ATTACHMENT B. Annual Project Report Form (Revised 11.21.19)

1. Project Number:

20120111-C

2. Project Title:

Modeling and stock assessment of Prince William Sound herring

3. Principal Investigator(s) Names:

PI: Trevor A. Branch.

Researchers: John Trochta, David McGowan, Beatriz Dias

4. Time Period Covered by the Report:

February 1, 2020-January 31, 2021

5. Date of Report:

March 2021

6. Project Website (if applicable):

https://pwssc.org/herring/

7. Summary of Work Performed:

Assessment model: In previous years, the age structured assessment (ASA) model run by the Alaska Department of Fish and Game (ADF&G) was expanded and updated to include a Bayesian formulation which naturally weights the input data sources, and better characterizes uncertainty through estimating Bayesian posteriors (Muradian et al. 2017). In addition, the assessment model was used to determine which historical data sets were the most informative given the trade-off between information gain and cost (Muradian et al. 2019).

The Bayesian age structured assessment (BASA) model continued to evolve since it was published. Since Muradian et al. (2019), the BASA model now also fits to aerial surveys of age-1 school sizes and run with a state-of-the-art, vastly more efficient estimation algorithm called the No-U-Turn-Sampler (NUTS), which was programmed into AD Model Builder by Cole Monnahan as part of additional efforts in the Branch lab to improve stock assessment methods (Monnahan et al. 2007, Monnahan and Kristensen 2018, Monnahan et al. 2019). This allows a much broader array of sensitivity tests to be run on the model in a Bayesian context and facilitates rapid evaluation of alternative models.

Preliminary results are shown from the BASA model fit to data up to and including 2020 (Figs. 1-3). It provides a good fit to the age composition data (Fig. 1), except for age-3 herring in 1987 and 1998. In 2019 the model estimates there to be a strong 2016 year-class, with a high proportion of age-3s, of a size not seen since 2002 (Fig. 2). Consequently, as the remaining cohort entered the population as age-4s in 2020, biomass continued to increase in 2020 as shown in milt and acoustic data that are fit well by BASA (Fig. 3). The median spawning biomass estimate in 2020 was approximately 21,000 metric tons which is above ADF&G's lower cut-off for fishing. However, uncertainty in this estimate indicates there is a 40% probability that 2020 spawning biomass was below the lower cut-off.

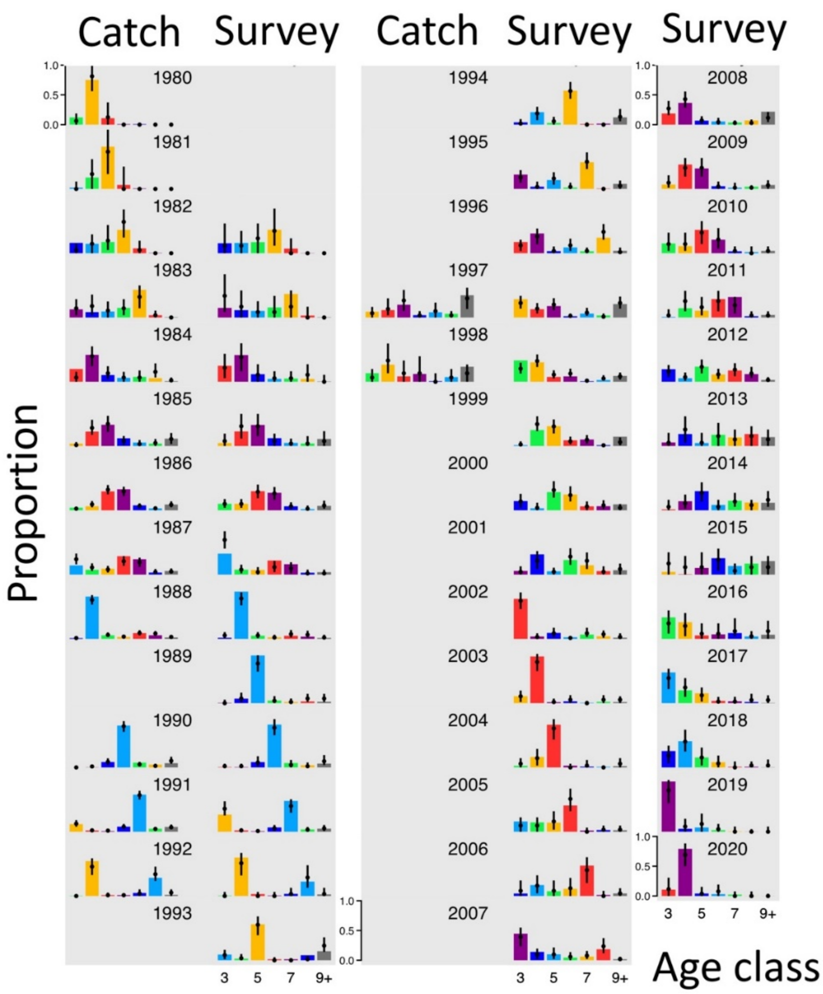

Figure 1. Draft fits of the Bayesian age structured assessment model (points = median, lines = 95% posterior predictive intervals) to the preliminary 2020 numbers at age data from catches and surveys (bars). Each color follows a single cohort as it ages through the fishery. Data are available only for ages-3 and above. Note the very large age-3 cohort in 2019.

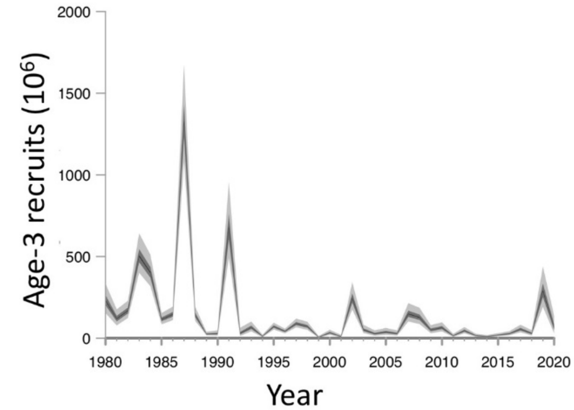

Figure 2. Bayesian age structured assessment estimates of numbers of age-3 recruitment in millions with 95% credibility intervals (light gray shading).

