Exxon Valdez **Oil Spill Trustee Council**

Long-Term Research and Monitoring, Mariculture, Education and Outreach

Annual Project Reporting Form

Project Number: 22120111-C

Project Title: Modeling and stock assessment of PWS herring

Principal Investigator: Trevor A. Branch, School of Aquatic and Fishery Sciences, University of Washington

Reporting Period: February 1, 2022 – January 31, 2023

Submission Date (Due March 1 immediately following the reporting period): March 1, 2023

Project Website: https://gulfwatchalaska.org/

Please check all the boxes that apply to the current reporting period.

☒ **Project progress is on schedule.**

☐ **Project progress is delayed.**

☒ **Budget reallocation request.**

Funding was only received on 1 July 2022, and I used the no-cost extension from the previous 5 yr period to cover costs, therefore I request using the remainder of this budget to cover the period to 30 June 2023 when the next year of funding is expected.

☐ **Personnel changes.**

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1. Summary of Work Performed:

In the ten-year proposal for this project, we had the following objectives.

1. Conduct annual stock assessments of Prince William Sound (PWS) herring using the Bayesian age structured stock assessment (BASA).
2. Review best practices globally for managing highly variable fish populations.
3. Create a management strategy evaluation (MSE) framework for PWS herring.
4. Evaluate alternative harvest control rules for setting herring catches.

5. Evaluate tradeoffs between cost and frequency of surveys and other types of data collected for use in the stock assessment.

6. Test the robustness of the management process to misspecification in parameter values or relationships assumed in the stock assessment model.

7. Create a spatial model of Prince William Sound herring.

8. Create a model of intermediate complexity (MICE) that captures key interactions between humpback whales, pink salmon, Alaskan pollock, and herring.

In this first year of the project, we have made progress on the first four objectives. We ran the 2022 assessment for PWS herring, have begun gathering data for best practices globally for harvest control rules of fish populations, have created an MSE framework for PWS herring, and have preliminary results for the evaluation of alternative harvest control rules for setting PWS herring catch. More details are provided below.

1. Bayesian age-structured stock assessment (BASA)

In previous years, the age structured assessment (ASA) model run by the Alaska Department of Fish and Game (ADF&G) was expanded to run in a Bayesian framework (Muradian et al. 2017), used to determine which historical data sets were the most informative (Muradian et al. 2019), used to assess which factors influence herring recruitment and mortality (Trochta & Branch 2021), and formed the basis of simulation testing of the utility of disease seroprevalence data (Trochta et al. 2022). BASA continues to evolve and is now fit 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), programmed into AD Model Builder by Cole Monnahan as part of broader efforts in the Branch lab to improve stock assessment methods (Monnahan et al. 2007, Monnahan and Kristensen 2018, Monnahan et al. 2019). Whereas previous iterations each took about 8 hours to obtain 1000 independent samples, the 2022 model obtained 2000 posterior samples in ~2.15 minutes, i.e. approximately a 500-fold improvement in efficiency. Thus the NUTS algorithm allows a much broader array of sensitivity tests to be run and facilitates rapid debugging and evaluation of alternative models.

A preliminary herring assessment was conducted in BASA in August 2022 based on small sample of age composition data, and final results (based on complete age composition data) conducted in mid-January 2023 based on all data collected in 2022. The 2022 assessment was fit to survey age composition data, the aerial survey measuring mile-days-of-milt, and the age-1 aerial schools survey (Fig. 1), but not to the hydroacoustic biomass estimate from the Prince William Sound Science Center, since funding for this survey has been discontinued. Disease antibody data were also available, and these data have been shown through simulation to improve estimates of disease outbreaks (Trochta et al. 2022). Work is ongoing to update BASA to routinely fit to the antibody data, but this requires substantial model reworking and is not yet fully integrated in BASA.

