Center for Independent Experts (CIE) Independent Peer Review Report of:

Acoustic-trawl method as it pertains to surveys of coastal pelagic fish species in the California Current Ecosystem.

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1. Executive Summary

The Chair identified six aspects that provided a focus for discussions during the review:

i. design of the acoustic and trawl sampling, representativeness of the data for the four CPS species;
ii. analysis of the survey data for estimating CPS abundances;
iii. evaluation of potential biases in sampling design and analysis;
iv. characterization of uncertainty in estimates of CPS biomass;
v. decision if acoustic-trawl estimates of CPS biomass can be used in stock assessments and management advice for Pacific sardine, jack mackerel, Pacific mackerel, and northern anchovy; and
vi. guidance for future research.

Several presentations were given to the panel prior to the discussion of each one of these aspects, which allowed for a better understanding of the documents provided before the meeting and elucidated a number of points that needed to be discussed. Among these documents, some were of major importance and completed the two synthetic "primary documents" produced by Dr David Demer and his team (the Advanced Survey Technologies Program: ASTP). They also presented, in great detail, some innovative methods, especially using multibeam acoustic instruments and species identifications.

In general, there was consensus between the participants of the Panel, and the final report reflects correctly these discussions and conclusions.

The general conclusion of the review process is that the design of the surveys, the selection of instruments and methods and the general protocol are adequate. They produce an accurate abundance estimate of the major stock of California Pelagic Species (CPS), i.e. the Pacific sardine stock, and to a lesser level of the other stocks (jack mackerel, Pacific Mackerel). The limited and coastal distribution of the northern anchovy requires additional information, as the general survey designed primarily for sardine

cannot give a comprehensive overview of the distribution of this stock. The conclusion is that (1) the acoustic-trawl surveys can be included in the 2011 Pacific sardine stock assessments as 'absolute estimates'; (2) information on mackerel and jack mackerel are useful for stock analysis; (3) a specific survey design should be used for abundance estimates of anchovy.

2. Background

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. A Statement of Work (Annex 2) is established by the NMFS Project Contact and Contracting Officer's Technical Representative, and reviewed by the 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. Further information on the CIE process can be obtained from www.ciereviews.org.

The California Pelagic Species, and principally sardine, mackerel and jack mackerel are distributed along a general area along the California coast but the surveys concern principally the part of the area belonging to US coastal waters. Some information was collected from the Canadian fishery. The Mexican area in which the fish are found was not included in the survey. Surveys are mostly performed during spring (in the southern part of the area: 2006, 2008, 2010) and during some years in summer (central and northern part of the area: 2008). They are done together with eggs and larvae surveys. The review focused on survey design, including the acoustic and trawl sampling, the precision and accuracy of results and their potential use in stock assessment.

3. Description of the Reviewer's Role in the Review Activities

My background is on fisheries biology, with particular expertise in pelagic fish behaviour related to acoustic research and fisheries acoustics survey. My Institute (IRD, "*Institut de Recherches pour le Développement*", France) is specialized in co-operative research with developing countries, and in this framework my research during the last 3 decades concerned pelagic stocks in Africa (Ivory Coast, Senegal), Caribbean (Venezuela, Cuba, French West Indies) and South America (Chile and Peru), where I worked principally on Clupeids (ethmalose, sardine, sardinella), Engraulids (several species of anchovies) and Carangids (Chilean Jack Mackerel). I have also conducted research in acoustic survey design and acoustic methods. I have developed works on acoustic sonar, being pioneer in the adaptation and use of multibeam sonar for behavioural research on fish schools.

During this period, I have chaired several ICES groups (ICES Fisheries Acoustics WG 1997-2000, the ICES Fisheries Technology Committee 2005-2007, the ICES study group on Fish avoidance to research vessels 2007-2010) and international networks. In my Institute, I have been chair of several Research Units (from 1995 to 2004) and some EU projects (among which the AVITIS project, 1997-2000 focused on the design of multibeam sonar).

Due to my area of expertise, my major contribution was on fish avoidance, distribution and identification, and on the impact and measurement of fish behaviour related to acoustic estimates and survey methods. Within this area, I was especially interested in the methods designed by the team on measurement of fish avoidance using multibeam sonar, on the definition of the "potential habitat" for sardine, and on species identification using multifrequency methods.

4. Findings by ToR

4.1. ToR 1- Reporting

Review documents detailing acoustic-trawl survey and data analysis methods and results according to the PFMC's ToR for CPS Stock Assessment Methodology Reviews. Document the meeting discussions. Evaluate if the documented and presented information is sufficiently complete and represents the best scientific information available.

The reviewers received important material for supporting their reviews. The two primary documents from Demer et al., 2011, on "Methods and example application" and Zwolinski et al, 2011, on "Estimates of distributions and abundances in spring 2006, 2008, and 2010" were particularly useful in that they clearly present the whole procedure. The documents provide an extensive description of the survey design and acoustic methods applied. The figures and flow charts allow a good understanding of these methods and the protocols. Within the large amount of scientific papers (more than 20) that were made available, I was particularly interested in three of them that proved particularly useful for understanding the methods elaborated: Zwolinski et al (2010), on potential habitat; Cutter and Demer (2007), on fish behaviour observed through multibeam systems; and Demer et al (2009), on a statistical-spectral method for echo classification.

In general, the documentation distributed to the Panel was complete and of high scientific quality (unfortunately, that was not the case of the internet facilities). Most of the questions that I listed before the meeting were elucidated thanks to these documents and the answers of the team. The documentation demonstrates that the scientific skills of the team are extremely high and that the methodology in general is accurate. The comments and criticisms that were made during the meeting were mostly marginal, aiming to help the team to improve its methodology where it can be done, but my general conclusion

was there are no weak areas and only a few specific points should be substantially improved in the future.

I fully agreed with the following statement from the Chair of the Panel: "*The Panel **commends** the Team for their thorough presentation, detailed background material, and willingness to respond to the Panel requests. Although the review focused on the areas of potential concern with the acoustic-trawl estimates of abundance, the Panel wishes to emphasize that the Team had already identified most of the issues identified by the Panel and had prepared information pertinent to these which helped to Panel in its deliberations. The work related to avoidance of CPS to vessels was particularly helpful, allowing the Panel to draw conclusions related to whether avoidance, or at least its effects on the acoustic-trawl survey results, is likely substantial* ".

4.1.1. ToR 1 Conclusions

The two primary documents represent an excellent synthesis and are quite helpful for the reviewers. Very few points remained unclear and these were clarified during the discussion. As a whole, the documents delivered before the meeting were of a very high standard and all the information needed was available. Overall, the quality of these reports and papers showed the high competence of the team in the field of acoustic surveys.

4.2. ToR 2 –Evaluation

Evaluate and provide recommendations on the survey method used to estimate the abundances and distributions of Pacific sardine and other CPS, and associated sources of uncertainty. Recommend alternative methods or modifications to the proposed methods, or both, during the Panel meeting. Recommendations and requests to FRD for additional or revised analyses during the Panel meeting must be clear, explicit, and in writing. Comment on the degree to which the survey results describe and quantify the distributions and abundances of CPS, in particular Pacific sardine, and the uncertainty in those estimates. Confidence intervals of survey estimates could affect management decisions, and should be considered in the report.

4.2.1. Stratification / Transect design

Sampling and stratification are defined in order to adapt to a particular case (in this case the sardine stock), but also to combine the requirement of different sampling methods (namely acoustics and CUFES (Continuous Underwater Fish Egg Survey). This implied some constraints for both methods, and particularly for acoustic design. The design is mostly based upon systematic sampling using parallel equidistant transects perpendicular to the coastline. This is acknowledged as the best compromise for pelagic stock surveys, and, in general, the biases and error are minimized when using this sampling strategy. Some adaptation in this general method has been made, particularly for inter-transect

distances vary in some sectors and years, but the results (and the maps delivered) show that the sampling effort is sufficient to provide a good representation of the mean density (i.e. abundance) of sardine in the area covered. I agree with the statement that "*CPS habitat is almost certainly spatially coherent, suggesting that correlation is very likely to be present in the CPS distribution, even if it cannot be quantified.*" As far as I know about variance estimates, I agree with John Simmonds' statement: "*Overall the approach is an acceptable approximation*".