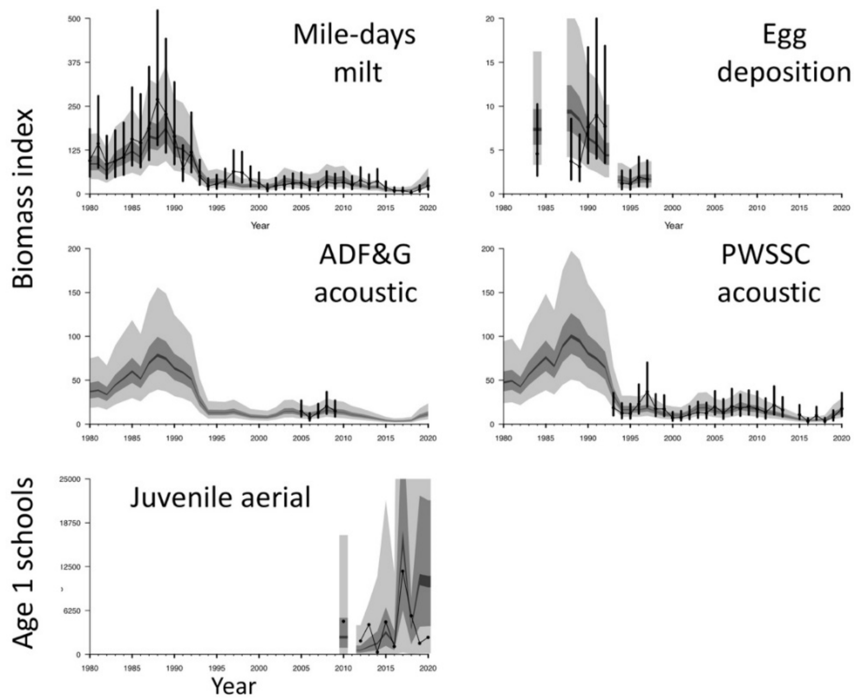

Figure 3. Estimated survey biomass from Bayesian age structured assessment (shading showing 50% and 95% posterior predictive intervals in dark and light gray, respectively) compared to indices of biomass in the population (points and lines showing observation CV). Continuing increases in both acoustic and milt indices for 2020, resulted in increased biomass (21,000 t, 95% CI 14,390-30,950 t), which is above the lower cut-off for fishing, but with a wide range of uncertainty.

Even though the juvenile (age-1 schools) aerial survey index from 2017 was the largest in the available record and agrees with large numbers of age-3s and -4s observed in 2019 and 2020, the juvenile aerial indices may still not be a reliable predictor of age-3 recruitment in every year. Model fits to age-1 school data continue to have wide uncertainty and show higher predictions in 2019 and 2020 because the cohorts that were age 1s in these years have not yet been observed as age-3s in the age composition, in which BASA shrinks age-1 predictions to the mean recruitment overall years. If the small juvenile aerial indices in 2019 and 2020 indeed reflect the eventual age-3s in 2021 and 2022, respectively, then low recruitment at background levels of the 2010s is expected in upcoming years. This would cause spawning biomass to stabilize and then decline in 2021 and 2022, as the 2016 cohort ages out of the population.

These BASA results (Figs. 1-3) are preliminary as we await final estimates of survey errors, but we anticipate the results to not change in the final run for 2020.

Sensitivity analysis for maturity: As part of the 2019 Synthesis Report, we evaluated different assumptions about maturity in the BASA model (11 in total) that bound the potential effects of mis-specifying maturity because of uncertainty in the mature vs. immature composition of the schools targeted by seine and cast net sampling. For example, fixed fast vs. slow maturity schedules, one maturity schedule for all years vs. two different schedules split at 1997, and a number of more esoteric options. The 11 models had negligible impact on biomass and recruitment estimates but had some implications for model stability. Therefore, we simplified the base BASA model to the most stable model option, which involved estimating one period of maturity instead of two as in Muradian et al. (2017), with the value of maturity also including availability of herring to sampling.

Global herring meta-analysis: The meta-analysis on global herring populations was published in Fish and Fisheries (Trochta et al. 2020). The key findings based on data from 64 herring populations, are that herring are more prone to collapses and recoveries than non-forage-fish taxa, and more frequently display strong year classes. Biomass recovery was most rapid in herring populations with high median recruitment, higher variability in sea surface height anomalies and higher variability in sea surface temperatures.

Factors affecting Prince William Sound herring mortality and recruitment: An in-depth analysis was conducted of the potential effects of ecological factors on Prince William Sound herring recruitment and mortality. In the latest version of these analyses, we now include more robust model selection techniques (Pareto-smoothed importance-sampled leave-one-out cross-validation, PSIS-LOO) and explore alternative assumptions about incorporating covariates (e.g., where they are fit as data). Only one covariate had widespread support across model selection criteria (3 of 4 criteria; Fig. 4), and that was adult pink salmon numbers which were associated with higher adult herring mortality. Weaker evidence was shown for walleye pollock adult abundance reducing herring mortality, North Pacific Gyre Oscillation (NPGO) increasing mortality, humpback whales increasing mortality, juvenile hatchery pink salmon decreasing recruitment, and a 1989 regime shift decreasing recruitment. Furthermore, the BASA model may be overly permissive of a variety of hypotheses, in which the dynamics of mortality or recruitment may be partially explained by many of the factors we explored. Trochta just successfully defended his PhD and this analysis is ready for submission to a peer-reviewed journal.

