research in acoustics, while the NWFSC team is specialized in fisheries ecology and uses acoustics to develop its knowledge on the abundance and ecology of hake. This is likely to produce some difficulties at the beginning, but there is no doubt that after a few surveys they will enrich each other with their respective expertise. The compatibility of the two methods and teams once completed will certainly produce a remarkable group of research on ecosystem approach of pelagic fish and the development of adapted acoustic instruments and methods. If scientific teams from Canada in the north and Mexico in the south are connected to this team, the

perspectives opened by the collaboration with US scientists for the monitoring and understanding of the California Current ecology and the assessment of pelagic fish populations are exceptional.

Suggestions for Research/evaluations:

At present, the analytical methods used for the CPS and hake are very different. There is nothing essentially wrong with this approach, as the species differ in their distribution patterns and acoustic characteristics. However, it is not acceptable that these analyses be done in total isolation from each other. At a minimum, the results should be cross-referenced to ensure that echogram classifications are unified and consistent among surveys. This is not difficult to do with Echoview software (which is used by both species groups). What must be avoided is independent but inconsistent classifications – such that separations of plankton and hake or hake and CPS are inconsistent. In the end, all extractions from the echogram, no matter the species or information, should come from a single classified echogram source.

The acoustic-trawl survey for hake can also be analyzed as a stratified cluster sampling design, with primary sampling units (transects) of unequal size (e.g., Cochran 1977; Lehtonen & Pahkinen 2004; Wolter 1985). A simple approach would be to follow Jolly & Hampton (1990) and assume that the primary sampling units (transects) were selected randomly from all possible transects within each stratum. A separate ratio estimator for a two-stage survey (Cochran 1977; Jolly & Hampton 1990) can then be applied to estimate the overall mean density of hake across strata, and the variance can be estimated trough bootstrapping of PSUs.

It is recommended that analysis be conducted to assess the expected precision (RSE) in estimates of hake abundance and sardine abundance as a function of sample sizes (number of transects). The expected RSE for varying sample sizes can then be accessed through bootstrapping. Dunn and Harrison (1993) show that a post-stratification of the systematic sample (e.g., pooling of 2 neighboring transects to yield post strata with two samples each), and the use of a variance estimator that treats the systematic sample of transects as a stratified random sample, may provide more accurate variance estimates than the common method of treating the survey as a stratified random, based on original strata boundaries. They argue that although both methods of estimating sampling error for a systematic survey are likely to provide an over-estimate of the true sampling error, the post hoc stratification is the better of the two.

For the hake component of the survey, it is also recommended that the subsampling for age (number of otoliths sub-sampled from each trawl catch) be evaluated. The effective sample size for estimating age is generally driven by the number of transects and trawl stations sampled, and may be little affected if less fish are aged at each station. Based on experience from many large scale surveys in Norway, the collection of 50 otoliths per trawl station could likely be reduced to 25 or less with negligible loss in the precision of abundance-at-age estimates. Using historic data, it would be an easy exercise to resample age-readings and then estimate the precision in

estimates of hake abundance by age-class for different sub-sample sizes (say, 10, 20, 30, 40, and 50).

It is recommended that the hake data from overlapping transects between US-Canadian ships conducted in the past be analyzed to assess ship differences. In the last couple years with the joint survey, the process has not been continued due to limited resources/lack of time. It is also recommended that everything be reviewed jointly after the survey to make sure everyone is interpreting things the same way.

More precise estimate of sardine biomass could be achieved by allocating more sampling effort to cover sardine habitat, with little loss in the precision in biomass estimates for hake. For example, if anchovy becomes the dominant CPS species during a period or most important to the coastal fishery then more effort could be allocated to better characterize anchovy habitat and perhaps increase sampling density. When the spatial pattern or locations of high-density patches of hake or CPS can be predicted in advance, using more current data from the fishing fleet or predictions from environmental data, then improved stratification and optimization of sampling effort across strata can bring down the variability in density and biomass estimates without increasing the cruise-time (see, e.g., Everson 1996; Jolly and Hampton1990).

Future surveys could include additional transects that are optimized towards the estimation of variograms for use in kriging (Mueller and Zimmermann 1999). A number of transects could be randomly allocated so that over time information on the spatial autocorrelation between transects is obtained for lags less than 10 nm. According to the NEFWS presentations and discussions at the review meeting, the spacing of transects at 10 nm lags is based on trying to achieve correlation between transects. This justification is hard to understand since the effective sample size for a given number of transects is reduced when neighboring transects are correlated. Systematic spacing that minimizes correlation gives the largest effective sample size for a given number of transects.

4.4 TOR 4. Evaluate the tradeoffs, in terms of costs, benefits, and consequences, of transitioning from independent surveys to a joint sardine-hake survey, particularly regarding its potential to provide population trend information to each of the assessments.

Many of the trade-offs and benefits of transitioning from independent surveys to a sardine-hake survey have already been discussed in the proceedings section and identified in the responses to the TOR's on the independent surveys. From the Panel' perspective the merging of the two surveys would be highly beneficial to both the SWFSC and the NWFSC. The current SaKe survey appears to meet the monitoring requirements of trends in biomass for assessment of the two species, as well as collecting additional information on several other CPS. There are also several benefits to a joint survey. The use of a single vessel to collect the required information for the two principal species (sardine and hake) biennially will likely reduce at sea costs and free

up vessel time for addressing other important aspects of research or ecosystem initiatives. The addition of a second (new) research vessel would reduce coverage time, allow time to undertake scientific activities related to the stock assessment and develop methods for surveying the ecosystem (e.g. oversampling in particular areas, scientific experiments to evaluate biases, reducing variance, use of new acoustic devices, etc.). Another major benefit of the joint survey to both the SWFSC and the NWFC is the combining of resources and expertise from the two Centers. Both have specific and different areas of expertise and experience that shared will enhance their capability to address the issues associated with stock assessment. The broad scope of their knowledge will better prepare them to move away from single species evaluations into the ecosystem approach to management.

Increasing demands related to move toward an ecosystem-based management approach implies that the continuation of two independent large-scale surveys focused on single species (sardine and hake) cannot be defended in the long run. To do so means that a few modifications will have to be made to accommodate the joint survey, but a baseline acoustic-trawl survey with equally spaced acoustic transects will continue to support the hake and sardine assessments and also provide reasonable estimates for other CPS. The survey design will also need to be modified to support an ecosystem approach to cover the complexities of other CPS. The join sardine-hake survey (SaKe) will allow concurrent sampling of multiple CPS while continuing to support stock assessment for hake and sardine. The two NOAA ships are very similar (new *Lasker* is a sister ship of *Shimada*), which suggest less concern about ship-effects and introduces the possibility a reduced survey time, thereby insuring a more synoptic coverage of migrating species. An added benefit of the summer is that it is more favorable for an acoustic-trawl surveying with generally calmer weather. Conducting single species or species-group surveys may have attractions but they are inherently inefficient. They also limit the "philosophical" as well as practical design of a survey. The transition from single to multi-species surveys (with supporting environmental data) represents a change in focus from a narrow set of data that may not be informative about ecosystem dynamics to one of broader thinking and strategies designed to track the performance of several components of ecosystems.