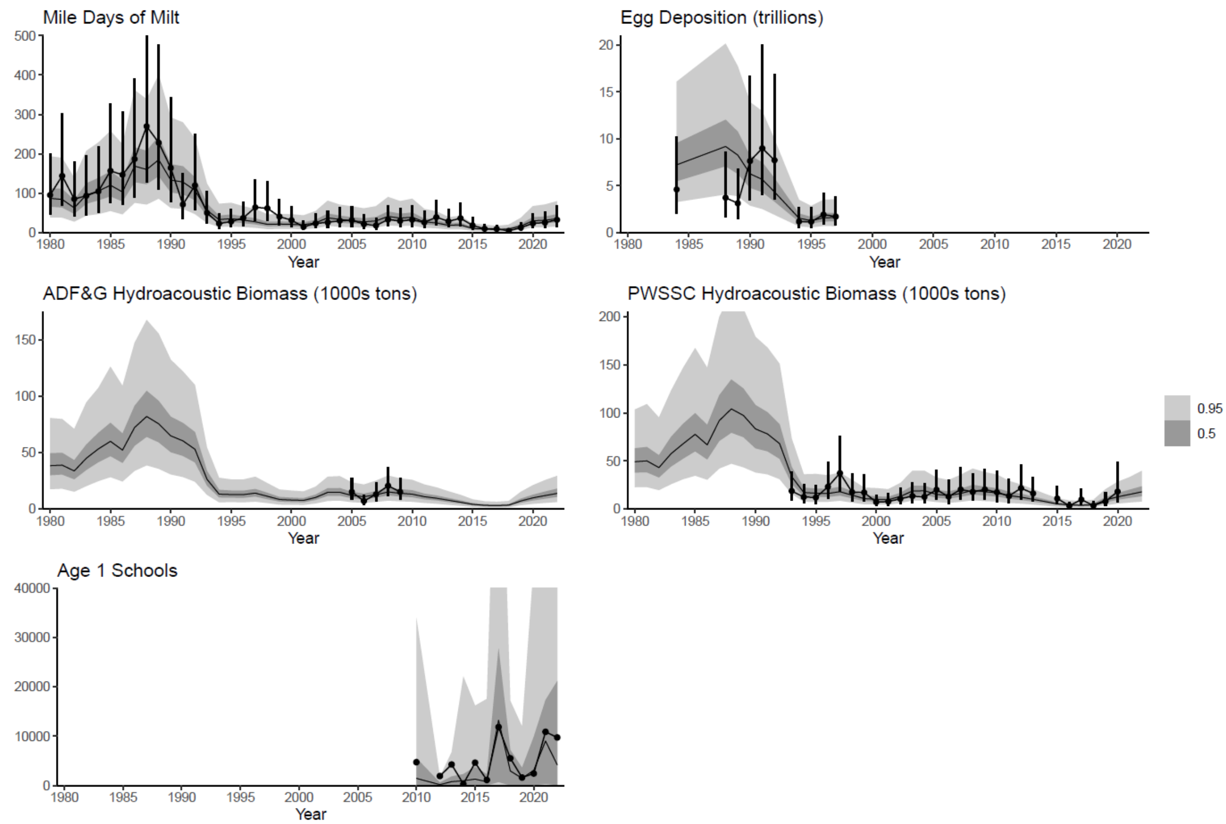

Figure 1. Bayesian age structured assessment model fits to the aerial survey for mile-days of milt, now discontinued survey series (egg deposition, Alaska Department of Fish and Game [ADF&G] hydroacoustic, Prince William Sound Science Center [PWSSC] hydroacoustic), and the aerial age-1 schools index.

Results from the 2022 assessment demonstrate continued good fits to the available survey data. Model estimates continue to support a strong 2016-year class, which continued to grow as age-6 individuals in 2022 (Fig. 2). This has led to continued biomass growth as has been observed in recent years. Model fits to the age-1 aerial school data also imply the possibility of a strong 2020- and 2021-year classes, possibly of similar magnitude as the 2016 class.

Figure 2. Bayesian age structured assessment model fit (points and lines showing 95% credibility intervals) to the purse seine catch and spawner survey age composition data (bars) for 1980-2022.

The model estimated spawning stock biomass to be 24,450 metric tons (95% CI: 16,240–37,580) in 2022, with an 18% probability that the biomass is below the lower regulatory threshold of 19,958 mt (Fig. 3). The estimated biomass is the highest estimated since 2009.