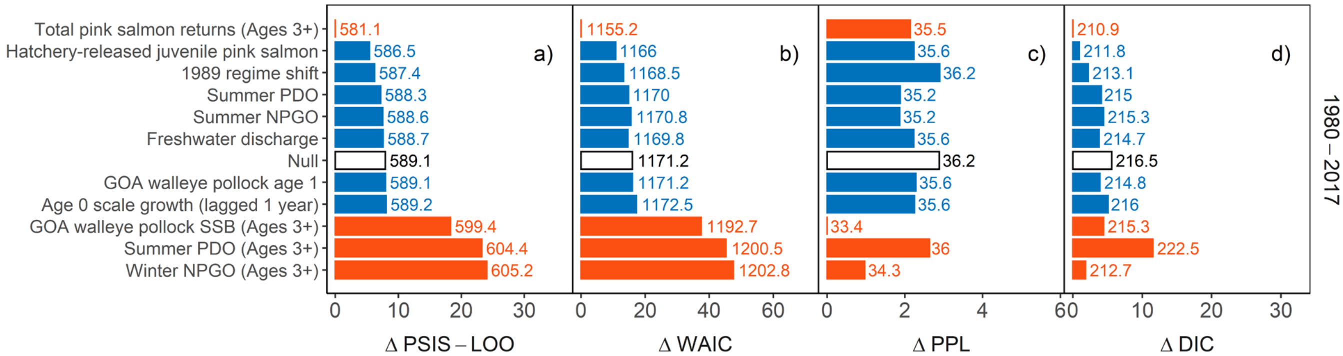

Figure 4. Model selection values across the most supported covariates for herring adult mortality (red) and recruitment (blue). The covariates (y-axis) are ordered from the most to least supported as shown by the lowest values across all criteria. Each subplot represents a different criterion from Bayesian model selection ordered from most to least robust. The criteria are Pareto-smoothed importance-sampled leave-one-out cross-validation scores (PSIS-LOO), Watanabe-Akaike Information Criterion (WAIC), Posterior predictive loss (PPL), and Deviance Information Criterion (DIC). The Null factor represents a model without any covariate effect and provides a benchmark for covariates to improve upon. Source: J. Trochta, PhD dissertation.

Simulating viral hemorrhagic septicemia virus (VHSV) outbreaks to examine the utility of antibody data within BASA: One poorly modeled component of the BASA model is the incorporation of disease prevalence data. There is the potential of novel antibody detection data (from principal investigator [PI] Paul Hershberger, project 21120111-E) to better inform the severity of VHSV outbreaks over time. We conducted a simulation analysis to test the accuracy and precision of estimates of annual infection rates and disease mortality from simulated antibody data. The analysis included a model of the truth that simulated more realistic disease dynamics by combining an epidemiological and an age-structured population model; and an estimation model simplified from BASA that takes antibody data as input and estimates time-and-age varying mortality due to disease. Simulations demonstrated that antibody data can provide accurate estimates of infection and mortality, whereas the current historical method of using prevalence data for VHSV in BASA results in biased estimates of biomass and recruitment (Fig. 5). Using antibody data improves model population estimates even if other sources of natural mortality are ignored, although improvements may be small if these other sources are more substantial. Incorrect assumptions regarding when herring are first exposed to transmission from the reservoir population (the host of the virus) and how samples for antibody testing are collected (e.g., non-random due to deliberately increasing sample sizes of ages with fewer fish) may however degrade the accuracy of estimates. A draft of this work is ready for submission once J. Trochta defends his PhD in February 2021.

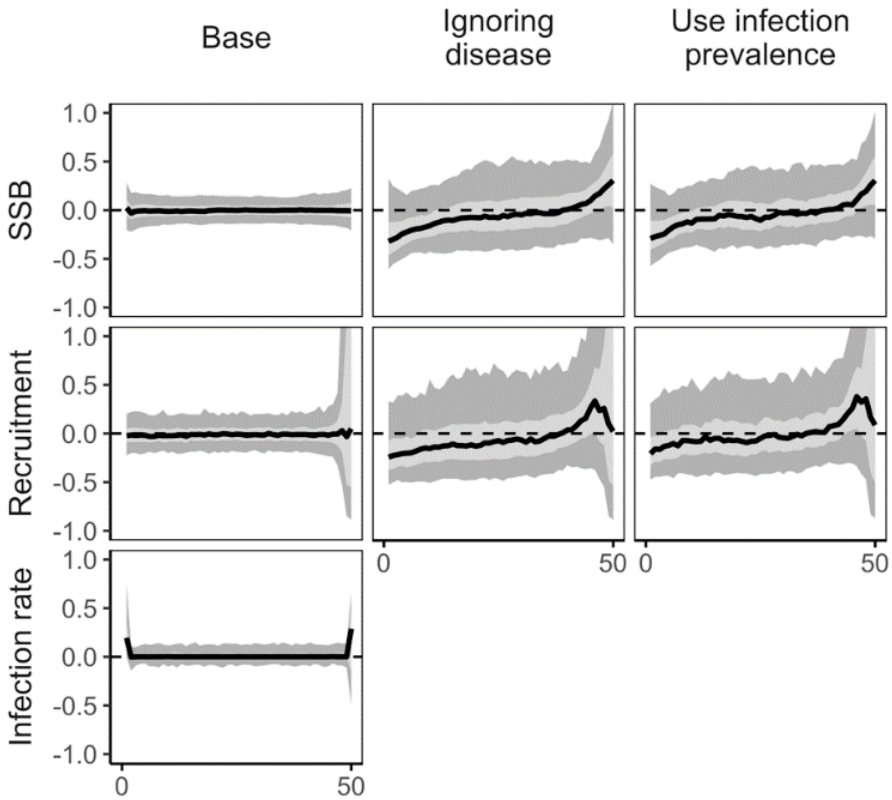

Figure 5. Time trajectories of error in estimates of spawning biomass (SSB), recruitment, and annual infection rate across 50 years of simulation from three scenarios. The Base scenario has disease outbreaks in the model of the truth and inputs simulated antibody data to estimate infection; Ignoring Disease uses the same model of the truth as the Base scenario but does not use antibody data; Use Infection Prevalence uses the same model of the truth but uses a simulated infection prevalence index identical to the one used for viral hemorrhagic septicemia virus (VHSV) in the Bayesian age structure assessment. Relative error is calculated between the actual values (from the operating model) and the estimated values (from the estimation model) for SSB and Recruitment. The raw error is calculated for the infection rates (i.e., estimated – truth). The black denotes the median relative error or error across converged simulations, the light gray denotes the inner-50th percentiles, and dark denotes inner-95th percentiles. Source: J. Trochta, PhD dissertation.