Any additional problems associated with the SaKe multi-species survey are few compared to the potential benefits. Although there have been some difficulties and predictable limitations, the surveys have been successful and the biomass estimates of both species used in the stock assessments. The few misgivings of scientific staff as expressed at the meeting are simply growing pains; this survey team has excellent people, outstanding administrative and management support, adequate availability of modern research vessels (with the possible exception of the Canadian component) and strong support from industry. It would be hard to ask for more. It is natural that new surveys will face logistic problems that will have to be refined and evolve with experience. A good example is the difficulty encountered in timing of fishing sets utilizing the 2-boat (acoustics and trawling separate) strategy in 2012 – this was dropped in 2013. Concern that sardine is distributed in more shallow waters during summer (which could

result in boat avoidance), like many of the other concerns, appear not to be problematic. Comparing 3 years spring and summer surveys data showed no statistical difference in sardine biomass estimates, and the summer estimates likely unbiased. The moderate to poor precision in sardine biomass estimates, however, can also explain why there are no differences. The continued development and use of new technology (e.g., stationary acoustic platforms, optic sampling methods, and multi-beam sonars) is important to evaluate such concerns for multispecies CPS surveys.

All panel members were in full agreement with the conclusion that the Joint survey is, and will continue to be, highly beneficial for the Centers and for the scientists. In the scientists' case the reasons will not be related to cost but to scientific exchanges of ideas. The two teams have developed excellence in slightly different domains and sharing their respective experience would be of great interest for both. Overall, this survey has made a great start and is fully consistent with both U.S. and international survey strategies to move away from single species surveys to multi-species and towards a more ecosystem-based approach to surveying fish stocks.

4.5 TOR 5. Evaluate the potential of the SaKe survey design and analysis, or an alternative, to evaluate the status and trends of hake, as managed by the International Hake Treaty, the southern stock of sardine, and other stocks in the Pacific Fisheries Management Council's Coastal Pelagic Fisheries Management Plan (CPS-FMP) including: northern anchovy (northern and central stocks), Pacific mackerel, jack mackerel, market squid, and krill.

Overall there was general agreement among the Panel members that continuation of the joint bi-annual SaKe survey with US and Canada conducted in 2012 and 2013 will provide sufficient information to evaluate the status and trends in biomass and abundance of the sardine and hake stocks in US and Canadian waters. For hake, there are no real drawbacks for a combined survey. Biological sampling for sardine is conducted during the day when acoustic data are being collected, but can be accommodated within daylight time frame, spatial distribution of hake allows for a lower sampling effort than for sardine, and the geographical coverage of the survey encompasses the entire hake range. Adaptation for hydrological sampling that differs between the two types of surveys will be required, but this is not a major issue if sufficient time is made available.

Changes to fit the SaKe to CPS survey requirements are more numerous than those for the hake. While the SaKe may accommodate sardines, the current acoustic sampling design may not be fully adaptable to anchovy and jack mackerel. Abundance estimates for anchovy may require a denser sampling intensity (smaller inter-transect distances) given their limited areas of concentration. For jack mackerel it is unlikely that the survey could cover the full distribution,

therefore no easy solution exists for securing accurate biomass estimates except for the use of data from fishing vessels exploring and exploiting this species, and research to define potential habitat and area of occupancy. Sardines are sampled during night by surface-water trawl, which overlaps with the time devoted to oceanographic data collection and collaborative research. Recruiting a fishing vessel may help to offset some of these logistics. Although this has no effect on hake surveys, it imposes a time duration of at least 80-90 days for complete coverage of the US-Canada areas. Finally the turn-over of sardine is faster than for hake, and an annual survey would be preferable to a biennial survey. Of course, if the sardine population collapses and remains at low abundance over many years as has happened historically, a biennial survey for monitoring the situation would be sufficient.

Sardines distribute closer to the surface than hake, swimming in dense schools that have the ability to avoid vessels. To compensate for these problems the SWFSC team has developed important research tools using multibeam sonars, which are able to observe outside of the vessel path and in the surface layers. So far the research results have shown that the biases induced by school behavior were not significant, nevertheless it is clear that multibeam sonar is a way to better monitor the pelagic ecosystem. This kind of instruments is less necessary for hake.

For the southern stock of sardine, and for 1-year old hake, there are strong indications of bias since an unknown portion of the stock may be in Mexican waters. Extending the survey into Mexico would be very beneficial. The potential for the joint survey to provide reliable abundance and biomass estimates for northern anchovy (northern and central stocks), Pacific mackerel, jack mackerel, market squid, and krill is difficult to evaluate given the information provided and presented to the Panel. However, the limited information presented on the life histories and distribution of Northern anchovies, Pacific mackerel, Jack mackerel, market squid and krill suggest that the SaKe can be expanded from one or two CPS species to a pelagic multi-species survey.

There was a slight difference in opinion from one reviewer on the SaKe design. The current SaKe survey design and analysis may be able to provide continuing advice to inform stock assessments and hence management agencies in the short term. Nevertheless, in the longer term this design will fail to address the full suite of assessment and management challenges, in particular those associated with productivity changes in the component species that will likely result from ocean climate dynamics. Having said this, there is no need to throw the baby out with the bathwater. As stated previously, the underpinnings of this survey are very sound, and it is within striking distance of being an exemplary multi-species (even ecosystem in time) acoustic-trawl survey comparable or better than almost any similar survey done worldwide. All the makings are there.

The optimal survey design of the SaKe will depend on the primary objective(s). Since the agency has a mandate to move toward an ecosystem approach, the combination of a baseline systematic survey design with even spacing of transects and some additional sampling effort focused on

selected CPS could be a good option. If the baseline spacing of transects is sufficient to support the hake assessment (relative standard error of 10% in biomass estimates should suffice) then additional sampling effort could be directed to other important species such as mackerel, or anchovy when needed.

The question of conducting an annual or biennial survey sampling is important. The experience of the last few years shows that "surprises" may happen and unexpected results can occur. It was only because of the annual joint survey that some of the uncertainty was reduced regarding the status of the hake stock. Moreover, an ecosystem approach to fisheries (EAF) frequently requires the following of global ecosystem, especially in areas such as the EBOE (Eastern Boundary Oceanic ecosystems, i.e. California, Canarias, Humboldt, Benguela systems), where strong changes from one year to the other occur (El Niño events) that are likely to change the characteristics of the ecosystems and the dimensions of the populations. Therefore, in an EAF framework annual surveys would be preferred to surveys every other year. One possibility for fulfilling the International Hake Treaty and the EAF needs would be to organize an international survey year 1, 3, 5… and another NOAA survey year 2, 4, 6… even if this survey does not cover the Canadian waters.

International co-operation between Canada and USA for surveying the sardine populations are not clearly defined as in the case of hake. Each other year the survey of Canadian waters was performed by the US vessels. Also, until 2013 no co-operation between Mexico and USA existed for surveying the sardine populations. This will change as Mexico operates now a large R/V equipped with modern acoustic devices and a well-trained team (CICIMAR, La Paz, Baja California) who will co-operate in this field. The opportunity should be taken to develop a full international survey of the California Current coastline in an EAF approach including Canada, USA and Mexico; such joint survey would provide unique information and data bases for the understanding of EBOEs.

