ATTACHMENT D ***EVOSTC Annual Program Status Summary Form***

Form Rev. 10.3.14

*Please refer to the Reporting Policy for all reporting due dates and requirements.

1. Project Number: *See*, Reporting Policy at III (D) (1).

15120111

2. Program Title: *See*, Reporting Policy at III (D) (2).

Herring Research and Monitoring Program

3. Program Lead Name(s): *See*, Reporting Policy at III (D) (3).

W. Scott Pegau

4. Time Period Covered by the Summary: *See*, Reporting Policy at III (D) (4).

1 February 2015 to 31 January 2016

5. Date of Summary: *See*, Reporting Policy at III (D) (5).

February 2016

6. Program Website (if applicable): *See*, Reporting Policy at III (D) (6).

http://pwssc.org/research/fish/pacific-herring/

7. Overview of Work Performed during the Reporting Period: *See*, Reporting Policy at III (D) (7).

This report covers the third year of work associated with the Herring Research and Monitoring (HRM) program. A detailed discussion of the findings of the program can be found in the synthesis titled, "Pacific herring in Prince William Sound: A synthesis of recent findings" that was submitted to the *Exxon Valdez* Oil Spill Trustee Council and available at http://pwssc.org/wp-content/uploads/2014/12/HRM-synthesis.pdf.

The goal and objectives of the HRM program are as follows.

Goal: Improve predictive models of herring stocks through observations and research.

Objectives

1) *Provide information to improve input to the age-structure-analysis (ASA) model, or test assumptions within the ASA model.*

2) *Inform the required synthesis effort.*

3) *Address assumptions in the current measurements.*

4) *Develop new approaches to monitoring.*

Program highlights

1) *Provide information to improve input to the age-structure-analysis (ASA) model, or test assumptions within the ASA model.*

- Disease prevalence consistent with other areas.

- Acoustic survey indicated a possible sharp decline in the adult population, but the spring spawn was broken up and late.
- Spawning was observed off Montague Island and fish were collected.
- Aerial surveys indicate a moderate age-1 class in 2015. This is consistent with the fall 2014 observations.
- The presence of a large age-3 year class is inconclusive. Not enough samples were collected in PWS, but one of four was almost all age-3 and large age-3 year classes were reported on either side of PWS.
- The population model indicated importance of previous egg deposition and disease surveys.
- A meta-analysis of herring stock variability has started.
- Condition of age-0 fish in the spring was similar to other years in spite of record warm temperatures.
- Trawl surveys show inter-annual differences in juvenile herring distribution.
- There was a change in P.I. for the acoustic survey projects.

2) *Inform the required synthesis effort.*

- A synthesis was presented to the EVOSTC Science Panel.
- Historic scale growth has been connected to environmental conditions in the Gulf of Alaska.
- A synthesis of *Ichthyophonus* in herring was published.

3) *Address assumptions in the current measurements.*

- There was a change in P.I. for the acoustic survey projects resulting in a reanalysis of the data.

4) *Develop new approaches to monitoring.*

- A chromogenic in situ hybridization (CISH) assay capable of detecting *Ichthyophonus has* been developed.

Program summary

To address the first objective by improving inputs to the ASA model we continued to monitor for disease prevalence, expanded the acoustic surveys for adult biomass, surveyed for juvenile herring using acoustic and aerial surveys, and monitored the condition of age-0 herring. The disease prevalence is consistent with other regions where similar monitoring is taking place. Acoustic surveys of adult herring found that the fish were spread out and in unusually small schools. This led to an estimated spawning biomass of 9-12 metric tons. This represents a large decline in the estimated spawning population. We are investigating how the record warm water temperatures may have affected the population. The program had been predicting a large age-3 recruitment to the spawning population. That was expected to lead to spawning late and in unusual areas. ADF&G and our surveys of the spawning population were too early to observe the primary spawning so we cannot say if the age-3 year class did join, but the spawning was late, there was an unusually large spawn event on Montague Island, and large age-3 year classes were reported in Kodiak and Sitka.

