Center for Independent Experts (CIE) Independent Peer Review Report:
Review of Shark Predation Mitigation as a Tool for Conservation of the Hawaiian Monk Seal

Dr John Harwood

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Executive Summary

I reviewed a set of documents relating to the potential benefits of shark predation mitigation for the conservation of the Hawaiian monk seal provided by the Hawaiian Monk Seal Research Program. In general, the quality of the science underpinning these documents is high, in the case of new information on the ecology of Galapagos sharks and tiger sharks at French Frigate Shoals (FFS) it involves cutting-edge methods.

Analyses of these data reveal that preweaning mortality of monk seal pups at FFS is substantially higher than anywhere else in the species' range. Approximately half of this additional mortality can be convincingly attributed to predation by Galapagos sharks. Most of the rest of the additional mortality is probably also due to predation, but the predators responsible cannot be identified with certainty. The estimated number of pups killed by sharks fell sharply in 2007 and remained around this level in 2008 and 2009. It is not clear to what extent this reduction was the result of the removal of 12 Galapagos sharks between 2000 and 2005, and shark deterring activities since 2005.

The number of pups born each year at FFS has been falling steadily since 1984 and it has declined dramatically since 2000. It is not clear how much of this decline can be attributed to high levels of preweaning mortality. This needs to be evaluated using a simulation model of the dynamics of this colony and the other colonies in the Northwestern Hawaiian Islands. The same model could be used to assess the likely conservation benefits that might result from reducing preweaning mortality. A simple calculation suggests that even if shark kills could be completely eliminated, the population benefits would be modest. However, this needs to be confirmed by a detailed and robust analysis. I provide some suggestions for how this could be achieved.

Background

Most of this introductory paragraph is taken from the Project Description in the Statement of Work (Appendix 2) for this review. The genus *Monachus* is in crisis; with just two extant representative species, the Hawaiian monk seal offers the best chance of its persistence. However, the Hawaiian monk seal population itself is heading toward extinction. Numerous threats afflict the species across its range. Shark predation on preweaned and newly weaned pups contributes to a unique and extreme situation at French Frigate Shoals (FFS) that peaked in 1997–1999 and stands out from the trends observed at other sites in the Northwest Hawaiian Islands (NWHI). Since then, predation has declined to 6-11 pups a year. This has been described as "an unsustainable rate" as a result of falling birth rates. Galapagos sharks (*Carcharhinus galapagensis*) and tiger sharks (*Galeocerdo cuvier*) both potentially feed on marine mammals; however, the Hawaiian Monk Seal Research Program (HMSRP) has only observed Galapagos sharks attacking and killing pups in nearshore water. Mitigation activities by HMSRP conducted over the last decade include harassment of sharks, intensive observation, translocation of weaned pups, deployment of devices to deter predation, and shark removal. HMSRP has developed premises about the identity and number of sharks likely involved, shark wariness to human activity, and opinions about shark culling based on peer reviewed science, inference, expert opinion and ample experience with the situation at FFS. Permitting for removal activities continues to be decisive given the sensitive topic and that removals are occurring within a marine national monument. One point of contention is the thoroughness of the science supporting NMFS course of action. This review considers the thoroughness of that science based on documents provided by Charles Littnan, the Lead Scientist at the HMSRP and other primary literature.

Description of the Individual Reviewer's Role in the Review Activities

HMSRP provided two sets of papers and reports for this review. One set of these, contained what Dr Littnan considered to be "the primary literature necessary for this review. ... The most critical document from the monk seal perspective is the Gobush Technical Memo. The Dale (2011) and Meyer (2010) papers are the most recent information on Galapagos shark movements and population information at French Frigate Shoals." All of the documents in this set are listed in Appendix 1. In addition, two additional sets of documents were provided (in Dropbox folders named "additional references" and "secondary_readings"). Only those documents from these two additional sets that are cited in this review are listed in Appendix 1. In addition, Dr Littnan later provided a draft of a manuscript by Gobush & Farry on "Deterring Shark Predation of Monk Seals" that included the most recent estimates of monk seal pup production and shark predation at FFS.