4.6. TOR 6. Evaluate the tradeoffs, in terms of costs, benefits, and consequences of:

The evaluations for each of the following scenarios are described in part above and in the report of the individual reviewers. The potential combination or multiples for the proposed scenarios is far too encompassing to be address in a report such as this. Most of the relevant comments regarding this TOR have already been discussed. That being said, each of the three sub-TORs will be addressed below with an overview of the responses by the individual reviewers. A general summary of the above criteria from the Panel's observations is described in a table prepared by Francois Gerlotto that follows the text for this section.

a) Separate hake and sardine surveys every year or every other year, with or without ecosystem sampling

This is essentially status quo for the period prior to the introduction of the SaKe survey and as stated throughout this report and in the Panel's conclusions in not recommended. Going down this road would result in the loss of a grand opportunity to work towards a true ecosystem-based survey that provides advice for stock assessment of the main commercial species plus the ecosystem information needed to fully understand productivity changes in those and other species that are currently occurring or are coming at us soon. Furthermore, it would lock independent surveys into a 2-year cycle that could very well miss important events, and would lack robustness to major "year effects" in surveys (hake with market squid, hake 2011 or the swift decline in Pacific sardine). The only advantage may be that this would make the ecosystem sampling more straightforward, although it would remain focused on single species every 2 years. There would unlikely be any cost savings.

b) Joint sardine and hake surveys every year or every other year, with or without ecosystem sampling

Joint sardine and hake surveys (with other species sampled as well) with ecosystem sampling, every year, is the ideal survey plan. This strategy would have optimal benefits both to stock assessment and supporting ecological research, and would likely not cost more than competing plans. It has the benefit of allowing concurrent sampling of multiple CPS and hake, as well as the collection of environmental and oceanographic data provided logistical and staffing limitations be worked out. Overall the joint SaKe is a far better platform than separate hake and sardine surveys for supporting ecosystem based management and moving forward with the demands of the future. Given the current situation and need for additional research it is the Panel's view that the SaKe be conducted bi-annually over a 5 year period. In particular it is important to solve logistical and staffing concerns so that environmental and oceanographic data collections can be part of the routine survey. Such data will be an essential part of ecosystem sampling. The possible move to annual surveys can be evaluated when the agencies has more experience with conducting joint surveys. The joint SaKe will allow the collaboration and cooperation of the NWFSC and SWFSC scientists, which will benefit both groups in terms of the development of effective survey sampling methods in support of stock assessments and ecosystem modeling. Combining the knowledge of advanced technology with survey sampling expertise will lead to improvements and efficiencies in the survey.

c) Alternative joint survey options for hake or sardine every year or every other year, with or without ecosystem sampling, particularly regarding their potentials to: i) estimate population parameters for hake, sardine, and other forage species; ii) put that information into the context of their biotic and abiotic environments; and iii) characterize their roles in the California Current Ecosystem. Provide specific recommendations for short- and long-term improvements to anticipated compromises associated with sardine-hake-ecosystem surveys.

The Panel was in complete agreement that the best way forward would be to conduct a joint survey that incorporates estimates of population parameters for hake, sardine and other forage species (CPS); and integrates the information into the context of their biotic and abiotic environments with the ultimate long term goal of evolving into an annual ecosystem survey. That being said in the short-term there are issues and concerns that must be addressed before major modifications to the joint sardine-hake survey are implemented. Several alternatives were discussed and compared to evaluate the costs, benefits and consequences of moving toward the ultimate goal (Table 1). Of these options only a one met all the evaluation criteria, however, if time is found to undertake research and sampling additional options become available. The final solution will depend upon many factors and will inevitably be a compromise on criteria focused on the Centers' priorities and their resources to implement the necessary changes.

The fundamental problem with the SaKe surveys as they are now being conducted is that they do not allow for the ecosystem research, and they limit the time available for research in support of the surveys available during the cruises. Surveys lacking supporting research are not the best way to move forward. As previously mentioned an additional priority should be to free up sufficient time for research, both ecological and in support of the survey estimates for stock assessment (e.g., target strength, migration). Even freeing up sufficient time to do all the research required in a full SaKe type survey is unlikely (unless transect intensity could be reduced substantially). The scientists involved are well aware of these needs, and must be given the time to do the work. As ship-time is not likely to increase significantly, the optimal strategy is to make the most of what is available now and in the near future – which in reality is quite a bit. The panel is aware of few surveys that are as well positioned in almost every way to make these advances.

Ecosystem sampling is fundamental to putting population parameters for hake, sardine, and other forage species into the context of their biotic and abiotic environments and to characterize their roles in the California Current Ecosystem. Survey options that cannot meet these requirements in the long-term should not be considered alternatives. In fact, among historic and current survey designs, only the independent surveys fulfill this requirement. The present SaKe design does not actually enable sufficient time to conduct the needed ecosystem sampling, despite its other advantages. A solution proposed by one reviewer takes full advantage not only of the past surveys and research, but will evolve from a multi-species to a more complete coastal marine ecosystem survey, done every year. The solution involves utilizing the next five years to address problems with the current design and outputs (for assessment and research) and possibly free up time for research. A time table is presented in the reviewers report.

An alternative design would be to conduct the joint survey using the two U.S. research vessels, thereby reducing the survey duration by approximately half. Canadian involvement is still required. There are however several possible ways to deploy the vessel. One of the concerns and priorities expressed throughout this report is the uncertainty associated synoptic assumption of

the survey. Separating the vessels could have several variations. Starting one vessel in the north and one in the center, both moving south, is thought to be problematic, as there would be a high probability of double counting. Starting one vessel at the north end and the other at the south is less risk prone, but still could double count. If one vessel started at the southern extremity and the other in the middle, both moving north, it would reduce the risk of double counting, but provide no common area for survey comparisons. Starting both vessels in the middle, surveying a common area first, then one heading north, the other south, would provide for comparisons and reduce the risk of double counting the most. There would be a small chance of under counting, but this is preferable to double counting. No empirical data were examined in concluding the above mentioned effects of varying vessel starting point and direction and some differences in logic may actually prevail.

Table 1. Summary of cost, advantage and disadvantages of the different possible survey strategies. The evaluation criteria include:

A+ or A-: estimate population parameters for hake, sardine, and other forage species;
B+ or B-: put that information into the context of their biotic and abiotic environments;
C+ or C-: characterize their roles in the California Current Ecosystem; and
D+ or D-: allow research to be performed in key questions.

Survey strategy	Cost	Advantage	Disadvantages
Separate hake and sardine survey each year **A+ B- C- D-**	2 surveys each year. 2 R/V each year 2 sets of equipment	Simple (continuation of the existing) with accurate results for the two groups of species	No EAF, duplicate of effort, no shared equipment and experiences
Separate hake and sardine survey each other year **A- B- C- D+**	1 survey each year. 1 R/V each year 1 set of equipment	Same as above Possibility of research for the other team during the other year (if 2 R/V available)	no data each other year for the two species. No EAF
Alternative joint survey for hake or sardine **A+ B+ C- D+**	1 survey each year 1 R/V each year 1 set of equipment	Rather simple; accurate information for one group on one year, and indicators on the other year	No real integration of the teams; no time for research (time and vessel availability)
Joint sardine and hake survey each year **A+ B+ C+ D-**	1 survey each year 1 R/V each year 1 set of equipment	EAF possible. Information shared by the teams. Accurate information on the two groups each year	Complex: requires making compatible different priorities. Difficulty for research (time and vessel availability)
Joint sardine and hake each other year **A-B+C+D+**	1 survey each other years 1 R/V each other year	EAF possible; low cost; accurate information on the two groups each other year	No information each other year; same complexity as above

Joint sardine and hake survey with 2 vessels one year and assessment survey + research survey the other year **A+B+C+D+**	2 surveys each year 2 sets of equipment 2 R/V each year	EAF; research on different points of the method and the ecosystem; accurate information each year; information shared by the teams; resolves the problems of compatibility	Complex; high cost; requires 2 R/V each year.

TOR 7. Evaluate proposals and provide recommendations to increase the efficacies and efficiencies (e.g., through advanced technologies) of sardine, hake, sardine-hake and sardine-hake-ecosystem surveys, based on SaKe 2012 and 2013 survey experiences.