The aerial surveys for providing an index of age-1 herring continued. This year there were over 1300 schools of age-1 herring observed in June. This is nearly double the median numbers of schools observed in the past six years. This was a little unexpected because the warm winter temperatures were expected to

lead to greater starvation. The project worked with the forage fish project of the Gulf Watch Alaska program to continue providing aerial surveys of forage fish. A stratified-random sampling designed was used in July in conjunction with the forage fish surveys. This year there was more directed effort on fish identification from the aircraft and repeated surveys of one location to help define observation variability. There were little to no capelin observed in the aerial surveys this year.

The condition of age-0 herring in March 2015 was similar to slightly better than in many of the previous years even though the water temperatures were unusually high through the winter (Figure 1). Our working hypothesis has been that warm water temperatures leads to higher winter metabolism and hence a greater energy loss should be expected during a warm winter. That hypothesis may be incorrect, or this is an indication of the importance of winter feeding.

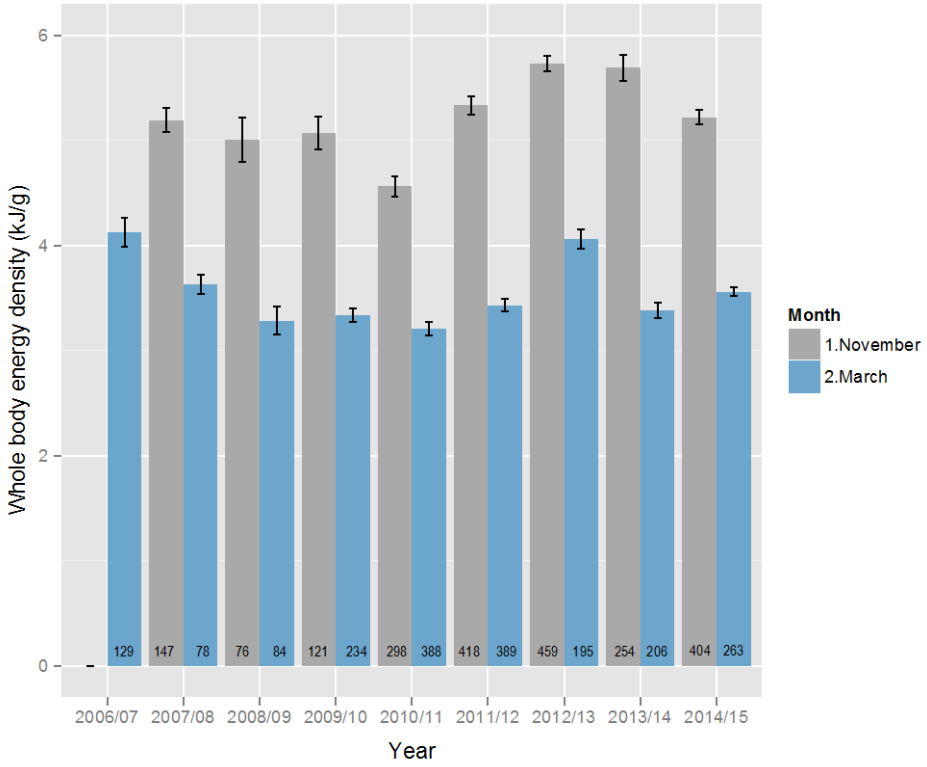

Figure 1. Whole body energy density of age-0 herring over time. In spite of the warm water temperatures during the winter of 2014-2015 the energy density of fish in March was similar to other years.

The Bayesian version of the ASA model was modified to accept inputs from the age-0 and age-1 surveys. It was also used to examine the most informative and cost effective inputs to the model. The disease prevalence was needed to match the collapse of the herring population in 1992-1993. The cost of disease prevalence measurements was low, so it ranked highest for benefit to cost. The egg deposition data was assumed to be the most accurate population estimate and found to be important in the past. The high cost of the data caused it to rank low for benefit to cost.

Of continued interest is the determination of age of first maturity. Preliminary analysis indicates that we were unable to determine age of first spawn from scale growth patterns, but histology proved to work.