Incorporating VHSV antibody data into the BASA model: Age-specific antibody data from 2012-2020 from P. Hershberger (project 20120114-E) were input into BASA. Using the equations from our simulation study, we estimated population-level infection, mortality, and immunity from VHSV (Fig. 6). Generally, low infection is estimated in recent years, with the highest infection rate in 2014. Population immunity increased as abundance decreased from 2008-2015, but since decreased with the addition of a large (susceptible) age-3 cohort to the spawning population in 2019. The model estimates that ~65% of herring infected with VHSV die, which is fairly large disease mortality. One crucial caveat to these results is that BASA assumes the detected antibodies reflect all forms of immunity; however, herring may exhibit other immune responses not captured by the current tests. This implies the disease-related estimates in Fig. 6 are lower bounds to the true disease impacts (VHSV infection is underestimated and mortality is overestimated). We are closely working with P. Hershberger to determine what proportion of the true immunity his tests capture and how best we should incorporate these data before finalizing their use within BASA.

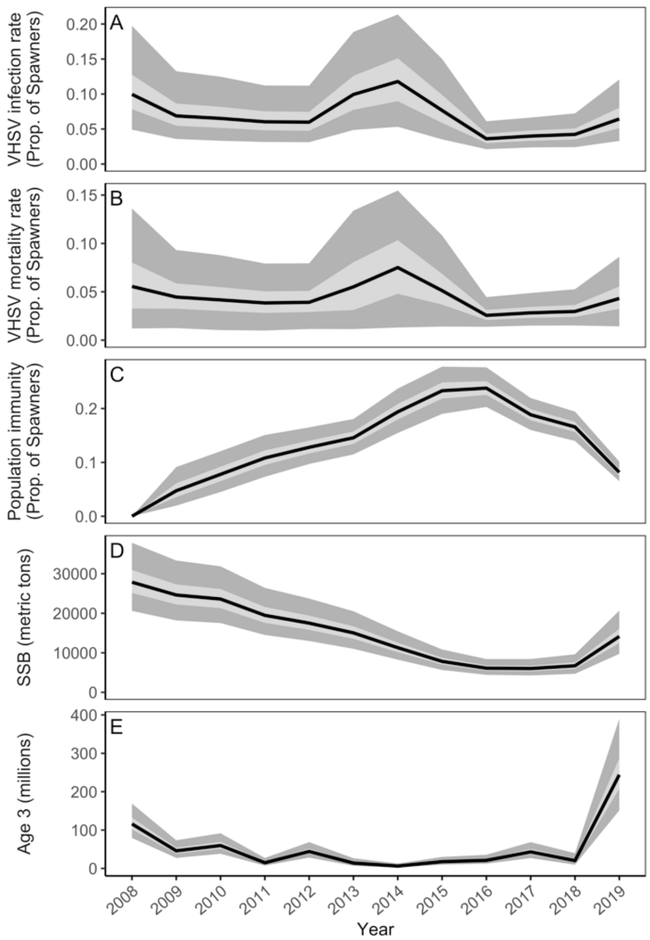

Figure 6. Bayesian estimates of disease and population levels over recent years from the Prince William Sound herring stock assessment. From top to bottom are time series estimates of the annual infection rate of viral hemorrhagic septicemia virus (VHSV) within only the mature numbers, or spawners, of the population (VHSV infection rate); the proportion of spawners that are lost to disease (VHSV mortality rate); the proportion of spawners that contain antibodies and have immunity at the beginning of each year (Population immunity); spawning stock biomass (SSB); and recruitment numbers at age-3 (Age 3). The black line denotes the median estimate from the posterior distribution, light gray the 50% credibility interval, and dark grey the 95% credibility interval. Source: J. Trochta, PhD dissertation.

Multi-decadal shifts in distribution and timing of Pacific herring in Prince William Sound: Work by David McGowan was completed in February 2020 but has been revised in response to ADF&G internal review and is briefly summarized here. Spawning patterns from aerial surveys were examined to describe patterns, finding that spawning shifted from historically productive regions towards the southeastern regions of Prince William Sound and contracted in space from 65% of historically occupied spawning areas to less than 9% (Fig. 7). Median spawn date shifted earlier by 26 days (eastern) and 15 days (western) from 1980 to 2006 and then shifted later in timing by a similar amount in just seven years.

This paper is complete and ready for submission to the *Canadian Journal of Fisheries and Aquatic Sciences*.