Representing a compromise between several and different (sometimes contradictory) needs, the transect design is not optimal for the anchovy stock estimate, as the inter-transect distance is too wide, and the transects do not get close enough to the shore. Therefore, the abundance estimate for this species is in large part a result of extrapolation hypotheses which prevents the results to be considered as absolute biomass measurements. For this particular stock, a dedicated sampling strategy and probably a specific survey have to be designed. Nevertheless, the possible risk of underestimation of the spring abundance must be taken into consideration. Surveys during different seasons and improvement of the potential habitat definition would resolve this problem.

The stratification/transect design is adequately defined for the sardine and in a lesser level to mackerel and jack mackerel (see remarks below) and should be able to provide correct estimates of abundance, especially for sardine. For the other CPS, more work and surveys are required before to declare that absolute abundance estimates for jack mackerel and mackerel are acceptable, and a different transect and stratification strategy, i.e. specific surveys are required for anchovy.

4.2.2. Trawl sampling

The trawl sampling strategy differs considerably from those used elsewhere in the world, mostly because of the egg surveys requirements. In this case, trawls are performed by night on predefined locations, while the most current method consists in deciding a trawl depending on the acoustic information collected: a trawl is then linked to a given concentration of fish. There are two major reasons for the ASTP to design this different sampling strategy: (a) the constraints of the egg surveys that require sampling in the area where eggs are found, and (b) the fish behaviour: by day fish are rather deep and form dense schools, while by night they are scattered and very shallow, i.e. out of reach of the echo sounders. Fish catchability is better by day for acoustics and by night for trawling. This has a drawback, that sampling is not related to dense concentrations. This may have negative effects when populations of fish are mixed. Fortunately, during some periods of the year the different populations of CPS are separated. Then this strategy imposed by the fish behavior is unlikely to produce biases in the evaluation of species proportion. I share Simmonds' comment that "*though there are some concerns that in the minority parts of the area where mixtures are observed species selectivity of the gear may be an issue*". One concern is that the catches are usually rather low (a few individuals), then risks of biases cannot be excluded. This would impose a higher effort in trawl sampling, especially in areas with multiple species. It would also require a particular effort in the selection of the most appropriate (the least selective) fishing gear as fish behaviour is known to impact trawl selectivity, and may affect estimates of species proportions in

areas where the species are mixed. In particular, comparisons between trawling and purse seine catches in a given area could help to evaluate the risk of biases due to the gear and the method. It could also be recommended to develop particular experiments with observation tools (cameras, multibeam sonar, net sensors etc.), in order to evaluate the magnitude of fish avoidance and escapement from the net.

For the survey and sampling design used here, the trawl appears to be adequate, but the small catches call for further studies, likely leading to improvements to the trawl sampling. The present approach should be pursued and more research work and experiments on fishing selectivity should be done in order to evaluate the biases linked to trawl sampling. Clearly, an optimal solution would be to have direct sampling of pelagic schools.

4.2.3. Allocation of effort between trawl and transect data collection

Due to the particular strategy imposed by the egg survey requirements (see above), there is low flexibility in the allocation of time between transects and trawling. Nevertheless, the balance is likely to provide useful results. In general, this point is not a major issue in the acoustic surveys, and authors (e.g. Simmonds and MacLennan, 2005) have showed that changes in the allocation of effort does not significantly improve the results. In this particular case, the catch sampling effort is rather important and cannot be reduced. In any case, this point is probably not critical.

4.2.4. Area coverage

There are two major points related to area coverage: the latitudinal extension of the survey area, and the definition of the surveyed zone inside the latitude limits.

Latitude. One major issue for sardine evaluation is the fact that during a part of the year a consistent part of the population is present south of the US water limits. In my opinion, the major risk is linked to the fact that part of the population may be present outside the survey area when the stock is located in the south of the region (winter and part of spring), as the Mexican waters are not sampled. This is obviously the case in early spring, as shown by the CUFES results since 1989 (Zwolinski et al., 2010, fig 2). A way to evaluate this risk is to compare the results from spring surveys to those from summer surveys. The results presented show that there is a strong similarity in the results from summer and spring over the survey period; therefore it is unlikely that, at least in 2006-2010, a significant part of the southern Pacific Sardine stock was missed. Nevertheless, this possible risk of underestimation of the spring abundance must be taken into consideration. Surveys during different seasons and improvement of the potential habitat definition would resolve this problem. Obviously, the best solution would be to perform joint US-Mexican surveys. If this cannot be done, indirect methods for evaluate the southern part of the stock have to be applied (surveys during different seasons, improvement of the potential habitat concept, etc.). The northern limit of the stock (in Canadian waters) is not such an issue, since the sardines are concentrated in the south during spring and a limited part of the stock crosses the border. It may be that non-migrating elements of the stock remain permanently in the Canadian waters, as it appears

for other species and other areas (e.g. the Chilean jack mackerel, the west African Ethmalosa, etc.), but they are marginal compared to the magnitude of the main population.
Concerning the other CPS, although no complete information was given to the panel on their biology, considering the average behaviour of related species (e.g. Chilean Jack mackerel, European jack mackerel, etc.), it is likely that their areas of distribution are larger than the surveyed area; however, the extent of their distribution remains unclear. Therefore, if an absolute estimate can be provided for the observed area, no absolute estimate for the whole population can be done for these groups. Concerning the anchovy, the distribution area is entirely covered, but the sampling is not appropriate (see above).

Surveyed area. An interesting study conducted on the definition of the "potential habitat" (Zwolinski et al, 2010 allows a better allocation of sampling effort. The potential habitat is based on sea surface temperature, chlorophyll and altitude of the sea surface, where temperature is the major factor, and roughly limited by isotherms 11-16º for the maximum extension and 13-14º for the "optimal" zone (Zwolinski et al, 2011). This principle of defining a habitat is essential as it allows the delimitation of the maximum extension of the area to be sampled, and it puts forth the hypothesis that no sardine can be found outside this habitat. I had long and interesting discussions with the authors and I concluded that the "potential habitat" designation is an excellent first step. I encourage the ASTP to continue in this field, towards the description of the actual habitat (instead of the potential one). Indeed, sardine is not physiologically limited by the 11-16º surface temperature, as part of the species is observed along the coast of Baja California in warmer waters (e.g. Robinson et al., 2007). Potential habitat is still a statistical observation that can be found to be incorrect in a given year. Contrary to this observation, the potential habitat designation is much wider than the observed distribution area of the sardine, which shows that other factors are involved in the definition of the habitat (probably dissolved oxygen, e.g. Bertrand et al., 2010). In any case, the research developed in this area is extremely important and remarkable results have already been obtained that help dispel some potential risks of biases, such as presence of sardine outside the sampled area and especially in offshore waters.

Except for anchovy, the extension of the surveys towards the coast is probably not a major issue. Nevertheless, the extrapolation method should be evaluated. At present the method consists in applying the average density along the transect to the non-explored surface onshore. Some results presented show that there is a trend along the transects, with an increasing density when being closer to the coast. Obviously, such a trend is not necessarily representative of what occurs outside the surveyed area, but at least it shows that the average is probably not the most accurate approach. One usual solution is to use the inter-transect data as representative of the inshore area. Some experiments with small vessels going very close to the shore could give answers to this question. In any case, the relatively small surface that this unexplored area represents is unlikely to become a real issue.