The proposal to transform the separate summer hake and sardine surveys into a single summer SaKe survey presents a great number of advantages compared to continuing performing separate surveys, as noted throughout this report. The most important advantage is the contribution toward an ecosystem approach to fisheries. Results of assessments of the two groups of species show clearly that an important part of the variability in the dynamics of the stocks, and especially the recruitment, is linked to variation of the ecosystem: in both cases the relationships between the recruitment and the ENSO was noted, as well as the relationships of hake distribution with currents, and of sardine with temperature. The effect of warm or cold decadal periods is also obvious, and explains why the sardine team is expecting a collapse of the stock in the coming years and an increase in the anchovy population. Therefore no real understanding (and consequently predictive capability of the models) can be expected without information on the pelagic ecosystem.

The enormous advantage of SaKe surveys over the independent surveys implies that some aspects of the methodology of the two teams must be adapted. Two separate surveys have been fitted to the particular characteristics of the populations surveyed (e.g. acoustic and biological sampling strategies), which do not coincide with those of the other population. Some compromises must be found, but the general characteristics of the two stocks have been proven to be generally compatible, as observed in 2012 and 2013. In a large part the "methodological conflicts" are more due to different habits of the teams than to real incompatibilities.

Another point must be stressed, and it has been said several times by the two teams (but mostly by the hake team), is that incomplete information (e.g. not including the Canadian part of the stock) could not be used by the assessment models. In the past the assessment group has rejected years with incomplete information without supporting analysis to do so. The Panel was uncertain

and even doubtful about this practice. Having information on half of the distribution area of a species provides a series of indicators regardless of whether the stock dynamics is in conformity with the prevision of the models or not. The Panel is not convinced that the results of the rejected acoustic surveys have been fully exploited and that annual surveys, even though the Canadian waters are not explored, would not provide valuable information to the stock assessment models. Another point is that it is quite likely, at least for hake, that an inter-transect distance of 20 NM would not give significantly different results from a survey with 10 NM inter-transect distance. The sampling effort required by the hake team is high and could be reduced in order to increase the biological sampling or the ecosystem observations.

There are great opportunities to address some of the issues discussed earlier with newer and developing technologies. For example, species identification issues may be addressed with camera systems and operational capabilities are nearly a reality. Such instrumentation may also help to investigate the species catchability in the fishing gear. More use of the multi-frequency systems on these research vessels might also lead to better classification of echogram images (at a minimum to separate plankton from fish). It was unclear if the synchronization issues of running ADCPs and fisheries echo-sounders simultaneously had been addressed, but the technology exists to do this if it has not already been done. Vessel avoidance by CPS also needs to be investigated. Given that the distribution of these species at the time of the survey is quite shallow (to 15 m apparently), boat avoidance is a potential issue. Research using forward-looking sonar might nullify concerns expressed in the previous CIE review. There is also the potential for multi-beam systems to assist with echogram classification and other acoustic issues. It should be stressed, however, that the single-split beam technologies now used are likely to remain the standard sampling tool for some time to come, and multi-beam systems which are only beginning to show potential for fisheries research should be used in a research mode only at this stage. The very strong expertise in acoustic and optical methods at SWFSC, in combination with the trawl sampling and gear expertise at NWFS and AFSC, can allow the development of more efficient sampling methods for ecosystem monitoring.

Efficiencies in the survey work might include attempts to do more of the analytical work at sea during the cruise. In parts of the world the goal of some surveys is now to have a preliminary estimate ready by the time the boat docks. This may be unrealistic in some cases but as a goal for a new survey design (even if partially achieved) it could save much lab time.

5.0 Recommendations

1. Although there were many potential options the Panel was in general agreement in recommending that, under the current situation, a bi-annual summer SaKe survey and the more flexible use of ship-time for research in intermittent years over a 5 year period

would address most the concerns expressed throughout this report. This will allow NOAA to develop effective survey methods in support of multiple objectives, and to improve the logistics and cost-efficiency of a joint survey: - the intent being to move the SaKe survey towards a more complete and annual fisheries ecosystem survey. A biennial SaKe in the short term will also allow more focus on research to develop a long-term approach for an ecosystem survey that will also provide sufficiently and reliable data for the single-stock sardine and hake assessments. Shared development of survey methods and the shared expertise within NOAA (i.e. SWFSC, NWFSC, and AFSC) will be particularly beneficial for the development of efficient future sampling tools (optical, acoustic, nets). Combining the knowledge of advanced technology at SWFSC with the survey sampling expertise in the NWFSC will lead to improvements and efficiencies in the survey.

2. Sufficient vessel time should be allocated during the alternate years to allow for a broad spectrum of research in support of the surveys and the assessments to be undertaken. It is imperative that the surveys also include time for ecosystem research on factors influencing productivity of commercial stocks and environmental forcing, and collaborative research with other scientists.

3. That a SaKe-type multi-species acoustic-trawl survey to be conducted by joint teams from the SWFSC and NWFSC replace the historic single species (or CPS group) surveys conducted separately by the SWFSC and the NWFS, with the intent of moving the SaKe survey towards a more complete and annual fisheries ecosystem survey. Negotiations should proceed with Canada (and Mexico) to collaborate with this strategy. Furthermore, to facilitate the transition, a science-management working group should be formed that includes key survey scientists from both the SWFSC and NWFSC. The working group should have an administrative chair and meet at least twice a year to plan the survey and research and work out any logistic difficulties.

4. Regular communications between the two institutes is also encouraged. It is important to note that between the SWFSC and the NWFSC there is the administrative will, the historical data, vessels available, access to advanced technologies and the expertise to address the issues and concerns associated with a joint sardine-hake survey. At the end of the 5-year test period a follow-up review should be convened to evaluate the progress made addressing the issues from this review, identify outstanding issues, evaluate of the potential to move to an annual multi-species survey and define the objectives of the annual ecosystem survey.

5. It is recommended that methods development, testing, and implementation be conducted through experiments embedded in the SaKe surveys, in conjunction with research

experiments in "off years". New sampling methods such as the use of open trawls and high sensitivity color stereo cameras (such as Deep Vision) may be used for the improved vertical sampling of fish and plankton schools recorded acoustically. Stereo cameras mounted in an open trawl cab be used to provide accurate length measurement and for species id. Also, the use of multi-beam sonars in addition to the standard acoustic methods may be employed for bias correction, for example by providing data on schools near the surface. Advanced technology can help improve the estimates of target strength for krill and multiple CPS, and thus improve the accuracy of biomass estimates.

6. During the 5-year "test period" for SaKe it is recommended that NOAA develop an effective system for handling the data flow for an ecosystem survey that covers plankton, multiple CPS and hake, and oceanographic and environmental data. In particular, the development of joint or linked database would help facilitate modeling and also improve QA/QC, as compared to the current situation where two groups dealing with sardine and hake surveys "go through the data" independently. Clearly, the use of acoustics for surveying multiple CPS and krill, as well as hake, suggest that a system be put in place for joint scrutinizing of the echograms along the cruise-track.

7. A weak link in most stock assessments is the absence of an index of juvenile abundance. Information presented at the meeting indicated that data on the abundance and juvenile fish of several CPS was available. It is recommended that the team explore the options to develop from existing data, or explore minor alterations to the SaKe survey design, that could result in the development of a juvenile index of abundance for one or more of the observed species.