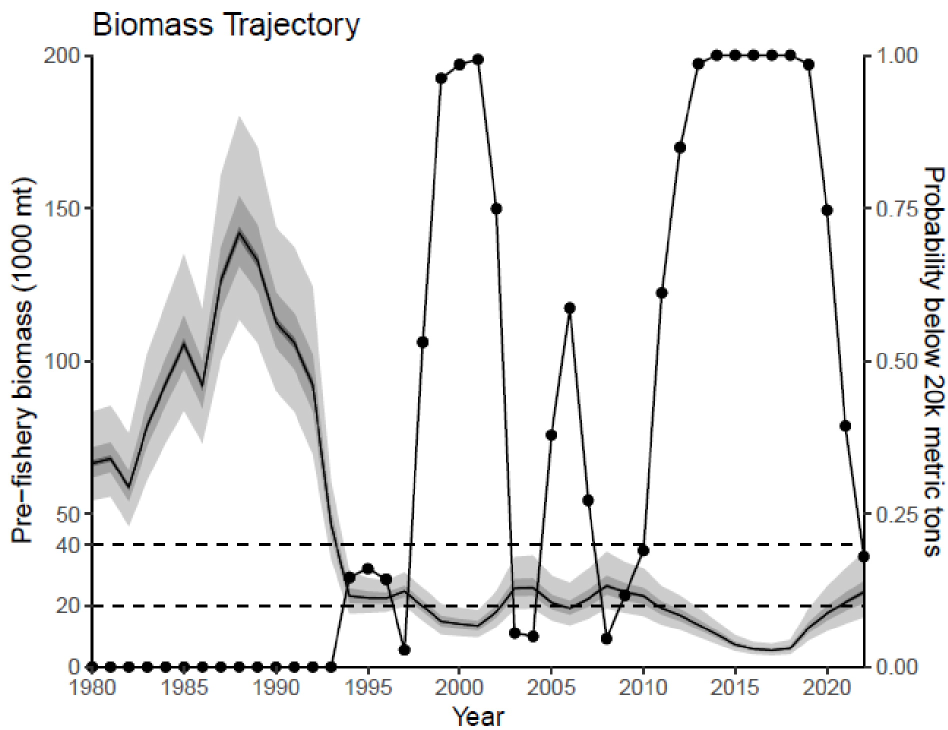

Figure 3. Spawning biomass estimates (shaded areas) and probability of falling below the lower regulatory threshold (points and lines).

New to this project is the new method of reporting the stock assessment results, which for the 2021 and 2022 stock assessments have been reported using a newly standardized eight-page summary document created in RMarkdown that can be automatically generated at the conclusion of the BASA model run and analysis routine.

2. Review best practices globally for managing highly variable fish populations.

To inform the design of the being performed on PWS herring, as well as the harvest control rules being assessed, a review of MSE and harvest control rules (HCRs) across the world is being performed. Current findings indicate that the most common control rules are constant harvest rate and threshold-based policies, though constant catch rules are not uncommon. Many MSEs are not currently used in an operational context, though South Africa, Australia, and some ICES stocks are currently managed by using MSEs. Most analyzed MSEs evaluated control rules on some catch-based metric (often total or annual catch), some catch variation metric (often average annual catch variation [AAV]), and some biomass depletion metric (often final year biomass/depletion, or lowest biomass/depletion). This information was used when considering what harvest control rules to select for testing for PWS herring as well as what performance metrics to utilize.

3. Create an MSE framework for PWS herring

Work began in early 2022 to develop an MSE framework for the PWS herring. MSE is a large-scale simulation framework that allows for testing the effect different management procedures (combinations of assessment models/frequency and harvest control rules) have on a given population over the course of many years. Briefly, the MSE framework is composed of an "operating model" (OM) that simulates the true state of the fish stock (as it is in the ocean) and an "estimation model" (EM) that attempts to re-estimate the true state using current stock assessment estimation procedures (Punt et al. 2016). In this particular case, both the OM and EM are age-structured population models that assume constant natural mortality and log-normally distributed recruitment, though the OM models recruitment as happening in distinct regimes.

4. Evaluate alternative harvest control rules for setting herring catches.

The MSE framework developed here is being used to simulate the effect of ten distinct HCRs on the PWS herring population. Five of these rules are simple threshold-based HCRs like the current 40-20 control rule that is in place currently. They include the current control rule that linearly scales the allowable harvest rate from 0.0 to 0.2 when biomass is between 19,958 mt and 38,555 mt, with a harvest rate of 0.0 below the lower threshold and 0.2 above the upper threshold, a rule that uses a maximum harvest rate of 0.1, a rule that uses a maximum harvest rate of 0.4, a rule that uses a lower threshold of 10,000 mt, and a rule that uses a lower threshold of 30,000 mt. We are also testing a rule that adds an additional step to a harvest rate of 0.6 when biomass is greater than 60,000 mt, a large-fish rule that is based on the biomass of fish >110 g (as opposed to the biomass of the entire stock), a rule that allows higher catches when a greater diversity of ages is present in the population, a gradient rule that accounts for recent trends in biomass, and a 'null' rule with no fishing for comparison.

A small number of simulations have been run for each of the ten control rules. Simulations lasted for 25 years, and the control rules were compared based on average annual catch, AAV, and depletion level in the final simulation year. Preliminary results identify the control rule that uses a lower limit threshold of 10,000 mt as the best performing control rule of those tested, followed closely by the rule that is currently in place (Fig. 4). These simulations also characterize the inherent tradeoffs between the three performance metrics. Annual catch and final year depletion are very strongly negatively correlated, while depletion and AAV, and annual catch and AAV are less so (Fig. 4).