The second objective deals providing information for the synthesis that has now been submitted to EVOSTC. More details about our understanding of herring can be found in that synthesis. We have continued to work with data from the herring scale analysis, which was used to examine the relationship between growth in the first year and environmental conditions. There is a strong correlation between growth in the first year and diatom abundance and weaker relationships to water temperature and zooplankton abundance in the Gulf of Alaska (Figure 2). It appears that fish need to be > 85 mm to be likely to reach an age that the fish can spawn this length

corresponds to a change in energetic allocation from growth to lipid storage. This suggests that herring must reach a size where they can increase lipid storage if they are to live to a spawning age.

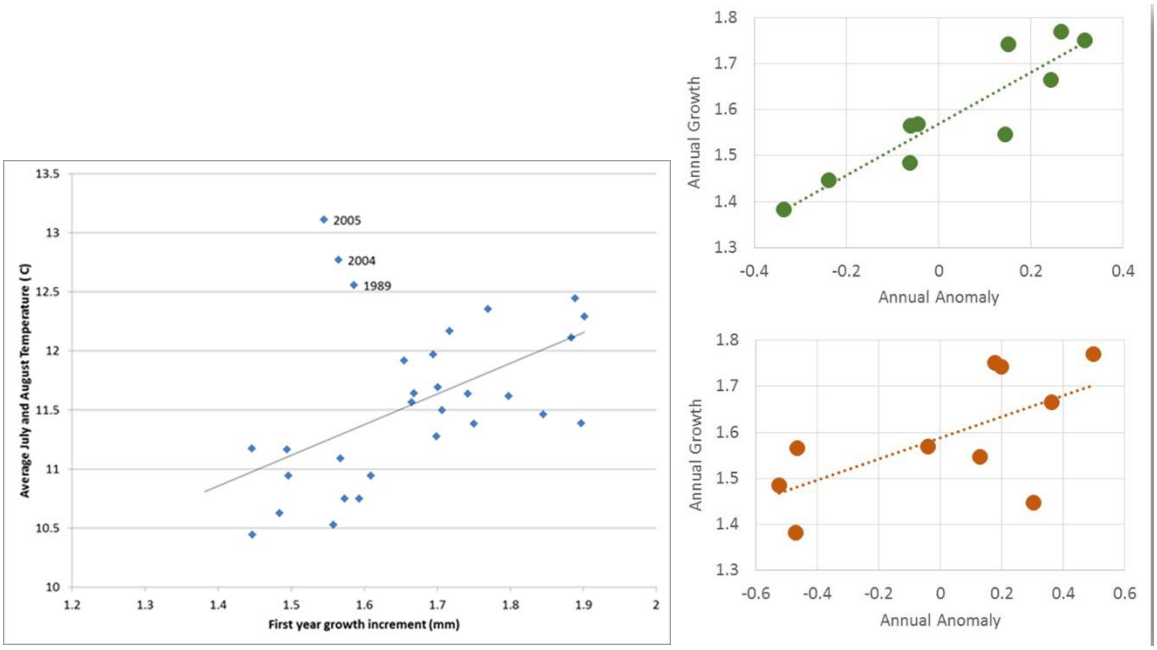

Figure 2 Age-0 growth versus temperature (left), diatom abundance anomaly from the CPR (upper right), and zooplankton abundance anomaly from the CPR (lower right). The 2004 and 2005 years that are anomalies in the temperature relationship are included in the diatom and zooplankton data.

In addressing the assumptions in measurements objective, the herring energetics intensive, acoustics intensive, and fatty acid projects are completing analysis and are working on final reports. The energetics information is being combined with information from the fatty acids project to determine minimum energetic and lipid levels exist in living herring to help understand minimum survivable conditions. The information is also showing that there are spatial differences in diets that affect the condition of the herring. It also shows that feeding occurs during the winter and the smaller, lipid-poor herring are feeding the most.