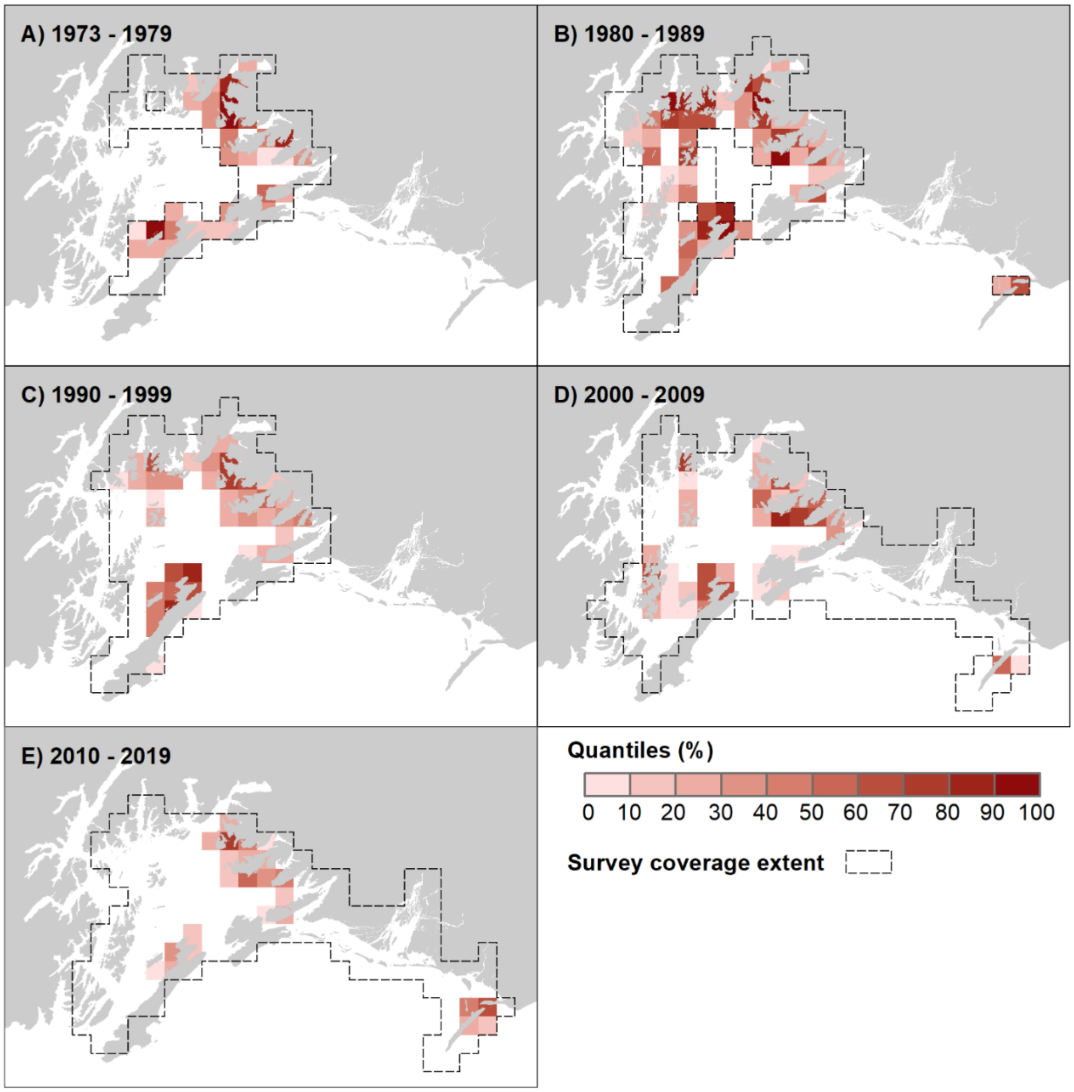

Figure 7. Distribution of spawning and extent of survey coverage from 1973 to 2019 by decade.

Factors influencing changes in herring spawn timing: The postdoctoral fellow (Beatriz dos Santos Dias) assessed which population, environmental and climatological data are associated with Prince William Sound herring spawn timing variability. This study continues efforts led by David McGowan and colleagues in which they estimated the spatio-temporal variability of herring spawning. Spawn timing displayed large decadal changes that coincided with shifts in ocean temperature. Between 1980 to 2006, the median spawn date shifted earlier by 25 to 30 days in eastern Prince William Sound and by 15 days in western Prince William Sound (Figs. 8 and 9). We explored a variety of potential drivers of these timing shifts: 1) population factors—aerial survey biomass index (mile-days of milt), mean age, and condition factor; 2) environmental variables—satellite derived Prince William Sound March and April sea surface temperature, Prince William Sound modeled freshwater input, winter, fall and spring downwelling index, winter and fall meridional and zonal winds, and Gulf of Alaska fall, spring and winter sea surface temperature; and 3) climatological variables—multivariate El Niño Southern Oscillation (ENSO) index, Pacific Decadal Oscillation (PDO), Pacific/North American teleconnection pattern (PNA), NPGO.

Spawn timing was earlier for the eastern region (Fig. 9). Population level factors were different in each region, earlier spawning was associated with older mean age in the Western Prince William Sound, while in the Eastern portion, earlier spawning was associated with lower mile-days of milt. Earlier spawning is also related to higher modeled freshwater input. Large short term (pulse effects) and long term (press effects) freshwater inflows can offer cues to trigger life history events, such as spawning in riverine, anadromous, and estuarine fish populations (Jonsson 1991, Taylor et al. 2014, Walsh et al. 2015), but in marine populations there are few studies examining freshwater input cues for spawn timing. However, it is well described that warm regimes in ocean temperature are correlated to changes in freshwater input, wind patterns and water column mixing, which leads to shifts in marine productivity. Ward et al. (2017) found that years with higher freshwater discharge produced lower than average fish productivity.

Another factor associated with years of earlier spawning is the weakening of winter meridional winds and downwelling index. Based on the lake-river hypothesis (Mooers and Wang 1998) these conditions disable strong throughflow from the Gulf of Alaska shelf to Prince William Sound, that will cause the young of the year herring to rely only on Sound production, which may affect their overwinter conditions in warmer years (Cooney et al. 2001, Gorman et al. 2018). Within the tested climate variables, the best model showed earlier spawning is driven by positive phase PNA. The PNA consists of anomalies in the heigh of pressure surface above mean sea level. A positive PNA phase is marked by warmer conditions in the North Pacific (Wallace and Gutzler 1981). The study highlights the main variables associated to earlier spawning for Prince William Sound herring. These environmental conditions were also linked to poor juvenile herring overwinter survival (Cooney et al. 2001, Gorman et al. 2018).

The manuscript for this work is currently being drafted and will be submitted to the *Canadian Journal of Fisheries and Aquatic Sciences*.

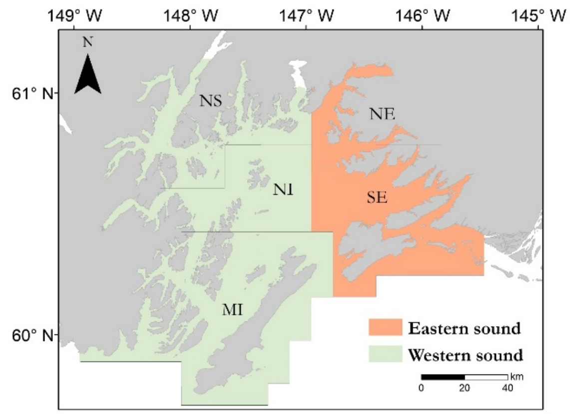

Figure 8. Observed trends in aerial survey data and population, environmental and climatological conditions for the best model. Data are from Dias et al. (in prep.).