8. During the panel Review a number of research recommendations were made to address specific uncertainties related to the SaKe survey that could be investigated in the short from existing data. These include:

    a. Survey transect intensity (spacing) and impacts on survey biomass and precision (plots of spacing vs. biomass would result and help determine optimal effort allocation).
    b. Relationship between U.S. survey biomass and total U.S.-Canada biomass to assess if the U.S. stratum could be used to index the state of the full stock.
    c. The validity of using a single variogram to estimate biomass developed from east-west transects over the entire range is uncertain. This approach should be investigated and if necessary the autocorrelations at intervals <10nm for the north south should be investigated.
    d. Hake boundaries are currently defined by kriging of the acoustic data, however, in most transects it is possible to determine the western boundary of their

distribution. In theory this would result in a positive bias in the biomass estimates – the significance of this approach should be investigated.

e. Both acoustic trawl surveys and the SaKe surveys were conducted using multiple frequency echo-sounders, yet only the standard 38kHz data are used in the estimation biomass. Studies should be undertaken to evaluate the use of the other frequencies for target categorization and species identification.

9. Recommendations for research to be implemented to enhance existing interpretations of the acoustic and trawl data include:

a. A key question related to assumptions of the acoustic trawl survey and the synoptic view is the rates of northward movement. Studies should be undertaken to determine the rates of movement of hake and sardine on their northward migrations.

b. Target strengths of individual species, and their dynamics, are critical to the conversion of acoustic backscatter to fish biomass. Experiments should be setup both in the lab, and *in situ*, to investigate the TS of the target species and the many other species observed during the survey.

c. Species identification and the composition of the observed acoustic targets is an important component in apportioning the backscatter. Studies should be undertaken to improve this aspect of the surveys. For example, cameras can be used to better assess trawl catchability of individual species and multi-frequency analyses of echograms help categorize aggregations and can contribute to species identification.

d. Vessel avoidance can be a major issue for CPS when they are near the surface of shallow water.

e. The team is also encouraged to peruse research the will improve or automate aspects of the SaKe survey through the adaption of existing or new advanced technologies.

6.0 Conclusions

The following represents a summary of the key conclusions reached by the Panel over the course of the CIE Panel Review of the Joint Pacific Sardine and Hake (SaKe) acoustic-trawl surveys meeting. It is interesting to note that although a consensus was not required, there was no real divergence in the views and recommendations amongst the Panel members. For the most part the members agreed on the uncertainties, the direction forward and the recommendations identified

in this report. These conclusions, agreed upon before leaving the Review meeting, formed the foundation of this final and the individual reports.

1) The Panel has come to the general consensus that the direct and indirect benefits of a Joint Pacific Sardine and Pacific Hake survey (SaKe) far outweigh the challenges or disadvantages of independent surveys. Collaboration and cooperation of the NWFSC and SWFSC scientists will add benefits to both groups in addressing survey, sampling and stock assessment issues. Combining the knowledge of advanced technology with the survey sampling expertise will lead to improvements and efficiencies in the survey. From an acoustic perspective the survey design and transect spacing provide adequate, possibly more than adequate, coverage to estimate the biomass of both species, although some sampling and research demands need to be addressed. That being said, even with the challenges and compromises identified to the Panel, the joint (SaKe) survey has been used to inform the 2013 and 2014 assessment without major issues.

2) Whether or not the survey should be undertaken annually or biennially is still open to debate. Ideally a joint survey every year would address some of the uncertainty associated with the assessment and provide information on coming recruitment. This was demonstrated by the reduced confidence intervals of terminal year biomass estimates in years with the survey index. That being said there are several logistics, resource and personnel challenges that must be met before an annual survey can be recommended. The panel was informed that the move from biennial to annual surveys would put additional strain on staff and resources, as well as limit the ability to conduct research in support of the surveys, including making essential oceanographic measures. In addition, the assessment team will only accept survey years that cover the full range of hake distribution in US and Canadian waters. The current hake assessment uses a truncated time series (1995 to present) when complete coverage is available. The Panel is not in full agreement with this practice given the large proportion of the biomass observed in US waters. Another consideration in the annual vs biennial dilemma is that Canada has only committed to a biennial survey.

3) Extension of the joint survey to a multi-species CPS survey is difficult to evaluate given the information provided and presented to the Panel. The limited information presented on the life histories and distribution of CPS such as Northern anchovies, Pacific mackerel, Jack mackerel, market squid and krill, suggests there is potential to transition the survey from two species to a pelagic multi-species survey. The data could be used not only to inform stock assessments but also broad scale ecosystems models that investigate impacts of environmental and climate change. This would be consistent with multi-national initiatives to complement single species assessments and move towards

ecosystem-based management. The programs are encouraged to consider how this might be achieved and collaborate with other researchers to this end in future endeavours.

Appendix 1: List of Background Materials

The Center for Independent Experts Panel Review of the Joint Pacific Sardine and Pacific hake (SaKe) acoustic-trawl survey

NOAA Western Regional Center
7600 SandPoint Way NE, Building 1
Workforce Management Conference Room
Seattle, Washington 98115
January 21-24, 2014

Agenda Item A. Introduction and Background: Species Biology and Surveys

1. a. K. T. Hill, P. R. Crone, N. C. H. Lo, D. A. Demer, J. P. Zwolinski, and B. J. Macewicz. 2012. Assessment of the Pacific sardine resource in 2012 for U.S. Management in 2013. NOAA Technical Memorandum NMFS. NOAA-TM-NMFS-SWFSC-501

1. b. K. T. Hill. 2013. Pacific sardine biomass projection in 2013 for U.S. management during the first half of 2014 (Executive Summary).

2. J.P. Zwolinski and D.A. Demer, "A cold oceanographic regime with high exploitation rates in the Northeast Pacific forecasts a collapse of the sardine stock," Proceedings of the National Academy of Sciences 109(11): 4175-4180 (2012).

3. J.P. Zwolinski and D.A. Demer, "Environmental and parental control of Pacific sardine (*Sardinops sagax*) recruitment," ICES Journal of Marine Science, doi:10.1093/icesjms/fst173 (2013).

4. J.P. Zwolinski, R.L. Emmett, and D.A. Demer, "Predicting habitat to optimize sampling of Pacific sardine (*Sardinops sagax*)," ICES Journal of Marine Science, 68: 867–879. (2011).

5. D.A. Demer and J.P. Zwolinski, "Corroboration and refinement of a method to differentiate landings from two stocks of Pacific sardine (*Sardinops sagax*) in the California Current," ICES Journal of Marine Science, doi.10.1093/icesjms/fst135 (2013).

6. Hicks, A.C., Taylor, N., Grandin, C., Taylor, I.G., and Cox, S. 2013. Status of the Pacific hake (whiting) stock in U.S. and Canadian waters in 2013. (2013 stock assessment for Pacific hake).

7. Ressler, P.H., Holmes, J.A., Fleischer, G.W., Thomas, R.E. and K.C. Cooke. 2007. Pacific hake, Meluccius productus, Autecology: a timely review. Mar. Fish. Review, 69:1-24

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10. Dorn, M. W. 1995. The effects of age composition and oceanographic conditions on the annual migration of Pacific whiting, Merluccius productus. ColCOFl Rep., Vol. 36: 97-105.

11. Agostini, V. N., Francis, R. C., Hollowed, A., Pierce, S.D., Wilson, C.D., and A.N. Hendrix. 2006. The relationship between Pacific hake (Merluccius productus) distribution and poleward subsurface flow in the California Current system. Can. J. Fish. Aquat. Sci. 63: 2648–2659.

12. Cook, K.D., Holmes, J., Fleischer, G.W., Thomas, R.E., and P.A, Ressler. 2006. Distributional changes observed in the geographic range of Pacific Hake (Merluccius productus) in association with ocean conditions off the Pacific coast of Canada and the United States. In: Proceedings from the 2006 ICES Annual Science Conference, Theme Session on: Large-scale changes in the migration of small pelagic fish and the factors modulating such changes. Available from: PISCES, Institute of Ocean Sciences, P.O. Box 6000, Sidney, British Columbia. Canada V8L 4B2.