I read and evaluated all of the documents that Dr Littnan described as primary literature, paying particular attention to the Gobush Technical Memorandum (Gobush 2010), and a number of the additional documents that appeared to be particularly relevant. This latter category includes two documents that have the same authors (Harting , Antonelis, Becker, Canja, Luers, and Dietrich) and title (Galapagos sharks and monk seals: a conundrum), but different dates (2008 and 2009). Dr Littnan kindly clarified the status of these two documents. The 2008 document was submitted to *Conservation Biology*, but was rejected. The 2009 document was revised on the basis of comments made by the reviewers of the 2008 manuscript and submitted to *Marine Mammal Science*, which also rejected it. The version of the 2009 document that was provided did not include any figures, but I believe these were virtually identical to those in the 2008 document. I therefore assumed that the text of the 2009 document was definitive, but I used the figures from the 2008 document. I will refer to the resulting hybrid document as (Harting et al. ms).

I also read all of the other documents Dr Littnan provided at least once. In addition, I accessed two other papers (Antonelis et al. 2006, and Baker & Thompson 2007) that provided useful insights into the status and dynamics of the Hawaiian monk seal population.

Summary of Findings for each Term of Reference

1) *Evaluation, findings and recommendations of data collection operations*

As indicated in the Background section, a vast amount of data has been collected on monk seals and sharks at FFS as part of the evaluation of the importance of shark predation and the potential impacts of shark removal. There is no space here to review all of the operations that were involved in collecting these data. Instead, I will focus on four topics that seem to be of particular importance: estimation of the number of pre-weaned pups at FFS that may die as a result of shark predation; estimation of the movement patterns of Galapagos sharks at FFS; evaluation of the potential vulnerability of pre-weaned monk seal pups to shark predation at FFS; and estimation of the size of the local population of Galapagos sharks at FFS.

The criteria developed by the HMSRP for identifying injuries that may have been caused by sharks (Appendix C in Gobush 2010) appear to be clearly defined and unequivocal. As a result, the estimates of the number of monk seal pups that were "probably" killed by sharks are likely to be reliable. However, I am less convinced about the attribution of all "possible" kills to shark predation (see ToRs 3 and 4, below).

The techniques that have been used to study the movements of both Galapagos and tiger sharks in the FFS are summarised very clearly in Meyer et al. (2010). The use of acoustic transmitters, in combination with recording stations, and satellite-linked transmitters that provide information on movements over a wide area and diving behaviour have provided a much clearer picture of the behaviour of these two species in FFS. However, for entirely understandable reasons, the sample sizes are very small (4 tiger sharks, 3 Galapagos sharks) and the movements of these animals are almost certainly not representative of the movements of the entire populations.

In some years (notably 1997), up to 80% of the pre-weaning monk seal mortality that is attributed to shark kills has been scored as 'possible', and overall these kills make up 64% of the total losses recorded between 1984 and 2008 (Harting et al. ms, p18). The basis for attributing 'possible' kills to Galapagos sharks is discussed below. However, these attributions would be more convincing if we knew how much overlap there was in the distribution of pre-weaned monk seal pups and Galapagos sharks away from the immediate vicinity of the pupping beaches (where both species can be observed directly) and at night. One way to obtain this information is to attach acoustic tags to pre-weaned pups. However, this is not permitted and so this issue remains unresolved.

A reliable estimate of the size of the Galapagos shark population in FFS is essential for evaluating the potential impact of removing 20-40 large/adult animals (ToR 5e). Dale et al. (2011) provide a number of estimates, based on recaptures of tagged animals. They conclude that an estimate of 668 animals, based on the Chao M_h model, is the most reliable, although a lower estimate of 371 based on the Jackknife M_h model has similar weight. However, the confidence interval for the latter estimate is entirely contained within the confidence interval for the first (289-1720), so that interval should probably be considered as the best available estimate of the likely range of population sizes for this species.