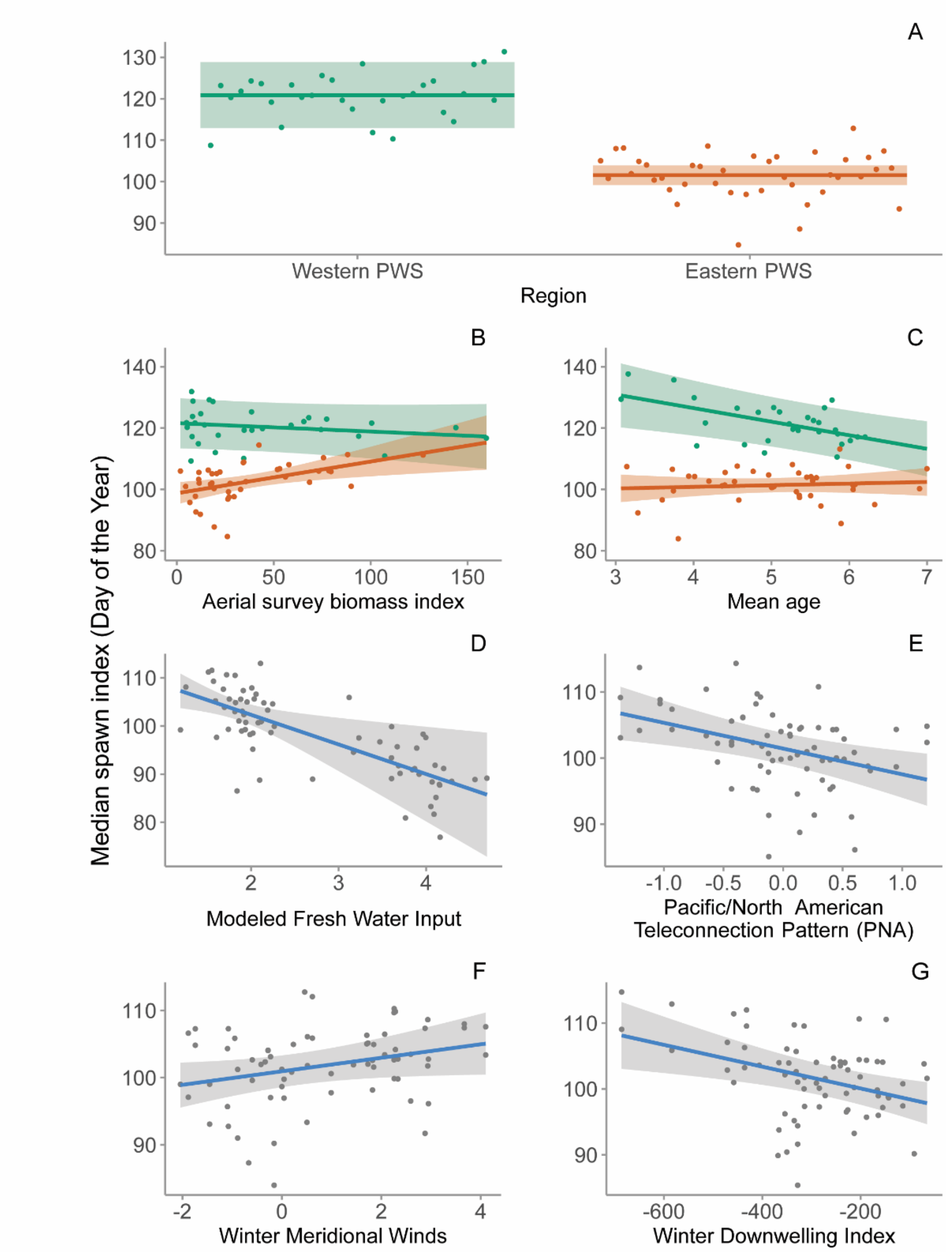

Figure 9. Observed trends in aerial survey data and population, environmental and climatological conditions for the best model. Data are from Dias et al. (in prep.).

Personnel changes:

Postdoc David McGowan departed the project at the start of 2020 for a permanent position at the National Oceanic and Atmospheric Administration (NOAA), and the final year of the postdoc funding was used to fund Beatriz Dias.

PhD student John Trochta defended his PhD in February 2021 and has accepted a permanent position with the Institute of Marine Research in Bergen, Norway, starting April 2021.

Postdoc Beatriz Dias has accepted a postdoc position with the University of Alaska Fairbanks starting in May 2021.

The PI is planning to take on a new MS/PhD student starting in September 2021 to work on the management strategy evaluation of Prince William Sound herring, for the next ten-year phase of this project, and to conduct the 2021 herring stock assessment.

Given these changes, there will be a personnel gap between May and September 2021 on the project.

8. Coordination/Collaboration:

A. Long-term Monitoring and Research Program Projects

1. Within the Program

Close collaboration and coordination with the components of the Herring Research and Monitoring program are an integral part of the modeling project, including assumptions going into the model, data collection (milt survey, acoustic survey, numbers at age, age at maturity, and other data). In addition, the development of the antibody data involves working closely with the disease component of the program.

2. Across Programs

a. Gulf Watch Alaska

David McGowan and Beatriz Dias have been collaborating with Rob Campbell with the Gulf Watch Alaska program on modeling the effects of environmental drivers on where herring spawning occurs and how it has changed over time, and on the effects of environmental drivers on spawn timing in Prince William Sound.

b. Data Management

Data and model outputs are being uploaded as they become available to the Gulf of Alaska Data Portal.

B. Individual Projects

A collaboration between John Trochta, David McGowan, and Alec MacCall (retired NOAA scientist) to incorporate the spatio-temporal information of the aerial milt surveys into the age-structured assessment model was put on hold with the departure of McGowan and imminent departure of Trochta to full-time jobs.

C. With Trustee or Management Agencies

Coordination with ADF&G scientists (e.g., Stormy Haught) is ongoing and required for data inputs collected by ADF&G and used in the BASA stock assessment model.

9. Information and Data Transfer:

A. Publications Produced During the Reporting Period

1. Peer-reviewed Publications

Published

Chong, L., T.K. Mildenberger, M.B. Rudd, M.H. Taylor, J.M. Cope, T.A. Branch, M. Wolff, and M. Stäbler. 2020. Performance evaluation of data-limited, length-based stock assessment methods. ICES Journal of Marine Science 77:97-108.