13. Phillips, J.A., Ralston, S., Brodeur, R.D., Auth, T.D., Emmett, R.L., Johnson, C., and V.G. Wespestad. 2007. Recent pre-recruit Pacific hake (Merluccius productus) occurrences in the

Northern California Current suggest a northward expansion of their spawning area. CalCOFI Rep., Vol. 48: 215-229.

Agenda Item B: Historical Individual Surveys

1. Protocols for the historic Pacific sardine survey are detailed in references B2. and B3.
2. D.A. Demer, J.P. Zwolinski, K.A. Byers, G.R. Cutter, J.S. Renfree, T.S. Sessions, B.J. Macewicz, "Prediction and confirmation of seasonal migration of Pacific sardine (*Sardinops sagax*) in the California Current Ecosystem," Fisheries Bulletin, 110:52-70 (2012).
3. J.P. Zwolinski, D.A. Demer, K.A. Byers, G.R. Cutter, J.S. Renfree, T.S. Sessions, and B.J. Macewicz, "Distributions and abundances of Pacific sardine (*Sardinops sagax*) and other pelagic fishes in the California Current Ecosystem during spring 2006, 2008, and 2010, estimated from acoustic—trawl surveys," Fishery Bulletin 110: 110-122 (2012).
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7. 2012. The 2011 Integrated Acoustic and Trawl Survey of Pacific Hake (Merluccius productus) in U.S. and Canadian Waters off the Pacific Coast. CRUISE REPORT, CRUISE NO: SH2011-03. NOAA Fisheries, Northwest Fisheries Science Center. 19 p.
8. Swartzman, G. 1997. Analysis of the summer distribution of fish schools in the Pacific Eastern Boundary Current. ICES Journal of Marine Science, 54: 105–116.

Agenda Item C. Joint SaKe Survey (Strengths and Challenges of Current Solution):

1. Joint SaKe Survey Protocols / Cruise Instructions
2. NMFS, NWFSC. 2013. The 2012 Joint U.S.-Canada Integrated Acoustic and Trawl Survey of Pacific Hake (Merluccius productus) and Pacific Sardine (Sardinops sagax). CRUISE REPORT, CRUISE NO: SH2012-04 NOAA Fisheries, Northwest Fisheries Science Center. 23 p.

Agenda Item D. Evaluation of Trade Offs (Strengths and Challenges of Proposed Future Solutions)

1. PowerPoint presentations to be provided during review.

E. Additional References

1. D.A. Demer and J.P. Zwolinski, "Reply to MacCall et al.: Acoustic trawl survey results provide unique insight to sardine stock decline," Proceedings of the National Academy of Sciences, doi:10.1073/pnas.1203758109, 109(19): E1132-E1133 (2012).
2. Hollowed, A.B. and K.M. Bailey. 2009. Climate and Fisheries: The Past, The Future, and The Need for Coalescence. In: R.J. Beamish and B.J. Rothschild (eds.), The Future of Fisheries Science in North America, 597. Fish & Fisheries Series, Springer Science + Business Media B.V.
3. Hollowed, A.B. , Hare S.R. and W.S. Wooster. 2001. Pacific Basin climate variability and patterns of Northeast Pacific marine fish production. Progress in Oceanography 49: 257–282.

4. D.A. Demer, G.R. Cutter, J.S. Renfree, and J.L. Butler. “A statistical-spectral method for echo classification”. ICES Journal of Marine Science, 66: 1081–1090 (2009).
5. Bakun, A. 1990. Global climate change and intensification of coastal ocean upwelling. Science. Vol. 247:198-201 (Electronic copy not currently included).

Additional References:

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Appendix 2: CIE Statement of Work

External Independent Peer Review by the Center for Independent Experts

Review of Pacific sardine and Pacific hake joint acoustic-trawl survey

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 (COR), 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: The CIE reviewers will serve on a methodology review panel to perform an independent peer review of the Pacific sardine and Pacific hake joint acoustic-trawl survey conducted by the NMFS's Southwest Fisheries Science Center (SWFSC) and Northwest Fisheries Science Center (NWFSC). In 2012, a newly integrated acoustic-trawl survey of both Pacific Hake and Pacific sardine was implemented in waters off the US and Canada. This effort was the result of a unique collaboration and partnership between SWFSC and NWFSC fishery scientists, as well as Canada's Department of Fisheries and Oceans (DFO) and the fishing industry. The survey's primary goal was to measure the distributions and abundances of Pacific hake and Pacific sardine. In addition, oceanographic and environmental data were sampled to estimate the physical oceanographic habitats for each target species. Results of this survey were used in the 2013 assessment of the Pacific hake stock in US and Canadian waters. A review of the joint acoustic-trawl survey of Pacific hake and Pacific sardine will be conducted to review the survey methodology and analytical approaches to estimate abundance, distribution and biomass of Pacific hake and Pacific sardine resources.

Requirements for CIE Reviewer:
Four CIE experts, three independent reviewers and one panel Chair, shall participate in a panel peer review in accordance with the SoW and ToRs herein. The three CIE reviewers shall have the combined expertise and working knowledge in acoustic-trawl survey design, operation, sampling and analysis; ecosystem survey design, operation, sampling and analysis; spatial sampling and analysis with experience in geo-statistics; and familiarity with groundfish and/or coastal pelagic species with annual migration. At least one reviewer shall have working knowledge and expertise in the application of acoustic fish surveys in stock assessments. Experience (and/or familiarity) with acoustic sampling for mid-water, bottom and pelagic species

is desirable. In addition to the three CIE reviewers, one CIE expert will serve as Panel Chair. The Panel Chair shall have excellent facilitation and communication skills and expertise in acoustic-trawl surveys and/or one of the areas of expertise outlined above. The primary role of the Panel Chair will be to facilitate an impartial review panel and provide a summary report of the panel proceedings. The Panel Chair may also actively participate in panel discussion and provide feedback during the panel meeting. The CIE reviewer's duties shall not exceed a maximum of 16 days to complete all work tasks of the peer review process. The Panel Chair's duties shall not exceed a maximum of 18 days to complete all work tasks of the facilitation and summary report process. The agenda for the Panel review meeting will be provided to reviewers along with background materials two weeks prior to the panel meeting.

Location/Date of Peer Review: Four CIE experts, one of which will serve as the Panel Chair, shall participate during a panel review meeting in Seattle, Washington to be held January 21-24, 2014.

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

Prior to the Peer Review: Upon completion of the CIE expert selection by the CIE Steering committee, the CIE shall provide the CIE expert information (name, affiliation, and contact details) to the COR, 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 each CIE expert. The NMFS Project Contact is responsible for providing the CIE experts with the background documents, reports, foreign national security clearance, and information concerning other 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 COR prior to the commencement of the peer review.

Foreign National Security Clearance: When CIE experts 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 experts who are non-US citizens. For this reason, the CIE experts 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/compliance_access_control_procedures/noaa-foreign-national-registration-system.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 each CIE expert all 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 on where to send documents. Pre-review documents will be provided up to two weeks before the peer review.

Any delays in submission of pre-review documents for the CIE peer review will result in delays with the CIE peer review process, including a SoW modification to the schedule of milestones and deliverables. Furthermore, the CIE experts are responsible only for the pre-review documents that are delivered to them in accordance to the SoW scheduled deadlines specified herein.

Panel Review Meeting: Each CIE reviewer shall conduct the independent peer review in accordance with the SoW and ToRs. **Modifications to the SoW and ToR cannot be made during the peer review, and any SoW or ToR modification prior to the peer review shall be approved by the COR and CIE Lead Coordinator.** Each CIE expert shall actively participate in a professional and respectful manner as a member of the meeting review panel, and their tasks shall be focused on the ToRs as specified in the contract SoW.