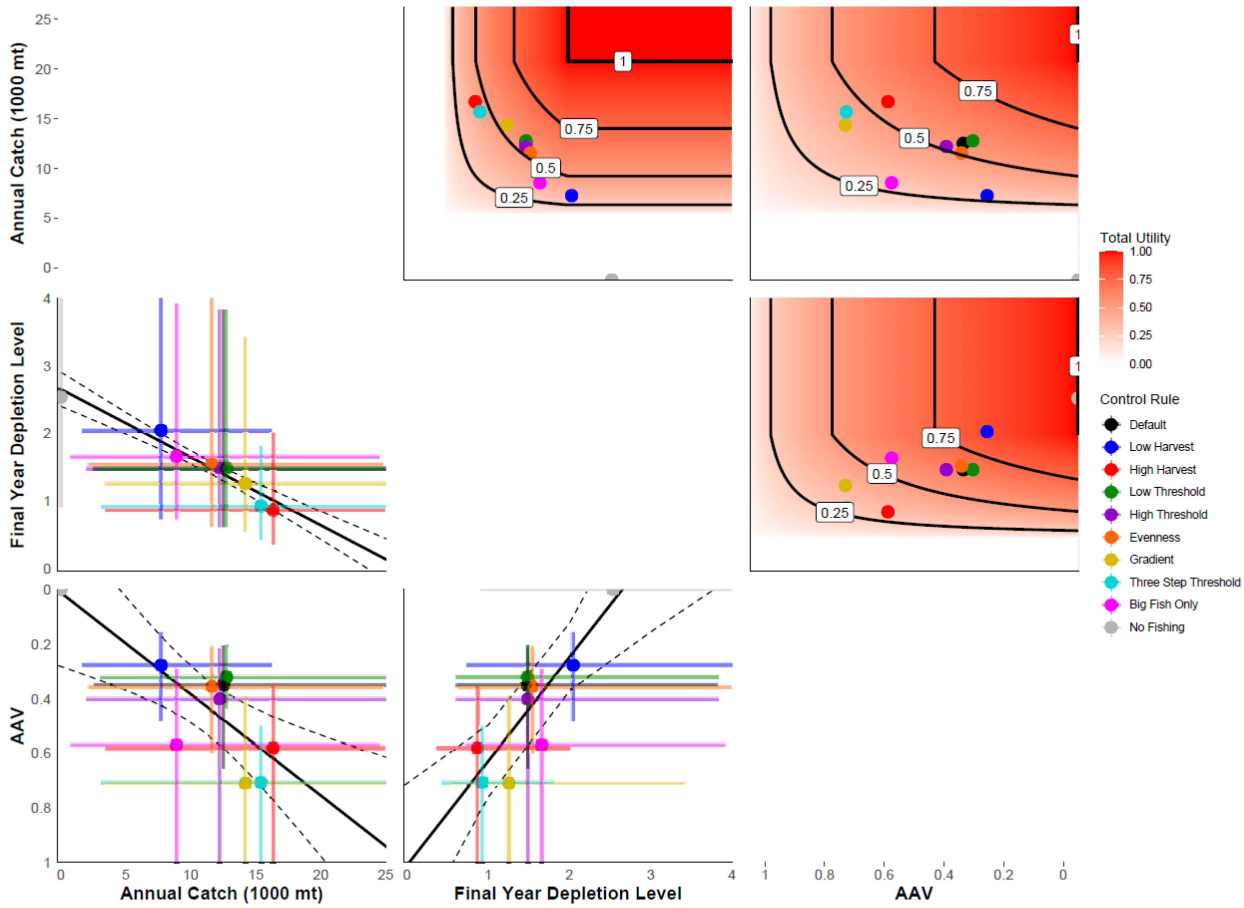

Figure 4. Preliminary performance of ten candidate harvest control rules tested in the MSE framework. Each rule is depicted by a different color, and the comparison is across annual average variation in catch (AAV), annual catch, and the final depletion in biomass.

Further simulations are planned for the coming months. These future simulations are planned to last for 35 years and compare the same ten control rules using the same three performance metrics as described above. The number of simulations will be expanded to 500 to fully evaluate how well the control rules perform in the face of uncertainty in population dynamics, monitoring data, and estimation framework.

References

Monnahan, C. C., T. A. Branch, J. T. Thorson, I. J. Stewart, and C. S. Szuwalski. 2019. Overcoming long Bayesian run times in integrated fisheries stock assessments. ICES Journal of Marine Science 76:1477-1488.

Monnahan, C. C., and K. Kristensen. 2018. No-U-turn sampling for fast Bayesian inference in ADMB and TMB: Introducing the adnuts and tmbstan R packag. PLoS One 13:e0197954.

Monnahan, C. C., J. T. Thorson, and T. A. Branch. 2017. Faster estimation of Bayesian models in ecology using Hamiltonian Monte Carlo. Methods in Ecology and Evolution 8:339-348.

Muradian, M. L., T. A. Branch, S. D. Moffitt, and P.-J. F. Hulson. 2017. Bayesian stock assessment of Pacific herring in Prince William Sound, Alaska. PLoS One 12:e0172153.

Muradian, M. L., T. A. Branch, and A. E. Punt. 2019. A framework for assessing which sampling programs provide the best trade-off between accuracy and cost of data in stock assessments. ICES Journal of Marine Science 76:2102-2113.

Punt, A. E., D. S. Butterworth, C. L. de Moor, J. A. A. De Oliveira, and M. Haddon. 2016. Management strategy evaluation: best practices. Fish and Fisheries 17:303-334.

Trochta, J. T., and T. A. Branch. 2021. Applying Bayesian model selection to determine ecological covariates for recruitment and natural mortality in stock assessment. ICES Journal of Marine Science 78:2875-2894.