2) Evaluation and recommendations of data quality

In general, the data described above is of high quality, and has been collected and analysed using the most appropriate and up-to-date techniques. My only concerns are with the assumptions that underpin some of the analyses and the overall interpretation of the implications of the results for the effectiveness of proposed conservation actions.

3) Evaluation of strengths and weaknesses, and recommendations of analytic methodologies

See ToR. 2.

4) Evaluation and recommendations of assumptions, estimates, and uncertainty

As noted under ToR. 1, the estimate of the number of preweaned monk seals killed at FFS each year by sharks includes a large number of 'possible' kills. These are "pup disappearances for which there was no other suspected or probable cause" (other than shark predation) (Harting et al. ms, p9). Harting et al. (ms) make a convincing case that they effectively excluded disappearances that could have been caused by bad weather, and that there were no obvious sources of entanglement that could have caused these deaths. I agree with them that some form of predation is the most likely explanation for these disappearances. They note (p10) that "differentiating predation by shark species was not possible" for these disappearances. I would further caution that it is not possible to attribute these disappearances to any particular predator, although I accept that sharks are the most likely cause.

There also seems to have been an improvement in the quality of the identification of 'possible' shark kills after 2000 (Harting et al ms, p10), and there seems to be some doubt about the true number of 'possible' shark kills in 1997, when some of the kills attributed to sharks may actually have been caused by aggressive male monk seals (Harting et al. ms, p20). This is particularly relevant to an evaluation of the potential effect of shark removals (ToR. 5d), because it is often stated (e.g. Gobush 2010 pp32-33) that the removal of 50 Galapagos sharks from FFS by commercial fishers in 1999 "was associated with the greatest drop in preweaned pup losses to shark predation to date". Some of this "drop" could be the result of a more rigorous definition of 'possible' kills.

5) *Evaluation, findings, and recommendations of result interpretation and conclusions*

   a. The Hawaiian monk seal population is significantly impacted by predation on pups.

      The evaluation of this statement depends on the geographic scale at which it is applied (i.e. does it apply only to FFS, to the entire Northwestern Hawaiian islands (NWHI) population, or to the species as a whole?).

      I think the following conclusions are justified by the available data:
      preweaning mortality at FFS has been substantially higher than in any other Hawaiian monk seal sub-population since at least 1996 (e.g. Harting et al ms, Fig. 3);
      most of this additional mortality can be reliably attributed to predation (probably by sharks);
      pup production at FFS has been declining steadily since 1984, and has declined sharply since 1999 (from around 90 in 2000 to 31 in 2009 (Gobush 2010, Gobush & Farry 2011));
      "The primary factors in the FFS subpopulation's decline have been poor juvenile survival exacerbated by lower reproductive rates" (Gobush 2010, p25), the low juvenile survival is "believed to be largely due to limited foraging success (Craig and Ragen 1999)" (Harting et al. ms, p4) ;
      the contribution of preweaned pup mortality to this decline has not, as far as I can tell, been evaluated quantitative, although it is repeatedly claimed that current levels are "unsustainable" (e.g. Harting et al. ms).

      So, predation on pups at FFS is an important factor, but its contribution to the overall dynamics of the population has not been evaluated.

      The rapid decline in numbers at FFS since 1984 meant that by 2004 it was of similar size to a number of other monk seal colony in the NWHI (Antonelis et al. 2006, Fig. 3). Numbers at some other colonies have been stable or even slightly increasing since 2004, whereas FFS has continued to decline (with a 50% drop in pup production from 2004 to 2009). As a result, predation at FFS is becoming an increasing less important feature of the dynamics of the overall NWHI population. Its importance will continue to diminish, because it seems inevitable that the colony will continue to decline, even if preweaning predation can be removed, because of low levels of survival to age 4 (Baker & Thompson 2007, Fig. 5).