A study of the external signs of *Ichthyophonus* showed that they were not a precursor to mortality or a reliable metric for determining the date of exposure. However, the long term persistence of external signs of *Ichthyophonus* may still be useful in determining population-level impacts of the disease.

During the November juvenile herring surveys we deployed an autonomous surface vessel (ASV) to survey waters inshore of the normal acoustic surveys. The ASV detected much higher fish densities in the nearshore waters than are observed along the traditional acoustic survey tracks. This demonstrates the potential for large fluctuations in acoustic estimates of juvenile herring abundance depending on how the fish are distributed within a bay. The results are also consistent with the hypothesis that age-0 herring prefer to be in shallower waters.

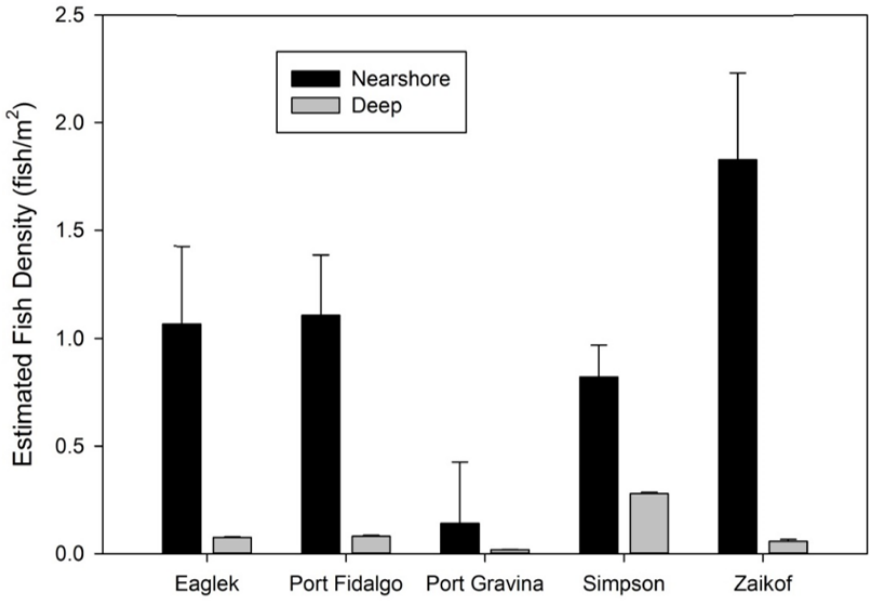

Figure 3. Acoustic density estimates during the November 2015 cruise. Dark bars are estimates derived from ASV sampling, and grey bars are from the traditional acoustic survey tracts.

In addressing the new approaches to monitoring most of the recent effort has been in analyzing results of previous testing. A new approach to detecting the presence of *Ichthyophonus* was developed. It uses a chromogenic in situ hybridization (CISH) assay to detect *Ichthyophonus* nucleic acid in standard histology sections. This provides greater ability to detect the presence of *Ichthyophonus* in archival samples and non-piscine intermediate hosts.

Community and Resource Managers

Results from the acoustic surveys of adult spawning biomass and disease prevalence work were provided to ADF&G for use in their ASA model.

We involved the fishing community in collection of juvenile herring in March instead of a dedicated scientific cruise to collect the fish necessary for the over wintering condition studies. Results of the program were presented to members of Cordova District Fishermen United. Working with both pilots and fishermen has improved communication between the scientists and the community and we are benefiting from more rapid reports of observations. It is through these communication lines that we are getting more reports about the summer distributions of fish and reports of herring spawn in a timely enough manner to allow ADF&G to collect the information they need. We continue to work with ADF&G and pilots in the area that are interested in making spawn observations to test protocols for data collection and reporting that can provide greater coverage of the spawn season.

Problems

Dr. Buckhorn was replaced by Dr. Rand this year. We arranged to contract with Dr. Boswell to provide technical support for the acoustics projects.

The expanded adult herring survey was unable to survey the main herring population in 2015 due to the fish not being aggregated during the cruise dates. We continue to explore means to increase flexibility in cruise dates to optimize our search effort. We are investigating means of determining the locations of staging grounds for fish spawning on Montague Island.