I fully support J. Simmonds' conclusion in this field: "*The observations on distribution are supported by information provided from fisheries and some survey data from*

Canada. In addition information was provided by CPSAS representative regarding location an season of fisheries. Taking all of this into account the SWFSC group should evaluate the data in more detail and propose methods for inshore and seasonally related latitudinal extensions to the area of occupancy for Pacific sardine. The magnitude of the extrapolation by survey should be evaluated and presented separately, so its contribution to the absolute estimate can [be] checked."

4.2.5. Prescreening algorithms for extracting school data

The general principle of extracting objects from daytime records and assigning these to individual or groups of species is a well-established approach for acoustic surveys. The current method utilizes the functionality of Echoview (Higgingbottom et al 2000). The method used here is based on a more formal approach, in terms of frequency ranges, though the spatial averaging at different stages is selected to match local situations. The method is described in detail in the background documents and in some of the papers delivered to the Panel. It seems to provide excellent results.

As far as I understood, this work is mostly done by the ASTP to "remove" all the non-fish echoes, which are in some way considered as biological noise. If this is the case, I regret that no attention is paid on this part of the biomass in the pelagic ecosystem: there is a large amount of information that can be extracted from the plankton and micronekton present in the CPS area, and any ecosystem approach should take them into consideration. One example is the use of trophic models to evaluate the productivity of the area. Another more recent approach taking advantage of the zooplankton distribution has been given by Bertrand et al (2010) who use the vertical distribution of the plankton to describe the stratification of the water masses, specifically to measure acoustically the depth of the oxycline. Considering that the acoustic data are collected during egg surveys, it is likely that micronekton/zooplankton distribution could be critical information for evaluating the survival of larvae, etc.

In any case, I would strongly recommend developing research on this part of the biomass, as it is easily available through acoustic sampling once extracted from the fish echoes.

4.2.6. Timing (day/night, school makeup)

As stated above, the sampling strategy separating acoustics (day) and trawls (night) is not current and whenever it is applied it is due to particular constraints. In any case, this is not optimal, although probably impossible to improve with no major changes in the survey strategy (e.g. use of purse seine or different types of trawls for fishing schools; use of specific acoustic surveys not linked with egg surveys, etc.). Day-time trawling requires particular trawls as the trawling speed must be fast (Clupeids in general are fast swimmers when avoiding a net).When species are not present in the same area, this is not a major problem, as usually the catch is monospecific and the only concern should be on how representative of the demographic structure the catch is. When multiple species are present ,this can become an issue if the species have different avoidance behaviour. In this case, the easily caught fish are overrepresented in the catches. The use of pelagic trawls by night on scattered fish has another drawback, i.e. when species (or age classes)

do not share the same bathymetric layer. In this case too, there is a risk of overestimation of one part of the community present.

On the contrary, night catches on scattered fish present some advantages, of which the most important one is that the catch is more likely to represent the community of fish present. Indeed, the daily catch using a trawl (but also a purse seine) is directed on schools that are strongly uniform in fish characteristics (same species, same dimension), and usually once a first school is caught, the net has to be lifted. Therefore, the fish present in the first school are overrepresented in the sampling, and another source of bias appears.

Finally, having no information on the actual fish present in given schools hampers any research on school typology or relationships between fish (species, age) and school behaviour. This point is not directly linked to abundance estimates, but could help understanding the discrepancies that often appear between fisheries research models and real life scenarios.

Overall, the particular case of the CPS presents some favorable situations: species are separated during a long part of the year; sardine which is the most important species seem to scatter in a single surface layer (primary document, part 1, figure 5); and they appear to be catchable by the existing trawl. In conclusion, although there is room for many improvements, the results are correct for the existing surveys (2006-2010).

4.2.7. Trawl design-net, tow speed, etc

Considering the contradictory sources of biases that have been listed above, it appears that the choice of a trawl is likely to be the only simple solution. Sardine and most of CPS (excluding anchovies) are rather fast swimmers and able to avoid the net. This means that trawling, for scattered as well as schooling fish, should be performed at more than 4 or 5 knots, which requires a particular kind of net. The modern research vessels are able to trawl at these speeds, and plans of this kind of net are currently available in the literature. Trawling is probably easier to do than purse seining and yields a less biased set of information for the particular case of general abundance estimates, and I recommend the use of fast speed trawls for improving the trawl sampling during these surveys.

4.2.8. Acoustic Equipment Specifications

The acoustic-trawl surveys have been conducted with four to five frequencies (typically 18, 38, 70, 120, and 200 kHz). The use of a vertical echo sounder is appropriate for assessing fish distribution and estimating abundance. Multiple-frequency data are likely to permit automatic group recognition (e.g., plankton versus fish versus invertebrates) and potentially species identification. Multiple-frequency methods were applied for apportioning the acoustic backscatter to CPS (e.g., Demer *et al*., 2009) as detailed in Demer *et al.* (background document).

The transducer is mounted on a blister or keel extending from the vessel hull, precluding observation of animals present nominally 10 m below the surface. The vertical echosounder is unable to provide information about organisms residing near the surface,

particularly at night. However, this is not a concern for abundance estimation because the acoustic observations contributing to the biomass estimates are made during the day. The pulse-repetition interval is, in general, 0.5 seconds, or one ping each 2.5 m at 10 knots. This may be low for observing small, near-surface schools close to the vessel, but is adequate for estimating biomass.

The acoustic data collected depends on the type of equipment installed and the settings decided at the start of the survey. For vertical echosounders, several issues should be considered in relation to these settings:

- Choice of frequencies. Each group of species is better observed by a given set of frequencies (e.g., plankton, small and big fish, fish with and without swimbladders, and squids). Multiple frequencies allow for group differentiation.
- 'VRM extraction process and overall threshold'. This may lead to exclusion of some of the total biomass (mostly plankton, but also small non-schooling fish), and must consequently be set given the survey objectives. This is especially important for visual analysis of the echograms.
- Ping rate. The ping rate will affect the description of small spatial structures (e.g., schools). A very low ping rate results in a loss of information about these structures, while a very high rate will lead to redundant data. The use of multiple acoustic devices may impose a certain ping rate, but this may affect the precision of the results or their use for some particular research topics, principally studies on school structure and behavior
- Transducer location. The choice between a fixed and a towed transducer depends on the location of the target species (e.g., shallow versus deep).
- Complementary sensors. Use of additional acoustic devices (e.g., multibeam and short-range and long-range scanning sonar may be used for behavior and avoidance observations; an ADCP may be used for measuring vertical stratification of the seawater and for describing habitat features) can add information, but this may affect fish behavior (e.g., the sonar signal may affect schools) or the transmission rates of other devices.

A particularly interesting effort undertaken during these surveys is the use of high frequency multibeam sonar, especially for measuring fish avoidance (see below) and fish stratification close to the surface. Using this instrument is helpful to define the avoidance magnitude during the survey, knowing that such behaviour can change from one moment to the other.

The use of multiple vessels in standard assessment surveys may add complexity to the interaction between the observer and the observed. The present surveys were conducted using four vessels ranging from 41 to 65 m in length, with displacements ranging at least two fold. Some of these vessels have been studied in details as far as noise effect to fish is concerned (De Robertis et al, Wilson et al., etc). Concerning the point of acoustic equipment specification, all the ships were equipped with similar tools (although not with all the frequencies), and the acoustic settings and use of equipment were similar.

Overall, I consider that the acoustic specification is appropriate for abundance estimation, noting that a layer near the surface is not sampled. However, the acoustic sampling may not be adequate for research on school characteristics and a description of the global pelagic ecosystem. For this part of the research, I recommend that the team continues to: (a) consider other existing methods (e.g. Lawson *et al*., 2001; Haralabous and Georgakarakos, 1996; Kloser *et al.* 2002; Lebourges-Dhaussy and Fernandes, 2010) for species identification; (b) evaluate the potential use of non-vertical echosounders; (c) develop methods that categorize the acoustic record and thus support automatic species identification, and (d) work on definition and precision of the VMR process.