I provide some recommendations for obtaining a more quantitative evaluation of the role of preweaning predation, and the potential effects of its eradication, under ToR. 7.

b. The primary species of shark involved in predation of seal pups is the Galapagos shark.

   The documents provided make a strong case that 'probable' kills of preweaned pups are almost entirely the result of attacks by Galapagos sharks. However, approximately 60% of all the kills attributed to sharks since 1984 cannot be attributed conclusively to any particular shark species (Harting et al. ms, p10).

c. A relatively small number of sharks are responsible for the majority of pup predation.

   This statement is primarily based on the fact that it appears to be unusual for Galapagos sharks to prey on monk seal pups, suggesting that it is a learned behaviour that may be confined to sharks at FFS. As with ToR. 5b, this may be the case for 'probably' kills, but it is much less clear that this is the case for all kills.

d. Removing a small number of large/adult Galapagos sharks targeted in the near-shore areas near pupping islets has the potential of mitigating the predation issue.

   There seems to be two sources of direct evidence for this. The direct evidence is the reduction in total estimated shark kills that occurred after the removal of 50 Galapagos sharks from FFS by commercial fishers in 1999 (Gobush 2010), and the sharp reduction in the number of estimated shark kills that has occurred in 2007 following the removal of 12 Galapagos sharks between 2000 and 2006 (Harting et al. ms). However, there is no reason to believe that the sharks removed in 1999 were in any way associated with predation on preweaned pups, and it appears that there may have been a change in the way in which 'possible' kills were recorded after 1999 (see ToR. 4). The estimated number of shark kills remained at a relatively low level in 2008 and 2009 (Gobush & Farry 2011), even though no sharks have been killed since 2005, and only 2 sharks have been killed since 2003 (Gobush 2010, Figure 7). These results are encouraging, but they do not demonstrate cause and effect, and it remains unclear whether further shark removals (especially if, as seems likely, they are carried out in deeper water, where catch rates are higher) will result in another decrease in recorded kills.

   Harting et al (ms, pp22-28) have an excellent discussion of the arguments for and against removal of predators to benefit endangered species. They use Goodrich and Buskirk's (1995) argument that such removals are likely to be beneficial if "the problem is caused by just a few individuals". As noted under ToR. 5c, there is evidence of this for some, but by no means all, of the shark kills at FFS.

e. Removing 20-40 Galapagos sharks is unlikely to cause significant deleterious impacts on that species' population at FFS nor any other unintended ecosystem consequences.

   This depends on the time frame of the removals, the actual size of the FFS population of Galapagos sharks, and what constitutes a "significant deleterious" impact. Even if we use the lower of the two estimates (371) provided by Dale et al. (2010), the removal of up to 5 adult animals per year is unlikely to lead to a catastrophic decline in shark abundance. However, the Galapagos shark is a long-lived species that reaches sexual maturity at a higher age than the Hawaiian monk seal. Removing more animals than this would be imposing an additional mortality on this species that is of a comparable scale to the mortality Galapagos sharks are believed to impose on monk seals.

   The conclusion that removals on this scale would not have unintended ecosystem consequences appears to depend heavily on the output of runs of the Ecosim model (Harting 2010). I accept that the use of Ecosim to model the marine ecosystem in the NWHI is probably based on firmer foundations than anywhere else on the planet. However, it can only predict consequences that are the results of indirect links in the underlying model, and there are no details of the model structure in Harting (2010). I suspect that there are some linkages that may not be captured. For example, if Galapagos sharks and tiger sharks are competitors (as seems possible), a reduction in Galapagos shark numbers could result in an increase in tiger sharks in the FFS, and this could result in an increase in predation on black-footed albatross fledglings (Meyer et al. 2010).

f. The methods used to monitor shark activity and monk seal pups are adequate to characterize the level of predation.

   As noted above, the methodology appears to be adequate to characterize predation close inshore, during daylight hours.

g. The methods used to study shark movement patterns represent the best available to understand the ecology of multiple shark species at FFS.