The NMFS Project Contact is responsible for any facility arrangements (e.g., conference room for panel review meetings or teleconference arrangements). 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. The CIE expert serving as Panel Chair shall complete a summary report of the panel proceedings including a summary of the individual reviewers' major findings and recommendations. The summary report shall not be a consensus report.

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**.

1) 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;
2) Participate during the panel review meeting in Seattle, Washington during 21-24 January 2014, and conduct an independent peer review in accordance with the ToRs (Annex 2);
3) No later than February 7, 2014, 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 Dr. David Die., CIE Regional Coordinator, via email to ddie@rsmas.miami.edu. The CIE report shall be written using the format and content requirements specified in Annex 1, and address each ToR in Annex 2.
4) Work with the CIE Chair in providing comments and elaboration on any points raised in the CIE Chair's summary report that might require further clarification.

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

1) 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;
2) Participate as the CIE Chair during the panel review meeting in Seattle, Washington during 21-24 January 2014, and facilitate the panel review maintaining the focus of the peer review in accordance with the ToRs (Annex 2);
3) Produce a Summary Report of the proceedings. The summary report shall not comprise a consensus report and will instead include a synoposis of each term of reference as per the chair's summary of each reviewer's determination. The CIE reviewers should have an opportunity to review and provide comments or elaboration on any points raised in the summary report that they feel might require further clarification. No later than February 21, 2014, the CIE Chair shall submit a Summary Report addressed to the "Center for Independent Experts," and sent to Mr. Manoj Shivlani, CIE Lead Coordinator, via email to shivlanim@bellsouth.net, and Dr. David Die., CIE Regional Coordinator, via email to ddie@rsmas.miami.edu. The Summary Report shall 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.

17 December 2013	CIE sends the experts' contact information to the COR, who then sends this to the NMFS Project Contact
07 January 2014	NMFS Project Contact sends each CIE reviewer and the CIE Chair the pre-review documents
21-24 January, 2014	The CIE reviewers participate and conduct an independent peer review during the panel review meeting. The CIE Chair facilitates the impartial peer review and participates in panel discussion.
07 February 2014	Each CIE reviewer submits a draft CIE independent peer review report to the CIE Lead Coordinator and CIE Regional Coordinator. These reports will be forwarded to the CIE Chair by the CIE Lead Coordinator
14 February 2014	The CIE Chair submits the working Summary Report to the CIE reviewers
17 February 2014	The CIE reviewers provide their comments and elaborate on any points raised in the summary report that require additional explanation to the CIE Chair
21 February 2014	The CIE Chair submits the draft Summary Report to the CIE Lead Coordinator and CIE Regional Coordinator
28 February 2014	CIE submits the CIE independent peer review reports and CIE Chair's Summary Report to the COR
6 March 2014	The COR distributes the final CIE reports to the NMFS Project Contact and regional Center Directors

Modifications to the Statement of Work: Requests to modify this SoW must be made through the Contracting Officer's Technical Representative (COR) who submits the modification for

approval to the Contracting Officer at least 15 working days prior to making any permanent substitutions. The Contracting Officer will notify the CIE within 10 working days after receipt of all required information of the decision on substitutions. The COR can approve changes to the milestone dates, list of pre-review documents, and Terms of Reference (ToR) of the SoW as long as the role and ability of the CIE experts to complete the SoW deliverable in accordance with the ToRs and deliverable schedule are not adversely impacted. The SoW and ToRs cannot be changed once the peer review has begun.

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

Applicable Performance Standards: The contract is successfully completed when the COR provides final approval of the contract deliverables. The acceptance of the contract deliverables shall be based on three performance standards: (1) the CIE reports shall have the format and content in accordance with Annex 1, (2) the CIE reports 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 notification of acceptance by the COR, the CIE Lead Coordinator shall send via e-mail the final CIE reports in *.PDF format to the COR. The COR will distribute the approved CIE reports to the NMFS Project Contact and regional Center Director.

Support Personnel:

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

1. Each CIE independent peer review report shall be prefaced with an Executive Summary providing a concise summary of the findings and recommendations.

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

   a. Reviewers should describe using their own words, the review activities completed during the panel review meeting, including a detailed summary of findings, 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.

   e. Each CIE independent peer review report shall be a stand-alone document for others to understand the proceedings and findings of the meeting, regardless of whether or not they read the summary report. Each CIE independent report shall be an independent peer review of each ToRs, and shall not simply repeat the contents of the summary report.

3. Each report shall include the appendices as follows:

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

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Terms of Reference (ToR) for the Center for Independent Experts Panel Review of the Joint Pacific Sardine and Pacific hake (SaKe) acoustic-trawl survey

The CIE Chair shall facilitate the panel review on the ToR, and each CIE reviewer shall conduct an independent peer review addressing each ToR:

1) Review background materials and documents that detail acoustic-trawl survey design and methods, and data analysis methods and results for:
    a. Pacific sardine surveys;
    b. Pacific hake survey;
    c. Joint sardine and hake (SaKe) surveys.

2) Evaluate the historic, independent sardine and hake survey designs, methods, and analytical approaches including data preparations and statistical (e.g. geostatistical) analyses to estimate target species abundances, distributions, and biomasses, and associated uncertainties.

3) Evaluate the current joint SaKe survey design, methods, and analytical approaches including data preparations and statistical (e.g. geostatistical) analyses to estimate target species abundances, distributions, and biomasses, and associated uncertainties.

4) Evaluate the tradeoffs, in terms of costs, benefits, and consequences, of transitioning from independent surveys to a joint sardine-hake survey, particularly regarding its potential to provide population trend information to each of the assessments.

5) Evaluate the potential of the SaKe survey design and analysis, or an alternative, to evaluate the status and trends of hake, as managed by the International Hake Treaty, the southern stock of sardine, and other stocks in the Pacific Fisheries Management Council's Coastal Pelagic Fisheries Management Plan (CPS-FMP) including: northern anchovy (northern and central stocks), Pacific mackerel, jack mackerel, market squid, and krill.

6) Evaluate the tradeoffs, in terms of costs, benefits, and consequences, of:
    a. separate hake and sardine surveys every year or every other year, with or without ecosystem sampling
    b. joint sardine and hake surveys every year or every other year, with or without ecosystem sampling,
    c. Alternative joint survey options for hake or sardine every year or every other year, with or without ecosystem sampling,

    particularly regarding their potentials to: i) estimate population parameters for hake, sardine, and other forage species; ii) put that information into the context of their biotic and abiotic environments; and iii) characterize their roles in the California Current Ecosystem. Provide specific recommendations for short- and long-term improvements to anticipated compromises associated with sardine-hake-ecosystem surveys.

7) Evaluate proposals and provide recommendations to increase the efficacies and efficiencies (e.g., through advanced technologies) of sardine, hake, sardine-hake and sardine-hake-ecosystem surveys, based on SaKe 2012 and 2013 survey experiences.