4.2.9. Vessel avoidance

Fish response to vessel passage has been documented for small pelagic species in other areas (e.g. Freon and Misund, 1999). There is a potential for bias in abundance estimates from acoustic surveys if vessel passage causes fish to change their orientation in the water column, or exhibit some kind of consistent movement, either avoidance or attraction. Sardine, in particular, are often found near the surface at least at some times of the year, and fishermen have noted strong avoidance responses to vessel passage. As echosounders used in the CPS acoustic-trawl survey are mounted approximately 3.75 to 7.5 m deep to which must be added a "blind zone", it is clear that for those fish between the surface and 10 m deep, no abundance estimate can be done using vertical echosounder. This is a critical issue to address when deciding how or whether to use the abundance estimates based on acoustic-trawl data for stock assessment.

The influence of fish avoidance has been investigated using two approaches: (a) the distribution under and to the side of the vessel was examined using multibeam sonar, and (b) volume backscattering (S_v; dB re 1 m^{-1}) of fish schools observed in successive pings was examined to test the hypothesis that a vessel impact would lead to a reduction in S_v and an increasing average depth during passage. Studies with similar equipment on European pilchard in the Mediterranean Sea show increased schools off track (Soria *et al*., 1996), while Chilean sardine in contrast showed no increase in schools off track (Gerlotto *et al*., 2004). Results from the first study indicated that CPS school counts peaked sharply under the vessel, and declined steadily with distance away from the vessel track and depth, suggesting no increase in schools off track, as might be expected if there is lateral movement in response to the vessel. Results from the second study indicated that in most cases for CPS in the CCE there was little evidence for differences in depth or backscatter from the front to the end of schools, suggesting that any diving behavior takes place before the school passes through the acoustic beam, although minor diving apparently was noted when schools were shallow.

Further complexity in potential fish behavior is caused by interactions among the stimuli. In the present case, the vessels vary substantially in size and horsepower and have different propulsion and noise-reducing arrangements. The potential exists for vessel-specific impacts on the survey results if the target species are sensitive to any of the stimuli described above (Hjellvik *et al*., 2008). An important work on fish avoidance to research vessels has been done by the ICES Study group on this question (SGFARV) and

a Cooperative Research Report is in press. Most of the major questions and recommendations on the field of fish avoidance will be listed in this document.

Vessel noise may potentially affect fish behavior during surveys. Fish may avoid the sound source, either by diving or moving to the side, or both. Such behavior may lead to reduced fish density under the transducer during the moment of recording. Furthermore, TS might change as a result of changing fish tilt angle during the avoidance response, thus impacting, in most cases reducing, estimates of density. The International Council for the Exploration of the Seas (ICES) has therefore recommended using noise-reduced vessels to reduce these potential impacts.

Nevertheless, the results from the recently built "silent vessels" are contradictory, and further work is needed in order to define the actual sources of stimuli that induce fish avoidance. For instance, particular parts of the sound spectrum, e.g. infrasound, appear to be responsible for changes in fish behavior in response to survey vessels (Ona *et al*., 2007; Sand *et al*., 2008). This implies that noise as measured by the ICES standard (Mitson, 1995) does not necessarily reflect the strength of the vessel's avoidance stimulus. Rather, the stimulus may be more associated with the size of the vessel and its displacement than the noise emission.

Some studies (e.g. Dagorn *et al*., 2001; Røstad *et al*., 2006) suggest that vessels may attract fish, thus increasing densities measured by acoustics. The authors argue that visual stimuli may attract fish and affect observations in shallow water and at short distances from the vessel. Nevertheless, this particular behaviour is unlikely to have any effect on an abundance estimate of CPS, as the attraction dynamics are too slow compared to the vessel speed.

During the surveys performed, there was clear evidence that schools seen on the surface dived to at least 10m (Cutter and Demer 2007). If this behaviour is general, then this diving behaviour is "good news" for the abundance estimate, as surface schools are observed below the blind zone under the ship. The question remaining is that of a possible horizontal avoidance before the ship has passed over the schools: if this is the case, this gives rise to concern that the abundance may not be correctly recorded.

As a general conclusion, I am convinced that avoidance of school is probably not a critical issue. Nevertheless, behaviour is never a stable pattern and is influenced by a number of parameters (climatic, meteorological, presence of preys or predators, physiological stage, background noise, etc.). In order to take these points into account, I recommend that a continuous monitoring and analysis be organized for the duration of each survey to provide an evaluation of the bias due to school avoidance, using multibeam sonars. Some information from the fishery seems to indicate that inside the fishing area there is a significant horizontal avoidance. This point should be studied, through a particular experiment, e.g. aboard fishing vessels.

4.2.10. Target strength

The TS calculation follows the conventional methods, and three formulas coming from peer reviewed papers are used to give TS – length relationships. The values used are standardized to 20 log slope, and use weight at length conversion to biomass.

I have no major comment to make on this particular point. The ASTP uses specific TS equations when available (sardine) and equations from related and similar species when unavailable; this is the common method. I recommend of course to investigate TS values locally and particularly for pacific mackerel (as the ASTP uses the Chilean Jack Mackerel equations) if this is to be used as an absolute estimate.

4.2.11. Hydrography

There are two points of importance here:

- Measurements of hydrographic variables are theoretically needed to correct the acoustic properties of the water in the sonar equation; this is not a major issue in this work as the surface temperature does not vary substantially. In any case, the bias induced by a permanent factor is marginal compared to the other sources of bias in an acoustic survey system.
- In order to improve the definition of the potential habitat, it is important to collect as many parameters as possible during the survey. Moreover, it is also necessary to obtain vertical information (CTD stations) with the idea to correlate acoustic characteristics of the biological distribution (e.g. plankton) with the stratification of water masses.

Hydrographic stations are therefore as necessary as the trawl samples, although they are usually performed systematically (as is the case in this survey design) and do not require any major recommendations.

4.3. ToR 3

Evaluate and provide recommendations for the application of these methods for their utility in stock assessment models and for their ability to monitor trends at the population level for Pacific sardine and other CPS. Survey methods or results that have a flawed technical basis, or are questionable on other grounds, should be identified so they may be excluded from the set upon which stock assessments and other management advice is to be developed.

I am not an expert in stock assessment modeling and my comments and recommendations in this area are limited. I supported the discussions and recommendations of the Panel in this topic and particularly the following conclusions and recommendations:

> *"Treating any survey estimate as an absolute estimate of abundance is a strong constraint in stock assessment models, and the appropriateness of that assumption can only be evaluated in the context of the other information available for the assessment.*

Pacific Sardine
Pacific sardine are an actively-managed CPS species with an SS3-based stock assessment. (...) Given current information, the Panel ***agrees*** *that the acoustic-trawl surveys can be considered to provide estimates of absolute abundance for the survey area with the associated length-composition, and the assessment author should consider the use of these data in the September 2011 sardine assessment. It* ***recommends*** *that prior to the September 2011 assessment, analyses be conducted using auxiliary information (e.g., trends in density along transects, information from ichythoplankton surveys south of the survey area, and catch information) to provide best estimates for the biomass outside of the survey area as well as range of possible biomass levels. In addition, the CVs for the estimates need to be modified to fully account for the uncertainty of the trawl data.*

Jack mackerel
Jack mackerel are a monitored CPS species. There are few recent data on which to base estimates of abundance and distribution for this species. The acoustic-trawl survey data are the only scientific information on abundance for the area surveyed. The Panel ***agrees*** *that even though less information is available for this species than for Pacific sardine on the key uncertainties, the estimates of absolute abundance for the survey area can be used as estimates of the biomass of jack mackerel in US.*

Pacific mackerel
While there is no reason why the acoustic-trawl surveys cannot be used to provide estimates of abundance for Pacific mackerel, the estimates of abundance for Pacific mackerel are more uncertain as measures of absolute abundance than for jack mackerel or Pacific sardine.