Hilborn, R., R.O. Amoroso, C.M. Anderson, J.K. Baum, T.A. Branch, C. Costello, C.L. de Moor, A. Faraj, D. Hively, O.P. Jensen, H. Kurota, L.R. Little, P. Mace, T. McClanahan, M.C. Melnychuk, C. Minto, G.C. Osio, A.M. Parma, M. Pons, S. Segurado, C.S. Szuwalski, J.R. Wilson, and Y. Ye. 2020. Effective fisheries management instrumental in improving fish stock status. Proceedings of the National Academy of Sciences U.S.A. 117:2218-2224.

Trochta, J.T., T.A. Branch, A.O. Shelton, and D.E. Hay. 2020. The highs and lows of herring: A meta-analysis of patterns and factors in herring collapse and recovery. Fish and Fisheries 21:639-662.

White, E.R., H.E. Froehlich, J.A. Gephart, R.S. Cottrell, T.A. Branch, R.A. Bejarano, and J.K. Baum. 2020. Early effects of COVID-19 on US fisheries and seafood consumption. Fish and Fisheries 22:232-239.

In prep.

McGowan, D.W., T.A. Branch, S. Haught, and M.D. Scheuerell. (undergoing internal review). Multi-decadal shifts in the distribution and timing of Pacific herring (*Clupea pallasii*) spawning in Prince William Sound, Alaska. Canadian Journal of Fisheries and Aquatic Sciences.

Trochta, J.T., and T.A. and Branch. (in prep.) Application of multiple methods of Bayesian model selection to ecological covariates in stock assessment. Canadian Journal of Fisheries and Aquatic Sciences.

Trochta, J.T., Groner, M.L., Hershberger, P.K., and T.A. Branch. (in prep.). A better way to account for disease in fisheries stock assessment: the powerful potential of seroprevalence data. Canadian Journal of Fisheries and Aquatic Sciences.

2. Reports

Not applicable.

3. Popular articles

Dias, B.S. 2021. About time. Delta Sound Connections

Trochta, J.T. 2020. Herring in their home environment: What matters? Delta Sound Connections p. 13.

McGowan, D.W. 2020. Big changes in where herring spawn in Prince William Sound. Delta Sound Connections p. 13.

B. Dates and Locations of any Conference or Workshop Presentations where EVOSTC-funded Work was Presented

1. Conferences and Workshops

Dias, B.S., D.W. McGowan, R. Campbell, and T.A. Branch. 2020 What affects spawning phenology of herring (*Clupea pallasii*) in Prince William Sound? Oral presentation. Alaska Marine Science Symposium.

Dias, B.S., D.W. McGowan, and T.A. Branch. 2020 Influence of environmental and population factors on herring spawn timing in Prince William Sound. Oral presentation. PICES Workshop VW6.

Trochta, J.T., M.L Groner, P.K. Hershberger, and T.A. Branch. 2021. Using antibody data to quantify disease impacts in fisheries stock assessment. Oral presentation. Alaska Marine Science Symposium, Anchorage, AK, USA.

Trochta, J.T., M.L. Groner, P.K. Hershberger, and T.A. Branch. 2020. Using antibody data to improve estimates of natural mortality in fisheries stock assessment. Invited talk. Quantitative seminar. School of Aquatic and Fisheries Science, Seattle, WA, USA.

Trochta, J.T. 2020. The rise of Bayesian: A stock assessment story. Invited talk. American Fisheries Society 150th Annual Meeting, Virtual.

Trochta, J.T., and T.A. Branch. 2020. Challenges to estimating maturity in stock assessment: a case study of Pacific herring in Prince William Sound, AK. Invited talk. Think Tank Seminar Series. School of Aquatic and Fisheries Science, Seattle, WA, USA.

Trochta, J.T., and T.A. Branch. 2020. Hard of herring: Detecting effects on herring survival from a noisy environment in the Gulf of Alaska. Invited talk. Alaska Department of Fish and Game, Juneau, AK, USA.

2. Public presentations

None

C. Data and/or Information Products Developed During the Reporting Period, if Applicable

Stock assessment of Prince William Sound herring for 2020.

D. Data Sets and Associated Metadata that have been Uploaded to the Program's Data Portal

Uploaded the BASA model and results using 2020 data. Metadata on the workspace summarizes the data sets and how to run the model, while detailed instructions and descriptions are contained within READ_ME files and line comments within the code. The upload includes: AD Model Builder files to run model, R code to pre-process data for model & post-process model output, figures and tables of key model output (fits to data, estimates of biomass and recruitment, parameter estimates), and raw model output (read in by R code to produce figures and tables).

10. Response to EVOSTC Review, Recommendations and Comments:

Sept 2020: Science Panel Comment – FY21: Science Panel Comments: The SP congratulates the PIs on their progress in multiple lines of investigation. The publication of their global analysis of herring demonstrated the unusually long period of low biomass and low recruitment in PWS herring compared to other herring populations around the world.

In proposal 21120114-O, the SP noted a statement that humpback whales consume about 20% of the herring biomass -- the same amount that the fishery harvested annually. If this is true, then perhaps whale predation should be more prominently included in the model. A similar comment can be made about seabird predation. The SP looks forward to attempts to reconcile the relative importance of whales and seabirds to herring among proposals. Perhaps there is conflicting evidence (or assumptions) among the different projects within the HRM program? In Figure 4, humpback whale counts are mentioned and a brief explanation is offered with the conclusion that whales are not important (indeed, the coefficient relating summer whale counts to herring is positive, perhaps more suggesting of bottom-up influence of herring on whale counts). Also, in Figure 4, hatchery pink salmon demonstrate a negative effect, but they are not given much explanation in the text. As there is some ongoing interest in the role, if any, of hatchery pink salmon on the lack of herring recovery, further explanation would be appreciated.