We expect that the ADF&G budget will not include funding to continue the surveys that they normally complete. These are critical inputs to the ASA model and for our understanding of the status of herring in Prince William Sound. We will need to find a way to cover these surveys if the state is unable to conduct them.

Other Significant Information

We found that age-0 herring from the Cordova Harbor have an usually high prevalence of *Ichthyophonus* and that the prevalence rapidly increases in May and June.

We have two positive indications for a moderately strong 2014 year class in spite of record winter water temperatures.

8. Information and Data Transfer: *See*, Reporting Policy at III (D) (8).

a) Publications

Batten, S.D., S. Moffitt, W.S. Pegau, and R. Campbell *In Press*. Plankton indices explain interannual variability in Prince William Sound herring first year growth. Fisheries Oceanography.

Conway, C.M., M.K. Purcell, D.G. Elliott, P.K. Hershberger. 2015. Detection of *Ichthyophonus* by chromogenic *in situ* hybridization. Journal of Fish Diseases 38: 853-857.

Hart, L.M., C.M. Conway, D.G. Elliott, P.K. Hershberger. *In Press*. Persistence of external signs in Pacific herring *Clupea pallasii* with ichthyophoniasis. Journal of Fish Diseases.

Hershberger, P.K., J.L. Gregg, L.M. Hart, S. Moffitt, R. Brenner, K. Stick, E. Coonradt, T. Otis, J. J. Vollenweider,K. A. Garver, J. Lovy, T.R. Meyers. *In Press*. The parasite *Ichthyophonus* sp. in Pacific herring. Journal of Fish Diseases.

Hershberger P.K., L.M. Hart, A.H. MacKenzie, M.L. Yanney, C. Conway, D. Elliott 2015. Infecting Pacific herring with *Ichthyophonus* sp. in the laboratory. Journal of Aquatic Animal Health 27: 217-221.

Muradian, M.L. 2015. Modeling the population dynamics of herring in the Prince William Sound, Alaska. MS thesis. School of Aquatic and Fishery Sciences, University of Washington, Seattle.

Muradian, M.L., T.A. Branch, S.D. Moffitt, and P-J. F. Hulson. *In review* Bayesian Stock assessment of Prince William Sound herring, Alaska. Fisheries Research.

Six articles were published in the Delta-Sound Connections.

b) Conferences: At the 2016 Alaska Marine Science Symposium there were eight posters and one oral presentation. Presentations on the herring disease program occurred at five venues. The modeling effort presented at the herring summit in B.C. Several investigators reported results at the Cordova community lecture series.

c) Data and information products: Disease prevalence numbers and acoustic estimates of adult herring biomass were provided to Alaska department of Fish and Game. Two Field Notes radio broadcasts were produced.

d) Data sets and metadata uploaded to data portal: We worked with Axiom to restructure the herring workspace and ensure that data on the workspace is up to date. Nearly 600 gigabytes of data was added to the workspace. A majority of that were raw acoustic files from the juvenile herring surveys and intensive. Updated data was provided by the energetics and conditions projects, herring scale analysis, aerial surveys, age at first spawn, disease, acoustic validation, and tracking projects.

9. Coordination and Collaboration: *See*, Reporting Policy at III (D) (9).

a) Within the HRM program fish captured by the validation project is provided to the acoustics, genetics, energetics, and disease projects. Data from the direct capture efforts are also used by the non-lethal sampling project. The energetics project processes juvenile herring for the disease project. They are also captured and processed fish from the Cordova harbor to provide a time series of disease prevalence and the energetic content of those fish. The disease project is working with the population modeling project to evaluate the best methods to incorporate disease prevalence data and how to bridge the change in methodology that occurred in 2007. The aerial survey project assists in collection of fish for the genetics project. The herring scale project provided hundreds of scale images to the age at first spawn project for their analysis. The coordination, outreach, and data management projects work with all other projects.