Northern anchovy
There is also no reason why acoustic-trawl surveys cannot be used to estimate abundance for northern anchovy. However, the perceived current size of the population, along with its more inshore distribution, means that the present survey data cannot be used to provide estimates of relative or absolute abundance for northern anchovy. "

Apart these recommendations that I fully support, I have a concern that I presented to the Panel, on the meaning and use of "absolute abundance estimate". If I am correct, "absolute estimate" means that the results of abundance measurement are given in actual biomass (e.g. number of individuals or densities in kilos). If this is the case, the only points to consider are those that play a role in the process from echoes (backscattering) to weights. This relates to TS, avoidance, trawl samples, extraction of fish from the global biological noise. We have seen that neither of these points was considered a major issue, and if there is need to carefully study each one of them and improve the results, they were unlikely to affect significantly the results. Therefore, most of the values that are given by these surveys are "absolute biomass estimates". Relative estimates exist when we know that there is some permanent and stable bias or unknown parameter (for instance, no information on TS), and, in this case, the results give a correct curve, correlated with the

actual one but weighted by an unknown factor. These two estimates can be called "true" estimates, as they vary similarly to the actual abundance and show similar curves.

We can face a situation where the results are neither absolute nor relative but wrong. This case may happen if the fishing capacities are bad, for instance, or when we begin to work with acoustic information from fishing vessel: some of these sets of data can be wrong (e.g. uncalibrated, including false echoes, no information on settings, non-scientific echo-sounder and no information on TVG, etc.). Such data are useless. The last case is when we have correct (not wrong) data but we are in a situation where we lack of essential information. For instance, we know that the stock is occupying a wider albeit unknown distribution area than the "window" observed by the survey. In this case, the results, even if they can be given in absolute values, are not representative of the truth. Let us call them "false" estimates. They can be given either in absolute or relative values, but they will remain "false".

In our cases, we face different situations:

- Sardine abundance is absolute (correct TS, no avoidance, correct sampling) and true (observation of the whole stock);
- Mackerel is absolute (correct TS, no avoidance) and false (present outside of the observation window);
- Jack mackerel is relative (no ad hoc TS equation) and probably false (present outside of the observation window);
- Anchovy is absolute (correct TS, no avoidance, good sampling) and false (inadequate survey design)

From these observations, it seems clear that we can expect to get an "absolute-true" value of abundance from anchovy with an appropriate survey design. We can expect an absolute value for jack mackerel with an appropriate TS equation but neither it nor the mackerel could be measured in "true" estimates, except if a clear correlation can be calculated between one parameter (e.g. mean density, school characteristics…) and the total biomass. In this case the abundance would become relative (no value of the actual overall biomass) and true (correlated with the actual biomass).

4.4. ToR 4

Evaluate the effectiveness of the survey methods for detecting the appropriate spatial scale and seasonal timing for annually estimating stock abundances.

Here too, my general conclusion does not diverge significantly from those of the panel and I support the following statements with some particular comments:

> ***Pacific Sardine***
>
> *Given current information, it is considered that the acoustic-trawl surveys can be considered estimates of distribution of abundance for the survey area. It is expected that the area survey covers the vast majority of Pacific sardine at the time when the surveys were conducted. There is a need for a number of analyses to be conducted using auxiliary information to provide best estimates for the*

biomass outside of the survey area as well as range of possible biomass levels. In addition, the CVs for the estimates need to be modified to fully account for the uncertainty of the trawl data.
(**note**: for sardine, the major points to take into consideration are the horizontal avoidance if it exists, the dimension of the stock existing outside the survey area in early spring, the accuracy of trawl samples)

Jack mackerel
Jack mackerel are a monitored CPS species. The acoustic-trawl survey data are the only scientific information on abundance for the area surveyed. Even though less information is available for this species than for Pacific sardine on the key uncertainties, the estimates distribution by the survey area can be used for jack mackerel in US waters. The estimate for summer may be more reliable as the various CPS are more separated at that time.

Pacific mackerel
A major concern for this species is that a sizable (currently unknown) fraction of the stock is outside of the survey area. While the estimates for survey area are valid, and some information on distribution is available, if the acoustic-trawl data are to be used to provide estimates of stock biomass, auxiliary information will be needed to estimate the annually-varying proportion of the whole stock in the survey area.
(note: this would require to select some indicator relating the abundance inside the surveyed area with the overall abundance. Some works have been done (e.g. Petitgas, 1994. Spatial strategies of fish populations. In: ICES CM 1994/D:14.) that could be applied and adapted for such a research.

Northern anchovy
The current size of the population, along with its more inshore distribution means that the present survey data cannot be used to provide estimate of relative or absolute abundance or distribution for northern anchovy. A few northern anchovy were sampled nearshore, mostly off Oregon and Washington (2006, 2008, and 2010), north of Monterey Bay (2006) and in the Southern California Bight (2006 and 2008). Apart from the occasional large catches (~ 300kg) off the mouth of the Columbia River and other likely locations such as off Santa Barbara and Monterey Bay, anchovy were scarce in these surveys, even off southern California where they once were the most abundant species. The sampling scheme would need to be modified (more transects and trawls in the areas where northern anchovy are found) if estimates of distribution of northern anchovy required.

As a last comment in this field, I consider that in an ideal situation:

- The acoustic surveys should be autonomous and not dependent on egg surveys, which impose some constraints in the acoustic survey design, such as the location of fishing samples.

- Surveys should be more frequent, e.g. in spring, summer and autumn, in order to evaluate better the parts of the different populations that are outside the surveyed area. In any case, if such an increase is impossible, summer surveys must be repeated as frequently as spring surveys.
- The research on the potential habitat for sardine (but also for other species) has to be continued and considered a priority; for such research the use of non-fish scatterers is indispensable.

4.5. ToR 5

Decide through Panel discussions if the ToRs and goals of the peer review have been achieved. If agreement cannot be reached, or if any ToR cannot be accomplished for any reason, then the nature of the disagreement or the reason for not meeting all the ToR must be described in the Summary and Reviewer's report. Describe the strengths and weaknesses of the review process and Panel recommendations.

There were no major disagreements between the Panel and the Team or among Panel members. Some of the points that I considered before the meeting as critical and questionable, deserving correction or discussions were exposed and consistent answers were given. I have been convinced, for instance, by the discussions on the potential habitat that did not convince me in reading prior to the meeting. The Panel received an important but essential set of documents that helped to get a correct idea and perform an efficient analysis of the works done by the team. I have been impressed by the wide range of expertise present in the Panel, which allowed considering all the points of the ToR. This would probably not have been possible in the case of individual reports with no common meeting. The exchange of ideas and expertise enriched considerably the results.

I agree with John Simmonds when he says that "*While generally the meeting facilities were good (...) there were considerable technical difficulties with the network access provided by SWFSC, this was barely functional, requiring additional printing and making exchange of documents more difficult*".

The Acoustic-Trawl Survey Technical Team was of a particularly high standard, and provided the Panel with all the information needed for analyzing its work. Some works were performed during inter-sessions under requirement of the Chair and delivered to the Panel in time. My general conclusion is that this team is of an outstanding level and that the survey methodology developed will become a case study to show how each part of the process was taken into consideration, analyzed, and the best possible answer was given. I have learnt a lot on multibeam sonar data analysis, for instance, and on innovative methods for avoidance estimates.