Trochta, J. T., M. L. Groner, P. K. Hershberger, and T. A. Branch. 2022. A novel approach for directly incorporating disease into fish stock assessment: a case study with seroprevalence data. Canadian Journal of Fisheries and Aquatic Sciences 79:611-630.

2. Products:

Peer-reviewed publications:

Dias, B. S., D. W. McGowan, R. Campbell, and T. A. Branch. 2022. Influence of environmental and population factors on Prince William Sound herring spawning phenology. Marine Ecology Progress Series 696:103-117.

Trochta, J. T., M. L. Groner, P. K. Hershberger, and T. A. Branch. 2022. A novel approach for directly incorporating disease into fish stock assessment: a case study with seroprevalence data. Canadian Journal of Fisheries and Aquatic Sciences 79:611-630.

Reports:

Trochta, J. T., J. A. Zahner, and T. A. Branch. 2022. 2021 Bayesian Age-structure Stock Assessment (BASA) results for Prince William Sound (PWS) herring. Report to HRM team members and ADF&G, 8 pp.

Zahner, J. A., and T. A. Branch. 2023. 2022 Bayesian Age-structure Stock Assessment (BASA) results for Prince William Sound (PWS) herring. Report to HRM team members and ADF&G, 8 pp.

Popular articles:

None

Conferences and workshops:

Zahner, J. A., and T. A. Branch. 2023. Evaluation of harvest control rules for Prince William Sound Pacific herring. Alaska Marine Science Symposium, 24 January.

Public presentations:

None

Data and/or information products developed during the reporting period:

None

Data sets and associated metadata:

Nearshore Component data are organized and presented coherently on the publicly available Gulf of Alaska Data Portal: https://gulf-of-alaska.portal.aoos.org/#metadata/4aaecfe2-de4b-4b6b-ba8e-bb715d26c6f1/project/folder_metadata/41873621.

Additional Products not listed above:

None

3. Coordination and Collaboration:

The Alaska SeaLife Center or Prince William Sound Science Center

This project includes extensive collaboration with personnel at the Prince William Sound Science Center, regarding historical hydroacoustic surveys of herring biomass, interpretation of stock assessment results, modeling ideas, and use of age-1 aerial survey for herring schools.

EVOSTC Long-Term Research and Monitoring Projects

This project includes extensive use of herring disease modeling projects in the stock assessment model, estimation of hydroacoustic surveys for herring biomass, ageing projects, herring maturity project, herring movement project, age-1 aerial surveys and more. In essence, every herring project and other broader ecosystem projects that have gathered long-term data are incorporated into PWS herring modeling efforts.

EVOSTC Mariculture Projects

None.

EVOSTC Education and Outreach Projects

This project regularly provides articles for Delta Sound Connections, and the principal investigator does extensive science communication through Twitter to 17,000 followers.

Individual EVOSTC Projects

None.

Trustee or Management Agencies

Coordination with Alaska Department of Fish and Game (ADF&G) scientists (e.g., Jennifer Morella) is ongoing and required for data inputs collected by ADF&G and used in the BASA stock assessment model. BASA model results are shared and coordinated with Sherri Dressel of ADF&G. The project, student Joshua Zahner, has provided training to ADF&G scientist CL Roberts at a fisheries stock assessment methods workshop on how BASA and Bayesian stock assessment models work.

Native and Local Communities

No direct involvement.

4. Response to EVOSTC Review, Recommendations and Comments:

May 2021 EVOSTC Science Panel Comment: This modeling project has been funded for the past ten years. During this time, a Bayesian age-structured assessment model (BASA) for PWS herring was developed, expanded to fit to new time series, e.g., age-1 aerial survey index and disease data (including a simulation test of the usefulness of disease data), sensitivity tested (e.g., alternative maturity schedules), and other model improvements were incorporated. Beyond stock assessment, this project also evaluated PWS herring dynamics relative to global herring populations, and examined factors affecting recruitment, natural mortality, spawning location, and spawn timing in PWS.

We remain very appreciative of the work conducted in this project over the years. The BASA model has proven to be very useful to examine and test model assumptions. It has also provided value added in the meta-analysis of global herring populations that provided insights on PWS herring recovery, examination of ecological and environmental factors affecting recruitment, and a better understanding of spawning timing and location. In terms of publications, the project has been very productive with three peer-reviewed articles, three more undergoing review and another in preparation. During this time, two graduate students were funded and graduated, and a total of three years of funding was provided to two postdocs.

The PIs have proposed a new 10-year work plan for this project to include eight objectives. Objective 1 involves the conduct of routine annual stock assessments of PWS herring including updated data. We appreciate further refinements of BASA, including incorporation of the latest disease information, as well as the proposed annual reporting of stock assessments of PWS herring to ADF&G and the fishing industry. However, before the conclusion of this project, the PIs should plan to transfer the BASA model to ADF&G, including the training of ADF&G biometricians for its operation. Herring biometricians in ADF&G's Central Region (PWS), Southeast Region (Sitka) and statewide office (Juneau) should be invited. This might be accomplished as part of a workshop or as a small focus group of herring stock assessment modelers. Development of a "how-to" manual may be useful to help facilitate future transitions associated with turnover of ADF&G biometric staff. Thus, we suggest that plans for transferring the model to ADF&G for routine stock assessment should be an important part of this current proposal. This transfer certainly would not prevent future research proposals by the PIs using BASA.