   State-of-the-art techniques have been used to understand the ecology of Galapagos and tiger sharks at FFS, although sample sizes are (understandably) small.

h. The influence of possible covariates of predation have been adequately analyzed

   This is more difficult to address. There appears to be some correlation between the presence of sharks close inshore and the density of monk seals pups, but the management implications of this finding are not obvious to me. Nor is it clear to me how much light would be shed by additional studies of covariates of predation events along the shoreline.

i. The involvement of tiger sharks in the predation issue?

   As noted above, approximately half of the estimated shark kills can be attributed reasonably reliably to Galapagos sharks. The other kills could have been caused by tiger sharks.

j. The Galapagos sharks display site-specific movement patterns versus wide-ranging movement patterns

   The telemetry data in Meyer et al. (2010) suggest that at least some Galapagos sharks are resident within the FFS. However, the sample size is small and some of the older acoustic tag data suggest that some Galapagos sharks may travel longer distances.

6) Determine whether the science reviewed is considered to be the best scientific information available.

The overall quality of the science described in the documents provided is high. My main concerns are over the interpretation of the results from these studies and the lack of a quantitative evaluation of the relative importance of predation for the FFS colony and for the wider NWHI population (see ToR. 7).

7) Recommendations for further improvements

As noted on several occasions above, the main feature that I found lacking in the documentation was any quantitative evaluation of the impact of current and historical levels of preweaning predation on the FFS subpopulation and the NWHI populations. The same framework that is required for these calculations could also be used to examine the likely consequences of reducing this predation.

As far as I can tell, an appropriate framework already exists in the model developed by Harting in his PhD thesis (Harting 2002). I was unable to download a copy of this thesis from the Montana State University website, but I heard Harting talk about it some years ago. I suggest that his model is updated with the most recent estimates of age-specific survival for FFS, and the other colonies in the NWHI from Baker & Thompson (2007) and with the annual shark kills observed at FFS since 1984. This model could then be used to determine what contribution shark kills have made to the observed decline at FFS, and to overall changes in the abundance of the NWHI population.

Ideally, the model should be recast in a state-space modelling framework and fitted statistically to the observed time series of beach counts and pup production estimates, but that is a major undertaking. As an interim measure, the model could be tuned to match the observed time series of pup production estimate for FFS. Once this tuning has been achieved, the model could be projected forward with different annual levels of shark kill (e.g. current levels (around 6 pups per year), increased levels (say 12 pups per year), and a number of different reduced levels (4, 2, 0 for example) to evaluate the likely benefits to both the local (FFS) and NWHI populations from shark removals.

On the basis of the evidence currently available, I think the potential benefits from shark removals are purely speculative and appear to be rather small. For example, even if shark predation could be reduced to zero from its current level (around 6 pups per year since 2007), this would probably only result in one additional female recruiting to the breeding population at FFS each year (based on the sex-specific survival rates for FFS in Baker & Thompson 2007). This will clearly be of limited benefit to a population where pup production has declined by 50% in the last 5 years. In practice, given how difficult it is to catch Galapagos sharks in shallow water around monk seal breeding beaches, any improvement in recruitment is likely to be less.

8) Conclusions and Recommendations in accordance with the ToRs.

The general quality of the science in the documents provided for this review was high and, particularly in the case of the data on shark ecology, involves state-of-the-art methods.

However, I feel that there has been too much reliance on qualitative expert opinion in the evaluation of the available data. Although this has led to conclusions that appear entirely reasonable:

- preweaning mortality at FFS is high,
- most of that mortality is probably caused by sharks,
- all of the sharks observed attacking monk seals are Galapagos sharks,
- Galapagos sharks appear to be resident in FFS and preying on monk seals appears to be unique to FFS,
- therefore removing some Galapagos sharks from FFS must benefit the monk seal population

I suspect that a thorough quantitative analysis of the likely consequences of shark removals may reveal that this is unlikely to be cost-effective in terms of monk seal conservation because of the large uncertainties involved and the high levels of juvenile mortality experienced by this population. I therefore recommend a modelling analysis along the lines described in ToR. 7.