Branch response to Science Panel:

The inclusion of whale predation could be integrated into the stock assessment, given reliable estimates of whale consumption. Other stock assessments have directly incorporated predator-prey relationships by linking population dynamics of the predator with the prey dynamics, but this requires a lot of data (e.g., time series of diet data, consumption rates, estimates on predator survival and growth, etc.). While we are not immediately aware of conflicting evidence amongst projects, the availability of predator (both whale and seabird) data and modeling approaches should be discussed with the other PIs to explore informing the stock assessment and clarify any potential issues. We should note that two different whale time series are explored (the first is model estimates of total whale abundance in the summer, and the second is observed counts, not total abundance, in winter). The model accounts for the different seasons in which these time series are available. In addition, the effect estimates are modeled on mortality, so a positive humpback whale effect implies a top-down influence of whales. Finally, our conclusion on the unimportance of humpback whales hinges on model selection criteria results (not shown), which indicated that despite an estimated positive effect of humpback whales on herring mortality, model fits were not improved substantially compared to models without a humpback whale effect on mortality. The same also applies to the negative effect of hatchery pink salmon (while there may be some effect, our modeling suggests most of the variability in Prince William Sound herring recruitment remains unexplained). Thus, while effects of these factors are suggested, they are uncertain and currently offer no benefit yet in improving stock assessment precision or accuracy.

Sept 2020: Science Panel Comment – FY21: The SP appreciates the implications of the departure of postdoc Dr. McGowan and the lag in start-up of replacement postdoc Dr. Dias on deliverables from this project. Despite his move to another position, will Dr. McGowan be able to publish his work on spatio-temporal patterns in herring spawning? Does his current employment allow an ability to wrap up other work he started? Specifically, what planned project work will no longer be completed? We look forward to Dr. Dias' work on the relationship between physical and population factors that may drive variability in spawning timing.

Branch response to Science Panel:

The work by Dr. McGowan on spatio-temporal patterns has been ready for submission to a journal but was delayed for almost a year by ADF&G internal review. Planned follow-up work by Dr. Dias is being written up now.

Sept 2020: Science Panel Comment – FY21: What are the program and project contingency plans for FY21 in regard to accomplishing goals and field activities? The SP understands that it may be challenging to develop extensive and detailed contingency plans for the future, but some planning is required. Will any unused funds for FY21 be repurposed for additional lab and/or data analyses? Or will they be requested to rollover to FY22 (pending proposal approval)?

Branch response to Science Panel:

This project is relatively unaffected by COVID, except that the PI has extra teaching burden due to preparation for online teaching. However, key personnel are leaving for permanent positions which will cause a gap in project progress this year. Unused funds will be repurposed for salary and to hire temporary personnel if possible.

Sept 2019: Science Panel Comment – FY20: The Science Panel is pleased with overall project progress and appreciates the ongoing multiple lines of investigation. The panel complements the PI and postdoc on the number of publications completed and in progress. While we very much appreciate collaborative efforts with Maya Groner to include disease dynamics in the model, we have concerns with connections to the disease data. The model does not include age structure; however, age structure influences disease. There are inconsistencies in proposal A and this proposal regarding the inclusion of the disease data in the model. Please see more detailed Science Panel comments about disease modeling under herring proposal 20120111-A (postdoc).

Branch response to Science Panel:

We apologize for not including sufficient information in the description of the disease model. The disease model indeed does include age structure, without which it would be almost impossible to estimate the severity of disease in each year. We are currently running simulations to determine what information could be extracted from the immunity data in terms of annual severity, additional annual mortality, and the degree to which each age group is susceptible to disease. Nothing similar has ever been included in stock assessments of other species.

Sept 2019: Science Panel Comment – FY20: The proposal indicated that the BASA model overestimated herring biomass relative to survey data. This was interpreted as model misspecification. Investigations into this model misspecification included placing different priors on survey coefficient of variation, allowing for autocorrelated recruitment, and fixing the sex ratio. In addition, the Science Panel wondered whether changes in natural mortality M could be an additional potential explanation worth examining.

Branch response to Science Panel:

One of the projects being done by PhD student Trochta, is examining factors that may influence changes in natural mortality, and results are almost ready for inclusion in future reports.

Sept 2019: Science Panel Comment – FY20: The panel noted that milestones and tasks were changed as the postdoc position evolved. These changes seem appropriate. The analysis of spatial variability in spawning looks to be a fruitful avenue of research. The Science Panel wondered if changes in spawning distribution could be related to historical serial depletion by fisheries. ADFG fish ticket data by stat area might provide some insights into this possibility. However, the panel appreciates that analyses of spatial distribution could be very substantial and time consuming.

Branch response to Science Panel:

Dr. McGowan has examined spatial distribution of fishing, which shifted substantially over time. Further analysis of the fish ticket statistical areas data is planned, and some data issues need to be resolved at this point. Nevertheless, our initial impression is that shifts in fishing reflect shifts in the fish distribution, rather than fishing causing serial depletion, which results in shifts in spatial distribution of the fish. This is bolstered by continued large changes in spatial distribution in the absence of fishing post-collapse.

11. Budget:

Budget Category:	Proposed FY 17	Proposed FY 18	Proposed FY 19	Proposed FY 20	Proposed FY 21	TOTAL PROPOSED	ACTUAL CUMULATIVE
Personnel	$48.7	$138.2	$144.3	$152.4	$64.8	$548.4	$ 447.3
Travel	$6.4	$13.7	$12.1	$9.3	$6.9	$48.4	$ 15.6
Contractual	$0.0	$0.0	$0.0	$0.0	$0.0	$0.0	
Commodities	$25.1	$25.7	$26.1	$25.0	$24.2	$126.1	$ 88.6
Equipment	$0.0	$0.0	$0.0	$0.0	$0.0	$0.0	
Indirect Costs (*will vary by proposer*)	$33.8	$86.9	$90.0	$91.6	$40.7	$343.0	$ 265.6
SUBTOTAL	$114.0	$264.5	$272.5	$278.3	$136.6	$1,065.9	$817.1
General Administration (9% of subtotal)	$10.3	$23.8	$24.5	$25.0	$12.3	$95.9	N/A
PROJECT TOTAL	$124.3	$288.3	$297.0	$303.3	$148.9	$1,161.9	
Other Resources (Cost Share Funds)	$0.0	$0.0	$0.0	$0.0	$0.0	$0.0	

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