Vessels were shared between the HRM and Gulf Watch Alaska (GWA) programs for collection of acoustics data during a humpback whale cruise, and bird observations during the November herring cruises. The aerial survey project is a collaboration between the herring program and the forage fish project in GWA. Aircraft time, survey methods, and results are shared between the projects. The HRM program has begun using data and expertise from the environmental drivers projects, particularly the continuous plankton recorder and PWS oceanography study to examine how environmental conditions affect growth of herring and to explain the migration patterns of tagged herring and the spatial patterns in stable isotopes and fatty acids. The disease component is receiving zooplankton from Dr. Campbell to determine if zooplankton may be a source of the ichthyophonus disease. We continue to follow the research of the bird and mammal projects to understand how to best incorporate their observations for understanding the predation pressure on herring.

b) We do not have direct collaboration with other EVOSTC funded projects.

c) There are investigators from US Geological Service and the National Oceanic and Atmospheric Administration that provide a link to those trustee agencies. Most of the collaboration is with Alaska Department of Fish and Game through Steve Moffitt at the Cordova office and Sherri Dressel as the statewide herring coordinator. ADF&G supports sampling for disease prevalence in adult herring, provides samples for the genetics projects, and provides several datasets and model results used for management. Data from the acoustic surveys of adult populations and disease prevalence data is provided to ADF&G for use in their age-structure-analysis (ASA) model. Adult herring collected from locations not sampled by ADF&G are provided to them for age-sex-length analysis. We provide information about findings to ADF&G and seek input on their needs.

10. Response to EVOSTC Review, Recommendations and Comments: *See*, Reporting Policy at III (D) (10).

See review, recommendations, and responses below. Responses are in italics.

FY15 comments

Next year, the Panel would like to see improvements in:

Inclusion of fundamental information

The Panel would like to see the inclusion in proposals of information regarding the 1) approach, design and analysis of studies and 2) explicit statements of how analyses are answering major questions. This key information is essential to evaluating proposals, and we expect to see brief descriptions included in the next set of proposals. We are not requesting that detailed descriptions be provided to the degree exhibited in original proposals or publications; PIs should use their expertise to identify and include essential, fundamental information that should be included to facilitate review. Good examples of the level expected detail include the GulfWatch proposals by Carls, Jones, and Piatt and the Marine Debris Removal proposal by Pallister (available on the EVOSTC website).

> *This message was sent to each of the P.I.s as they developed year 5 proposals.*

The Science Panel would also appreciate having more detail about how the herring programs contribute to the existing and proposed herring assessment process and model. In particular it would be useful to have a short paragraph on each of the tuners used in the model: spawn assessments and acoustic data.

> *Descriptions of the ADF&G and Bayesian models were provided to the EVOSTC staff for distribution to the Science Panel prior to the synthesis meeting.*

The Panel appreciates that any additional requests for information in proposals can be perceived as onerous and that the Panel had indicated in prior years that they did not want the entire original proposal text included every year. However, the minimal, essential information requested should not take long to incorporate and could remain in subsequent proposals. From a Panel perspective, proposals cannot be evaluated without key, fundamental information on major hypothesis and models, in part so changes to the design can be placed in proper context. We appreciate your efforts in refining your multi-year proposal submissions.

Planning Succession Necessitated by Attrition of Experienced Personnel

This continues to be an area of concern for the Panel. The departure of Michele Buckhorn, who serves as the lead PI for three of the twelve submitted projects, could have a large impact on the overall success of the Program. We understand from our discussion with Scott that they are working to address the issue but feel that this highlights the issue of a need for junior scientists to be trained within the projects so smooth transitions in scientific personnel.

The Panel continues to support efforts to increase future capacity with regard to PIs turnover and continues to encourage that post-docs be integrated into the programs.