It is clear that the whole Panel was of high quality and the discussions always were of high level. The role of the rapporteur was essential, as we were fed with the results of the discussions almost in real time. I want to highlight the role of three key participants in this meeting : André Punt, who leaded the group with an extreme efficiency and made it possible to maintain the discussions and work at a high level; John Simmonds appeared

to be essential for most of the conclusions and recommendations expressed, and especially in all the matters related to precision measurements and variance estimates of the results; and David Demer, who prepared the works of the panel and answered in a very clear and convincing way to all the question, showing that most of them have been anticipated by the team. These three persons allowed me (and probably the other members of the team) to follow the whole work, even in areas where my expertise was not strong.

5. Recommendations

I fully support the general conclusions that the Panel listed, as below:
Pacific Sardine It is Recommended that the acoustic-trawl surveys be considered estimates of distribution of abundance for the survey area.

It is recommended that there is a need for a number of analyses to be conducted using auxiliary information to provide best estimates for the biomass outside of the survey area as well as range of possible biomass levels. In addition, the CVs for the estimates need to be modified to fully account for the uncertainty of the trawl data.

Jack mackerel Even though less information is available for this species than for Pacific sardine on the key uncertainties, it recommended that estimates distribution by the survey area can be used for jack mackerel in US waters.

Northern anchovy: It is recommended that if estimates are required the sampling scheme would need to be modified

There are a series of specific aspects detailed below:

1. Immediate (prior to the next stock assessments)

a. Analyses should be conducted using auxiliary information (e.g. trends in density along transects, information from ichythoplankton surveys south of the survey area, catch information) to provide best estimates for the biomass outside of the survey area as well as the range of possible biomass levels.
b. The CVs for the estimates need to be modified to fully account for the uncertainty of the trawl data.

2. Short-term

a. Investigate 'gross' species selectivity effects by comparing the ratio of catch rates and acoustic density in areas where single species dominate.
b. Conduct sensitivity tests in which stations are pooled and allocated to acoustic values over a larger area.
c. Consult experts in trawl design to evaluate the current trawl design in relation to the survey objectives

d. *Develop methods that categorize the acoustic record and thus support automatic species identification and continue to work on definition and precision of the VMR process and check the performance of the selection process on each survey.*
e. *Develop further studies on effect of avoidance: study trends in frequency response over depth strata in schools, compare results from the 18 kHz and other transducers to examine possible avoidance reactions.*
f. *Continue to consider the advantages and disadvantages of conducting acoustic-trawls surveys at different times of the year and extending the survey into Canadian and Mexican waters.*
g. *Evaluate the potential to give age-based abundance or biomass estimates for sardine and consider their utility in the SS3 assessment given the lack of contrast in length-at-age at older ages and the ability to directly estimate total mortality from the survey result.*

3. Long-term

a. *Evaluate if differ fishing trawling practices / gears would be beneficial.*
b. *Use a trawl/vessel configuration that can support directed trawl sampling.*
c. *Conduct repeated trawl sampling experiments to obtain better understanding of small-scale variability.*
d. *Test the efficiency and selectivity of the trawl by comparing samples from the same area taken with the survey trawl and purse seine.*
e. *Apply state of the art acoustic and optic technology to investigate fish behavior and escapement at various critical positions of the trawl.*
f. *Conduct validation tows on various kinds of backscatter to assure that the filtering algorithm is performing as intended to separate out CPS.*
g. *Make efforts to obtain in situ target strength measurements for CPS species in California Current Ecosystem.*

6. Conclusion

The work of the Panel was facilitated by the great professionalism of the team and its help for any problem and question. The reports and presentations provided an excellent basis to evaluate the performance of the acoustic-trawl survey. Thanks to the excellent preparation of the meeting; I found the work easy and I expect that the results of the meeting will be of high quality.

The work submitted to our expertise appeared to be of a high standard and no correction or important change was required. The recommendation is to aim to improve the methodology with no fundamental change.

The framework of the expertise process is also remarkable, among the expertise processes in which I have participated around the world, this one is certainly the best, in every point: preparation, documentation, organization, members, etc.

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Appendix 1: Bibliography of materials provided for review

Primary Documents

David A. Demer, Juan P. Zwolinski, Kyle A. Byers, George R. Cutter, Josiah S. Renfree, Thomas S. Sessions, and Beverly J. Macewicz 2011 Acoustic-trawl surveys of Pacific sardine (Sardinops sagax) and other pelagic fishes in the California Current ecosystem: Part 1, Methods and an example application.

Juan P. Zwolinski, Kyle, A. Byers, George R. Cutter, Josiah S. Renfree, Thomas, S. Sessions, Beverly J. Macewicz, and David A. Demer 2011 Acoustic-trawl surveys of Pacific sardine (Sardinops sagax) and other pelagic fishes in the California Current ecosystem: Part 2, Estimates of distributions and abundances in spring 2006, 2008, and 2010

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Appendix 2: Statement of Work for John Simmonds

External Independent Peer Review by the Center for Independent Experts

Panel Review of an Acoustic-Trawl Method for Surveying CPS

3-5 February 2011

Scope of Work and CIE Process: The National Marine Fisheries Service's (NMFS) Office of Science and Technology coordinates and manages a contract providing external expertise through the Center for Independent Experts (CIE) to conduct independent peer reviews of NMFS scientific projects. The Statement of Work (SoW) described herein was established by the NMFS Project Contact and Contracting Officer's Technical Representative (COTR), and reviewed by the 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 project. Further information on the CIE process can be obtained from www.ciereviews.org.

Project Description: The Pacific Fishery Management Council (PFMC) uses information from surveys to make decisions related to harvest guidelines for managed coastal pelagic species (CPS) (i.e., Pacific sardine and Pacific mackerel) and Overfishing Levels (OFLs) / Acceptable Biological Catches (ABCs) for monitored CPS (i.e., northern anchovy, jack mackerel and market squid). The current assessments for Pacific sardine and Pacific mackerel are based on the 'Stock Synthesis' framework. The assessment for Pacific sardine uses age- and length-composition data from four fisheries, the results from an aerial survey, and measures of female spawning biomass and total egg production (DEPM) from combined trawl and egg surveys, to estimate the parameters of a population-dynamics model. The survey outcomes and hence model-derived estimates of Pacific sardine spawning-stock biomass (SSB) have recently decreased, resulting in dramatically lower harvest guidelines for 2008 and 2009. The Southwest Fisheries Science Center's (SWFSC's) current standard survey covers the 'core' spring-spawning area between San Diego and San Francisco. The exploited stock ('northern subpopulation') is believed to migrate seasonally, potentially from northern Baja California, Mexico in the spring to British Columbia, Canada in the summer. The DEPM is an indirect measure of fish distribution and abundance. As the sardine population recovered from historic lows and recently reoccupied its former historic range, migrating as far north as Canada in the summer, multiple types and more direct estimates of CPS biomass, particularly sardine biomass, may be needed to improve stock assessments.

Three CIE reviewers will serve on a Panel to evaluate an acoustic-trawl method for surveying CPS. The SWFSC's Fisheries Resources Division (FRD) has explored the use of acoustic-trawl methods, which are commonly used by other regions and countries to estimate the abundances and distributions of CPS. Acoustic-trawl methods may provide a more robust (i.e., accurate and precise) and efficient means to routinely survey the Pacific sardine populations as well as the populations of jack mackerel, Pacific mackerel, and northern anchovy. In spring 2006, 2008, and 2010, and summer 2008, FRD conducted acoustic-trawl surveys off the U.S. west coast, from the Mexican to Canadian borders, and developed methods for estimating the abundances and distributions of CPS from these data. The Panel will review the acoustic-trawl survey design and analysis methods, documents, and any other pertinent information for acoustic-trawl surveys of Pacific sardine, Pacific mackerel, jack mackerel, and northern anchovy.