Appendix 1: Bibliography of materials provided for review and additional literature cited (*)

*Antonelis, G.A., Baker, J.D., Johanos, T.C., Harting, A.L., 2006. Abundance of the Hawaiian Monk Seal (*Monachus schauinslandi*): status and conservation issues. *Atoll Research Bulletin* **543**, 75-101.

*Baker, J.D. & Thompson, P.M. 2007. Temporal and spatial variation in age-specific survival rates of a long-lived mammal, the Hawaiian monk seal. *Proceedings of the Royal Society, Series B* **274**, 407-415.

Dale, J.D., Stankus, A.M., Burns, M.S. & Meyer, C.G. 2011. The Shark Assemblage at French Frigate Shoals Atoll,nHawai‘i: Species Composition, Abundance and Habitat Use. *PLoS ONE* **6** (2).

Gobush, K.S. 2010. Shark Predation on Hawaiian Monk Seals: Workshop II & Post-Workshop Developments, November 5-6, 2008. NOAA Technical Memorandum NMFS-PIFSC-21.

Gobush, K.S. & Farry, S.C. 2011. Efforts to deter shark predation of Hawaiian monk seal pups. Unpublished ms.

*Harting, A.L. 2002. Stochastic simulation model for the Hawaiian monk seal. PhD. Dissertation. Montana State University, Bozeman, Montana, USA.

Harting, A.L. 2010. Shark Predation on Hawaiian Monk Seals Workshop Honolulu, Hawaii. January 8-9, 2008. Pacific Islands Fisheries Science Center.

Harting , A.L., Antonelis, G.A., Becker, B.L., Canja, S.M., Luers, D.F. & Dietrich, A. ms. Galapagos sharks and monk seals: a conundrum. Manuscripts submitted to *Conservation Biology* and *Marine Mammal Science*.

Meyer, C.G., Papastamatiou, Y.P. & Holland, K.N. 2010. A multiple instrument approach to quantifying the movement patterns and habitat use of tiger (*Galeocerdo cuvier*) and Galapagos sharks (*Carcharhinus galapagensis*) at French Frigate Shoals, Hawaii. *Marine Biology*.

Appendix 2: A copy of the CIE Statement of Work

Attachment A: Statement of Work for Dr. John Harwood

External Independent Peer Review by the Center for Independent Experts

Review of shark predation mitigation as a tool for conservation of the Hawaiian monk seal

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

Project Description: The genus *Monachus* is in crisis; with just two extant representative species, the Hawaiian monk seal offers the best chance of its persistence. However, the Hawaiian monk seal population itself is heading toward extinction. Numerous threats afflict the species across its range. Shark predation on preweaned and newly weaned pups contributes to a unique and extreme situation at French Frigate Shoals (FFS) that peaked in 1997–1999 and stands out from the trends observed at other sites in the Northwest Hawaiian Islands (NWHI). Since then, predation has declined to 6-11 pups a year, an unsustainable rate as a result of falling birth rates. Galapagos sharks (*Carcharhinus galapagensis*) and tiger sharks (*Galeocerdo cuvier*) both potentially feed on marine mammals; however, the Hawaiian Monk Seal Research Program (HMSRP) has only observed Galapagos sharks attacking and killing pups in nearshore water. Mitigation activities by HMSRP conducted over the last decade include harassment of sharks, intensive observation, translocation of weaned pups, deployment of devices to deter predation, and shark removal. HMSRP has developed premises about the identity and number of sharks likely involved, shark wariness to human activity, and opinions about shark culling based on peer reviewed science, inference, expert opinion and ample experience with the situation at FFS. Permitting for removal activities continues to be decisive given the sensitive topic and that removals are occurring within a marine national monument. One point of contention is the thoroughness of the science supporting NMFS course of action. This review is of particular importance as NMFS considers applying for additional permits in the future. The Terms of Reference (ToRs) of the peer review are attached in **Annex 2**.