Agenda
The Center for Independent Experts Panel Review of the Joint Pacific Sardine and Pacific hake (SaKe) acoustic-trawl survey

NOAA Western Regional Center
7600 SandPoint Way NE, Building 1
Workforce Management Conference Room
Seattle, Washington 98115
January 21-24, 2014

Tuesday, January 21, 2014

8:30 a.m. Welcome, Purpose, and Introductions (Michelle McClure and Russ Vetter)

8:45 a.m. Review Meeting Agenda, Terms of Reference and Assignment of Rapporteur Responsibilities (Panel Chair)

Agenda Item A. Introduction and Background: Species Biology and Surveys

9:00 a.m. i. Biology of Pacific sardine (Russ Vetter)
ii. Biology of Pacific hake (Michelle McClure)
iii. Brief history of the collaborative SWFSC-NWFSC surveys (Michelle McClure)
iv. Focus of this review (Russ Vetter)

10:30 a.m. Coffee Break

Agenda Item B: Historical Individual Surveys

10:45 a.m. History of acoustic-trawl surveys of Pacific sardine (David Demer)

11: 30 a.m. Q & A

12:30 p.m. Lunch

1:30 p.m. History of acoustic-trawl surveys of Pacific hake (Larry Hufnagle)

2:30 p.m Q & A

3:30 p.m. Coffee Break

4:00 p.m. Public Comment

4:15 p.m. Panel Discussion

5:30 p.m. Panel Adjourns for the Day

Wednesday, January 22, 2014

8:30 a.m. Welcome and Schedule Overview

Topic C. Joint SaKe Survey (Strengths and Challenges of Current Solution)

8:45 a.m. Development of Collaborative Sardine and Hake Surveys (SaKe) : Personnel, Equipment, Ships, Transects, and Acoustic, Biological, and Ecological Sampling (David Demer and Larry Hufnagle)

9:45 a.m. Q & A

Wednesday, January 22, 2014 (Continued)

10:30 a.m.	Coffee Break
10:45 a.m.	Strengths and Challenges of Jointly Conducting the Survey -- Sardine (David Demer)
11:30 a.m.	Q & A
12:30 p.m.	Lunch
1:30 p.m.	Strengths and Challenges of Jointly Conducting the Survey -- Hake (Larry Hufnagle)
2:30 p.m.	Q & A
3:30 p.m.	Coffee Break
4:00 p.m.	Public Comment
4:15 p.m.	Panel Discussion / Report Drafting
5:30 p.m.	Panel Adjourns for the Day

Thursday, January 23, 2014

8:30 a.m.	Welcome, Schedule Overview, and Review of Primary Questions

Topic D. Evaluation of Trade Offs (Strengths and Challenges of Proposed Future Solutions)

8:45 a.m.	Proposals for Annual or Biennial, Single- or Multi-Species Surveys with or without Ecological Sampling (Russ Vetter and Michelle McClure)
9:45 a.m.	Q & A
10:30 a.m.	Coffee Break
12:30 p.m.	Lunch
1:30 p.m.	Panel Discussion
3:30 p.m.	Coffee Break
4:00 p.m.	Public Comment
4:15 p.m.	Panel Discussion / Report Drafting
5:30 p.m.	Panel Adjourns for the Day

Friday, January 24, 2014

8:30 a.m.	Welcome and Overview of the Day
8:45 a.m.	Report Drafting
12:30 p.m.	Lunch
1:30 p.m.	Report Out by Reviewers
2:00 p.m.	NWFSC and SWFSC Leadership Wrap Up with Panel (Closed Session)
3:00 p.m.	Panel Adjourns

Appendix 3: List of Participants

Participant List for the
Center for Independent Experts Panel Review of the
Joint Pacific Sardine and Pacific Hake (SaKe)
Acoustic-Trawl Survey

NOAA Western Regional Center
7600 SandPoint Way NE, Building 1
Workforce Management Conference Room
Seattle, Washington 98115
January 21-23, 2014

CIE Review Panel

Gary Melvin, Center for Independent Experts (CIE), Panel Chair
François Gerlotto, Center for Independent Experts (CIE)
George Rose, Center for Independent Experts (CIE)
Jon Helge Vølstad, Center for Independent Experts (CIE)

Participants

Julia Clemons, NMFS, Northwest Fisheries Science Center
Dezhang Chu, NMFS, Northwest Fisheries Science Center
Steve de Blois, NMFS, Northwest Fisheries Science Center
David Demer, NMFS,Southwest Fisheries Science Center
Stephane Gauth, Department of Fisheries and Oceans, Canada
Owen Hamel, NMFS, Northwest Fisheries Science Center
Jim Hastie, NMFS, Northwest Fisheries Science Center
Allan Hicks, NMFS, Northwest Fisheries Science Center
Lawrence Hufnagle, NMFS, Northwest Fisheries Science Center
Jan Jacobs, American Seafoods Company
Jason Link, NOAA Fisheries, Senior Scientist for Ecosystem Management.
Bev Macewicz, NMFS,Southwest Fisheries Science Center
Michelle McClure, NMFS, Northwest Fisheries Science Center
Bill Michaels, NMFS, Office of Science and Technology
Stacey Miller, NMFS, Northwest Fisheries Science Center
Mike Okoniewski, Pacific Seafood
John Pohl, NMFS, Northwest Fisheries Science Center
John Stein, NMFS, Northwest Fisheries Science Center
Mark Strom, NMFS, Northwest Fisheries Science Center
Ian Taylor, NMFS, Northwest Fisheries Science Center
Rebecca Thomas, NMFS, Northwest Fisheries Science Center
Russ Vetter, NMFS,Southwest Fisheries Science Center
Dan Waldeck, Pacific Whiting Conservation Cooperative
Cisco Werner, NMFS,Southwest Fisheries Science Center
Steven Winter, NMFS, Northwest Fisheries Science Center
Juan Zwolinksi, NMFS,Southwest Fisheries Science Center

Appendix 4. Primary questions for consideration by the Review Panel

The Center for Independent Experts Panel Review of the Joint Pacific Sardine and Pacific hake (SaKe) acoustic-trawl survey

Primary Questions for Consideration

1) What sampling and analyses do you recommend to empirically estimate and predict total stock abundances by age classes, and their annual recruitments, growths, and natural mortalities; and understand the effects of their biotic and abiotic environments, to inform:

- Individual Pacific sardine and Pacific hake assessments?
- A multi-species approach to stock assessments?
- An ecosystem approach including needed predator and prey distribution and abundance, and appropriate ecological sampling (e.g., krill distribution, oxygen minimum zones, etc.)?

2) Please discuss the costs and benefits for each species of:

- Conducting surveys annually vs. biennially;
- Changes in individual sampling protocols to accommodate multiple species focus of joint survey.

3) Are there particular improvements for the sampling of either target species/group (especially if they're low-cost) that you would recommend?

- Please articulate the pros/cons of surveying from North to South, vs. South to North.
- Is there a transect density that appears to optimize precision under sea-time limitations? How about without limitations?
- Are rates of and approaches to biological sampling appropriate?
- We have received comments about using multiple ships for this survey in the past. The hake portion of this survey necessarily includes two vessels (U.S. and Canada), and the commissioning of the Lasker provides

the opportunity to use two (sardine) or three (hake) vessels for this survey in the future. Please discuss the constraints and benefits resulting from a multi-vessel vs. single-vessel survey.
    - Given the configuration of the Lasker (one net-reel), are there specific approaches that would maximize our ability to adequately sample all relevant species?
- Is our sampling for the various species adequately spanning the stock distribution? (N-S, offshore-onshore, other?)
- Anything else you think we need to know?

4) A priority for Pacific hake is to maintain a continuous time series with previous data collection efforts if the survey design is changed. Do you have specific recommendations for studies and/or calibration efforts that would allow us to maintain the time series with recommended changes?

5) What types of ecological data and information will enhance single and multiple species surveys and what are the best sampling approaches to collect these data?

6) Discuss the current use of available data in stock assessment and management decisions, and costs and benefits of changes to the current joint and past biennial surveys. How can we improve upon the collection and analysis for these data types? Please include a list of strengths and weaknesses of each survey.