> *We are trying to ensure we have a means to replace personnel if they leave the program. For each project a person has been identified to cover for a PI if they depart. There are impacts during the transitions, but we feel we can ensure critical components continue while a new PI is brought on. Dr. Buckhorn was a junior scientist that was under the tutelage of Dr. Thorne. Unfortunately, the junior scientists are most likely to move as they find other opportunities. We were able to bring on Dr. Rand to replace Dr. Buckhorn with minimal interruption. At this point the post-docs are funded through NCEAS and we don't have the ability to influence their projects to provide benefit to our program.*

Improved data submission by Herring Program PIs

We understand that many PIs in the Herring program are behind in providing metadata and data to the central data repository. With the new forms that have been developed, and the availability of assistance from Axiom staff, it is important for each PI to comply with the data submission requirements set forth as a condition of their funding.

> *Data submission to the Ocean Workspace is up to date and the PIs are getting better at ensuring data is updated on a regular basis. At this point we need to work on the metadata submission. Almost all of the PIs have met with Axiom staff to get training on data and metadata submission.*

Coordination & Collaboration/Synthesis

The Panel appreciated the programs' explicit statements recognizing the synergisms among project efforts. It is clear that most projects are already working together where it is practical or advantageous to the achieving the goals of individual projects. We also appreciated that the programs recognized the need to integrate data across projects to arrive at a synthetic view of the status and trends of herring populations in PWS. However progress in these areas will need to be more explicit and fully developed. Details provided to the Panel were too limited to be able to truly evaluate progress in this area. Discussion on the conference call with the PI was encouraging in that details of the stock models will be provided to the panel in advance of the February synthesis meeting.

The details on the stock models were provided as requested. Hopefully the level of detail provided in the synthesis, during the science review, and in this report helps to make the collaborations more obvious. There have always been close ties between the two programs at the administrative level, but we are gaining connections between individual projects. The requirement of the synthesis as a deliverable this past year was a great driver for developing those connections.

FY16 comments

The Science Panel was pleased with the progress of the individual projects and the overall Program. The Panel is gratified to see several new and younger scientists with fine and promising records of past preparation and accomplishments. For example, the progress made already by Dr. Gorman to work through the backlog of samples left after the departure of Tom Kline is impressive. Dr. Pegau's active leadership is critical to the study's success and especially to achieving important syntheses among separate projects.

We hope this comment reflects the effort we made to address earlier concerns of the Science Panel.

11. Budget: *See,* Reporting Policy at III (D) (11).

Budget Category:	Proposed FY 12	Proposed FY 13	Proposed FY 14	Proposed FY 15	Proposed FY 16	TOTAL PROPOSED	ACTUAL CUMULATIVE
Personnel	$201,500.0	$377,300.0	$535,700.0	$506,700.0	$518,000.0	$2,139,200.0	$1,191,307.0
Travel	$26,800.0	$31,500.0	$47,000.0	$47,300.0	$46,600.0	$199,200.0	$101,234.0
Contractual	$336,960.0	$544,799.0	$456,188.0	$435,116.0	$362,757.0	$2,135,820.0	$1,684,652.0
Commodities	$81,600.0	$33,700.0	$104,100.0	$102,700.0	$67,100.0	$389,200.0	$255,570.0
Equipment	$187,200.0	$0.0	$0.0	$0.0	$0.0	$187,200.0	$221,569.0
Indirect Costs (*will vary by proposer*)	$108,500.0	$173,030.0	$168,200.0	$161,100.0	$144,370.0	$755,200.0	$510,385.0
SUBTOTAL	$942,560.0	$1,160,329.0	$1,311,188.0	$1,252,916.0	$1,138,827.0	$5,805,820.0	$3,964,717.0
General Administration (9% of subtotal)	$84,830.4	$104,429.6	$118,006.9	$112,762.4	$102,494.4	$522,523.8	
PROJECT TOTAL	$1,027,390.4	$1,264,758.6	$1,429,194.9	$1,365,678.4	$1,241,321.4	$6,328,343.8	
Other Resources (Cost Share Funds)	$0.0	$0.0	$0.0	$0.0	$0.0	$0.0	N/A

Most of the discrepancy in spending can be traced to projects with personnel changes that led to reduced spending during the transition. All investigators are aware that spending must be completed this fiscal year and have plans to use any remaining funds to increase analysis efforts.

We appreciate your prompt submission and thank you for your participation.