The Panel report will be used to guide improvements to the acoustic-trawl survey and analysis methods, the resulting time series of estimates of abundance and distribution for CPS species, and estimates of their uncertainty. The report will also be used to evaluate the appropriateness of using the results from the survey as inputs to the assessment model for Pacific sardine and Pacific mackerel. The assessment models for Pacific sardine and Pacific mackerel will be reviewed by separate Stock Assessment Review (STAR) Panels. However, the report of this Methods Review Panel will be considered by the assessment analysts and STAR Panels.

An overview of the ToRs for the Panel is attached in **Annex 2**. The tentative agenda of the Panel review meeting is attached in **Annex 3**. Finally, an outline of the summary report of the Panel is attached as **Annex 4**.

Requirements for CIE Reviewer: Three CIE reviewers shall participate in the Panel and conduct an impartial and independent peer review in accordance with the SoW and ToRs herein. Three CIE reviewers shall have expertise and work experience in the design and execution of fisheries-independent acoustic-trawl surveys for estimating the abundance of coastal pelagic fish species, and expertise with sardines is desirable. The CIE reviewers shall have knowledge of the life history strategies and population dynamics of coastal pelagic fish species.

Each CIE reviewer's duties shall not exceed a maximum of 14 days to complete all work tasks of the peer review described herein.

Location/Date of Peer Review: The CIE reviewers shall participate as independent peer reviewers during the panel review meeting at NOAA Fisheries, Southwest Fisheries Science Center, 3333 North Torrey Pines Court, La Jolla, California, 92037-1023, during 3-5 February 2011 in accordance with the agenda (Annex 3).

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

Prior to the Peer Review: Following the CIE reviewer selections by the CIE Steering committee, the CIE shall provide the CIE reviewers' information (name, affiliation, and contact details) to the Contracting Officer's Technical Representative (COTR), who will forward this information to the NMFS Project Contact no later the date specified in the Schedule of Milestones and Deliverables. The CIE is responsible for providing the SoW and ToRs to the CIE reviewers (reviewer hereafter). The Project Contact is responsible for providing the reviewer with the background documents, reports, foreign national security clearance, and information concerning other pertinent meeting arrangements. The Project Contact is also responsible for providing the Panel Chair (Chair hereafter) a copy of the SoW in advance of the Panel. Any changes to the SoW or ToRs must be made through the COTR prior to the commencement of the peer review.

Foreign National Security Clearance: When a reviewer who is a non-US citizen participates in a panel review meeting at a government facility, the Project Contact is responsible for obtaining a Foreign National Security Clearance for the CIE reviewers. For the purpose of their security clearance, each reviewer shall provide requested information (e.g., name, contact information, birthdate, passport number, travel dates, and country of origin) to the Project Contact at least 30 days before the peer review in accordance with the NOAA Deemed Export Technology Control Program NAO 207-12 regulations (available at the Deemed Exports NAO website: http://deemedexports.noaa.gov/sponsor.html).

Pre-review Background Documents: Two weeks before the review, the Project Contact will electronically send to each reviewer, by email or FTP, all necessary background information and reports for the review. If the documents must be mailed, the Project Contact will consult with the CIE on where to send the documents. The CIE reviewers shall read all documents in preparation for the review, for example:

- documents on current survey methods, in particular, related to DEPM and aerial surveys of sardine and other CPS;
- document on SWFSC acoustic-trawl surveys conducted between 2006 and 2010;
- documents from past Panels; and
- miscellaneous documents, such as the ToR, SoW, agenda, schedule of milestones, deliverables, logistical considerations, and PFMC's ToR for CPS Stock Assessment Methodology Reviews.

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

Panel Review Meeting: Each CIE reviewer shall participate in the Panel and conduct an independent review in accordance with the SoW and ToRs. **Modifications to the SoW and ToR cannot be made during the review, and any SoW or ToR modification prior to the review shall be approved by the COTR and CIE Lead Coordinator.** Each reviewer shall actively participate in a professional and respectful manner as a

member of the Panel, and their review tasks shall be focused on the ToRs as specified in the contract SoW.

Respective roles of the CIE reviewers and Chair are the PFMC's ToR for CPS Stock Assessment Methodology Review (see p. 6-8). The CIE reviewers will serve a role that is equivalent to the other panelists, differing only in the fact that they are considered 'external' members (i.e., outside the PFMC's membership and not involved in management or assessment of west coast CPS, particularly sardine). The reviewers will serve at the behest of the Chair, adhering to all aspects of the PFMC's ToR as described in Annex 2. The Chair is responsible for: 1) developing an agenda; 2) ensuring that Panel members (including the Reviewers) and those being reviewed (the "proponents") follow the ToR; 3) participating in the review of the methods (along with the Reviewers); and 4) guiding the Panel (including the Reviewers), FRD, and NWSS to mutually agreeable solutions.

The Project Contact is responsible for any facility arrangements (e.g., conference room for Panel meetings or teleconference arrangements). The CIE Lead Coordinator can contact the Project Contact to confirm any meeting facility arrangements.

Contract Deliverables - Independent CIE Peer Review Reports: In addition to participating in the Panel, each CIE reviewer shall also complete an independent-review report in accordance with the SoW, i.e., in the required format as described in Annex 1; and addressing each ToR as described in Annex 2.

Other Tasks – Contribution to Summary Report: Reviewers will assist the Chair with contributions to the Summary Report. The Panel is not required to reach a consensus and, therefore, the reviewers should provide a brief summary of their views on the findings and conclusion reached by the Panel in accordance with the ToRs (format defined in Annex 1).

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

1) prepare for the review by thoroughly reading the documents provided by the Project Contact;
2) participate in the panel review meeting in La Jolla, CA during 3-5 February 2011 as indicated in the SoW, and conduct an independent review in accordance with the ToRs (Annex 2); and
3) write an independent-review report, addressed to the "Center for Independent Experts," and submit it to Mr. Manoj Shivlani, CIE Lead Coordinator, via email to shivlanim@bellsouth.net, and CIE Regional Coordinator, via email to David Die ddie@rsmas.miami.edu, no later than 17 March 2011 indicated in the SoW. The report shall be written using the format and content requirements specified in Annex 1, and address each ToR in Annex 2.

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

28 December 2011	The CIE sends the CIE reviewers' contact information to the COTR, who forwards it to the Project Contact.
10 January 2011	The Project Contact sends the pre-review documents to the CIE reviewers.
3-5 February 2011	The CIE reviewers participate in the Panel review meeting and conducts an independent review.
3 March 2011	The CIE reviewers submit their reports to the CIE Lead Coordinator and CIE Regional Coordinator for final review and revisions.
17 March 2011	The CIE submits independent peer review reports to the COTR for contractual compliance.
24March 2011	The COTR distributes the final reports to the Project Contact and the regional Center Director.

Modifications to the Statement of Work: Requests to modify this SoW must be made through the COTR 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 COTR can approve changes to the milestone dates, list of pre-review documents, and ToR of the SoW as long as the role and ability of the Reviewer to complete the SoW deliverable in accordance with the ToRs and the deliverable schedule is 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 reports by the CIE Lead Coordinator, Regional Coordinator, and Steering Committee, the reports shall be sent to the COTR 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 email the contract deliverables (the CIE independent peer review reports) to the COTR (William Michaels, via William.Michaels@noaa.gov).

Applicable Performance Standards: The contract is successfully completed when the COTR provides final approval of the contract deliverables. The acceptance of the contract deliverables shall be based on three performance standards: (1) the CIE report shall have the format and content in accordance with Annex 1; (2) the CIE report shall address each ToR as specified in Annex 2; and (3) the CIE report 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 COTR, the CIE Lead Coordinator shall send via email the final CIE reports in pdf format to the COTR. The COTR will distribute the approved CIE reports to the Project Coordinator, the regional Center Director, and the PFMC.