Requirements for CIE Reviewers: Three CIE reviewers shall conduct an impartial and independent peer review in accordance with the SoW and ToRs herein. The combined expertise among the CIE reviewers shall consist of working knowledge and recent experience in shark ecology, marine mammal ecology, population viability, conservation of endangered species, wildlife management and/or predator control. Each CIE reviewer's duties shall not exceed a maximum of 10 days to complete all work tasks of the peer review described herein.

Location of Peer Review: Each CIE reviewer shall conduct an independent peer review as a desk review, therefore no travel is required. Each reviewer will communicate with the Pacific Islands Fishery Science Center (PIFSC) Project Contact or the appropriate designated PIFSC staff by email and phone during the course of the review.

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

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

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

Desk Review: Each CIE reviewer shall conduct the independent peer review in accordance with the SoW and ToRs, and shall not serve in any other role unless specified herein. **Modifications to the SoW and ToRs can not be made during the peer review, and any SoW or ToRs modifications prior to the peer review shall be approved by the COTR and CIE Lead Coordinator.** The CIE Lead Coordinator can contact the Project Contact to confirm any peer review arrangements.

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

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

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) Conduct an independent peer review in accordance with the ToRs (**Annex 2**).
3) No later than October 28, 2011, each CIE reviewer shall submit an independent peer review report addressed to the "Center for Independent Experts," and sent to 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. Each CIE report shall be written using the format and content requirements specified in Annex 1, and address each ToR in **Annex 2**.

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

September 28, 2011	CIE sends reviewer contact information to the COTR, who then sends this to the NMFS Project Contact
October 4, 2011	NMFS Project Contact sends the CIE Reviewers the report and background documents
October 7-21, 2011	Each reviewer conducts an independent peer review as a desk review.
October 28, 2011	CIE reviewers submit draft CIE independent peer review reports to the CIE Lead Coordinator and CIE Regional Coordinator
November 16, 2011	CIE submits the CIE independent peer review reports to the COTR
November 23, 2011	The COTR distributes the final CIE reports to the NMFS Project Contact and regional Center Director

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

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

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

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

Support Personnel:

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

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

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

3. The reviewer report shall include the following appendices:

   Appendix 1: Bibliography of materials provided for review
   Appendix 2: A copy of the CIE Statement of Work

Annex 2: Terms of Reference

Review of shark predation mitigation as a tool for conservation of the Hawaiian monk seal

7) Evaluation, findings and recommendations of data collection operations
8) Evaluation and recommendations of data quality
9) Evaluation of strengths and weaknesses, and recommendations of analytic methodologies
10) Evaluation and recommendations of assumptions, estimates, and uncertainty
11) Evaluation, findings, and recommendations of result interpretation and conclusions
    a. The Hawaiian monk seal population is significantly impacted by predation on pups.
    b. The primary species of shark involved in predation of seal pups is the Galapagos shark.
    c. A relatively small number of sharks are responsible for the majority of pup predation.
    d. Removing a small number of large/adult Galapagos sharks targeted in the near-shore areas near pupping islets has the potential of mitigating the predation issue.
    e. Removing 20-40 Galapagos sharks is unlikely to cause significant deleterious impacts on that species' population at FFS nor any other unintended ecosystem consequences.
    f. The methods used to monitor shark activity and monk seal pups are adequate to characterize the level of predation.
    g. The methods used to study shark movement patterns represent the best available to understand the ecology of multiple shark species at FFS.
    h. The influence of possible covariates of predation have been adequately analyzed
    i. The involvement of tiger sharks in the predation issue?
    j. The Galapagos sharks display site-specific movement patterns versus wide-ranging movement patterns
12) Determine whether the science reviewed is considered to be the best scientific information available.
13) Recommendations for further improvements
14) Brief description on panel review proceedings highlighting pertinent discussions, issues, effectiveness, and recommendations