PI Response: We appreciate the kind words and the support of the BASA model and further development. The annual model code and data will be posted on the Gulf of Alaska Data Portal and can be downloaded and run by ADF&G scientists or adapted for use in other regions. In addition, one of the workshop topics proposed by Scott Pegau covers modeling and would be a good avenue for transfer of knowledge and to allow for future implementation of the model. We *discussed these ideas and comments this week with Dr. Sherri Dressel, with whom over the past 10 years we organized two sessions where the past student (Trochta), experienced in Bayesian models and in BASA, flew to Juneau to work with a focused small group of biometricians to discuss features of the model. We intend to continue this more informal training approach in the future because running Bayesian stock assessment models requires substantial background knowledge and is best explained to a small group. For the incoming University of Washington MS student, four quarter-long courses constitute the background knowledge needed in age-structured modeling, Bayesian methods, AD Model Builder, and C++ or equivalent. We recognize that adapting and adopting the BASA model and MSE methodology for management of Prince William Sound and other State herring stocks will require staffing of ADF&G scientists with a similar background acquired from courses taught by Prof. Cunningham at UAF Juneau, or Profs Punt and Branch at the University of Washington. Given considerations of ADF&G biometric staffing, we agree with the Science Panel that the development of a "how-to" manual would be useful and will plan to prepare documentation for ADF&G in case current staffing does not allow immediate implementation of model features or the MSE, and to help bridge gaps resulting from any staff turnover both at the University of Washington and ADF&G.*

With this in mind, we added the following text to the proposal in Section 4, Project Design, B.

Procedural and Scientific Methods, pages 5 and 6: "The annual stock assessments could also be run by ADF&G scientists with a suitable background in AD Model Builder and Bayesian age-structured models. In the past we have conducted informal training with a select group of biometricians, and we anticipate this would continue given that biometricians with a suitable background are available, such that by the end of the project, annual Prince William Sound stock assessments could be run by ADF&G using BASA. In addition, a "how-to" manual will be made available to assist in the transfer of knowledge and enhance the ability of ADF&G to adopt the methods developed in this project if biometricians with suitable backgrounds are not immediately available. This would also bridge any gaps resulting from personnel turnover at either the University of Washington or ADF&G."

May 2021 EVOSTC Science Panel Comment: Objective 2 involves a review of best practices to manage highly variable fish populations. Three options were proposed. Among these, option 1 seems to be most appealing as it should result in a set of harvest control rules to be included in the proposed management strategy evaluation (MSE). Option 2 is a review of how uncertainty is incorporated into catch setting in other regions. While this may be a worthwhile endeavor, we place lower priority on option 2 for the purposes of PWS herring at this time. Apropos to this option, it may be sufficient to report the probability that the true spawning biomass is below the fishery threshold, as was done in the assessment for 2020 as reported in the most recent annual report. Option 3 does not seem to be necessary, as performance metrics used to assess control rules are rather well known and easily assembled; indeed, common ones that might be included in the proposed herring MSE are already listed under this option.

PI Response: In Section 4, Project Design, B. Procedural and Scientific Methods, on pages 6 and 7, we have retained option 1 (review of harvest control rules) and deleted option 3 (performance metrics) given this feedback. We now expound slightly on option 2 (how to include uncertainty in biomass estimates in catch setting) to make it more clear why this is directly relevant—in short, the Bayesian assessment provides a distribution of possible stock status, requiring managers to weigh risk against catch levels, such that catches could be higher if the uncertainty in the stock assessment was smaller. This is a key difference compared to non-Bayesian stock assessments. This also ties directly into the costs and benefits of different streams of data being collected.

May 2021 EVOSTC Science Panel Comment: Objectives 3-6 concern the development and use of an MSE. Specifically, the PIs propose to conduct an MSE involving an operating model (i.e., "truth") that generates data mimicking those available in reality. The resultant data are then fed into BASA, and then a harvest control rule is used to set annual catches for the next year. By repeating this process, the PIs propose to: (1) evaluate different harvest control rules, (2) assess the trade-offs between cost and frequency of future surveys, (3) and test the robustness of the management system and BASA to misspecification. We suspect that the results of the MSE will be highly dependent upon the assumptions made about future recruitment, so careful thought should go into recruitment, perhaps involving alternative recruitment scenarios. The proposal includes a list of alternative control rules. To this, we recommend including alternative fishery thresholds to open or close the fishery at low levels of spawning biomass.