Key Personnel:

William Michaels, Program Manager, COTR
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NMFS Project Contact:

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

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

2. The main body of the Reviewer's report shall consist of the following sections, in accordance with the ToRs: Background, Description of the Reviewer's Role in the Review Activities, Summary of Findings for each ToR, and Recommendations and Conclusion.

   a. The Reviewer should describe in their own words the review activities completed during the panel meeting, including providing a detailed summary of findings, recommendations, and conclusion.

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

   c. The Reviewer should elaborate on any points raised in the Summary Report that might require clarification.

   d. The Reviewer shall provide a critique of the review process, including suggestions for improving both the process and products.

   e. The CIE report shall be a stand-alone document for others to understand the proceedings and findings of the meeting without having to read the Panel report. The report shall be an independent review of each ToR, and shall not simply repeat the contents of the Panel report.

3. The Reviewer's report shall include the following separate appendices:

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

Annex 2: Terms of reference (ToRs) for the peer review of the acoustic-trawl method for surveying Pacific sardine and other CPS

The CIE reviewers will participate in the panel-review meeting to conduct independent peer reviews of the acoustic-trawl method as it pertains to surveys of coastal pelagic fish species (CPS) in the California Current Ecosystem (CCE), principally Pacific sardine, but potentially also including jack mackerel, Pacific mackerel, and northern anchovy, depending on their biomasses and distributions, and the sampling effort afforded. The survey area is the CCE off the west coast of the United States of America (US), generally between the Mexico-US and the US-Canadian borders. The latitudinal and offshore extents of the surveys are seasonal, extending further north in the summer and further offshore in the spring. Survey estimates are to include absolute biomasses, and their total random sampling errors, and spatial distributions. The review solely concerns technical aspects of the survey design, method, analysis, and results, and addresses the following ToR:

ToR 1 – Review documents detailing acoustic-trawl survey and data analysis methods and results according to the PFMC's ToR for CPS Stock Assessment Methodology Reviews. Document the meeting discussions. Evaluate if the documented and presented information is sufficiently complete and represents the best scientific information available.

ToR 2 – Evaluate and provide recommendations on the survey method used to estimate the abundances and distributions of Pacific sardine and other CPS, and associated sources of uncertainty. Recommend alternative methods or modifications to the proposed methods, or both, during the Panel meeting. Recommendations and requests to FRD for additional or revised analyses during the Panel meeting must be clear, explicit, and in writing. Comment on the degree to which the survey results describe and quantify the distributions and abundances of CPS, in particular Pacific sardine, and the uncertainty in those estimates. Confidence intervals of survey estimates could affect management decisions, and should be considered in the report.

ToR 3 – Evaluate and provide recommendations for the application of these methods for their utility in stock assessment models and for their ability to monitor trends at the population level for Pacific sardine and other CPS. Survey methods or results that have a flawed technical basis, or are questionable on other grounds, should be identified so they may be excluded from the set upon which stock assessments and other management advice is to be developed.

ToR 4 – Evaluate the effectiveness of the survey methods for detecting the appropriate spatial scale and seasonal timing for annually estimating stock abundances.

ToR 5 – Decide through Panel discussions if the ToRs and goals of the peer review have been achieved. If agreement cannot be reached, or if any ToR cannot be accomplished for any reason, then the nature of the disagreement or the reason for not meeting all the ToR

must be described in the Summary and Reviewer's report. Describe the strengths and weaknesses of the review process and Panel recommendations.

The Reviewer’s report should be completed, at least in draft form, prior to the end of the meeting.

Annex 3: Participants and Agenda

Participants

Methodology Review Panel Members:
Martin Dorn, SSC, NMFS, Alaska Fisheries Science Center
François Gerlotto, Center for Independent Experts (CIE)
Olav Rune Godø, Center for Independent Experts (CIE)
André Punt (Chair), Scientific and Statistical Committee (SSC), Univ. of Washington
John Simmonds, Center for Independent Experts (CIE)

Pacific Fishery Management Council (Council) Representatives:
Kerry Griffin, Council Staff
Greg Krutzikowsky, Coastal Pelagic Species Management Team (CPSMT)
Mike Okoniewski, Coastal Pelagic Species Advisory Subpanel (CPSAS)

Acoustic-Trawl Survey Technical Team:
Kyle, A. Byers, NMFS, Southwest Fisheries Science Center
George R. Cutter, NMFS, Southwest Fisheries Science Center
David Demer, NMFS, Southwest Fisheries Science Center
Josiah Renfree, NMFS, Southwest Fisheries Science Center
Beverly J. Macewicz, NMFS, Southwest Fisheries Science Center
Juan P. Zwolinski, NMFS, Southwest Fisheries Science Center

THURSDAY, FEBRUARY 3, 2011 – 8:00 A.M.

A. Call to Order, Introductions, Approval of Agenda, and Appointment of Rapporteurs

B. Terms of Reference for the CPS Methodology Reviews
(8:30 a.m., 0.5 hour)

C. Presentation on the acoustic-trawl survey — David Demer
(9:00 a.m., 1.5 hours)

BREAK

C. Presentation on the acoustic-trawl survey (Continued) — David Demer
(11 a.m., 1 hour)

LUNCH

C. Presentation on the acoustic-trawl survey (Continued) — David Demer
(1 p.m., 1.5 hours)

D. Panel discussion — Panel
(2.30 p.m., 1 hour)

BREAK

E. Requests to FRD — Panel
(4.00 p.m., 1 hour)

FRIDAY, FEBRUARY 4, 2010 – 8:30 A.M.

F. Responses to Panel Requests (FRD) David Demer
(8.30 a.m., 2 hours)

BREAK

G. Panel discussion Panel
(11 p.m., 1 hour)

LUNCH

H. Requests to the FRD Panel
(1 p.m., 1 hour)

I. Report drafting Panel
(2.30pm, 1 hours)

BREAK

J. Responses to Panel Requests (FRD) David Demer
(4 p.m., 0.5 hours)

K. Requests to FRD Panel
(4.30 p.m., 0.5 hours)

SATURDAY, FEBRUARY 5, 2010 – 8:30 A.M.

K. Responses to Panel Requests (FRD) David Demer
(8.30 a.m., 1.5 hours)

BREAK

L. Report Drafting Panel
(11am , 1 hours)

LUNCH

M. Report review Panel
(1 p.m+)

Annex 4: Panel Summary Report (Template)

- Names and affiliations of Panel members

- List of analyses requested by the Panel, the rationale for each request, and a brief summary of the proponent's responses to each request.

- Comments on the technical merits and/or deficiencies in the assessment and recommendations for remedies.

- Explanation of areas of disagreement regarding Panel recommendations:
  - among Panel members; and
  - between the Panel and the proponents

- Unresolved problems and major uncertainties, e.g., any special issues that complicate survey estimates, estimates of their uncertainty, and their use in stock assessment models.

- Management, data, or fishery issues raised the public (i.e., non-Panel and proponent participants) at the Panel meetings.

- Prioritized recommendations for future research, and data collections and analyses.

Appendix 3: Panel Membership or other pertinent information from the review meeting.

Andre Punt (PFMC, Chair),	aepunt@u.washington.edu
Martin Dorn (AFSC),	Martin.Dorn@noaa.gov
François Gerlotto (CIE),	francois.gerlotto@ird.fr
Olav Rune Godø (CIE),	olav.rune.godoe@imr.no
John Simmonds (CIE),	ejsimmonds@googlemail.com
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G. Krutzikowsky (CPSMT),	Greg.Krutzikowsky@state.or.us
Kerry Griffin (PFMC),	Kerry.Griffin@noaa.gov
Mike Burner (PFMC),	Mike.Burner@noaa.gov
observers, and SWFC/FRD.	

Bill Michaels <William.Michaels@noaa.gov>,
Vetter Russ Russ.Vetter@noaa.gov