PI Response: Under item 6, on page 9, we propose examining the effect of different recruitment relationships. This is not meant to be exclusive, and the MSE could also look at other recruitment scenarios identified as important, such as autocorrelated recruitment, random recruitment, or multiple consecutive years of good recruitment (or bad recruitment). Under item 4 rule we propose to examine the effects of allowing fishing at different biomass levels (the example given is 25% vs. 40% of unfished spawning biomass), which covers this request.

May 2021 EVOSTC Science Panel Comment: We appreciate the proposed assessment of tradeoffs between cost and frequency of future surveys. Undoubtedly, this effort would build upon the work by Muradian et al. (2019). That paper examined the relative contributions of several time-series data on the model output and performance. Several questions arise but the key one concerns the data that provides the most useful output of the model for herring assessment. Specifically we questioned the cost:benefit of the acoustic assessments and the specific implications of the results presented in Table 3 of that report. We had difficulty duplicating some of the cost estimates including the aerial survey, which was estimated to cost

about $16 K/year, and does not appear to be correct to us. We request that the PIs carefully check these cost estimates for the proposed MSE work.
PI Response:

PI Response: We will revisit estimates of cost for each survey into the future, for the future MSE work, which will differ from average costs of $16k/yr for the 33 aerial surveys conducted during 1980-2013 (Muradian et al. 2019), supplied by ADF&G. Notably, the proposed budget for the 2022 aerial survey is about $60k.

Muradian, M.L., T.A. Branch, and A.E. Punt. 2019. A framework for assessing which sampling programs provide the best trade-off between accuracy and cost of data in stock assessments. ICES Journal of Marine Science 76:2102-2113

May 2021 EVOSTC Science Panel Comment: Results of the cost:benefit MSE will be critical to future decision-making about which data sets to maintain as EVOS funding comes to an end. Likewise, tests of the robustness of management to BASA model misspecification will be important to set future herring research priorities.

Objective 7 involves creation of a spatial model to capture subpopulation structure and objective 8 involves the development of a model of intermediate complexity (MICE) to integrate important competitors and predators into the herring model. The PIs propose to develop a MICE for PWS herring that only models the abundance and interactions of the key species suspected of having strong interactions with herring: humpback whales, pink salmon, and Alaskan pollock. We strongly support the use of these models but we are disappointed with the timeline proposed. The philosophy for this objective seems to be to wait until the data are available, then extract insight from modeling the data. We suggest giving a higher priority to the spatial model, expecting that there will be data issues. However, some spatial data are already available – for instance, fisheries data by area, spawning timing by location, and results from the PWS herring migration study.

Moreover, if proposal 22220111-G is funded, it would make sense to begin the study design right away to explore scenarios for connectivity of Kayak Island herring to PWS herring. We also discussed the need for finer versus broader spatial details. For example, an appropriate scale for disease should be considered. We noted that herd immunity involves multiple spatial scales. With other diseases, sustained local hotspots have caused diseases to persist showing that interaction of moving groups of herring is influential.

PI Response: While it would be ideal to prioritize spatial models and MICE models, it requires substantial training to develop these skills over and above the training required for stock assessments and MSE work. Thus, the proposed timeline takes into account the training required rather than the availability of data. We have already identified an incoming MS student who will *be capable of conducting stock assessments and MSE work but plans to move on to a different topic and area of interest for their PhD. When they graduate, we will hire and train one or two PhD-level students to develop and run the more advanced spatial models and MICE models. If we hired three students at the start of the ten-year period, to work on all three projects simultaneously (MSE, spatial, MICE), there would be no funds to continue with modeling for the final five years of the proposal.*

May 2021 EVOSTC Science Panel Comment: This proposal strikes close to the core of all EVOSTC work because it informs the status of a key resource that was impacted by oil. Further, the past performance and output of the assessment modelling has set the direction for much of the associated collaborative and interdependent projects. Moreover, it appears to us that the proposed MICE for PWS herring has considerable potential to evaluate the management of the PWS herring fishery in an ecosystem context. Such an outcome would be a welcome result of the EVOS Trustee Council program.

PI Response: We appreciate these kind comments.

September 2021 EVOSTC Science Panel Comment: In many ways, this proposal sits at the core of all EVOSTC work because it informs the stock status of herring, a key ecosystem component and fishery resource in PWS that was impacted by the oil spill. A Bayesian age-structured assessment model (BASA) for PWS herring was developed to reconstruct the history of herring stock status in PWS. It has been expanded to fit new time series, sensitivity analyses have been conducted, and other model improvements were incorporated. This project also evaluated PWS herring dynamics relative to global herring populations, and examined factors affecting recruitment, natural mortality, spawning location, and spawn timing in PWS.

The PIs have proposed a new 10-year work plan for this project to include eight objectives. Objective 1 is to conduct ongoing annual stock assessments of PWS herring. Objective 2 involves a review of best practices to manage highly variable fish populations. Objectives 3-6 concern the development and use of a management strategy evaluation that would evaluate different harvest control rules, assess the trade-offs between cost and frequency of future surveys, and test the robustness of the management system and BASA to misspecification. Objective 7 involves creation of a spatial model to capture subpopulation structure and Objective 8 involves the development of a model of intermediate complexity (MICE) to integrate important competitors and predators into the herring model. The MICE modeling would be transformative by taking an ecosystem approach to the assessment and management of PWS herring.

We note the synergy of this last objective with the new pink salmon - Pacific herring study, if it is funded. The PI has been very responsive to our previous comments. We appreciate the PI's consideration of mechanisms for transfer of the BASA model to ADF&G scientists and agrees with the PI's plan to post model code and data on the Data Portal, provide informal in-person training such as was done by former student John Trochta, consideration of a potential workshop as proposed by Scott Pegau, and preparation of a "how to" manual to facilitate future knowledge transfer to bridge gaps created by personnel turnover at UW or ADF&G.

PI Response: the ecosystem model including pink salmon is planned near the end of the proposed ten-year modeling study, to allow for longer-term information from the pink salmon-Pacific herring study to be gathered. As part of the training and handover, Joshua Zahner instructed CL Roberts (ADF&G herring biometrician) in the use of the BASA model in September 2022, piggybacking on a training course in Bayesian methods led by Prof. André Punt at Friday Harbor Marine Labs, which both Joshua Zahner and CL Roberts attended. After consultation with AXIOM, the full code and results for BASA are planned to be posted on a GitHub site for each stock assessment cycle, allowing for reproducibility of the analyses.

We appreciate and agree with the PIs clarifications and responses to our remaining comments. This has been a very productive project, yielding three peer-reviewed publications, three more undergoing review and another in preparation. During this time, two graduate students were funded and graduated, and a total of three years of funding was provided to two postdocs. PAC Comments Date: September 2021 The PAC meeting was held on September 28-29, 2021. It is noted that the PAC requested that the Trustees prioritize the ongoing projects with long-term data sets.

Executive Director Comments: The BASA model developed from this project will be one of the legacies of the HRM program which will be transferred to ADFG to assist and improve herring stock assessments and management. Council-funded herring projects provide data for this modeling project. I concur with the Science Panel comments.

PI Response: We thank the Executive Director and Science Panel for their comments.

5. Budget:

EXXON VALDEZ OIL SPILL TRUSTEE COUNCIL
PROJECT BUDGET PROPOSAL AND REPORTING FORM

Budget Category:		Proposed FY 22	Proposed FY 23	Proposed FY 24	Proposed FY 25	Proposed FY 26	5- YR TOTAL PROPOSED	ACTUAL CUMULATIVE
Personnel		$62,295	$65,827	$67,599	$69,421	$71,293	$336,435	$13,012
Travel		$4,509	$4,734	$8,719	$7,809	$8,199	$33,970	$3,172
Contractual/Tuition		$18,672	$19,606	$20,586	$21,616	$22,697	$103,177	$7,515
Commodities		$4,800	$800	$3,100	$3,100	$3,100	$14,900	$0
Equipment		$0	$0	$0	$0	$0	$0	$5,046
Indirect Costs	Rate = 55.5%	$39,740	$39,606	$44,077	$44,583	$45,839	$213,844	$8,982
	SUBTOTAL	$130,016	$130,573	$144,082	$146,528	$151,128	$702,327	$37,727
General Administration (9% of subtotal)		$11,701	$11,752	$12,967	$13,188	$13,602	$63,209	N/A
	PROJECT TOTAL	$141,717	$142,324	$157,049	$159,716	$164,729	$765,536	
Other Resources (In-Kind Funds)							$0	

COMMENTS:
The Contractual row represents tuition, which is excluded from Indirect costs. For FY22, funds were awarded on July 1 instead of February 1; therefore, we supported the personnel, tuition, and some commodities on a no-cost extension from FY17-21 EVOSTC funding for PWS herring modeling. The remainder of the FY22 budget will support the project through July 1, 2023.

In the original budget we included funds for a fast multi-core computer and student laptop totalling $4,000 (+$2,200 indirect). Instead we purchased a much faster computer with more cores, RAM, and hard drive space for $5,046, which was over the threshold for capital equipment and therefore not subject to indirect costs. Thus, the total computer expenditure was $5,046 instead of $6,200 but is listed under equipment instead of commodities.

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For FY 22 the money was only awarded 1 July instead of 1 February, therefore we supported the personnel, tuition, and some commodities on a no-cost extension from EVOSTC funding for FY17-21 for PWS herring modeling. The remainder of the FY22 budget will support the project through to 1 July 2023.

Note: in the original budget we included money for a fast multi-core computer and a student laptop, totaling $4,000 (plus $2,200 in indirect costs). Instead, we purchased a much faster computer with more cores, RAM, and hard drive space for $5,046, which was over the threshold for capital equipment, and therefore not subject to indirect costs. Thus, the total computer expenditure was $5,046 instead of $6,200 but is listed under Equipment instead of Commodities.